

A Century of Telemedicine

Curatio Sine Distantia et Tempora
A World Wide Overview – Part I



Editors:

Anton Vladzomyrskyy, Malina Jordanova, Frank Lievens

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A World Wide Overview – Part I

2017

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PREFACE

Dear Reader,

The book “A Century of Telemedicine. Curatio Sine Distantia et Tempora: A World Wide Overview” Part I is now in your hands. This is the first book of the new series, dedicated to a more detailed history of Telemedicine and eHealth in various countries.

The chapters reveal different national and cultural points of view on the development and implementation of Telemedicine/eHealth solutions for the treatment of patients and wellbeing of citizens. The book provides a glimpse and summarizes the best practical achievements, existing solutions and experiences in an initial set of six countries. The goal is to share these national experiences with international, other national and regional institutions and policy makers as well as with all groups or individuals involved with healthcare.

The book offers a wide range of bottom-up and top-down approaches and solutions as well as a logical follow-up of the previous monograph (Vladzimirsky A., Jordanova M., Lievens F. A Century of Telemedicine: Curatio Sine Distantia et Tempora. Sofia, Bulgaria, 2016). It provides directions for a wide variety of decisions, able to affect the form and functioning of the healthcare sector over the next decades, and offers clues towards the expected future of health organization at community level.

The results and guidelines presented apply to all – national and local administration, individual practitioners, group practices, healthcare systems, as well as to providers of health-related services where there are Telemedicine/eHealth interactions either directly to the patient or from provider to provider for the purposes of healthcare delivery.

Telemedicine/eHealth offers enormous possibilities. The technological solutions are available and ready for implementation. If carefully realized, taking into account the needs of the community, cultural frames and economic development, Telemedicine/eHealth is able to improve both access to and the standard of healthcare, and thus to close the gap between the demand and supply of affordable, high quality healthcare to everyone, at any time, everywhere.

The editors are convinced that this book will provide useful information to those who are preparing to introduce or expand Telemedicine/eHealth in their regions or countries. It will allow them to rely on the experience of others and will make them aware of the benefits and problems that were encountered during and after implementation of systems or services, and as such, will help them to possibly avoid mistakes and reduce potential problems.

Yet, it is necessary to underline that:

- The content of the book is divided in chapters covering various areas of Telemedicine/eHealth;
- Each chapter presents the expertise of one country;
- Countries included in the book are chosen on basis of a random selection method;
- Chapters, except the one for the International Society for Telemedicine and eHealth, are listed alphabetically;
- The original style of the authors was respected as much as possible;
- “How”, “Where”, “When” are only part of the questions that authors are trying to answer;
- In order to shorten repeated references the abbreviation “ibid” is used. It originates from Latin *ibidem*, i.e. "in the same place";
- Despite the amount of information included in each chapter, no doubt that many events and facts are still out-of-sight. We hope to be able to fill these gaps in later editions.

We firmly believe that everyone involved in Telemedicine/eHealth will find this book not only interesting, but most valuable as well.

Enjoy your reading!

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AUSTRALIA

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Introduction

Australia is a land of contrast. It is one of the most highly urbanised nations in the world [1], with one of the lowest population densities [2]. Only ten percent of the population occupies 95 percent of the land area, spanning over 7.5 million square kilometres with the vast majority of the population clustered in capital cities located on the coastal fringes separated by many thousands of kilometres [3]. This unique conglomeration of urban and remote populations has driven both the development and uptake of telemedicine in Australia.

Furthermore, there are two additional major trends in the Australian population, which have major implications for the provision of health and social services. The Australian Bureau of Statistics reported that in 2011, there were 3.08 million people aged 65 years and over in Australia [4]. The urban-rural divide offers another challenge, the majority of the residents in some rural communities are aged over 65 years [5].

Consequently, different programs and policies may be required to meet the health and social needs of the Australian population that may benefit from innovative approaches and the introduction of new technology. A recent report concluded that approximately a quarter of people aged over 65 with chronic health conditions could benefit from the advancements that telehealth can provide (e.g., remote monitoring) in a *Digitally Enabled Health System* [6].

Health policy in Australia is driven by the country's complex interaction of geography, history and politics. Australia is a federation with responsibility for health shared between the six states (i.e., New South Wales, Victoria, Queensland, South Australia, Tasmania and Western Australia), two territories (Northern Territories, and Australian Capital Territory) and the commonwealth government. In addition there are a variety of health service providers, as Australia's healthcare system is a

hybrid model combining a diverse range of private, public and not-for-profit entities.

The Australian healthcare system has many actors, who are involved in the administration and delivery of healthcare services. The states have primary responsibility for hospital services, while the Commonwealth is largely responsible for funding of medical services, general practice, research and pharmaceuticals. Historically, the Commonwealth did not always pursue this role in relation to healthcare, and it was only after a successful referendum to alter *The Constitution* that the Commonwealth was provided with the legislative power for social services which included: 'pharmaceutical, sickness and hospital benefits, medical and dental services' [7]. This provision provided the Commonwealth with the power to legislate directly in relation to the provision of health services and funding [8].

The healthcare system underwent another shake-up by the mid-1970's, with the introduction of Medibank Private Limited, an Australian government-owned private health insurer and currently Australia's largest health insurance provider. The Australian Commonwealth Government contributes to medical expenses and hospital care through a scheme called Medicare. Medicare is a publicly funded universal health care system in Australia, used for the provision of funding of primary healthcare for all Australians. It is this direct government involvement in the delivery of health services, coupled with Australia's geography and remote population that have nurtured innovative and pioneering approaches towards telemedicine that define uniquely Australian experiences. Medicare pays for a benefit for visiting a doctor, radiography services, optometry examinations – but not corrective lens, and pathology services. The states each administer public hospital systems, which receive funding from Medicare and the Commonwealth for the services provided. Medicare does not pay towards ambulance costs, dental services, physiotherapy, podiatry, or chiropractic services. There have been debates and inquiries around providing Commonwealth funding for oral health services [9]. However, none have recommended a Medicare model for funding oral health care.

This chapter describes the history of telemedicine in Australia. It commences with the evolution of telemedicine concepts throughout Australia's history. It presents the regulatory, legal and policy context, and describes the major industry players in Australian health care. The chapter then examines the emergence of telemedicine practice in Australia, with a focus on Australia's economic, demographic and social conditions.

This chapter can only provide a brief description of the telemedicine landscape in Australia. The interested reader is directed to the chapter's sections: 'Industry Players in Australian Telehealth' and 'Recent

Telemedicine Initiatives’, which contain key references to current activities across the country [101-127]. Additionally, Appendix 1 presents a list of Australian websites of interest. These will provide a good foundation for discovering other initiatives not explicitly mentioned in the text.

Australia is an active innovator in the telehealth space, as we will see later in the chapter, when we examine some recently introduced and future-looking concepts. This chapter also examines the challenges of telemedicine in Australia, both in terms of implementation, uptake and causes of failure, and in relation to the gaps in regulatory and legal frameworks.

New technologies have the potential to transform telehealth through increasing access to new services. The contention of the authors is that the development and emergence of new technologies, supported by appropriate regulatory frameworks will see the gradual implementation, expansion and uptake of new telemedicine services in the future that move beyond the traditional one-on-one, patient to doctor teleconferencing model. Recent telemedicine projects and critical thinking by representative telehealth bodies in Australia has indicated that large scale implementations are likely to be more successful if they are patient-centric, drive social engagement with peers, and work in the background in an ‘ambient’ mode that requires little or no input from the user that help reduce the ‘digital divide’ for those demographics, such as the aged, with limited digital skills.

History of Telemedicine in Australia

Telemedicine has been defined in many different ways according to policy, legal and technological constraints [10]. However, all definitions involve the use of remote communication or digital technologies to provide or enhance the provision of health care. In this chapter, telemedicine refers to the provision of health care at a distance, mediated through a number of tools, including teleconferencing, wearable technologies, and other digital technologies to complement conventional face-to-face consultation and treatment. This includes Australia’s early usage of the telegraph, as well as audio and video conferencing and clinical decision support platforms, as well as more recent initiatives such as remote patient monitoring via ‘the internet of things’ and mobile health.

Indigenous Australia

Any commencement of an examination of health practices in Australia must start with the indigenous inhabitants where archaeological evidence places the existence of the first people at over 70,000 years ago [11], the longest continuous culture on the planet. There has always been a connection between medicine/health and communication tools. For

example, in indigenous Australia, traditional knowledge and intellectual property was transmitted via songlines which traversed the country east to west and north to south [12]. Songlines enabled the transmission of a diverse body of knowledge across the country via words, melodies and rhythms which indicated key geographical elements and resources, as well as spiritual locations. Songlines also represent key channels of energy through the physical body intimately connected with health and well being, which were a key component of traditional indigenous health beliefs [13].

Colonisation

In the late 18th Century Australia was originally colonised by the British for use as a penal colony. Early medical practice was hampered by the remoteness of Australia from the United Kingdom. With early medical knowledge evolving from medically trained convicts, such as William Redfern, a Canadian-British surgeon sent to the new penal colony for encouraging mutineers [14], the fledgling colony's health care gradually grew to cater for convicts, settlers and officers alike.

Lack of quick communications meant that colonial Australia had to be self-reliant making use of the existing medical knowledge, which was often supplemented with indigenous knowledge in relation to specific plants and remedies [15].

The Telegraph

According to Vladzmyrsky and co-researchers there is a strong connection between telemedicine and electrical and electronic communication tools [16]. In this context, telemedicine of some form started almost as soon as these technologies (telegraph, telephone, and radio) were invented.

Australia, and its vast distances and isolated population meant that access and reliance on technology was essential to transmit medical knowledge and services. With the telegraph dramatically changing the way in which medical services could be accessed, ushering in the first wave of what we currently regard as 'telemedicine'. Consequently, it was not until the 1850's that technological advances for the transmission of information by telegraph, telephone and radio allowed for the expansion of telecommunication and informatics. In Australia, the first recorded use of the telegraph to perform telemedicine is from 1874 [17]. This occurred in the remote community of Barrow Creek, 280 km north of Alice Springs, and the site of a telegraph repeater station [18]. Due to poor treatment of the Kayetetye women by white men and the fencing in of the water hole, the repeater station was attacked. A telegraph was sent from the station to

Adelaide, whereby medical assistance from Dr Charles Gosse, a surgeon, attended the telegraph office to provide instructions for the proper treatment of the wounded [19].

Another example of the impact of the telegraph in increasing access to medicine was a remote medical procedure performed in 1917. The telegraph was used to tend to injuries arising from a stockman falling from his horse 300 km from medical assistance in the remote north of Western Australia [20]. The stockman received internal injuries from the fall and was brought to the postmaster and telegraphist Fred Tuckett at the Halls Creek repeater



Fig. 1: Traeger in 1928 demonstrating the first pedal radio [24]

station who had St John's Ambulance training [21]. Tuckett contacted a Perth doctor, some 2000 km away and gave a description, with 'a rupture of the urethra, blocking the bladder passage' being the remote diagnosis [22].

Only an operation could save the man. But there were neither instruments nor anaesthetics at Halls Creek. With morphia, permanganate of potash, a razor, a pocket knife and

considerable strength of mind, Tuckett followed the meticulous instructions telegraphed down the line by Morse code. The stockman survived for thirteen days but died of pneumonia [23].

Royal Flying Doctors Service (RFDS)

The plan for the Flying Doctor Service was conceived in 1912 by the Rev. John Flynn, superintendent of the Australian Inland Mission of the Presbyterian Church. Flynn organised bush hospitals for remote and rural settlers and itinerant workers such as stockmen, miners, and railwaymen. On 15 May 1928, his long-held dream was finally realised when, H.V. McKay, provided in his will for 'an aerial experiment'.

The RFDS concept became practical and broadened when an Adelaide electrical engineer, A.H. Traeger, developed a low-cost, portable, pedal-driven, Morse radio transmitter-receiver with a range of 300 miles. This transceiver, together with the use of aeroplanes, made possible a system of regular long-distance medical consultations and the flying of doctors to patients in emergencies.

In Fig. 1, Alfred Traeger demonstrates the first pedal radio he developed in 1928. This photograph was taken by Rev. John Flynn.



Fig. 2. Traeger's invention, the Morse typewriter [25]

Modern Telehealth started in Australia in 1929 with the use of this pedal radio to call the Australian Inland Mission Aerial Medical Service, later

renamed the RFDS. Traeger also developed a unique typewriter which converted letters into Morse code, which was vital for practical use by the general public (see Fig. 2). Pressing letter keys, displayed in Fig. 2, activated strips of metal containing notches and indentations representing the dots and dashes of the Morse code. These transceivers could receive the reply by voice telephony transmitted by the more powerful base stations.

Fig. 3 shows the associated list of pharmaceuticals supplied to remote communities. This sheet was kept next to the transceiver and allowed each drug to be identified simply by number. Later in 1951 Sister Lucy Garlick introduced a body chart which represented key areas of the body by number, again to make identification easy for the general public. The chart provided positions of their aches, pains and injuries for relay via radio to the remote clinician.

Today the RFDS still provides primary and emergency health services over a massive area exceeding seven million square kilometres. It is one of the largest aeromedical and dental organisations in the world flying almost 70 aircraft from 23 airbases. According to the RFDS, in 2015 over 280,000 patient contacts were made with more than 62,000 patients [26].

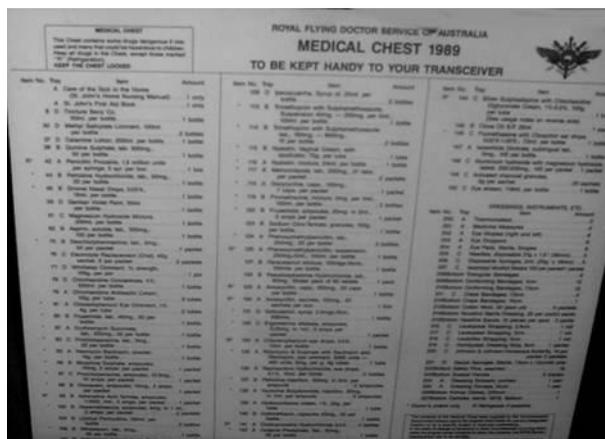


Fig. 3: List of pharmaceutical products next to the transceiver [27]

The Telephone

Building upon the developments of telemedicine in relation to the telegram, Australia entertained the use of the telephone system to provide telemedicine services. In 1973, publishing in *The Lancet* a team from the Royal Melbourne Hospital outlined the development of a technique that enabled patients to transmit their electrocardiogram via a telephone [28].

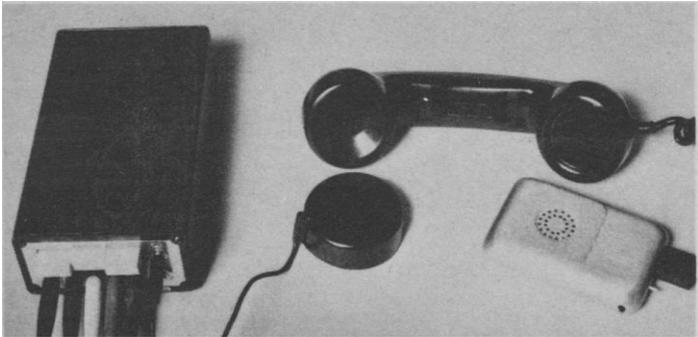


Fig. 4: Personal Telephone Electrocardiogram Transmitter [29]

The study involved giving patients with acute arrhythmia, pacemakers or paroxysmal palpitations personal transmitters to transmit the electrocardiogram (ECG) data via telephone. The layout of the system appears in Fig. 5.

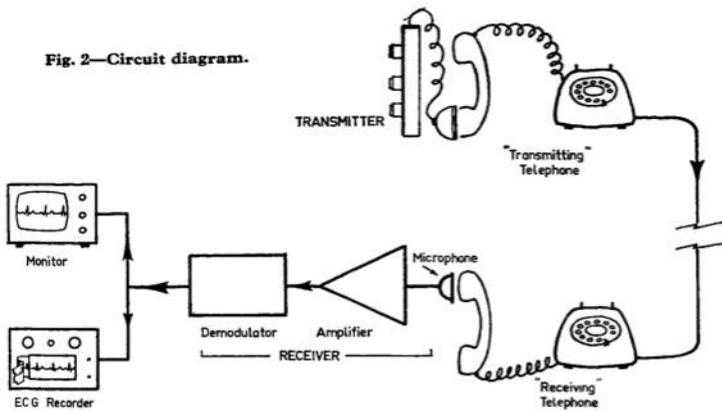


Fig. 5 Circuit diagram of the Personal Telephone Electrocardiogram Transmitter [30]

The system telemetry required continuous monitoring, using the Holter technique, which was expensive, especially given the high cost of storage. The system proved helpful in a clinical context.

The National Broadband Network (NBN)

More recently, the National Broadband Network (NBN), a publically funded initiative by the Australian government, was established to replace most existing broadband infrastructure in order to provide all Australians with high-speed connection, regardless of where they reside. The NBN is a hybrid technology scheme utilising optical fibre, satellite, as well as fixed wireless designed to give Australia access to fast, affordable and reliable Internet services. The basic service will eventually provide 25Mbit/s download and 5 Mbit/s upload to all Australians, and higher speed services are also available at higher cost. This means that in those areas currently with the NBN, telehealth services can easily be supported. The roll-out of the NBN is likely to continue until 2020 at least.

Two new ‘Sky Muster’ satellites were launched to cover regional and remote areas of Australia where the economics of fibre and fixed wireless could not be supported by the low population densities. One issue is that, although broadband speeds are adequate, the satellites are in relatively high Earth orbits such that the latency involved (possibly up to 500msec) could be an issue for some particular telehealth services.

In terms of geographical area covered, the NBN is possibly the largest public network in the world, providing coverage to 13 million households. The NBN does not sell directly to end customers, but provides its infrastructure through third parties (i.e., other communications operators).

NBN policies have been very controversial in Australia. Still, the Network boosted research and applications in e-health and telemedicine, making Australia one of the early implementers of telemedicine, investing in a number of projects in the last two decades [31]. Given the current rollout throughout Australia of the NBN, several trials are exploring the potential for remote health service provision. In recent years, telemedicine use in Australia has rapidly expanded, resulting in predictions that this will supersede face-to-face healthcare in rural areas by 2025 [32].

In the last four years, telemedicine use in Australia has been reported for clinical applications including hand injuries [33], diabetes management [34], dentistry [[35], wound management [36], oncology [37], psychiatry [38], [39] rehabilitation [40], chemotherapy [41], ophthalmology [[42], neurology [43], asthma [44], general practice [45], palliative care [46-47], nephrology [48-50], speech pathology [51] and podiatry [52]. Despite this, telemedicine still remains to be integrated into the mainstream healthcare delivery system [53].

The Emergence of Modern Telemedicine

Christenson describes telehealth as a disruptive product [54]. Disruptive products are introduced into a market, and although not immediately competitive against existing products, over time result in transforming the market to a new state, particularly suited to the product. A good example of this is the transistor radio. The transistor radio was introduced into a market where most radios were large furniture pieces that produced excellent sound. In that market the expensive and scratchy transistor radio was not immediately competitive, but resulted in changing consumer behaviour so that radios were used extensively outside the home.

A historical overview of telemedicine in Australia since Tuckett's over the telegraph operation, confirms telehealth and telemedicine to be a disruptive technology that has survived a long period of incubation while a series of technologies, including network infrastructure, clinical applications, standards and electronic health records, matured.

In 1979, the Australian Department of Health conducted a literature review surveying the development of telemedicine [55]. The report made known the state of the contemporary developments in the United States and other jurisdictions, however, it did not provide any detailed recommendations as to future policy directions.

Following this report, in 1997, the House of Representatives Standing Committee on Family and Community Affairs conducted an inquiry into health online focused on health information management and telemedicine [56]. The Committee found that a major factor inhibiting the development of telemedicine services 'is the absence of adequate telecommunications services to rural and remote communities' [57]. The report found that telehealth is essential to solving the challenge of providing health services to remote communities. Interestingly, and a pressing problem in the development of telehealth interventions, is the recommendation that the committee supports the 'full introduction of Telehealth but rejects the continuation of trials.' [58] The Committee noted that 'Many projects did not go beyond the trial stage once funds ran out leading to a great deal of wasted resources, particularly as the information and knowledge gained from them was never disseminated' [59]. Additional barriers identified by the Committee was the lack of incentives for GP's [60], along with difficulties for registration, given the existing state based approach to regulation [61] and the fact that it would diffuse responsibility for patient care [62].

Furthermore, Greenhalgh describes that telemedicine projects have been evaluated in different ways since their inception [63]. Early installations tended to be proof of concept systems evaluated on the basis of their

technical designs [64]. Following that, installations tended to be evaluated using experimental methodologies comparing cohorts using the technology with matched cohorts using conventional health care approaches. Stakeholder experiences were studied using qualitative ethnographic methodologies of patients' use of technology [65].

Greenhalgh suggests that future telemedicine evaluations require interdisciplinary study designs, clinical insights that embrace complexity and deploy sociotechnical systems theories [66]. The Australian Telehealth Document Repository managed by the University of Western Sydney [67] is a comprehensive collection of Australian Telehealth resources and has over 1000 entries, including journal papers, media articles, conference papers, etc. A review of the repository indicates that the earliest is a paper from 1973 entitled, "Clinical Value of the telephone-transmitted electrocardiogram" – the paper was described in the previous section. The repository shows that interest in the telemedicine area in Australia only really picked up in the mid-nineties after a long unexplained gap of approximately 15 years where there are no publications recorded. The reason for the timing of the renewed interest in the area probably stems from the timing of the introduction of network bandwidths capable of sustaining at least a limited form of telehealth services. Fig. 6 shows the historic development of downstream bandwidths generally available to the Australian population in metropolitan areas. It is clear that the increased number of telehealth initiatives correspond to the time when at least several tens of Kb/s became practical.

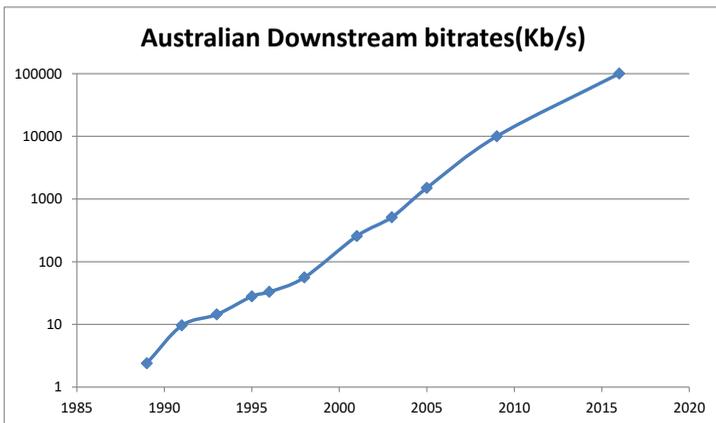


Fig. 6: Australian download rates

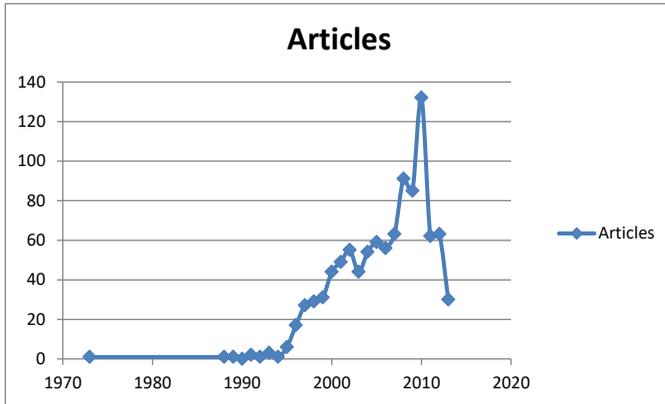


Fig. 7: Number of articles per year

Fig. 7 shows a gradual increase in the number of journal papers, books, and media articles concerning telehealth in Australia which gives some indication of the time and money being invested in the area since the 1970's in testing out new ideas and models of remote healthcare in the community. Note that there appears to be a sharp decline since 2010 to 2014 (the year in which the repository ends). More recent initiatives, such as the telehealth pilot trials sponsored by the federal government, as well as current and the potential future of telehealth activities in Australia are described later in this chapter.

Another interesting aspect from these figures is the breakdown of publications on a state-by-state basis. Table 1 shows the number of articles published in each state. It is clear that Queensland leads the country in the telehealth domain. New South Wales and Victoria follow despite much higher populations. The large land area of Queensland coupled with a sizable population seems to make it a natural choice for the testing of telehealth initiatives.

Western Australia, despite having a small percentage of the population, has the largest percentage of Australia's land area; almost exactly one third of the country. Hence, it is a relatively active jurisdiction in the telehealth area to overcome 'the tyranny of distance'. However, in this regard, the Northern Territory seems to be lagging well behind its peers, given that this state also has a relatively large land area and a very widely distributed

indigenous population in remote areas who could presumably gain great advantage from telehealth services.

Table 1: Summary of telemedicine articles by state

State	Articles	Population (M)	Area %
Queensland	326	4.8	22.5
New South Wales	232	7.6	10.4
Victoria	141	5.9	3.0
Western Australia	100	2.6	32.9
SA South Australia	63	1.7	12.8
Tasmania	29	0.5	0.9
Northern Territories	5	0.2	17.5

Since 2007 Standards Australia has published a series of guidelines in the telehealth domain as well as related areas such as collaborative care, diagnostics, electronic health record interoperability and information

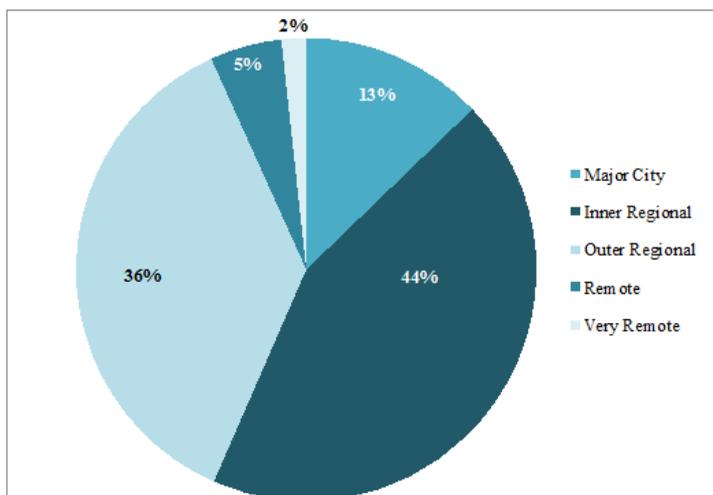


Fig 8: Telehealth services by patient remoteness area [71]

security [68]. For example, from 1st July 2011, Medicare rebates and financial incentives were made available for telehealth under the *Connecting Health Services With the Future* initiative which ended on 30

June 2014 [69]. However, Medicare Benefits Schedule (MBS) online [70] has a selection of telehealth-related information up to March 2014, which reveals various interesting statistics around the types and number of telehealth consultations and their geographical spread. For example, in Fig. 8, inner and outer regional areas were the biggest users of telehealth as might be expected, but there was still a large proportion of urban users in major cities (almost 13%).

In the 2.5 years covered from September 2011 to March 2014 the numbers of telehealth consultations went from below 2,000 to over 25,000 as per Fig. 9.



Fig. 9: Number of telehealth services per quarter [72]

This is an appreciable growth in uptake but is also the reason for the cancellation of the financial incentive scheme: it proved to be too popular even though the government were using this scheme to drive this very outcome. The other interesting thing about Fig. 9 are the annual dips in numbers of consultations over the Australian summer months.

Fig. 10 shows that Specialists made for about 65% of telehealth consultations, GP's around 35%, and midwives/nurses only 0.4%. However, other statistics contained on MBS online reveal that, taking into consideration the numbers of clinicians in each category, they all had a remarkably consistent number of approximately 17 consultations each on average.

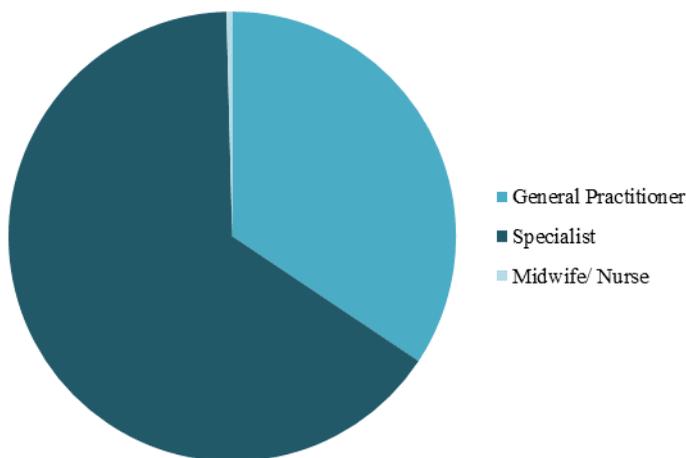


Fig. 10: Telehealth consultations by service kind [73].

Currently, MBS benefits are still available for services provided to patients located in regional, rural and remote areas, and new MBS telehealth items were introduced for initial specialist and consultant physician video consultations of ten minutes or less of clinical contact with the patient. On 1st November 2012, the MBS telehealth items were amended to require that the patient and remote specialist be at least 15 kilometres apart. However, this minimum distance requirement does not apply to residents of aged care facilities or patients of an Aboriginal health service.

Medicare benefits are also available for clinical support provided by a health professional to the patient during a telehealth consultation [74]. There are currently 23 telehealth MBS items available to medical practitioners, nurse practitioners, midwives, practice nurses and Aboriginal Health Workers [75].

Despite the delays in integration of health informatics into mainstream healthcare education, the healthcare industry displays considerable interest in the area. Furthermore, academic institutions have a major role in training health professionals in telehealth skills. Thus, the growing momentum in telemedicine in Australia must be supported by educational initiatives to ensure health care providers are appropriately trained in this field. It is essential that practitioners and the public embrace these technologies to extract their full value. Health professionals must be trained in the use of ICT tools. However, this needs to be further explored, as more needs to be

done in health courses or in continued professional development to prepare health professionals for the use of this technology. Unfortunately, the vast majority of Australian biomedical, nursing and medical tertiary degrees do not include health informatics training [76]. Aung and collaborators note the particularly low level of health informatics knowledge amongst Australian health care professionals [77]. Another study in oral health professions students indicated, that the assumption that today's health professionals and students are computer literate must be challenged, as it may still be the case that a digital divide exists in the future health workforce [78].

Regulatory, Legal and Policy context

Government

The Australian healthcare landscape is complex. Responsibility for health care falls within State jurisdictions, however most funding comes from relevant Federal government departments, which is a result of the fiscal imbalance between the Commonwealth and the states. The Commonwealth has the control of key revenue sources including income, corporate and consumption taxes [79]. As mentioned previously, Australia has a universal system of care (Medicare) that provides free health care for essential services, but also has a strong private health sector. A great deal of health care is moderated through a strong primary care setting. Access to specialists is available solely by referral from general practitioners (GP). GP's are largely small businesses owned and operated by a small number of GPs in partnership.

GPs are reimbursed for consultations from Medicare for consultations listed on the MBS. As described above, the MBS allows people in telehealth eligible areas of Australia to have access to specialist video consultations under Medicare [80]. This provides many patients with easier access to specialists, without the time and expense involved in travelling to major cities.

Legal and Regulatory Environment

Given the complex nature of the Australian constitutional settlement, there has been a variety of legal and regulatory environments that impact the capabilities of telehealth. It is not telemedicine alone that faces these challenges, but the Australian health system as a whole. It was only on 1st July 2010 that regulation of health practitioners was nationalised [81]. Oversight of all health practitioners now rests with the Australian Health Practitioner Regulation Agency (AHPRA) [82], as opposed to state based regimes.

Regardless of this development in harmonisation, the complexity of the health regulatory landscape delivers uncertainty as to the appropriate regulatory regimes relating to the use of telehealth in Australia. A report commissioned by the Victorian Government by DLA Piper [83] found that the regulatory patchwork within a state presented some barriers for the adoption and uptake of telehealth services. The report also contains up-to-date reference material from 2015 for Victoria-specific legal issues surrounding the delivery of telehealth services. It states:

“No Australian State or Territory yet has a fully implemented telehealth system. A significant barrier to a widespread uptake of telehealth is the medico-legal uncertainty that surrounds the implementation of such a system. Indeed, there are a number of important medico-legal risks that must be addressed. However, provided the risks are identified, acknowledged and dealt with appropriately, this should not be a barrier to a successful Victorian telehealth system” [84].

Note that one issue the document picks up involves the various jurisdictions that a telehealth service may have to operate over. This can be a problem equally within Australia as well as internationally:

“It is beyond the scope of this document to more fully consider the legal frameworks of other jurisdictions, and suggests that health services that have entered into arrangements with hospital and health service providers in other states and territories or internationally to provide or receive medical services using telehealth should receive legal advice on the laws that apply to the specific circumstances” [85].

Telemedicine Standards

Australia has been active in the development and deployment of standards for eHealth. Standards relevant for Electronic Health Records (EHR) include standards for EHR architectures, concept standards and messaging standards [86]. ISO/TS 18308 specifies a reference architecture for electronic health records that includes specifications for the representation of data, privacy and security and ethical issues. Australia began classifying diseases using the International Classification of Diseases standard (ICD-9) in the mid-80's and was one of the first countries to make the transition to ICD-10 [87]. The internationally defined medical terminology standard SNOMED-CT [88] is widely adopted in hospital and general practice,

however, limitations have been noted when events encoded with SNOMED need to be used outside a hospital setting [89].

Standards to ensure that data from one system's repository is appropriately received and deciphered following transmission to another system's database are known as messaging standards. Health Level 7 (HL7) was initially developed to enable US hospital sub-systems to exchange clinical data, but Version 2 was quickly adopted in Australia [90]. HL7 provides a standard template for the structure of a message that includes high level segments for patient identification, observations and other categories of a health event. Although HL-7 Version 3 was adopted by the Australian government for its promise of semantic interoperability, the simpler and more flexible Fast Healthcare Interoperability Resources (FHIR), is rapidly emerging as the messaging standard of choice [91].

Early Australian experience with messaging standards led Australian practitioners and analysts to advance a new standard for electronic health records that aimed to specify the pragmatic use of concepts beyond their meaning. The central artefact in the openEHR model is the archetype [92]. An archetype describes the meaning of a concept and additionally describes the context of its use and mis-use. This standard has the potential to capture the pragmatics of health care concepts and has been incorporated into the European CEN 13606 standard for electronic health records [93].

Policy Development

In recent years several bodies have published their visions and lists of recommendations for the future of telehealth in Australia. The common theme in them is the threat to society from the growing demand for healthcare by a rapidly ageing population that is living longer with increasing levels of chronic disease. Australian society, in common with many others around the globe, urgently needs to make efficiencies in its healthcare system to dramatically reduce the looming costs involved. It is also natural that, in general, people prefer to be cared for at home rather than enter hospital or have to attend day clinics. Telehealth is in an ideal position to meet both of these economic and social demands by offering alternative healthcare delivery models that can be more economically sustainable and allow health workers to cater for a growing number of patients who can remain at home.

In April 2013 the Australian Telehealth Society released a document *Towards a National Strategy for Telehealth in Australia 2013-2018* [94]. The document called for a single 'strategic' direction-setting reference document to maximize the value to Australia of new developments in telehealth. They recommended that this reference document should:

1. draw on existing documents and perspectives (including those of consumers);
2. align initiatives with emerging healthcare reform agendas and budget processes;
3. guide enhanced innovation aspects, including funding and business models;
4. inform and inspire public policy directions, including initiatives for health cohorts;
5. enable adoption of related clinical and technological changes in healthcare.

Another industry organization, the Australian Information Industry Association (AIIA) released in 2014 a whitepaper called *One in Four Lives: The Future of Telehealth in Australia* [95]. This Industry Initiative was developed by organisations from several sectors including the AIIA, BT (originally Banker's Trust Group), Medibank Private, Philips, and the University of Western Sydney and is supported by not-for-profit operators and leading health academics. The authors' argument is that, going on current trends, healthcare in Australia will consume 100% of state revenue by 2050. This is due to the growing wave of chronic diseases, ageing population, and growing demands and expectations by consumers. They call for innovative models of care and greater use of technology, such as those that telehealth can provide, to head off this looming financial and healthcare crisis. The authors also state that new models of funding telehealth, which can make the system sustainable are required. Report authors also called for collaboration between industry and government to ensure that the data is shared to create informed policy decision [96].

The paper sets out 6 key recommendations:

1. The Australian Government develops a National Telehealth Strategy for a sustainable market
2. Eligibility for existing MBS attendance items is broadened to allow for coordinated care through multidisciplinary teams delivering care through different modalities.
3. Home Care Packages provided on a Consumer Directed Care basis allow for appropriate provision of further Clinical Services where requested.
4. MBS video consultations items continue to be supported for Telemedicine consultations provided by GPs, specialist practitioners and residential aged care facilities, with the introduction of a co-payment capability

5. The acute sector is funded through DRG codes that are not dependent on the care being delivered within a hospital setting for specific programs – early discharge programs, hospital in the home, step-down care
6. The current funding structure for Health in Australia – covering the MBS Schedule, Activity Based Funding and private contributions – be reviewed in light of the National Telehealth Strategy, with a view to encouraging Telehealth as an option to support the long term sustainability of the health system [97].

Another forward-looking source is the 2014 Commonwealth Science and Industrial Research Organisation (CSIRO) report *A Digitally Enabled Health System* [98], which includes a vision for a digitally enabled health ecosystem that includes telehealth as one key component along with patient-centric data such as the Australian My Health Record scheme which will be described in the following section. It also calls for digital tracking of people and assets in hospitals, and using predictive data to anticipate and plan staff and bed availability. The report envisages a future landscape where diverse sources of health-related data and information are brought together in a seamless manner to ease the tracking, coordination and management of personalised medicine for individuals in the community. This model also enables the sustainability of healthcare into the future by making efficiencies in service delivery, improving preventative medicine, and reducing numbers of patients entering hospitals. The success of the preventative measures in particular will depend upon the emerging area of ‘Big Data’ and analytics through techniques such as machine learning. In this way, telehealth can help transform healthcare by helping the community maintain their own health rather than the healthcare system reacting later, and with much greater expense, to treat disease [99].

In July 2016, the Australian Digital Health Agency was created to lead the development and implementation of Australia’s digital health. To help describe what digital health looks like now and in future, the organisation launched a national consultation with the general public, clinicians, healthcare providers and funders.

Personal Electronic Health Record

The Commonwealth Government launched a system in 2012 known as the Personally Controlled Electronic Health Record (PCEHR). It is a secure online summary of an individual’s health information. The PCEHR system was established by the *Personally Controlled Electronic Health Records Act*

2012, to create a ‘voluntary national system for the provision of access to health information relating to consumers of healthcare’ [100].

In addition to the technical aspects, already described, the rationale for the the PCEHR is outlined in the objectives of the enabling legislation.

- (a) Help overcome the fragmentation of health information in Australia;
- (b) Improve the availability and quality of health information;
- (c) Reduce the occurrence of adverse medical events and the duplication of treatment; and
- (d) Improve the coordination and quality of healthcare provided to individuals by different healthcare providers [101].

Nonetheless, after three years, only two million people have registered. In 2105, the Government proposed changes to the personally controlled electronic health record system and the Healthcare Identifiers Service with the aim of increasing the number of individuals and healthcare providers participating in the system. Starting in 2016, PCEHR was renamed ‘My Health Record’, and a trial of the system is currently running in order to inform Government about future approaches to increasing individual participation in the system.

The primary change was the participation arrangements for individuals. The old system operated on a basis where individuals who wanted to be registered gave consent for their information to be uploaded to their PCEHR by healthcare providers and Medicare. In contrast, with My Health Record (MyHR), all Australians are set up with a record, but can opt out. This would address the low take-up rate of the PCEHR [102]. Oversight of the PCEHR is the responsibility of the Australian Commission for e-Health was also created [103].

Through MyHR there would be opportunities to access information about a patient’s health history, hospitalisations, MBS and Pharmaceutical Benefits Scheme (PBS) history, referrals, lab reports, existing allergies, etc. Nonetheless, oral health is not included in the scheme.

Industry Players in Australian Telehealth

The provision of healthcare in Australia, and correspondingly, the use of telehealth, is influenced by a number of key stakeholders. These include:

The Royal Australian College of General Practitioners (RACGP).

The RACGP has developed a number of resources to help general practices get started with video consultations. These include clinical

guidelines, technology options, and some illuminating real telehealth case studies. They have also worked closely with the National Health Services Directory (NHSD) [104] which lists health service providers that offer telehealth and/ or are *My Health Record* enabled and allows consumers to do map-based searches for e-health providers. The NHSD is a government initiative that established software and processes that enables listings of health care providers to be maintained largely automatically for patients to easily search online, in a single directory [105].

Telehealth, Health Informatics Societies

In addition to the Australian Information Industry Association (AIIA) mentioned above, another two major associations, the Australasian Telehealth Society [106] and the Health Informatics Society of Australia [107] also have major roles in the setting of Australian standards and strategies in telehealth.

The Australasian Telehealth Society (ATHS) was formed in 2008 with a view to advancing telehealth in the health, industry, government and academic domains. It represents a forum for those involved in telehealth in Australia and New Zealand. It is the National Member for Australia and New Zealand of the International Society for Telemedicine and eHealth (ISfTeH). Among other roles and activities, the ATHS co-hosts the ‘Success and Failures in Telehealth’ (SFT) event, an annual peer-reviewed national conference [108], with the University of Queensland’s Centre for Online Health [109].

The University of Queensland’s Centre for Online Health was established in 1999 and researches the efficacy and economics of telehealth, provides education and training, and acts as a clinical provider of telehealth services [110].

The Health Informatics Society of Australia (HISA) is an organisation that is interested in the intersection of information and digital health so that the right information about the patient is available at the right time and in an appropriate form so that it can be used most effectively. Thus, the patient receives the best care and is supported in their decisions, while health care workers jobs are made easier and safer [111]. HISA, also runs a large and well attended annual conference, the Health Informatics Conference (HIC).

Telstra

Telstra is Australia’s largest domestic telecommunications company and it has invested in approximately 20 healthcare companies in recent years to form *Telstra Health* which has a large telehealth component catering for specialist clinicians and general medical practices, as well as for domestic

users wishing to remain at home and/ or managing chronic conditions using digital devices and connectivity [112].

Tunstall Healthcare

Tunstall Healthcare is one of the world's largest telehealth providers and also has connected health and care solutions in Australia. Their products are targeted at older people and those with chronic conditions who wish to remain at home, so involve highly automated and connected sensors to track various physiological parameters as well as movement and falls with associated alarm monitoring [113].

The Australian College of Rural & Remote Medicine

The Australian College of Rural & Remote Medicine acts as a central resource for telehealth practitioners supplying information on education and standards, technical advice and information, as well as providing a directory of telehealth providers. Their vision reads:

We believe that TeleHealth must enhance the clinician-patient relationship (not fragment it) and we are focused on promoting achievements of practitioners who have optimised use of technology to improve the care for their patients [114].

It is this approach, centred on the clinician-patient relationship and ensuring access throughout the many underserved communities that is an essential element of telehealth delivery.

Commonwealth Science and Industrial Research Organisation (CSIRO)

The Commonwealth Science and Industrial Research Organisation (CSIRO) was initially formed in 1916 and serves to enhance Australia's potential through science programmes that are intended to provide positive economic, environmental and social impacts [115]. Their e-Health Research Centre and Digital Products and Services Flagship has, in recent years been looking closely at telehealth as part of a future-looking, fully digital healthcare ecosystem as a way to ameliorate the growing costs of providing healthcare to a rapidly ageing population.

Telehealth Research and Innovation Laboratory (THRIL)

The Telehealth Research and Innovation Laboratory (THRIL) [116] at the University of Western Sydney, was Established in January 2011, THRIL is a multidisciplinary department bringing together expertise from

the Schools of Computing & Mathematics, Science and Health, Medicine, Nursing & Midwifery, as well as other strong external research groups.

Australian Institute of Health Innovation

The Centre for Health Informatics within the Australian Institute of Health Innovation at Macquarie University, Sydney, [117] has a long history at the cutting edge of health informatics research in Australia. Current direction span informatics for health care consumers, patient safety and the growing need for intelligent systems to inform health analytics and evidence based medicine.

Melbourne Networked Society Institute

The Melbourne Network Society Institute (MNSI) based at the University of Melbourne is an interdisciplinary research institute focused on understanding the impact of increasing connectivity between people, places and things. The Institute was established in 2009 as the Institute for a Broadband-Enabled Society, with funding from the University of Melbourne, the State Government of Victoria, and industry partners. The Institute had the initial aim to undertake research to develop applications and services that exploit the capacity of the National Broadband Network. Currently, the Institute is actively investigating whether there is a role for other digital technologies in the telehealth domain, particularly those already available from mass consumer markets as this lowers barriers to entry in terms of cost, availability, and reliability.

Recent Telemedicine Initiatives

In 2012 the Australian Government's Department of Health invited interested parties to apply for funding from the *Telehealth Pilots Programme* [118]. Nine projects were selected to receive a share of the A\$20.6 million on offer. Their mission was to both develop and deliver telehealth services with a focus on aged, palliative or cancer care services, including opportunities for the extension of telehealth services in the future and the business case for doing so. What is noticeable about this website [119] is that it lacks any mention or link to the results or conclusions of these nine projects. As we described earlier in the chapter, a similar finding was made way back in 1997 by the House of Representatives Standing Committee on Family and Community Affairs [53]. However, some results are available from other sources; for example the results of the *Staying Strong Telehealth* pilot which was aimed at elderly Aboriginal and Torres Strait Islander populations with chronic health problems [120].

In the *Staying Strong* pilot, 111 patients used in-home telehealth equipment while 25 went to hubs at nearby health centres in regional towns in Queensland and New South Wales. 90% of these participants had five or more chronic conditions (the most common being high blood pressure, high blood cholesterol and Type 2 diabetes).

The results showed that the daily telehealth checks meant that participants required fewer regular visits to a GP as they were generally better informed about their condition. Hence GP's could attend other patients, and costs for unnecessary visits were saved. There were also additional benefits for the health workforce: prior to the pilot, nurses were spending about 40 minutes on travelling to check each patient's vital signs – restricting them to seeing approximately 11 patients a week. During the pilot, the nurses were able to see up to 40 patients per week, greatly improving their time efficiency and cost-effectiveness.

Another potential benefit of telehealth the pilot recognised was demonstrated when a participant was saved from having a heart attack when a change in remotely monitored vital signs prompted immediate admission into hospital. The results from the pilot also claimed a 40% saving against traditional face-to-face consultations.

Funded by the Australian Government Broadband Enabled Telehealth Pilots Program in 2013 the CSIRO, along with local health districts, hospitals, and industry partners, carried out Australia's first large scale telehealth clinical trial over a 12 month period. 150 patients around Australia were recruited to take part in the trial using a combination of fibre and fixed wireless connectivity. The 2014 CSIRO report *A Digitally Enabled Health System* [121] includes the overall conclusions from the trial which found that self-management of chronic conditions at home and timely interventions by remote health workers can help users of telehealth to remain at home and improve their quality of life. Monitoring of patients remotely was also shown to be cost-effective and improved access to quality care. One additional benefit was a reduction in social isolation for some participants.

A project update was released in August 2016 [122]. The research, undertaken by CSIRO together with partners, involved trialling telehealth systems with 287 patients over a 12 month period. The participants were selected on the basis of their typically high usage rate of medical services and need for regular hospitalisation as they suffered from a wide array of chronic conditions. The ability of telemonitoring to improve health and economic outcomes was assessed both qualitatively and quantitatively using data remotely recorded from the patient, as well as via regular questionnaires they had to fill out. The study also looked at the changes in

work practices required and barriers to implementation and found that technical issues and patient adherence had the least impact: instead they found that workplace leadership and the flexibility of existing practices and management structures were of the greatest importance to a successful telehealth implementation.

The report showed savings of 24 per cent over the year to the healthcare system made through falls in the number and cost of GP visits, specialist visits and procedures carried out. It also reported several highlights of this pilot program. For example, reductions in rate of:

- MBS expenditure (46.3% ;savings \$611 - \$657);
- PBS expenditure (25.5%; savings \$44 - \$354);
- Admission to hospital (reduction of 0.22 – 1.0 hospital admissions);
- Length of stay (75.7% reduction: 7.3 – 9.3 days);
- Mortality (40% reduction).

It also reported high user acceptance and use of telemonitoring technology (83%); and of clinicians who would recommend telemonitoring services to other patients (89%).

Analysis of this model suggests that for chronically ill patients, an annual expenditure of \$2,760 could generate a saving of between \$16,383 and \$19,263 pa, representing a Return on Investment (ROI) of between 4.9 and 6.0.

At the state and territory level, governments in Australia also usually have a telehealth function as part of their Departments of Health.

Western Australia

Western Australia the WA Country Health Service [123] allows more public patients to access specialist care and acute care. It also provides an emergency telehealth service to support local clinicians in rural areas via videoconferencing links to metro specialists. The service was introduced in 2011 and as of June 2015 had conducted more than 40,000 remote clinical consultations via its installed base of 720 videoconferencing units and 63 emergency telehealth equipment in 63 regional sites.

Victoria

In Victoria *health.vic* has a telehealth function under their rural health category which works with health services to disseminate information and provide support on telehealth models of care. It also aims to identify and address key barriers to the uptake of telehealth [124]. They also present some working examples of telehealth in the community, including stroke

rehabilitation, mental health reviews, and after-hours urgent care support for rural health centres.

Queensland

In Queensland, the Telehealth Support Unit [125] supports various telehealth services across the state and also works in close collaboration with the Royal Flying Doctor Service. The Telehealth Support Unit provides eHealth tools, support and the technical capability necessary to deliver a range of healthcare services to Queenslanders. The most commonly attended telehealth outpatient clinics are for services such as; orthopaedic surgery; diabetes; medical oncology consultation; paediatric medicine; gastroenterology; general medicine; cardiology; midwifery; pre-Admission and pre-anaesthesia; and obstetrics [126].

New South Wales

In New South Wales (NSW), the recently released *NSW Health Telehealth Framework and Implementation Strategy: 2016-2021* [127] provides a framework to drive telehealth in NSW. The strategy outlines actions, timeframes and responsibilities to embed telehealth in the core business of NSW Health by 2021. It recognises what many Local Health Areas and Specialty Health Networks are doing to test, finance and develop telehealth models of care.

Northern Territory

In the Northern Territory eHealthNT [128] develops and implements digital solutions to improve patient care and outcomes, including supporting online electronic health records and data exchange between healthcare providers. It also has, via the Health eTowns project, between July 2009 and June 2013 delivered various outcomes via telehealth for largely indigenous populations in various towns and over 40 remote communities across the Northern Territory, and even in six sites in the East Kimberley region of Western Australia. The eHealthNT website states:

These improvements included:

1. Delivery of specialist healthcare services to remote communities
2. Implementing video, audio and data-sharing facilities to assist doctors and health professionals with remote monitoring, consultation and treatment of patients
3. Delivery of interactive online education and training programs that allow students and trainees to access

mainstream education programs that are currently only available in larger cities

4. Introduction of a telehealth connection service
5. Using high-speed broadband to close the healthcare and education gap currently experienced by these communities [129].

Tasmania

GP Assist (Tasmania) is an innovative service which is delivering one of the most progressive After Hours General Practice solutions in Australia. GP Assist provides after hours support to rural GPs to encourage them to stay in country areas.

GP Assist involves a team of registered nurses (RNs) and doctors working together, using their professional skills combined with ICT to provide guidance and advice to patients of rural GPs by phone. Local doctors are only disturbed by the GP Assist doctor if face-to-face care is urgently required. The practical application of ICT includes the use of decision support software by the RNs, text messaging to communicate with the triage doctors; who by virtue of laptop computers and a secure virtual private network are able to work remotely from the RNs whilst viewing and appending the patient's medical record [130].

In addition, the Telecare Online Services network of Tasmania was developed to improve access to health care for Tasmania's rural and isolated communities. The network facilitates support and delivery of health services via the use of video conference equipment. The network services use the internet to enable face-to-face visual communication between patients, primary health care providers and specialists to take place without the need for significant travel [131].

Transformation of Telehealth By New Technologies

Telehealth in Australia to date has traditionally involved variations on the teleconferencing model where patient and doctor engage in a clinical variation of the social Skype call or business telepresence meeting. In more recent times, remotely monitored digital devices work in association with the above to supplement the quality of information and hence care made available as seen earlier in the *Staying Strong* trial [116]. In the future, such networked sensors and alarms will be able to work in the background, requiring no input or interaction from the user with a remote medical worker, creating an 'ambient telehealth' model which is appealing particularly for those demographics, such as the aged, with typically limited IT skills.

In this section we examine future-looking Australian telehealth initiatives using novel digital technologies at various sites in the state of Victoria which is very active in telehealth.

Kinect for Autism Project

In the Victorian regional town of Ballarat innovative speech pathology services for children with Autism Spectrum Disorder (ASD) and their families in rural areas were tested. The Microsoft Kinect™ sensor played a key role, being used as a novel remote feedback and assessment tool for the quality of parent-child interactions. Kinect sensor data was collected at the Clear Messages [132] speech pathology clinic where volunteer parent-child sessions were recorded. This data was combined with reference parent-child interactions recorded previously in a laboratory setting with ‘neuro-typical’ children, i.e. those unaffected by ASD, to act as a baseline against which ASD behaviours could be compared and contrasted. A variety of activities were recorded, including active and passive play such as jumping and dancing, shared book reading, and playing the ‘Simon Says’ mimicking game.

This project has since developed an automated tracking and analysis system. The software provides meaningful statistics based on the quality of the parent-child interaction with a dashboard display that takes the output of the Kinect sensor and displays both real-time and cumulative measurements alongside avatar skeleton figures. Measurements include head-height offset, proximity, number and position of touches, voice recognition, real-time pose recognition, as well as an overall quality factor for the session. As the speech-pathology intervention progresses the automatically generated quality factors from the toolbox can either show up improvements or the need for alternative intervention methods to be employed. The toolbox could be used in future iterations as an ‘expert system’ that would provide speech-pathology support in areas that are typically underserved.

Telemedicine via Alternative Worlds

Virtual Reality for Music Therapy

This project based in Melbourne at the Royal Talbot Rehabilitation Centre [133] is developing an online virtual reality platform designed to deliver telehealth group singing interventions for people with quadriplegia to improve respiratory function, voice, mood, and social connectedness [134]. Quadriplegia is the reduction or loss of function in the arms, trunk, legs and pelvic organs as a result of cervical spinal cord injury. Respiratory dysfunction is a major cause of illness and death following quadriplegia. Previous clinical research has demonstrated that group singing can help

people with quadriplegia to breathe better, speak louder and to make social connections.

Many of the motivational and emotional benefits come from singing with others rather than in isolation. Disproportionately high numbers of people with quadriplegia live in rural and remote areas; areas often poorly served by traditional health services however, telehealth is becoming an accessible and cost-effective means to treat patients in their homes. Currently thousands of Australians with quadriplegia are significantly disadvantaged in terms of accessing the group music-making that able-bodied people take for granted. Successful demonstration of this proof-of-concept in this particularly vulnerable group will provide future scope to benefit other groups who are unable to access face-to-face music participation due to physical or geographical constraints.

The main technical issue that this project is addressing is latency – the delay between when someone starts singing and when the person hears it at the other end of a videoconference. This latency is due to the time it takes for the signal to travel from one computer to the other over the internet and causes difficulties if it reaches levels beyond 30msec in allowing for synchronous point-to-point live music performance. Dedicated audio processing units are employed to deliver studio-quality audio with latency in the order of 5msec.

Patient Monitoring and Telerehabilitation

Telerehabilitation, where supervised rehabilitation is delivered directly into the home using broadband technology, has the potential to improve access to this important treatment. If telerehabilitation is to be adopted in clinical practice it must use a cost-effective model where multiple patients can be treated at once, similar to the traditional group day-clinic setting where pulmonary rehabilitation is traditionally delivered.

COPD Virtual Exercise Class

Austin Health [135] is a clinical teaching and training, organization based in Melbourne and affiliated with several Australian universities. At Austin Health pulmonary rehabilitation is used as a highly effective treatment for people with chronic respiratory disease providing virtual exercise classes, with the aim of improving the quality of life of patients and reduce hospital admissions. The virtual class consists of exercise training and education that is delivered in a group setting. Access to these programs is often limited by debilitating symptoms and inability to travel. As a result, less than 10% of people who need pulmonary rehabilitation ever undertake this program.

This telehealth project has optimised a multi-participant telerehabilitation model via video conferencing, which can support six patients using exercise bicycles at home, and a clinician using common network conditions and a readily available videoconferencing solution. It also has the benefit of socializing the experience as participants can hear and see each other during the session. And just like going to the gym, it is always better to go with a friend to make the training session more likely to occur!

To further enhance the application of the model to the clinical setting, a pulse oximetry App has been developed, which is integrated with the videoconferencing software and seamlessly and unobtrusively provides real-time feedback of the physiological responses (heart rate and blood oxygen level) of patients during rehabilitation sessions. This enables clinicians to monitor multiple individuals simultaneously during home-based programs. Overall, this project has defined a real-time multi-participant telerehabilitation model that will provide access to a low-cost, easily accessible and viable model of pulmonary rehabilitation for individuals with chronic lung disease.

Tele-diagnosis

Video Conferencing HD3D Tele-psychiatry

Psychiatric consultations that involve cognitive assessments such as finger to nose tests or pupil dilation examinations require skilled psychiatrists that are often not available outside capital cities. In addition, these assessments require fine grained observations or observations through space that are not readily reflected in a 2D video. A HD3D Tele-psychiatry installation aimed to develop a mechanism to capture the assessments using a 3D camera for a remote psychiatrist wearing 3D stereoscopic glasses linked to a 3D monitor to observe [136]. Experiences with this installation provides a flavour for some of the challenges inherent in establishing innovative telehealth deployments in Australia (see Fig. 11).

A HD3D video conferencing installation was initially built using off-the shelf proprietary video conferencing equipment and bench tested using the Melbourne Networked Society Institute's test environment, which is capable of simulating contemporary telecommunications networks. The installation required in-house written software to enable the codecs to transmit 3D images and to enable the 3D camera to be remotely controlled from the psychiatrists end. Testing indicated a minimum of 3Mbs bandwidth was required for the HD3D transmission to occur with sufficiently picturequality to conduct a real time consultation. However this level of bandwidth could not be utilised in most rural areas in the state of

Victoria, where the project was located due to the prevalent network conditions.

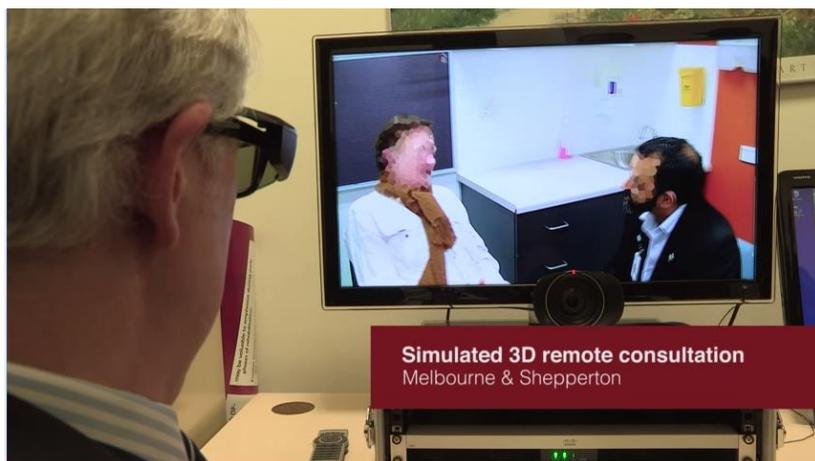


Fig. 11: Psychiatrist with stereoscopic 3D viewing a consultation in 3D.

The decision was taken to move the installation site to the only network in the state where operational healthcare delivery would not be compromised. Challenges included overcoming security issues that required extensive consultation for the pilot to proceed.

The experience of viewing eye dilations, finger to nose tests and other cognitive assessments in HD3D was compelling for psychiatrists. They expressed a great sense of immersiveness and indicated a willingness to regularly use the equipment. The pilot demonstrated that technology based on internet transmission of 3D video was plausible, albeit requiring significant bandwidth.

Teledentistry

In this section, the outcomes of two teledentistry projects in the areas of teleconsultation and telediagnosis will be presented. The main aim of the studies was to address priorities established by *Australia's National Oral Health Plan* [137]. One study aimed to assess the feasibility of a teledentistry model for teleconsultation and telediagnosis in Residential Aged Care Facilities [138]. Results indicated that the proposed teledentistry approach for oral health screening is feasible and reliable as an alternative to traditional oral health examination. Three RACFs within Victoria, Australia,

participated in this study; two in metropolitan Melbourne and one in rural Victoria. These RACFs worked in partnership with the University of Melbourne's Melbourne Dental School, which acted as the central coordination and examination site. This study proposes an innovative solution towards closing the service delivery gap in the provision of sustainable oral health care services to underserved populations (e.g., nursing homes, rural areas). Another study targeted children and adolescents living in regional and remote areas of the Australian state of Victoria. Specialist oral health consultations were conducted with 43 children, in three regional areas of Victoria, via paediatric teledentistry (Fig. 12) [139]. Three general dental practitioners in regional areas were trained in the use of teledentistry. They linked with specialists at the Royal Children's Hospital of Melbourne who worked with the local dentist to conduct the teleconsultation [140]. The model provides an effective and cost-effective

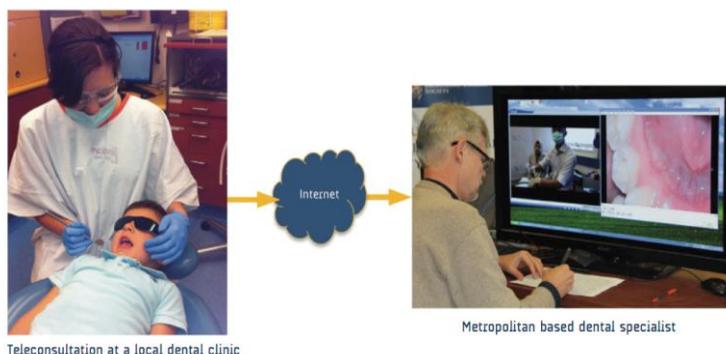


Fig. 12. Teledentistry

alternative to deliver treatment to remotely located patients [141].

These experiences demonstrate that teledentistry is a mature field [142]. However, in Australia, as in many countries, teledentistry initiatives are behind e-health progress. Teledentistry has yet to be employed as a routine delivery system. For example, as already mentioned, there are Medicare benefits available for teleconsultation between medical specialists but not available for teleconsultation in oral health. Nonetheless, if dentistry parallels medicine, the implementation of teledentistry will occur in various institutions and organizations around the world.

However, for teledentistry to be an effective oral health care model which incorporates evidence-based approaches, it needs to expand beyond pilot

and field tests. For true self-sustainability and institutionalisation, a telehealth program cannot depend on the altruism of practitioners/people. Furthermore, teledentistry schemes, so far have generally made only the initial steps towards institutionalisation. Thus, full implementation and institutionalisation may take longer and require additional tools. It is also required to be adequately resourced in terms of staff, equipment, telecommunications, technical support and training. In particular, training for teledentistry operators is essential. Users should be trained in the use of the equipment and have access to technical support to troubleshoot any difficulties.

While the field of teledentistry can grow and develop in a consistent fashion, at the current level of development, it cannot provide the complete answer to everything. To date, most teledentistry programs have focused on distance management and administration of remote facilities, learning and continuing education, consultation and referral services rather than direct patient care. However, given current technological trends, its potential applications will only increase in the future and will be implemented in an increasing number of countries around the world.

Moreover, teledentistry will never realise its full potential if it does not receive the attention it deserves. Teledentistry solutions require rigorous evaluation to inform policies and strategies on ICT and telehealth applications in oral health.

Royal Children's Hospital Melbourne

The Royal Children's Hospital (RCH) in Melbourne has been providing teleconsultations since 2011 [143]. The telehealth program is targeted towards rural, regional or interstate families. The main reasons for offering teleconsultations were to increase convenience for families and consumers, reduce the number of doctors travelling to provide outreach clinics, provide additional services without making demands on available physical space, and take advantage of the Medicare incentive for telehealth.

A reviewed telehealth activity at the RCH indicated a total of 852 consultations with an increase in the average consultation from 14 per month in 2012, to 49 per month in 2014. One-third of all activity was provided by two departments: neurology and respiratory medicine. By June 2014, almost all (92%) RCH's of departments (n = 34) had provided at least one video-consultation. However, most telehealth activity was provided by few clinicians. A review of actual and billed activity between July 2013 and April 2014 showed that 36% of booked telehealth appointments (n = 144 of 395) were not billed to Medicare; financial and other processes have since

been streamlined. Overall, the findings have been valuable in planning the future expansion of telehealth at the RCH [144].

Challenges of Delivering Telehealth in Australia

Although telemedicine has been seen as delivering strong benefits throughout Australia, successful implementation has faced many challenges. One of the key areas of difficulty have been translating research from trial into practice.

A review showed that Australia has been one of the early implementers of Telehealth and has invested in a significant number of projects in the last few years [145]. Despite this early interest and effort, it has not been able to harness its full potential. Telehealth is still not fully integrated into the Australian mainstream healthcare delivery system. Researchers in this area [146] have identified several factors hindering its full implementation and utilisation:

1. Lack of Medicare/health insurance reimbursement for services provided through telehealth;
2. Lack of incentives for providers to use telemedicine (other than the reimbursement) in order to encourage physicians to take interest in using it;
3. Lack of Political will to integrate telemedicine into mainstream healthcare delivery system;
4. Complexity of the technology;
5. Tele-consultations involve coordination between 3 or more persons and intermediary agencies vs. only 2 for a routine consultation;
6. Lack of similarity between 'face to face' vs. tele-consultations imposes limitations to the extent of diagnostic examination that can be done by a physician;
7. Rules and regulations for confidentiality and privacy of information;
8. Difficult to use interface for users of the solutions deployed;
9. Technological pre-requisites limits wide spread deployment. (Infrastructure, network, bandwidth availability, etc.);
10. Capacity for implementation of telehealth services;
11. Installation and maintenance issues;
12. Fragmented funding for projects;
13. Lack of adequate education and awareness for providers and consumers;
14. Scalability and limitations of the systems in use;
15. Social factors (equity and accessibility);
16. Implementation gap, getting beyond the trials;

17. Cost of the equipment.

Conclusion

Australia has had a long history of using telehealth due to the size and nature of the country. Telehealth initiatives over the years have taken advantage of all types of new technology from the telegraph, the telephone, teleconferencing, and now virtual reality as we have seen in this chapter. While it is difficult, if not impossible, to predict future changes in ICT and its uses in society, there is no doubt that it will have an impact in all aspects of social interaction and health provision in Australia. To tackle both current and future challenges in patient care will require more organised health team efforts and the efficient coordination of care. It is clear that the future of telehealth can no longer be the traditional teleconference model. Increased efforts should be placed in the use of the Internet for timely interventions and effective treatment purposes. Such schemes should also be as ‘ambient’ as possible for ageing and special-needs demographics, which includes expert systems working autonomously to either augment the clinician’s knowledge and treatment of the ‘patient’, or perhaps to even replace the clinician entirely where no good local alternative exists for specialist services. It should also improve the outcomes of rehabilitation and the social engagement for people with chronic conditions where it is good for them to know “I’m not the only one”. The sharing of experiences and knowledge with others in a virtual rehabilitation or therapy class can be a very positive experience. In the future we are likely to move away from the purely one-on-one model to more patient-centric, socialised experiences and therapies in safe, controlled virtual environments thanks to the transformations that new digital technologies can provide.

Several initiatives are currently progressing in different areas to address these barriers. This will create new opportunities to support, promote and facilitate models that use ICT tools and technologies for the improvement of health. The Personally Controlled Electronic Health Record scheme is currently being adapted and being driven harder by government: it is a vital cog in the success, or otherwise, of the greater telehealth machine. There is also a need for more studies and information on the economic benefits of telehealth. Legal and ethical considerations also need to be addressed in a cohesive national approach, as well as policies on data transfer and confidentiality if telehealth is to be a success into the future.

Appendix

This chapter represents an outline of telehealth initiatives, programs and activities in Australia. More information is available via the following websites:

1. Australian College of Rural and Remote Medicine: www.ehealth.acrrm.org.au.
2. Australian Commission for e-Health. My Health Record system: <https://myhealthrecord.gov.au/internet/mhr/publishing.nsf/Content/find-out>.
3. Australian Health Practitioner Regulation Agency: <http://www.medicalboard.gov.au/Codes-Guidelines-Policies/FAQ/Information-interjurisdictional-technology-consultations.aspx>.
4. Australian Information Industry Association: www.aiia.com.au/news/aiia-news/aiia-news/2014/calls-for-national-telehealth-strategy.
5. Australian Institute of Health Innovation. Centre for Health Informatics. <http://www.mq.edu.au/research/research-centres-groups-and-facilities/healthy-people/centres/australian-institute-of-health-innovation/centre-for-health-informatics>
6. Australian Telehealth Society: <http://aths.org.au>.
7. Australian Digital Health Agency: <http://www.digitalhealth.gov.au/about-the-agency>.
8. Centre for Online Health, University of Queensland: <http://coh.centre.uq.edu.au/>.
9. Commonwealth Science and Industrial Research Organisation; <http://www.csiro.au/en/Research/BF/Areas/Digital-health/Improving-access/Home-monitoring>.
10. Department of Health (Australia): <http://www.health.gov.au/internet/main/publishing.nsf/Content/e-health-telehealth>
11. Department of Health (Australia): Medicare Benefits Scheme Online: <http://www.mbsonline.gov.au/telehealth>.
12. Department of Health (Australia), Staying Strong Telehealth: <http://www.nbnco.com.au/blog/health/saving-lives-and-money-with-telehealth.html>.
13. Department of Health (Australia), Telehealth Pilots Programme: <http://health.gov.au/ehealth-nbntelehealth>.
14. Department of Human Services (Australia): <https://www.humanservices.gov.au/health-professionals/services/medicare/mbs-and-telehealth>

15. eHealth Research Group (EHRG), Western Sydney University: <http://thrill.uws.edu.au>.
16. Government of Tasmania, Department of Health and Human Services, Telecare Online Services:
17. http://www.dhhs.tas.gov.au/service_information/services_files/telecare.
18. Health Informatics Society of Australia: www.hisa.org.au.
19. Melbourne Networked Society Institute, University of Melbourne: <http://networkedsociety.unimelb.edu.au>
20. National Health Services Directory; <http://www.nhsd.com.au/>
21. Northern Territories Government, Department of Health <http://www.ehealthnt.nt.gov.au/index.aspx>
22. NSW Ministry of Health, A Framework and Strategy for the Future of Telehealth in NSW: <http://www.health.nsw.gov.au/telehealth/Publications/NSW-telehealth-framework.pdf>.
23. Queensland Government, Queensland Health: www.health.qld.gov.au/telehealth/
24. Royal Australian College of General Practitioners (RACGP): <http://www.racgp.org.au/your-practice/ehealth/telehealth/>
25. Royal Children's Hospital of Melbourne: http://www.rch.org.au/info/az_guide/Telehealth.
26. Standards Australia: <http://www.e-healthstandards.org.au/Home/Publications.aspx>.
27. Telstra Health: <https://www.telstrahealth.com/home/solutions/teleHealth.html>.
28. Victoria Government, Department of Health and Human Services: www2.health.vic.gov.au/hospitals-and-health-services/rural-health/telehealth.
29. Western Australia Government, Western Australia Country Health Service: <http://www.wacountry.health.wa.gov.au/telehealth>.
30. Another excellent resource is, of course, the Global Knowledge Resources for Telemedicine & eHealth at Med-e-Tel website: http://www.medetel.eu/?rub=knowledge_resources&page=info

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BRAZIL

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Introduction

Brazil is the fifth largest country in the world, both in area and population and the biggest country in South America covering 47% of the continent, bordering all but two countries, Chile and Ecuador. It is the only country in the region that speaks Portuguese and it is the largest Portuguese-speaking country.

Most of its territory is located under the Equator, and it is politically divided into 26 states, and one federal district combined into five macro regions. Most of the Amazon rainforest, considered the “lungs of the Planet” and the Amazon River, the largest river in the world are inside Brazilian borders and together they harbour a unique ecological system.

Brazil is ranked as having a high human development index and occupies the 75th position among 188 countries assessed by the United Nations Development Agency (UNDP), 2015 [1, Fig. 13].

Considered as a continental country, Brazil faces different types of climate, ranging from tropical in the north to temperate zones in the south. Its five regions are very diverse especially regarding its population density as well as its social, economic and cultural development.

Brazil, Russia, India, China and South Africa are members of the BRICS countries. The term "BRIC" was used, for the first time, in a 2001 publication by Jim O'Neill, “Building Better Global Economic BRICs”, referring to an association of major emerging economies or newly industrialised countries, which were large, fast growing economies that exercised significant influence in their regions [2]. South Africa joined the BRIC countries in 2010 and all BRICS are members of the G-20.

Brazil has always struggle to bring health and economic development to all its regions, but towards the end of the twentieth century, more precisely in October 1988, a new Brazilian constitution went into effect stating that health was a duty of the State and welfare of the people and that it should be

free to all. The beginning of the Unified Health System (SUS) immediately improved access to health care to a significant proportion of the Brazilian population.



Fig. 13: Brazilian States and its 5 macro regions

Today, the Unified Health System (SUS) is enshrined into the Brazilian society and almost thirty years after its inception, continues its efforts towards universal access, decentralization of services, strengthening social participation and public awareness of a right to health care, primary health care and the very successful family health program. In spite of the difficulties, the National Health System is investing in disease prevention measures; providing medicines and vaccines; strengthening surveillance; building capacity and development of human resources for health, and intensifying technological development and research.

However, it cannot be undermined that in 1988, the Brazilian population was 140 million and today, according to the National Statistics Agency (IBGE) [3], it surpassed 206 million. This fact alone strains the Health System, not to mention an aging population with their specific needs, new and emerging diseases, immigration, the continuous development of expensive health technology and the need to keep its health workforce trained and working in urban and rural areas.

Considering that health is a duty of the State and that the whole population should be covered by the National Health System, Brazil invests less than 5% of its Gross Domestic Product (GDP) in the health sector [3],

which is not enough to cover all its growing needs, and spends much less than countries that have similar health systems.

To overcome the considerable challenges, the Brazilian Health System needs to strengthen its political support and restructure its financial constraints as well as redefine the roles of both the public and private sector [4].

However, with the explosion of Information and Communication Technology (ICT) in the last decades, new approaches to delivering health care began to take shape using ICT as an enabler. The use of ICT for health in Brazil has two major components. One in education (tele-education) and the other in healthcare (telecare). Together they are called telehealth [5].

Telemedicine in Brazil

While modern telemedicine began in the 1960s, with the technological race of the military and space sectors of the United States and the Soviet Union, telemedicine in Brazil began a little uncoordinated in the late 1990s as much in the public as in the private sector, although there were some pioneering experiences in distant patient monitoring before that [6].

The last decade of the twentieth century established important milestones for telemedicine in Brazil, starting with telephone counselling and a home care ECG, launched by the Instituto do Coração in São Paulo, where a health professional could assess patients from their own residences [6].

In 1993, the Cardiology Foundation in the State of Bahia developed imaging tools at the University Hospital to support diagnosis of heart diseases in remote areas [7].

In 1994, in the wake of a series of National Health Conferences that established and later consolidated the Brazilian National Health System launched by the new constitution of 1988, the Oswaldo Cruz Foundation (Fiocruz), a research and scientific institution linked to the Ministry of Health of Brazil, envisioned a Health Channel Project to combine communication and health education using closed circuit TV. It was an innovative technology for capacity building and training, and the channel produced standard audio-visual materials that distributed messages and alerts to other institutions to raise awareness to certain diseases and to encourage health promotion. Four years later, all Brazilian States had access to its educational materials [8].

In 2008, the Ministry of Health invited the Health Channel to participate in its Digital Inclusion Program. In 2010, it became a regular television channel of the Brazilian Health System. Today, the Health Channel can also be seen by satellite dish with digital reception and through the web TV

channel, producing daily programmes from 8 a.m. to midnight including own and partner productions [9, Fig. 14].



Photo: Peter Cardoso Illiciev

Fig. 14: Health Channel, a television channel of the Brazilian Health System

Back in the 1990s, the Ministry of Health of Brazil, with support from the World Bank (WB) and the Inter-American Development Bank (IDB) created, among other projects, a Health Information National Network to support decision-making, improve data collection and ensure that information management and dissemination would be available to all to strengthen the newly created National Health System.

Also, new initiatives were being developed, such as: the Virtual Hospital at the University of Campinas (UNICAMP), conceived in 1997, as an information resource organized by theme that began as a reference centre and as an alternative to the increased number of low quality publications without peer or systematic reviews that were being published. It also inferred that health professionals based in rural areas, should use the Internet to support its training and capacity building [10].

That same year, in 1997, the first telemedicine course was approved and delivered at the University of São Paulo (USP), as part of the graduate syllabus for medical students [11].

The use of ICT was growing fast in Brazil and in 1999, the Hospital Sirio Libanês, in São Paulo, inaugurated its first teleconference room to facilitate teleconsulting, second opinions and tele-education, and the Federal University of São Paulo (UNIFESP) developed a Telemedicine Laboratory inside the Health Informatics Centre and begun to strongly encourage the development of telemedicine in the country [11].

A great novelty came in the year 2000 when the telemedicine course at USP delivered its first 3D film presentation of a dermatological surgery. It had a huge repercussion that encouraged other developments and use of ICT for education [11].

While telemedicine was expanding, it created opportunities to establish partnerships with other countries in areas of teleradiology, telepathology, teleconsulting, such as: the partnership between the Mother and Child Institute of Recife (Instituto Materno-Infantil de Recife) and the Saint Jude Children Research Hospital in Memphis, USA that, through biweekly teleconferences and clinical discussions, could improve the outcome of children with leukaemia in Recife. The same Saint Jude Children Research Hospital supported a pilot project for teleconsulting between a Base Hospital in the Brazilian Northern State of Rondônia and the Children's Institute (Instituto da Criança) in São Paulo [6].

By the year 2000, telemedicine was rising in Brazil and the need to create an entity to represent the thriving Brazilian telemedicine, was being discussed. The opportunity came in 2001, at the Sixth Congress of the American Telemedicine Association held in June, in Florida. One year later, the Brazilian Council for Telemedicine and Telehealth was created as a private and non-profit organization to promote and strengthen actions towards telemedicine and telehealth to foster government actions and private initiatives to push forward and give visibility to telemedicine.

Fourteen years later, the Brazilian Council for Telemedicine and Telehealth changed its name to Brazilian Association of Telemedicine and Telehealth and continues to promote knowledge sharing, exchanging of experiences and strengthening education and research among the scientific community nationally and internationally. The Brazilian Association of Telemedicine and Telehealth is a member of the International Society for Telemedicine and eHealth (ISfTeH) since 2005.

Earlier in 2002, the Federal Medical Council and later the São Paulo State Medical Council approved the first resolutions for telemedicine that laid the foundation of its regulated advancement in the country [12].

In February 2003, the Medical School and the University Hospital of the University of São Paulo with the State Medical Council, among other entities, presented during a Hospital fair and forum, a medical digital station (Fig. 15). The station was visited by the Minister of Health and the State Health Secretary that witnessed a live demonstration of a cardiac procedure performed from another town, that was a great success [13].

One week before the fair, one of the leading cardiologist in Brazil and former Minister of Health delivered a first telecardiology lecture via teleconference, using a satellite connection, to students at the University of

Acre, one of the Northern states of Brazil. Until today, the Medical School of the University of São Paulo delivers a series of lectures to several Universities in various States and continues to be one of the most important activities of its teaching department.



Fig. 15: Medical Digital Station at a Hospital Fair in 2003

These activities led to the development of a “cyber outpatient clinic” and a “cyber distant tutor” programmes at the University of São Paulo (USP) that were the seeds for the telemedicine and virtual man projects as new tools for medical students to get more involved with their learning (Fig. 16-17).



Fig. 16: Virtual Man learning tools



Fig. 17: 3D inner ear structure as part of the virtual man learning tool

By November 2003, the First Brazilian Congress of Telemedicine and Telehealth and the Second Congress of Latin American Internet in Medicine was held in São Paulo with several activities on teleophthalmology, telenursing, telepsychiatry, teledermatology. It was also the beginning of the discussions for the teledentistry programme and the seed to the Amazonian Telemedicine Centre at the University of the State of Amazonas (UEA), later inaugurated in 2006.

The following year, in 2007, the São Paulo University Hospital opened its telemedicine and telehealth research laboratory [11].

In Rio de Janeiro, telemedicine started in 2003 when the Medical School of the State University (UERJ) and the NGO Mission for Children, facilitated a videoconference with the Johns Hopkins University to discuss a complicated pediatric case. This was a milestone that shifted a paradigm in Rio de Janeiro, and set the stage for sharing experiences with other Universities in Brazil and abroad using ICT as a catalyst [6].

Nowadays, the Telehealth Centre at the State University of Rio de Janeiro (UERJ) developed its own platform offering teleconsulting to health professionals of the National Health System, and although its main target is the State of Rio de Janeiro, 86% of the teleconsulting are from health professionals from ten other Brazilian States [7].

A great strength of the Telehealth UERJ is the virtual learning environment and the tele-education activity that offers a wide range of topics to support students, teachers, community health workers and others. One of the biggest merits of the State University of Rio de Janeiro was the development of the first Graduate Master Telehealth Course in Brazil, and, in 2012, the publication of the first Brazilian Journal of Telehealth, the only scientific Journal of its kind in Latin America [7, Fig. 18-19].



Fig. 18: UERJ Telehealth Platform

In 2015, the Telehealth UERJ and the Brazilian Council of Telemedicine and Telehealth (CBTms) organized the VII Brazilian Congress of Telemedicine and Telehealth alongside the XX International Conference on Telemedicine and Telehealth of the International Society for Telemedicine and eHealth (IsfTeH), and the Rio de Janeiro Telehealth Symposium (CBTms2015) consolidating its presence in the international arena.

In 2005, the State of Minas Gerais, conducted a pilot project in Telecardiology in 82 towns with less than 10,000 inhabitants, focusing on preventive strategies of heart problems, which resulted in 60,000 electrocardiograms (ECG) performed locally, and then assessed by the University Hospital in the Capital city [7] [14].



Fig. 19: Brazilian Journal of Telehealth

Minas Gerais is the fourth largest State in the country and has the largest number of cities of all Brazilian states, 853. Before this pilot project, a brief assessment showed that there was no record of any electrocardiogram performed by the National Health System in 423 cities [15]. The introduction of the telecardiology project was responsible for 70% reduction in patient referrals, strengthening its consolidation and growth. It was an encouragement for the advancement of Telehealth in Minas Gerais (Fig. 20).

To date, the telecardiology project in Minas Gerais covers more than 90% of the State and performed over 2,5 million ECGs and almost 75,000 teleconsulting activities in 780 cities. On average, 2,000 ECGs and 40 teleconsulting per day in 2015 [15].

These are just a few examples of the growing use of ICT for education in Universities, and the use of teleconferences by Clinics and Hospitals that created new opportunities, in many Brazilian States for the advancement of research and development of telemedicine centres.

However, the major turning point occurred in 2006 with the beginning of the Telemedicine University Network (Rede Universitária de Telemedicina - RUTE), an initiative of the Ministry of Sciences and Technology, coordinated by the National Research and Education Network (RNP), and

the launching in 2007, of the Brazilian Telehealth Programme by the Ministry of Health.

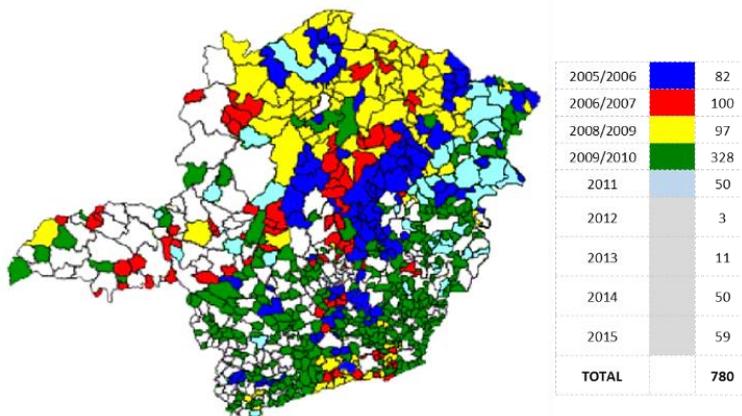


Fig. 20: Telecardiology Minas Gerais
<http://www.telessaude.hc.ufmg.br/quem-somos/cobertura>

Brazilian Telehealth Programme

In 2005, the World Health Organization (WHO) recognized the advances in information and communication technologies (ICT) and its impacts on health care delivery, research and education and proposed an eHealth strategy that was approved by its Member States at the World Health Assembly in May that year.

Following this resolution (WHA58/28), many countries saw it as an opportunity to strengthen its health systems through the development of its own eHealth related policies [16].

Brazil was already experimenting with ICT in the health sector and adopted eHealth for healthcare and education as a national policy for development and capacity building of human resources for health.

The Brazilian Telehealth Programme was initially called Telemedicine, but quickly changed to Telehealth as it expanded its scope to incorporate other health professionals, bringing their expertise to the teams.

The Programme began in 2007 as a pilot project and a tool to support primary health care and the national family health strategy. It was built on an already well-conceived and successful local experiences with telehealth in nine Universities, from all five macro regions. In the North, the State of Amazonas; in the Northeast, the States of Ceará and Pernambuco; in the

Southeast, the States of Minas Gerais, Rio de Janeiro and São Paulo; in the Midwest, the State of Goiás and in the South, the States of Santa Catarina and Rio Grande do Sul. See Fig. 21 below.



Fig. 21: Map showing the Brazilian States participating in the Pilot Project of Telehealth in 2007

Its main purpose was to build capacity and provide training to 4,500 family health teams from 900 basic health units [7]. A family health team includes a nurse, a medical doctor, a nurse technician, four to six community health workers and a dentist.

The overall objective of the programme was to improve the quality of care provided by those teams, contributing to reducing costs and making these teams more agile and efficient to strengthen the National Health System to benefit 10 million people.

The Brazilian Telehealth Programme was built on four main pillars:

- 1) Teleconsulting - a consultation among health professionals to discuss a case or answer a question about a procedure or a conduct. It can be in real time (synchronous), usually through a chat, web or video conference or it can be asynchronous (through offline messages).
- 2) Telediagnosis - a standalone service that uses ICT to deliver a diagnosis.
- 3) Tele-education - using ICT to deliver conferences, lectures, lessons; etc.

- 4) Second Opinion - response to the questions originated by the teleconsulting component. Answers are based on relevance and bibliographic review of the best scientific and clinical evidence available.

Any teleconsultation, teliagnosis, tele-education or second opinion requested by any health professional working at the National Health System can be answered by teleconsultants from any Telehealth Centre in the country [17. Fig. 22].



Fig. 22: Teleconsulting

The big challenge, at the very beginning, was to raise awareness and involve local authorities in the process, and convince them of the benefits that the programme would bring. Also, it was necessary to empower the family health teams and have consultant teams ready at base. Another huge test was to face the low connectivity in the North and Northeast regions of the country, especially in the Amazon. Therefore, the development of the project was different in each region and it grew according to local conditions and motivation of its teams and institutions.

Among the lessons learned, it became clear the need for continuous education and digital inclusion to break the isolation of health professionals living in rural and remote areas. It was also highlighted the need to build credibility and confidence between the local teams and the University based teams. To break the ice, it was critical for the University teams to visit as many local areas as possible, to get acquainted to local realities and plan their responses through the teleconsulting accordingly to the local contexts.

This strategy was important for the success of the pilot project that evolved into the Brazilian Telehealth Programme in 2011.

As the programme was taking shape, two other major initiatives - the Telemedicine University Network (Rede Universitária de Telemedicina - RUTE) and the Brazilian Open University (UNASUS) emerged and progressively became involved with the Telehealth Programme. Together, they engaged in a comprehensive and integrated range of actions that supported capacity building of the health workforce from the National Health System to assist education, research and health care through telehealth. [17].

Telemedicine University Network (RUTE)

The Telemedicine University Network (Rede Universitária de Telemedicina - RUTE) was built on an already existing National Research Network (RNP) created in 1989 by the Ministry of Science and Technology (MCT). The main goal of RNP was to build a National Internet infrastructure to assist Universities to have access to the Internet.

In May 1995, when the commercial Internet was released in Brazil, the RNP reassessed its role, expanding its services to all sectors of society. It offered an important support for the consolidation of the commercial Internet in the country. In its first year of operation, it answered more than 3,000 questions about the use of Internet. It was also responsible for the first security centre for Brazilian networks. At this point, numerous computer manufacturers such as Compaq, Equitel, IBM, Philips, among others, started to support RNP, providing equipment, software, and even financial contributions to some of its project activities [18].

In October 1999, ten years after the initial activities of the RNP, the Ministry of Science and Technology (MCT) and the Ministry of Education (MEC) signed an agreement, for the implementation and maintenance of the National Network for Education and Research, today called Interministerial Program RNP (PI-RNP) to strengthen the academic network.

In 2006, the Telemedicine University Network was created using the existing RNP infrastructure to deliver advanced communication through the national backbone infrastructure to Universities and Teaching Hospitals to formally establish telemedicine units encouraging assistance, research, monitoring and management of collaborative network.

The Telemedicine University Network was already developing initiatives in partnership with the Ministry of Health to reduce infant mortality, and in 2010, the Ministry of Health opened a specific budget line to strengthen the collaboration with the Telemedicine University Network to make it a long term cooperation [5].

Today, Telemedicine University Network is present in all 27 States and has already implanted and launched 122 operational Digital Health Units, supporting 60 Special Interest Groups (SIGs), that interact through video and webconferences, discuss and delivers daily, two to three hours of real time case discussions, presentations, lectures and lessons in several health specialties and sub specialties. The Telemedicine University Network is endorsed by the Brazilian Association of Universities and Teaching Hospitals (ABRAHUE) and the Federal Council of Medicine (CFM) [19].

In 2016, it celebrates 10 years of operation and it is responsible for the advancement of education and research through distance and specialized learning. Its biggest strength is the grouping of experts, health professionals, and students in the most updated discussion. Any health institution can request to participate in any SIG activities.

The Telemedicine University Network is an enabler for the Brazilian Telehealth Programme (Fig. 23).



Fig. 23: Telemedicine University Network in action

Open University (Universidade Aberta do SUS - UNASUS)

The Open University of SUS (UNASUS) was conceived in 2010 to provide health professionals from the National Health System with multiple opportunities for training and continuing education, using eLearning technologies. It was an innovative effort aligned with the contemporary use ICT and social media to build capacity of the health workforce.

UNASUS is built on three pillars. The first is a collaborative network of higher education institutions, which currently encompasses 35 institutions; the second is the Open Access Educational Repository Collection on Health (ARES) and the third pillar is the Arouca Platform, an information map where health professionals can locate and access educational opportunities, whether short or long term, being practical or academic in nature, totally financed with public funds.

The learning process of UNASUS is focused on the professional-student requirements, recognizing the daily practical needs of these professionals. The ultimate goal is a lifelong learning, aimed at solving current problems in the daily routine of health professionals. The teachers are, therefore, facilitators of the learning process prioritizing the experience and prior knowledge of the students. The courses use a dynamic approach ensuring adherence of students [20, Fig. 24].



Fig. 24: Students at UNASUS course

Students can interact and follow the courses as many time as they want or need to master the information to build their capacity. They can also choose their own formative route, taking into account their previous training, current interests and motivation, based on the principle of andragogy, a theory of a lifelong education of adults, widely spread by the American Educator Malcolm Knowles [21]. At the end, they can document their learning through online tests and inclusion of certificates at the Arouca Platform.

UNASUS work in a network of 35 public higher education institutions approved by the Ministry of Health and accredited by the Ministry of Education to provide distant learning. The partnership among these

institutions allow for greater exchange of experience and knowledge sharing for the benefit of the health workforce. The network produces a wealth of information in various formats, such as: videos, texts, audios, eBooks, apps that can be used and adapted to local needs [22].

Teledentistry

While telemedicine was growing fast in the last decades of the twentieth century, teledentistry involved calling a colleague on the telephone to discuss a case. In the 1990s, it was relatively common to have workshops to discuss clinical cases and perform surgical procedures transmitted by videoconference. However, teledentistry began to evolve when Chen et al, in 2003, suggested that oral health care and eLearning should be used for dentistry [23]. For the authors, the rudiments of teledentistry began as part of computer science applied to dentistry, outlined in a Conference in 1989. Later in 1997, the term teledentistry was used to define the practice of video conferencing for discussion and support to diagnostic for dental treatment at a distance [5].

In 1999, teledentistry based on Integrated Services Digital Network (ISDN) was tested in Germany, Belgium and Italy.

In Brazil, teledentistry grew almost in parallel with the advancement of telemedicine and later telehealth. Just as tele-education was growing at the University of São Paulo (USP) with the “cyber outpatient clinic” and the “cyber distant tutor” programmes for medical students, there were several initiatives in distance learning for dentists, such as: courses for clinicians provided by the Brazilian Association of Dentistry, and the oral health guidelines for the Indigenous Health District in the Amazon provided by the Faculty of Dentistry in Ribeirão Preto [5].

To support teledentistry, the telemedicine discipline at the Medical School of the University of São Paulo developed seven distance learning modules involving health related themes for dentistry.

As the family health programme was growing in the country, other health professionals were being incorporated to the teams. In the year 2000, dentists were included in the family health teams and in 2003, the Ministry of Health launched the largest oral health programme in the world, called “Smiling Brazil” (Brasil Sorridente) [24].

It was the rising of teledentistry, and soon, there were meetings organized by the Brazilian Congress of Telemedicine and Telehealth that brought Deans of Universities, students, practitioners, teachers and interest parties to the table, to discuss the expansion of teledentistry.

One of the first Schools of Dentistry to adhere to teledentistry was at the University of São Paulo (FOUSP). Its Teledentistry Centre was created

shortly after the pilot project of the Brazilian Telehealth Program in 2007. FOUSP developed a discipline of teledentistry for undergraduate and graduate students, and in 2013, they created and were in charge of the Teledentistry Special Interest Group (SIG) of the Telemedicine University Network, in partnership with the Brazilian Association of Dental Education and the Latin American and Caribbean Centre on Health Sciences Information (BIREME/PAHO/WHO).

The Teledentistry Centre at FOUSP was also responsible for the establishment of the Brazilian Network of Teledentistry, and the “Teacher Training and Support for Schools of Dentistry to create Learning Networks and Collaborative Work in Health” course. This three modules programme was intended as a refresher course to promote interactive educational techniques and ICT to support the learning process of teleassistance in dentistry. The course included a series of initiatives to strengthen and consolidate the Brazilian Teledentistry Network, aimed at dentistry schools that were considering the inclusion and development of teledentistry and telehealth educational and assistance centres in their curriculums; therefore, contributing to the expansion of the Brazilian Teledentistry Network.

The course attracted international students and secured the participation of 32 different Brazilian and three Latin American Schools of Dentistry, as well as the State Health Secretariat of the Midwest State of Mato Grosso. It was an immediate success setting the stage for its growth.

The consolidation of the Teledentistry Center at FOUSP and the Brazilian Teledentistry Network were important for the establishment of a working group of Teledentistry at the International Society for Telemedicine and eHealth (ISfTeH), and Brazil has been actively participating in all Med-e-Tel Conferences pushing Teledentistry even further (Fig. 25).



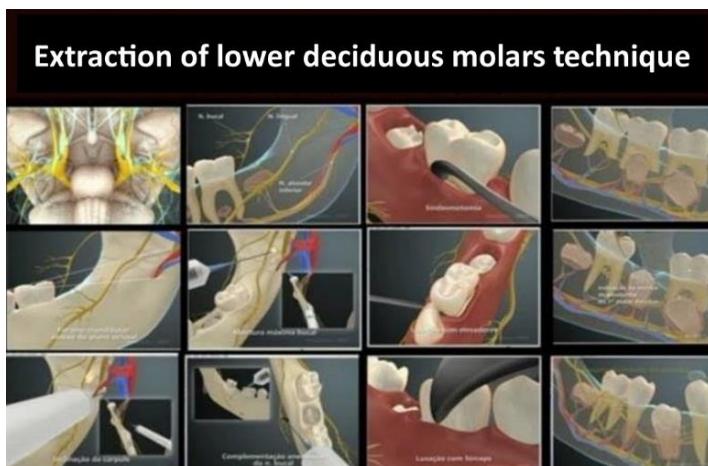


Fig. 25: Teledentistry class at São Paulo University

Final Remarks

In addition to providing teleconsulting, the Brazilian Telehealth Programme is a public policy to strengthen education and capacity building of human resources, improving surveillance and health information to support the National Health System. One of the main values of the Brazilian National Health System is its comprehensiveness covering from health promotion, risk prevention, health care delivery and recovery. The Telehealth Programme is responsible for reducing referral of primary health care patients to higher levels of care, relieving the pressure of National Health System.

As the Telehealth Programme grew and was getting integrated into the National Health System, it brought the National Council of State Health Secretaries (CONASS) and the National Council of Municipal Health Secretaries (CONASEMS) to embrace its values.

The positive results of the first assessment of the Programme, led to its expansion from the initial primary health care to include secondary and high complexity levels of care as well. The Programme also established new concepts and resulted in telehealth being included in the roll of health services available to health professionals. These accomplishments are reflected in the Brazilian legislation, which adopted eHealth as a national policy.

Nowadays, the Brazilian Telehealth Programme is offered in 24 out of 27 States in more than 2.000 cities involving 30.000 health professionals from the Family Health Programme. From 2008 to August 2016, it provided over 3 million telediagnosis, it participated in 2,9 million tele-education activities and delivered almost 500.000 teleconsultations and 1.039 second opinions. It has 46 fully operational Telehealth Centres and there are 9 Centres in the implementation phase. See fig. 26 below.



Fig. 26: Map of Brazilian Telehealth Programme in 2016. 24 States marked in blue have fully operational Telehealth programmes. 2 yellow States are in the implementation phase.

The Brazilian Telehealth Programme is today, the largest telehealth programme worldwide and, in 2011, the Programme received from the Pan American Health Organization (PAHO) an award of recognition as a successful telehealth model that could be used as an example to other countries [25].

Note

This chapter highlights some of the history of Telemedicine in Brazil. It does not pretend to be complete and we apologise in advance if relevant initiatives were left out. Consider this a summary of a few important activities that led to the development of the Brazilian Telehealth Programme.

However, more on the Telemedicine and Telehealth as well as tele education in Brazil can be found at:

1. Brazilian Association of Telemedicine and Telehealth (Associação Brasileira de Telemedicina e Telessaúde) - http://www.abtms.org.br/?page_id=816&lang=en
2. Brazilian Internet Steering Committee (Comitê Gestor da Internet no Brasil) – www.cgi.br
3. Brazilian Journal of Telehealth (Jornal Brasileiro de Telessaúde) - <http://www.jbtelessaude.com.br/jornal>
4. Federal Council of Medicine (Conselho Federal de Medicina) - <http://portal.cfm.org.br>
5. Global Knowledge Resources for Telemedicine & eHealth at Med-e-Tel website - https://www.medetel.eu/?rub=knowledge_resources&page=info
6. Medical Digital Station (Estação Virtual Médica) - <http://edm.org.br/edm>
7. National Research Network – Our History (Rede Nacional de Ensino e Pesquisa – RNP. Nossa História) - <https://www.rnp.br/institucional/nossa-historia>
8. National Research Network (Rede Nacional de Ensino e Pesquisa - RNP) - <https://www.rnp.br>
9. Open University for the Unified Health System – (Universidade Aberta do SUS – UNASUS) - <http://www.unasus.gov.br>
10. Telehealth Brazilian Network (Telessaúde Brasil Redes) - http://dab.saude.gov.br/portaldab/ape_telessaude.php
11. Telehealth in Brazilian States - http://aps.bvs.br/rede-de-colaboradores/?l=pt_BR
12. Telemedicine University Network (Rede Universitária de Telemedicina – RUTE) - <http://rute.rnp.br>
13. Virtual Health Library of Telehealth - <http://aps.bvs.br>
14. Virtual Man (Homem Virtual) - <http://homemvirtual.org.br>

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CZECH REPUBLIC

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Introduction

The Czech Republic is a country in the Central Europe, bordered by Germany to the west, Austria to the south, Slovakia to the east and Poland to the northeast. It is a parliamentary republic, has 10.5 million inhabitants and the capital and largest city is Prague.

The health care system and the basic related legal regulations will be presented in brief. The most important routinely used applications are selected. In addition, several examples how pilot studies are implemented in to routine practice are listed. Research projects represent various topics. Those, which are based on good ideas and would not be too expensive for implementation are selected and depicted in the text. Finally, an information about the development on the border between health and social care is included. The issues of assistive technologies that frequently utilize the same technology as telemedicine are also discussed.

The Czech National eHealth Centre as a coordinating and educational center for eHealth and telemedicine (https://www.fnol.cz/narodni-telemedicinske-centrum_78.html) was established betwee, 2007 and 2013. One of its aims is to serve as information hub for up-to-date information in the field of eHealth. Results of many recent projects in telemedicine and eHealth are regularly presented at various conferences, in particular the annual Med-e- Tel conferences and have been published in the Global Knowledge Resources for Telemedicine & eHealth on the Med-e-Tel website (https://www.medetel.eu/?rub=knowledge_resources&page=info).

The eHealth systems include electronic health records (EHR); telemedicine; consumer health informatics; health knowledge management; medical decision support systems; m-Health (use of mobile devices for different applications in healthcare); telemedicine (provision of clinical health care from a distance). In [1], the following application fields of m-Health were identified: diagnostic and treatment support; remote monitoring; remote data collection; education and awareness; helpline;

communication and training for health care professionals. Specification of basic types of services can be found in [2]. Recently appeared additional application areas on the edge of medicine, social care, and technology, namely assistive technologies and ambient assisted living. We can expect that with the development of new technologies, new applications in eHealth and telemedicine will appear in the near future.

It is necessary to note that many of the above mentioned activities have been to a certain degree implemented in routine health care services. However, there are many activities, in particular in the relation physician – patient, that are not yet satisfactorily supported. Until now, they have been addressed within the frame of various projects, but not included in standard health care system covered by health insurance.

Historical Background

The technological development in most European countries is similar. Some differences in frequency of technology applications between cities and rural areas, especially in the 19th century and first half of the 20th century are observed. The main technological phases are illustrated in Table 2. The starting years indicate more or less first applications of the corresponding technology in medicine and health care.

Table 2 Main technological phases of telemedicine development

Telegraph and telephone	1840 – 1920
Radio broadcast	1920 – 1950
Television / space technology	1950 – 1990
Digital technologies and Internet	1990 – now
Mobile technologies and wearables	2005 – now
Internet of (every)thing	2010 - now

Almost in each country there are examples of milestones when these technologies were used for the first time for health care purpose and when they started to be used more regularly.

Radio and television also contributed to education of the public. Various programs informing about diseases, prevention, healthy life style and nutrition can be found from the beginning of regular broadcasting.

When looking back to the past decades it is worth mentioning that for countries in Central and Eastern Europe the time when important

technological innovations were applied on a larger scale was around the end of the 1980ies and beginning of the 1990ies, i.e. from wide usage of personal computers, over Internet, wireless communications up to smart phones and Internet of things.

First Regular Tele-consultancy

It is quite remarkable that one of the first medical areas where teleconsultations started in the former Czechoslovakia was psychiatry. Thus tele-psychiatry entered the stage in the 1960's although at that time the terms tele-psychiatry or telemedicine were not used. The foundation-stone of tele-psychiatry in the whole Central and Eastern Europe was the establishment of the first Czech telephone help line in 1964. The founder was Miroslav Plzak, MD at the Department of Psychiatry of the First Faculty of Medicine of the Charles University and General University Hospital in Prague. The hot line was named "Line of Trust". Thanks to the enormous personal initiative of M. Plzák, the line was integrated into the official health care system. The mission of the hot line was prevention and decrease of suicidal tendencies, help in crisis and help to clients with depression and other psychiatric disorders. In 1965, another telephone help line was established in Brno, named "Line of Hope", initiated by prof. Josef Hádlík, MD. In 1967, "Line of Trust for Youth" was started at the Department of Psychiatry in Prague.

After 1989, number of established telephone hot lines significantly increased. In 1996, 37 such hot lines were registered in the Czech Republic and in 2000 approximately 60 hot lines were operating. However, fast development of telephone hot lines created some problems, in particular at those newly established, namely shorter operating hours due to lack of qualified personnel and overload of existing personnel.

Development of another communication means – Internet – led to development and growth of Internet consultancy and online chats with experts on medical servers. Since 1999 e-mail consultancy has been provided on the portal www.lekarna.cz, which gradually developed into an online chat with experts in psychiatry on topics announced in advance.

Currently, a system of psychological and psychiatric telephone hot lines exists in the Czech Republic. In addition, specialized psychiatric Internet counselling centers and chats for patients from various diagnostic groups (e.g. alcohol addiction, eating disorders, personality disorders) are operating.

Recent Development

The crucial breakthrough in the development of telemedicine came with the development of digital computer technologies and Internet in the 1990's. Since then, we witnessed enormous increase of various telemedicine applications and currently we hardly find any health care area that is not touched by telemedicine. Most frequently, telemedicine is used in form of teleconsultations. They represent medical examinations or consiglia during which the personal contact between a doctor and a patient or among doctors is replaced by modern telecommunication means. Telemedicine started to be utilized in another area as well, namely care for elderly and chronically ill at their homes – tele-monitoring.

Information resources are nowadays mostly accessible through the Internet and offer widely accessible educational material. Where the object of information and education is represented by health care data we talk about tele-education as one of the applications of telemedicine. This form is used for distant education of students and health care professionals, as well as for public access to general health care information.

The case studies of the recent applications, pilot projects and research projects will be presented in the next sections.

Health Care System in the Czech Republic

Before describing case studies of telemedicine applications, let's introduce the legal, financial and organizational healthcare context in the Czech Republic. It helps understanding the position of telemedicine and out-patient care.

The supreme institution on governmental level, responsible for health care system in the Czech Republic, is the Ministry of Health [3]. The health care services can be provided by both public and private institutions that got the approval from corresponding regional administration, or in special cases from the Ministry of Defense (e.g. army hospitals and ambulances), Ministry of Interior (e.g. health care institutions for police and fire brigades) or Ministry of Justice (e.g. prison hospital). The health insurance is mandatory. The public health insurance system in the Czech Republic identifies the following three key participants – as described below:

- Insured Person - the recipient of health care services;
- Health Care Services Provider - a legal entity that is usually a medical facility being the provider of healthcare services – this could be a hospital, clinic or emergency care center, etc.; it could also be a physical entity (person) who is a healthcare professional licensed to provide healthcare services – such as a general practitioner, dentist, physiotherapist, etc.;

- Health Insurance Company - an entity or institution, which provides health care insurance coverage to the insured person for the purposes of paying for covered medical services and charges.

Public health insurance in the Czech Republic is provided through health insurance companies. The largest one is the General Health Care Insurance Company. In addition, there are also several so-called departmental, professional, or business health insurance companies.

All employees or self-employed persons have to pay health insurance. It is calculated based on a certain percentage of their income. There is a defined minimum monthly payment. The health insurance for children, students (up to 26 years of age), retired persons, and unemployed is paid by the state.

The basic legal regulations in the health care system are the following:

- Resolution of the Czech National Council No. 2/1993, on “The Charter of Fundamental Rights and Freedoms”, which is part of the basic rights constitutionally guaranteed in the Czech Republic.
- Act No. 48/1997 Collection of Laws (Coll.), on public health insurance and on changes to certain related laws, as last amended.
- Act No. 592/1992 Coll., on premiums for general health insurance.
- Act No. 258/2000 Coll., on the protection of public health and on changes to certain related laws.
- Act No. 372/2011 Coll., on health services and the terms and conditions for the providing of such services (The Act on Health Care Services).
- Act No. 373/2011 Coll., on specific health services.
- Act No. 374/2011 Coll., on emergency medical [rescue] services.
- Act No. 551/1991 Coll., on the General Health Insurance Company of the Czech Republic [in Czech, “VZP”].
- Act No. 280/1992 Coll., on departmental, professional, business and other health insurance companies.
- Act No. 378/2007 Coll., on pharmaceuticals and on changes to certain related laws.
- Act No. 123/2000 Coll., on medical devices and on changes to certain related laws.

If a foreign national meets the requirements for participation in the public health insurance program, the person first chooses one of the health insurance companies and registers with one of them. The health insurance company is required to accept each person who meets the requirements for participation in the public health insurance program – i.e. a person who has permanent residence in the Czech Republic or a person who is an employee of a company or institution that has a registered address or the permanent

residence in the Czech Republic. The Act on public health insurance and the Act on health services define the rights and obligations of individuals participating in the Czech public health insurance program. Related legal regulations specify which health services are covered by the public health insurance. The regulations are regularly updated. Additional services can be covered by a private insurance.

eHealth and Telemedicine in the Czech Republic

In 2010, the fundamental steps towards the introduction of eHealth in the Czech Republic were summarized in the National Plan of eHealth Development that was presented by the Czech National Forum for eHealth and ICT Union (Information and Communication Technology Union). Both these associations collaborate closely with the Ministry of Health of the Czech Republic. The aim of the National Plan of eHealth development was to prepare politically acceptable starting point for creating a comprehensive national concept of eHealth development in the Czech Republic. It defined following key areas:

- National policy, legislation and standards;
- Electronic health care documentation;
- Electronic patient identification;
- Electronic health care professional identification;
- Health care information network;
- Electronic education for citizens and health care professionals.

Another assumption of the National Plan is that further development will be supported by modern ways of care organization, such as home care and tele-monitoring, and that it allows continuous care provision wherever and whenever needed with possibility of immediate utilization of all important existing information about the patient health state.

The first summary on e-health applications in the Czech Republic can be found in the study E-Health in Central and East European countries focused on the Czech Republic, Hungary, Poland and Slovenia, and supported by the European Commission, DG Information Society, eHealth Unit [4]. Bellow, the focus is on the attempts to develop methods and applications for eHealth in the Czech Republic. Several case studies of solutions developed during the last decade are presented but the state of the hospital or ambulance information systems will not be discussed as they are considered as a standard support of health care services.

The information systems can vary depending on the providers, required functionalities and types of health care institutions that use them. It is necessary to mention that most of the currently used information systems do not provide interfaces to telemedicine systems. Mostly, the telemedicine

systems allow patient data export in defined formats that could be imported into the information systems.

In this section, we first present projects of the health insurance companies and then - successful solutions that have been operating for more than a decade, some of which are run by larger medical institutions, some by private companies.

Case Studies of eHealth Applications Offered by Health Insurance Companies

The IZIP project supported by the greatest health insurance company VZP is compared with projects mVITAKARTA and Kartazivota of smaller health insurance companies.

IZIP project [5] originated as an Internet health book providing communication between patient and physicians, where its existence and content was a sole decision of the patient. IZIP was not an electronic health record (EHR), although it was often mistakenly or deliberately interpreted in this way. Due to the continuing financial support, especially from VZP, the project IZIP was not exposed to competitive pressures. IZIP was developed without following the international standards, "best-practices" and outcomes achieved in other international and European projects on EHRs. IZIP did not implement the international standards such as ISO/HL7 10781:2009, ISO/EN 13606 and other standards of Health Level 7 Inc., integration profiles IHE (Integrating the Healthcare Enterprise) or recommendations expressed by the EuroRec Institute in terms of quality guaranteed by Seal 1 and Seal 2. Therefore it was inconsistent with international efforts to interoperability and quality of EHR. IZIP did not create EHR that would fully replace the existing paper documentation and to allow its effective use in healthcare. Later it was presented as an "electronic health notebook", which is much closer to its content and functionalities. It contained basic health state information, emergency dataset (e.g. blood group, last tetanus vaccination, risk factors, allergies and medication), personal patient insurance account. It offered possibility to schedule preventive examinations, vaccination schedule, etc. However, due to certain failures and organizational, financial and administrative issues the project was stopped in 2012. The consequence was that these issues destroyed the trust of Czech citizens and unfortunately many health care professionals in the use of the EHR in Czech health care.

Other smaller health insurance companies have launched similar projects as IZIP, e.g. **(m)VITAKARTA** [6] and **Kartazivota** [7]. However, their authors present them only as a health notebook or basic data for emergency purpose, not EHR. Kartazivota is a project of the Health Insurance

Company of the Ministry of the Interior. It offers three basic electronic services: personal insurance account (detailed list of expenses for the patient's health care in last 3 years); correct and safe care (important patient data / contact information, patient and family history, chronic diseases, allergies, surgeries, injuries, medication, etc.); emergency (important information extracted from the previous list). It is accessible via smart phone. VITAKARTA ONLINE and mVITAKARTA represent a project of the Sectoral Health Insurance Company. VITAKARTA ONLINE is a desktop application (a portal with web interface) and mVITAKARTA is an application for smart phones, having versions for iPhone, Windows Phone and Android based phones. In addition to the basic functionalities available in IZIP and Kartazivota, it offers more interactive functions, e.g. adding more items, concerning current health state, personal diary. Further extension of functionalities is planned.

Case Studies: Institutions and Regions

Czech National eHealth Centre: In 2012, the Czech National eHealth Center (NTMC) [8] was established as a coordinating and educational center within the new rapidly developing sector of medicine – eHealth and telemedicine. Nowadays there are many activities in eHealth in Czech Republic, but most of them deal only with partial tasks. The aim of NTMC is to unify these activities under one organizational structure, to search and explore new trends and practices in this field, to test and implement these innovations and principles into practice and last but not least, to develop and use the modern methods in undergraduate and postgraduate education.

The creation of NTMC was initiated by the University Hospital Olomouc (FNOL) – Department of Internal Medicine I – Cardiology and Faculty of Medicine and Dentistry of Palacký University Olomouc (UPOL) where the father of the idea to establish the Centre, Prof. MUDr. Miloš Táborský, PhD, FESC, MBA currently works. The NTMC has many cooperating partners from the ranks of university institutes, health organizations, technology companies and other relevant subjects. At the beginning the cooperation was supported mainly by EU funds under the projects of Education for Competitiveness Operational Programme:

- Partnerships and cooperation in the field of eHealth;
- Implementation of modern methods from eHealth to teaching medicine;
- Interactive cardiology – modern teaching methods.

Other important projects of NTMC have been:

- UNiversal solutions in TElemedicine Deployment for European HEALTH care (United4Health);

- Support and development of international scientific cooperation of Czech National eHealth Center.

The NTMC established partnership with leading technical universities in the Czech Republic, namely Czech Technical University in Prague and Brno University of Technology.

The ambition of NTMC is to become a top workplace, which will be unique in the Czech Republic in scope of its activities and which will collaborate with other specialized educational, research and care providing workplaces within the Czech Republic and also from abroad.

The objective of NTMC is not only to provide common telemedicine health care. It is especially active on the development and scientific verification of new telemedicine procedures, getting top know-how from foreign subjects and experts; dissemination of the know-how into other professional workplaces throughout the whole Czech Republic; education of new experts in the field of telemedicine and application of modern methods in teaching within medical and paramedical fields.

In 2014, a special Telemedicine course was started up at the Faculty of Medicine and Dentistry UPOL. The Centre offers students and academic staff participation in studies and trainings in foreign top level health care and research institutions and technological companies dealing with eHealth and telemedicine.

Based on the initiative of the Czech National eHealth Centre an informal group of academic institutions active in the field of eHealth, telemedicine and assistive technologies was formed in 2013. The main goal of this partnership is current and future cooperation of academic institutions throughout the Czech Republic in the field of telemedicine, eHealth and assistive technologies. Examples of cooperation may be joint projects, grants, conferences, education, and commercialization.

Cardiology home monitoring: Based on the proven benefits of remote monitoring for patients with heart failure, and thanks to the initiative of professional medical societies, in particular the Czech Society of Cardiology, the health insurance companies began to reimburse payments of remote monitoring of cardiac patients since July 2014. Sudden heart failure cardiovascular patients is the biggest threat. INTIME study [9] (the first large randomized trials in the world) showed significant decrease in total mortality in patients with advanced heart failure connected to a remote monitoring system - Home Monitoring - by more than 50% compared with normal controls. The INTIME study lasted 12 months and involved 664 patients with advanced heart failure, and severe left ventricular dysfunction from 36 centers worldwide. Czech Republic was represented by two Prague

top-level hospitals - Na Homolce and IKEM (Institute of Clinical and Experimental Medicine) whose cardiology departments participated in the study. Thanks to home monitoring the patients can get the specialists' care before they even notice the first signs of health state deterioration. In the Czech Republic, the remote monitoring is used primarily in patients who have a pacemaker or cardioverterdefibrillator (ICD) implanted and are at risk of arrhythmic storm, or a series of incorrect discharges. They are at risk of sudden cardiac death. In case of deterioration they receive a greater number of correct electrical discharges. Currently, the number of patients with these devices is increasing in the Czech Republic every year by about 8,000 new implanted pacemakers and almost 3000 cardioverter. As prof. MD. Milos Taborsky, PhD., MBA stated there were about 2500 patients with heart rhythm disorder monitored remotely in the Czech Republic in more than 10 cardiovascular centers in 2015, but their number has been growing. Worldwide remote monitoring technology is used by more than one million patients with implanted pacemakers and ICD, and the results of long-term studies indicate that this relatively simple technology clearly improves the quality of life of patients, improving their collaboration with physicians and also is effective in terms of cost. A Patient Monitoring Unit, so-called CardioMessenger, costs approximately 1,000 EUR and is operational throughout the life of the implant, which varies depending on device type from 5 to 8 years. Costs to ensure the transfer of data reports are not high thanks to the reduction of telecommunication service price. Home Monitoring is a wireless monitoring system that protects patients anywhere in the world. It allows them quieter life, to lower the number of regular inspections and to be constantly guarded. The device is similar to a kind of mobile phone. It communicates wirelessly with the implanted device, and at the same time regularly, once every 24 hours, sends the information to a secure website. In the case of a significant worsening of the patient's condition or implanted device the system immediately sends alerts to the physician by e-mail, short text message or fax. Thus the doctor can immediately see that the patient needs care earlier than the planned usual check. However, in the Czech Republic, the Reimbursement decree still does not address the labor cost needed for patients monitoring and data evaluation. Remote monitoring is also suitable for patients with other diagnoses such as diabetes (diabetes mellitus), hypertension, pulmonary arterial hypertension, anticoagulation therapy with warfarin, risk pregnancy, transplantation and more. Most of the above mentioned experts of the National telemedicine center have carried out clinical telemedicine applications (together with remote monitoring of heart rhythm disturbances) since 2005. Currently there are 18 doctors and technical staff monitors 700

patients in five clinical areas. The national telemedicine center is involved in many international cooperation programs aimed at the development and validation of new scientific telemedicine practices and their introduction into clinical practice.

ICT in Emergency Medical Care: The Prague Emergency Medical Service (EMS) implementation of the GEmMA (General Emergency Medical Analysis) emergency management system enabled EMS to manage its operations through the creation of Electronic Mission Records (EMiR) [10]. The GemMA system, developed by the KTTP Ltd. Company, is intended for the management and storage of information obtained during individual ambulance trips performed by individual rescue groups of the EMS. KTTP analyzed processes and data obtained during ambulance trips carried out by the Emergency Medical Service in the course of the second half of 2003. By the end of 2003, KTTP was commissioned to develop an information system for the Emergency Medical Service on the basis of the above-mentioned analysis. The system has been designed directly according to the requirements of the EMS, and it currently consists of the following modules:

- **Ambulance Module** - it is designated for ambulance groups. Collection of information about the course of an ambulance trip in chronological order, collection of information about the course of medical care provided, including acquisition of data about the vital functions of the patient, pharmacotherapy, and where the patient is eventually taken to. The data are used as input for billing insurance companies, and they are also a source of medical information for prospective and retrospective surveys.
- **Mobile Ambulance Module** - it is designated for mobile support of ambulance groups, print out of emergency patient care reports in the field, online synchronization of the field data with Dispatch center and other functionalities regarding EMS mobile support.
- **Insurance Module** - it is designated for the billing of activities carried out within the framework of individual ambulance trips to individual billing subjects (insurance companies, ministries, etc.). Interconnection with systems of various insurance companies via the internet.
- **Data-mining Module** is designated for analysis of collected data, information search according to various criteria, possibilities of reporting etc.
- **Medical transportation Module** is designed for managing of medical transportations.

KTTP extended the systems intended for Emergency services and currently it provides complex information system to such organizations. The complex solution consists of following parts:

- **Dispatch centre** - GPS localization of vehicles, localization of incoming voice call, allocation of nearest vehicles, GIS & maps, duplex data communication with vehicles, CCTV integration, duplex communication with 112 emergency center (112 is an emergency phone number across Europe).
- **GEMMA system** including solution for "mobile point of care" and online communication with main GEMMA system.
- **ERP (Enterprise Resource Planning) system for organization management** customization of Microsoft Dynamics NAV intended for healthcare environment

The project target was to replace workflow of handwritten medical documentation with primarily electronically created reports. A second target was to utilize the mobile technology in the field and provide additional information from interoperable eHealth & Insurance registers for decision support at the emergency scene.

Physicians at the emergency scene access the Emergency Service Centre application server via secured 3G HSDPA (High-Speed Downlink Packet Access) mobile connection. This connectivity provides exchange of information between central Prague EMS backend system and mobile crews.

eHealth on regional level: Good practice example – Vysočina region: The regional Department of Health in collaboration with the Department of Informatics and several health care organizations established by the Vysočina region has been implementing a number of activities that use modern information technology in health care for several years. The website [11], which is updated following the new health care legislation, is one of the specific examples of the effective use of IT in health care. The Vysočina region is a good practice example of support of bottom-up solutions. The representatives did not wait for a central solution but started their own eHealth project respecting legal requirements and technological standards. At the same time they collaborated with health care professionals in the region who knew the situation, services and procedures to be performed.

For more than six years the Vysočina region has been developing its own project of exchange of medical records between regional hospitals and medical rescue services of the Vysočina region – eMeDocS (Fig. 27). As the president of the region stated, the most important outcome of the project was the quick access to sophisticated electronic patient information and especially the historical medical data, important at rescue intervention, both when going to patient’s home and in the field. The system is currently used by all hospitals established by the Vysočina region and regional medical

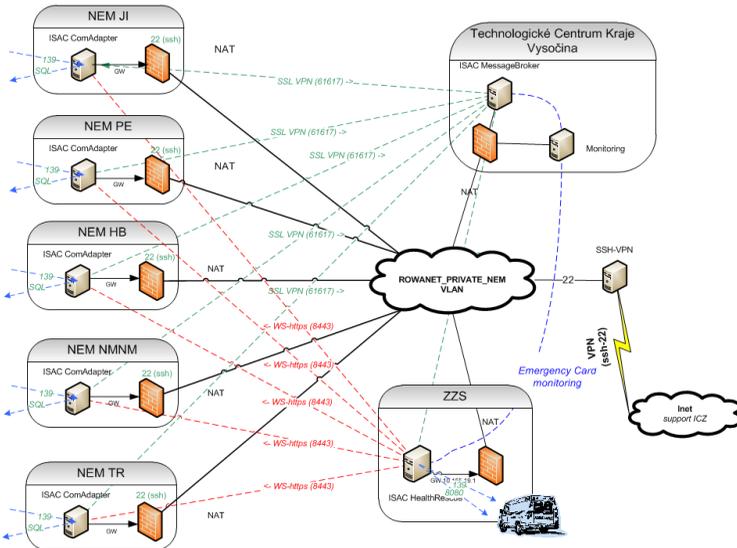


Fig. 27. Network topology of the eMeDocS project

(NEM xx = hospital in city xx, Technologické centrum Kraje Vysočina = Technology Centre of Vysočina region, ZZS = emergency medical service)

rescue services, and a further 13 health care facilities and emergency services in other regions. The Council of the Region Association decided to accept the standards defined by the Vysočina region as recommendation for setting the functionalities of the health information exchange on the national level.

With the support of the Ministry of Health the Vysočina region submitted a project to a work program of the European Commission CEF TELECOM, which has a chance of getting European funds to build the National Contact Point for eHealth in the Czech Republic. If approved, the project will

implement a system upgrade to eMeDocS and extend its functionalities by cross-border exchange of medical records for patient summary service.

The core of the eMeDocS project is development of a technological communication platform based on standards for the exchange of structured medical documentation between medical service providers. The essential issue is an easy but secure access to patient information by hospitals and emergency services. The communication network will integrate general practitioners in the near future. The Vysočina region plans to implement the communication interface for GPs this year. In this way, the triangle of information sources will be closed and in case the patient is unable to communicate, the system will provide relevant information about his/her history, evaluate critical risk factors, which often have major influence on the choice of pre-hospital emergency care. The development team plans extending the project with new features as new requirements are brought in by the users.

The electronic exchange of patient information presents the history reports on trips to the patient, on his/her life functions, patient history, medication dosage, information about treatment in hospitals of the Vysočina region (or others already involved in the network). Data are available by logging doctors or paramedics e.g. on tablets, which are part of the equipment of all emergency ambulance cars of the regional emergency service.

Recently the system with standards set by the Vysočina region has been adopted and is used by the University Hospitals in Brno, Hradec Králové and Pilsen and the Masaryk Hospital in Usti nad Labem. The President of the Vysočina region informed about preparation of a new project that would allow each patient to access his/her health records through electronic identity according to the eIDAS rules (EU REGULATION No 910/2014 on electronic identification and trust services for electronic transactions in the European internal market), a chance to view their electronic medical records via the electronic ID card.

The system does not support only health care professionals, but also patients. The e-Ambulance portal allows residents of the Vysočina region to order visits to physicians via the Internet. It is already used by more than 43,000 people. In the past they had to register in person at any of the five regional hospitals, nowadays they can log into the system via mojeID (myID) - electronic identity operated by CZ.NIC.

The mojeID service brings the users enhanced convenience when ordering to the doctor. It is a contribution to the development of e-government services operated by the Vysočina region. In the future the region plans to

integrate mojeID into other services, so that logging on all regional portals is for citizens as comfortable as possible.

CZ.NIC Association opened a special validation center in Jihlava hospital in November 2015. Here the Vysočina region residents can obtain the highest possible level of identity verification within mojeID. This level corresponds to the European legislation eIDAS and in the European project STORK 2.0 it provides the registered identity the same level of confidence as Swiss electronic identity card has.

From 2012 eAmbulance permits online ordering to a doctor in five regional hospitals in Jihlava, Havlíčkův Brod, Nové Město na Moravě, Pelhřimov and Třebíč. Almost 100,000 doctor visits were conducted via online bookings till early 2016. More than 16,000 residents of Vysočina region registered in the mojeID service since the beginning of its operations.

Applications Provided as Commercial (above standard) Services

ITAREPS (Information Technology Aided Relapse Prevention in Schizophrenia) program [12] was developed for rapid and targeted recognition of early warning signs of psychotic disorder relapse. It employs modern communication and information technology for timely intervention during initial phase of relapse.

The program allows reducing the number of illness exacerbations and subsequent psychiatric hospitalizations. ITAREPS can significantly improve and speed up communication between the patient and his/her outpatient psychiatrist. It helps patients to stay in touch with their doctors regardless of their actual availability. As a result, the program can improve functional outcome, quality of life of patients with schizophrenia [13].

The participants in the project are a patient, a selected family member, and an outpatient psychiatrist. ITAREPS enables long-term follow-up of mental health of individuals with severe psychiatric disorder, using 21st Century technologies. The program was developed by experts from Prague Psychiatric Center, with support of Academia Medica Pragensis Ltd. for Eli Lilly and Comp., an exclusive partner of the project.

AS mentioned above, the project is aimed at the monitoring of early warning signs in schizophrenia patients. Antipsychotic drugs in combination with non-pharmacological tools of relapse prevention represent a program for this decade. At the threshold of the 21st Century, one chapter of schizophrenia treatment, focusing on modulation of monoaminergic neurotransmission in CNS (Central Neural System), has been round-off. Now there is a wide choice of second-generation antipsychotics, effective and well-tolerated drugs. However, at the same time drugs affecting other levels of the illness are not available yet. Therefore, at this transitional

period, it is very important to introduce supplementary non-pharmacological interventions, which could significantly improve lives of the patients. The motivation for development of the ITAREPS application came from psychiatric practice and previously published studies. It has been shown that decreased number of relapses may likely prevent certain pathophysiological processes in the CNS responsible for deterioration of the overall clinical condition. These changes contribute to the social decline and can interfere with a treatment response. Moreover, available data indicate that increased relapse/hospitalization rate is associated with structural abnormalities of the CNS. It has been proven that programs designed to monitor early warning signs in schizophrenia can substantially reduce number of relapses. It appears that patients with schizophrenia and their relatives are generally able to register early warning signs. The objection that schizophrenia patients lose their insight early and therefore are not able to register worsening of their condition is not acceptable. Approximately 60% of patients keep their insight till the very last day prior to the full relapse exacerbation. Schizophrenia patients are able to identify early warning signs with a similar sensitivity and specificity as mental health professionals. Despite the evidence from these encouraging data, somewhat surprisingly there are very few comprehensive programs of monitoring and early intervention in the world. The ITAREPS application brings the advanced form of relapse prevention in schizophrenia. It ensures simply what often poses a big problem in clinical practice. It enables the patient and the family member to be in a regular contact with a psychiatrist and report to him/her continuously on his/her condition. ITAREPS is a program suitable for psychotic disorders in general, particularly for schizophrenia. The principle is simple: the patient and the family member participating in the project completes every Thursday a 10-item Early Warning Signs Questionnaire (EWSQ, Patient Version and Family Member Version). Reminder for a completion of the EWSQ is sent automatically by the ITAREPS to their mobile phones as the Short Message Service (SMS). The result, 10 numbers, is sent back by both of them through SMS. Questionnaire completion requires approximately 2–5 minutes. Ten items of the Early Warning Signs Questionnaire cover full spectrum of symptoms that are most frequently regarded as early warning signs of psychosis relapse. Patient Version and Family Member Version were developed based on the data from research in the field of psychosis relapse prevention conducted over the past two decades. The questionnaire basically inquires just about one issue: whether there has been, both subjectively and objectively, a new onset or a worsening of symptoms since the last week evaluation. Individual items are scored on a five-point scale. 0: No change or improvement 1: Mild

worsening 2: Moderate worsening 3: Severe worsening 4: Extreme worsening. In this way an eventual change in condition over the past 7 days can be detected and measured.

The project started in 2003 and in 2005 it was introduced to clinical practice. However, the service was not paid by the Czech health insurance companies. The authors developed and maintained the application within the frame of various projects and with the support from foundations. Till 2015, more than 900 patients entered the program. In the meantime, ITAREPS won several awards - Creative Mobile Award, National Psychiatry Award - and in 2014 it was finalist of European Health Award. Currently the service is recognized and paid by the Sectoral Health Insurance Company and by the Health Insurance Company of the Ministry of Interior. Few years ago it was successfully tested in Japan in frame of a randomized controlled trial. The results were published in [14]. The study proved that ITAREPS decreased the risk of repeated hospitalization to one fifth. Number of hospitalization days was reduced by 90%.

eVito [15, Fig. 28] is a commercial system developed and provided by eVito medical a.s. company. It is an example of a system that started as support for wellbeing and fitness. Continuously it has developed into a larger modular system incorporating additional functionalities and services for teleconsultations with medical experts and telemonitoring of vital parameters. eVito system has been developed in collaboration with leading experts - not only medical doctors but also nutrition experts and sports coaches. Currently the main focus from a medical point of view is on users having problems with hypertension, diabetes, obesity, atherosclerosis or cardiovascular system.

eVito helps a person to gain a comprehensive view of his/her own health and understand what influence he/she has on it. Modern certified devices are available for measuring, storing and transmitting the data to the user account. The user can see and evaluate his/her data, consult the trends with medical doctors (MDs), ask nutrition experts, etc.

The system has the following basic characteristics:

- Mobile application - eVito mobile application with the help of GPS (Global Positioning System) phone monitors the speed, duration, route and elevation of outdoor sports activities. The activities are automatically sent to the user account while the mobile phone application allows to monitor the user's most recent values from measuring devices.
- Consultations with experts - The user can choose a part of his /her data, share it with a doctor, coach or nutritionist, and thus work

effectively on the improvement, comfortably, using the computer at a time of the user's choice. Those taking care of sick people can also receive system alerts using eVito (children, grandchildren, home care professionals...).

- Help Desk - eVito professional team is ready to help with possible difficulties.
- Certified devices - eVito certified devices allow to continuously monitor important information about the health and lifestyle: steps made, weight, blood pressure, blood sugar or heartbeat, based on consultations with medical experts and with arrival of new portable medical devices, new functionalities are added.
- Online portal - The user can log in to his/her eVito user account through an online portal using any kind of web browser. The portal is the heart of eVito System of Active Health where the first thing the user sees are his/her latest data and their evaluation, recommendations, etc.
- Wireless data transfer - Simple and convenient data transfer -



Fig. 28 eVito system – basic modules

measurement data are automatically transferred wirelessly (using one of the three available ways) to the user account.

- Maximum data safety – Health data belong to the most sensitive ones. The eVito system is registered at The Office for Personal Data Protection of the Czech Republic. The data at eVito servers are under maximum protection, such as in internet banking systems.

InspectLife [16, Fig. 29] is another example of an assistance service. It is more focused on seniors, however it supports patients with certain diagnoses as well. In particular the InspectLife Diabetes service is intended for patients with diabetes. It passed the certification and is classified as medical device of class I.

The family of InspectLife services has been developed and is provided by the MediInspect Company, which provides information systems and complex solutions especially in the form of software-as-a-service to the clients. The company utilizes advanced information technologies and methods for its solutions. MediInspect integrates high-tech devices (communication devices and sensors for measuring physiological signals and parameters) of closely cooperating suppliers.

Surveillance assistance service InspectLife was designed to help seniors keep their independence and to promote safety. It is dedicated mainly to active seniors and their relatives. It helps to notify trained employees of assistance service, who are able to provide help in case of emergency or health state deterioration. The senior simply pushes emergency button or automatic emergency notification is launched. Family members have the opportunity to get actual information and provide help. Both assistance service and device can be customized individually.

Service can help in following situations:

- Senior's health deteriorated or senior feels unsafe. Senior notifies about the situation by pushing emergency button.
- Senior fell down and is not able to recover. Device can detect potential fall.

Note. In both situations senior can talk to operator of the surveillance service.

- Relative person is worried about the condition of senior. In certain situations relative person is permitted to get information about location and actual state of senior.
- Service is helping also in the following situations:
 - Senior forgot to charge the device.
 - Senior left the device somewhere and is not wearing it.
 - Senior is not using the device.

- Senior is in environment with insufficient coverage of mobile network.

InspectLife Diabetes services is intended for patients with diabetes, in particular diabetes mellitus type I, who need or want better compensate their illness and communicate with their medical doctors, more frequently remotely. The service offers more intensive patient monitoring. The core is acquisition of complete and precise values of blood glucose level. Measured data are automatically sent to a web-based application where they are immediately accessible for authorized persons. The patient and the doctor can use teleconsultations for discussion on treatment course, while they both have current and historical values available.

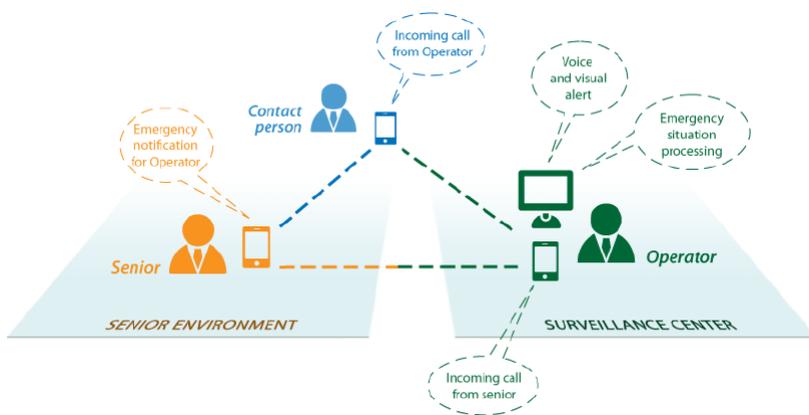


Fig. 29 InspectLife Surveillance – scheme of operation

Medical Data Transfer (MDT) Company [17] has been successful on the Czech and Slovak markets of unique services in the field of patient telemonitoring since 2008. All Czech and Slovak cardiac centres cooperate with MDT. It has treated more than 20 000 patients and evaluated more than 3.5 million ECG records (electrocardiograph). Renowned Czech and Slovak cardiologists specialized in arrhythmology cooperate with MDT.

The company offers a wide portfolio of diagnostic methods to health care institutions and their patients. It provides trans-telephonic monitoring of patients by means of event recorders to detect symptomatic and asymptomatic arrhythmia episodes, as well as Holter ECG monitoring with on-line data transfer and complete data evaluation. Long-term BP (blood pressure) monitoring, Holter BP monitoring, INR (International Normalized Ratio) monitoring, blood glucose monitoring, as well as diagnosis of heart failure are among other provided services.

The services use several operational models:

- Purchase of the devices;
- Rental of devices for out-patient departments;
- Monitoring of paying patients.

If a medical doctor does not choose to purchase or rent the device but he/she has patients who may profit from a long-term ECG monitoring, the patient may have to pay for monitoring him/herself if payment is not covered by the patient's health insurance.

The monitors are accessible for all patients. They do not need to come into the doctor's office to get a monitor; it is enough to make a call to MDT or complete an on-line form. After that, the monitor is sent to the patient via registered mail. The patient will receive the device accompanied by detailed instructions and telephone numbers of MDT technical support (which is available for the entire monitoring period), a cell phone for automatic ECG record sending, a return envelope to be used to return the device, and other equipment or accessories necessary for monitoring.

All recordings are regularly evaluated by MDT clinical technicians. In the case of any technical issues, the patient will be called in order to solve the problem. All ECG records are evaluated by a cardiologist. The results are sent to the patient by mail or can be accessed through an MDT web interface.

Basic motivation for the launch of the MDT project is to obtain a source of high-quality data for clinical research. MDT provides its partners with complete technical and administrative support for clinical trials focused on the collection and processing of patient's vital data during both long-term and short-term monitoring. MDT respects and follows GCP (Good Clinical Practice) principles as one of quality indicators.

The current used technology enables monitoring the following vital parameters:

- ECG (several options for different indications);
- Blood pressure (both long-term and short-term monitoring);
- Blood glucose levels;
- Prothrombin time;
- Weight;
- Activity;
- O₂ saturation;
- Functional lung assessment.

MDT is able to offer a solution for a wide range of indications by combining these diagnostic methods. All used methods are based on the immediate transfer of data obtained from the patient. Technical support is provided for 24 hours a day, 7 days a week.

MDT provides administrative service for clinical studies performed by the partners:

- Drafting of project documents;
- Change request form;
- Regulatory support;
- Monitoring of source documents;
- Logistics support;
- Data collection on site;
- ECG Core Lab - independent ECG data evaluation and processing performed by specialists;
- etc.

During the practical design and development of several above mentioned applications and deeper analysis of the others, the developers have learned many important lessons that are worth to mention, i.e.:

eHealth applications, that healthcare needs, must be based on the latest technological platforms allowing future flexible development.

During their design and implementation it is essential that primary data and other information are stored mainly in a structured form and not in a of free text form.

Transferring information between health care providers must always be based on a responsible approach of both parties in the relevant legal and human relation to the data subject, i.e. a patient.

Application of international classifications and standards, use of ontologies and systems designed to allow integration with clinical practice guidelines, or other systems supporting medical decision-making must be of good quality and economic efficiency.

Data storage and data transfer must be properly secured and at the same time they should allow the highest possible degree of interoperability.

Legislation must clearly and unambiguously define relationship to the issued data from the perspective of individual stakeholders, i.e. health care providers, patients, health insurers and providers of information and communication technologies.

Another very important issue that must be considered is the attitude and motivation of potential users, both care givers (health and social care professionals) and patients (and even informal care givers – families, communities). If a system is introduced as mandatory, there are usually certain negative bias towards it and it is more difficult to persuade users to participate actively. The health insurance companies have to find ways how to motivate all users (health care providers, patients). Good examples are to introduce bonus programs, prevention programs for patients and also some extra services for medical doctors.

ePrescription

The Chamber of Deputies of the Czech Parliament approved in 2013 an amendment to the Drug Act, which introduced mandatory use of electronic prescriptions from 2015 onward. However, problems with implementation of the software system and also the legal regulation appeared and defined procedures were not positively accepted by medical doctors and pharmacists. All these issues finally caused delay in introduction of mandatory use of electronic prescriptions. It is rather a paradoxical situation since the first electronic prescription was already issued in January 2008. But since that time it was used on voluntary base. The patient comes to see his/her doctor, who examines the patient and prescribes medication - but not on paper. The doctor enters a prescription in a central database. If desired, a certificate on the e-prescription can be issued. The patient needs to get only the generated code. With that, the patient goes to the pharmacy to pick up the drug.

The form of e-prescriptions should give to patients the advantage of obtaining the prescription in several ways - in print, in the form of e-mail or SMS compared to traditional paper prescriptions. The protection of personal data is realized in a simple way: the prescription contains only the patient's name, the rest of the data is encoded in the barcode identifier. The pharmacy is equipped with the barcode reader, so the pharmacist can see the information about prescribed medication on the screen.

One of the expected biggest advantages of the proclaimed e-Prescription is the identification of potential undesirable interactions of medications taken at the same time. However, the problem with voluntary mode was that not all doctors entered data about patients and the prescribed medications. Therefore the data in the central database were not complete. It was expected that the mandatory use would help to get more complete information about medication combinations of each patient. The pharmacists should be able to prevent bad dosing, inappropriate combinations of drugs or giving the patient more products with the same active ingredient. This will protect the patient.

Currently (2017) the e-Prescription is not yet fully in operation. Detailed analysis showed both problems of the implementation and bad communication with health care professionals. Based on the negative experience with introduction of previous electronic applications they refused to use e-Prescription in the current form. On the other hand those medical doctors who tried and use e-Prescription usually continue with it. The current plan of the Ministry of Health is to introduce the e-Prescription as mandatory from 2018.

Pilot Projects in eHealth and Telemedicine

This section focuses on selected pilot projects that represent a final state of international or national research projects. They all proved the viability of the proposed concepts. Several projects focused on different aspects of home care, independent living of elderly and support of handicapped people. They all use telemedicine and m-Health functionalities to a certain extent. Some of them were finally introduced in routine practice. That usually happened in cases when it was possible to integrate them in already existing applications at (almost) no additional costs. Some applications are offered as paid services, or they are at least partially reimbursed by the health insurance companies. Unfortunately results of some projects have to wait for either new grants for covering implementation and maintenance costs, or decision about financial model of the service. Information about current state at each presented project is indicated in the text.

EuroMISE Center was a partner in the European project **I4C-TripleC**, where results of the European project I4C (Integration and communication for the continuity of cardiac care) [18] were implemented and validated in the project TripleC in two Czech hospitals. The knowledge received from the project TripleC was further enhanced. The priority was to propose and develop appropriate techniques of structured data entry, representation and processing aimed at minimizing the effort of users (physicians, nurses) of the system and maximizing the clinical outcome of the collected data. The proposed solution was implemented in a pilot application 'Multimedia distributed electronic health record' (MUDR) [19], [20]. The results are available for implementation in hospital information systems.

A voice-controlled **DentCross** component for EHR in dental medicine was developed and semantic interoperability in the domain was studied. The synergy of the voice-control and the graphical representation of data made hand-busy activities in the dental practice easier, quicker and more comfortable. Dental EHR with the interactive voice-controlled DentCross component is running in routine practice at the Department of Stomatology of the University Hospital in Prague-Motol [21]. However, it is running as a separate application that is not connected with the hospital information system.

MeDiMed [22] is a system for transferring video-documentation of patients between health facilities. The project is coordinated by the Masaryk University in Brno; it has been running since 1999. MeDiMed allows sending images and descriptions of examinations in DICOM format. The images can also attach any other files (e.g. documents, presentations). The transmission is protected by asymmetric encryption. MeDiMed is connected to about 100 medical organizations in the Czech and Slovak Republics. The

database content can be directly utilized for e-learning support of both under- and postgraduate students of medicine, it can also support starting radiologists in medical clinics. It is used for research purposes in radiology.

A more recent **ePACS project** [23] has been operated by the General University Hospital in Prague till 2016 and its development was financially supported by the Ministry of Health of the Czech Republic. Currently the ePACS is operated by the Coordination Center for Health Care Information Systems of the Ministry of Health. Unlike project MeDiMed this project uses to protect the transmission by a special hardware device. Currently ePACS is connected to more than 300 health care organizations not only from the Czech Republic. It allows remote consultations between experts; exchange of image documents when transferring a patient between hospitals; easier access to patient images acquired in other hospitals; closer and more efficient collaboration of radiologists and clinicians.

K4Care - Knowledge-Based Home-Care eServices for an Ageing Europe. An integrated knowledge-based intelligent technology was developed to help in the management and provision of health care services to chronically ill patients anytime and anywhere through the Web. Efficient and quality health care management is achieved with a model that not only organises health care according to national and international standards, but also allows the adaptation of the model to specific health care systems, the extension of the model with new services, and the update and upgrade of services already provided. According to the users' demands the whole range of mobile devices can be used: laptops, tablet PCs, or personal digital assistants (PDAs) (Fig. 30). The system was developed in an EU consortium [24]. The care of chronically ill patients involves life-long treatment under continuous expert supervision. Admission to hospital and residential facilities can be unnecessary and even counterproductive, and could saturate national health services and increase health care costs.

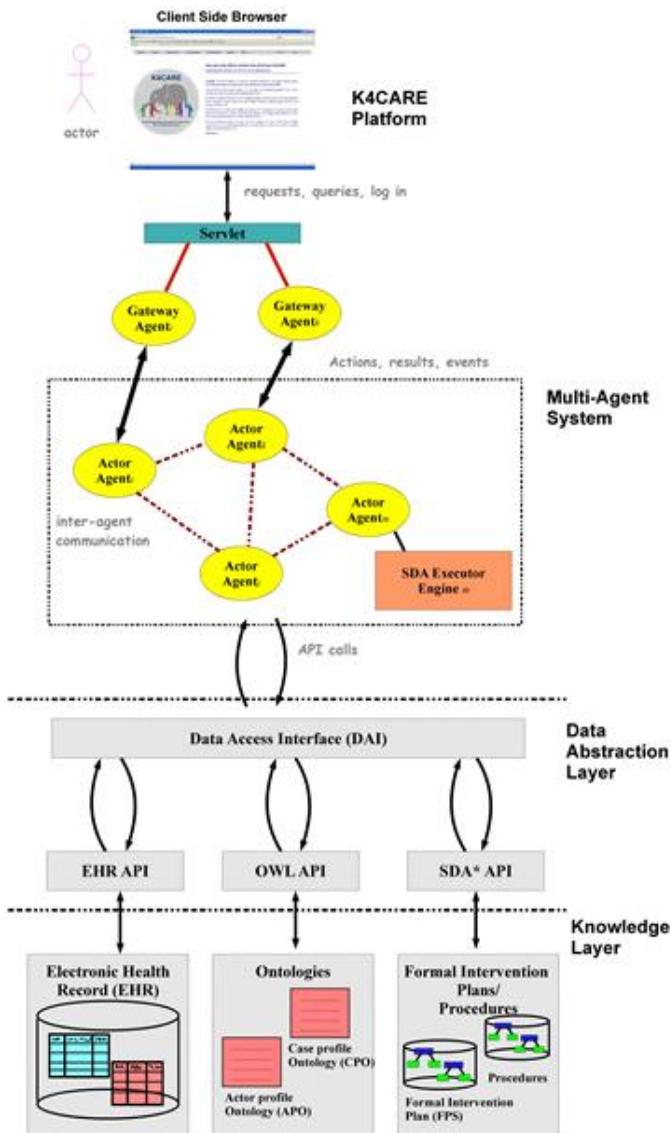


Fig. 30 K4Care system architecture

The health care model is organised at the level of actors, by defining the actions allowed to each actor, and at the level of services, by defining the procedures that implement each service as a combination of actions and document accesses. The result is a formal model evaluated in eight EU (European Union) countries (i.e., Czech Republic, Finland, France, Hungary, Italy, Romania, Spain, and UK); which is modular, incremental, scalable, adaptable, updateable, standard-driven, knowledge-based, and computable with ICT.

All the documents (e.g., requests, authorisations, prescriptions, scales, laboratory results, etc.) in the health care model are XML files, which are managed by a sophisticated relational database that also stores information about the actors (i.e., health care professionals, patients, relatives, etc.), roles, groups (e.g., evaluation units) and relations between actors (e.g., who the family doctor for a particular patient is). Each sort of document in the Health Record is formalised by a XML Schema that prevents the system from incorporating wrong documents, and a couple of XSL files allowing the documents to be shown or filled through the Web [25].

The users of the system are: health care professionals, patients, and citizens in general. Professionals can be of several sorts (defined as a hierarchy in the Actor Profile Ontology - APO): physician in charge, family doctor, head nurse, nurse, social worker, etc. Each user in the system has a modifiable default profile obtained by automatic personalization of the APO that avoids a nurse for example starting a service or accessing a document not allowed to nurses.

The services provided, are accessible by web browsers and wireless devices, such as mobile telephones or personal digital assistants (PDAs) – predecessors of smart phones. Most of the services in home care are performed either by nurses or social workers. An application for PDAs [26] is developed that provides these care givers with all necessary data and information they need at the patient's home and allows them to enter new data about the patient's health state. The family doctor can check the patient's health state remotely. In the designed system; the patient history is stored, which allows checking trends in monitored values, visual checking of development of injuries or varicose ulcers, for example. The application also marks, which data was not filled so far, so the nurse cannot forget to fill the required data. It is considered important to have a proof-of-concept of the approach so tests in real environment and nurses as users were performed. The device is equipped as a regular PC and not far from it with its computing power, yet still a lot more portable than a notebook. The key advantages are various connectivity possibilities: cable, Wi-Fi, Bluetooth,

and GSM. Another advantage is the weight (and size), which is around or slightly above regular GSM phone. The possibility to acquire photo-documentation is found especially helpful. It is necessary to note that the pilot implementation was performed before the era of smart phones.

The project outcome is a systematic analysis of the home care area, followed by design of data model, functional analysis, formalization of background knowledge, overall architecture and finally implementation. In the end the developed, potential end users tested the software platform. The results of the K4CARE project were presented to representatives of ministries and regional governments. However, at that time, the concept of home care and its ICT support was not ready. Therefore the system was not implemented in the Czech environment. Currently (2017), the ICT support of caregivers in home care is under discussion again. With current technologies, the implementation could be much more efficient and could integrate more services than originally planned and implemented in the prototype.

OLDES – Older People’s e-Services at Home [27, Fig. 31], an EU Project, started in 2007. It planned to offer and test new technological solutions for improving quality of life of seniors and challenged persons, through the development of a very low cost and easy to use entertainment and health care platform, designed to support their independence when living on their own at their homes with tele-assistance e.g. of local public services. To achieve this goal, OLDES decided to combine tele-medicine, tele-assistance, tele-entertainment and tele-company into a federated internet based system intended for 3 very different and complementary groups of users: the customers (elderly persons who need some sort of support), their care givers (e.g. organized in public or non-for-profit services) and health professionals (medical doctors and nurses). Each of these groups requires/ensures specific type of services and consequently the OLDES platform provides them by group specific access rights.

OLDES was designed as an easy-to-use, plug-and-play system which can be easily customized towards the needs of the individual user by modifying the set of ensured services for three types of application scenarios. The simplest base level scenario is intended for a vivacious elderly who requires no extra services but who can benefit from more social contacts – this level includes communication and tele-company through a low-cost PC and open-source internet based software. The intermediate level is complemented by simple sensors (e.g. to measure the ambient temperature) for the management of generic monitoring situations (e.g. very hot periods in the summer). Finally, an upper and tailored level scenario expects that there

will be engaged health-monitoring sensors depending on the health profile of the user. Moreover, this most complex level has to be ready to create, send and handle an alarm signal generated automatically in the case the monitored signals of the considered patient meet certain predefined condition.

When designing the OLDES platform, special attention was given to the design of communication interface for the customers who are not expected to be accustomed to using computer and internet. That is why it was decided to hide the technology from its elderly users and ensure all communication through a television screen controlled by a remote controller customized for that purpose. This solution called for innovative approach and special attention had to be devoted to a user-centered design of an easy to use graphical user interface (GUI).

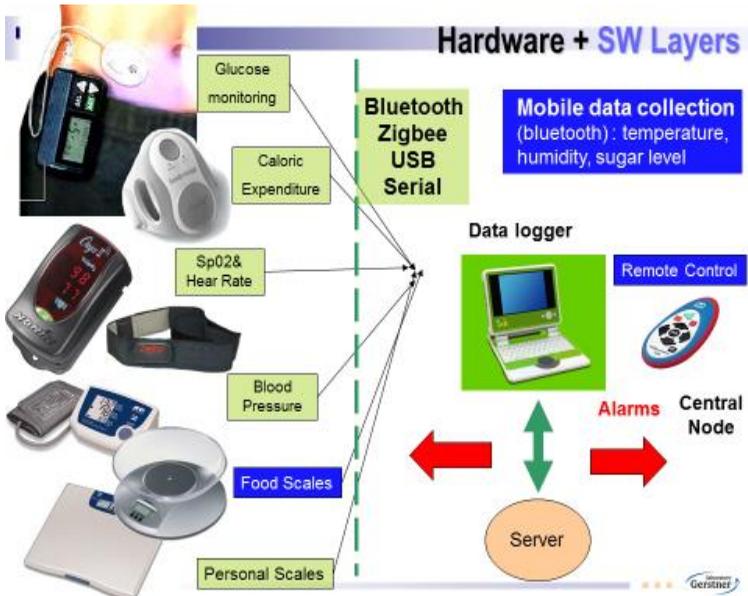


Fig. 31 OLDES system solution for the pilot testing

In 2010, the final year of the project, the OLDES solution was successfully tested at two different locations: in Italy (Bologna) with the involvement of a group of 100 elderly people (including 10 senior citizens

suffering from heart disease) and in the Czech Republic (in Prague) with the involvement of a group of 10 diabetic patients. In this way it was possible to confirm that the OLDES platform ensures the intended flexibility and configurability as it works well for all the three types of user scenarios customized to the needs of the target application by different types of sensors (heart versus diabetes monitoring). The acceptance study conducted among all the users confirmed that the patients involved in the project very well accepted the easy to use “plug and play” system. After peer review evaluation, the OLDES project has been selected as one of the 25 nominees for the IT @ 2011.

The suggested OLDES approach proved to be an effective solution for municipalities, hospitals and their contact centres for the provision of health and social services. That is why the project partners decided to proceed in further development of the second generation of the system called SPES. The new project **SPES (Support to Patients through E-service Solutions)** [28] starting in April 2011 aims at transferring the original approach and results achieved in the implementation of the OLDES platform into 4 new geographical contexts (Ferrara, Vienna, Brno and Kosice), focusing on new target diseases: *dementia, mobility challenged persons, respiratory problems and social exclusion*.

Results of both mentioned projects OLDES and SPES are available for implementation. The user partner of the SPES project – a civic association ProDeep is utilizing the project results for supporting handicapped and elderly persons. Some of the services are paid, some are reimbursed from health or social insurance.

ENABLE - A wearable system supporting services to "enable" elderly people to live well, independently and at ease project (an EU Framework Program 6 project) developed a personal, user centered *enabling system*, with services, for use by an elderly person in or out of the home, to mitigate the effects of any disability and to increase quality of life: independence, autonomy, mobility, communications, care and safety. The system is based on a distributed open platform, enabling other services to be added by third parties, by "plugging" into defined interfaces. The platform includes a mobile phone, enabling the user to get out and about, for visiting, shopping, recreation, etc., whilst maintaining contact for help and services. The prototype developed in the frame of the project has the following functions: communication and alarm service from anywhere; falls prevention and monitoring; location service; environmental control; diary service; vital signs, lifestyle and symptom monitoring services. The Czech partner of the project – civic association Zivot90 (Life90) [29] – utilizes the

results in its work which is focused on various types of monitoring and care for elderly and handicapped, e.g. rehabilitation, physiotherapy, activation training. Most of the services are paid since they are not reimbursed by insurance companies.

Localization and Navigation of Visually Impaired People: GPS/GSM navigation system for visually impaired people allows immediate localization and navigation of the person in case of orientation loss. It uses combination of GPS navigation technology and possibilities of GSM/GPRS mobile networks. A visually impaired person can be easily navigated based on his/her detected position. In case of need, he/she can call the specially created phone line that acquires the information about the position from the GPS device. Mobile transmission of voice and data using GPS and GPRS technologies is utilized for communication of the visually impaired person with the navigation call centre. Researchers and students from the Czech Technical University in Prague [30] developed the system. It is necessary to note that the system is determined for open space where the GPS signal is sufficient. Moreover, it does not provide information about obstacles on the path. The navigational unit can be loaned to every blind and partially sighted person in the Czech Republic. The unit is first loaned for three months, which gives the users enough time to try out the device and the services. It is possible to purchase the navigational unit for permanent use. This device is regarded a compensatory aid and a benefit for it can be claimed. The system is in routine use and it is continuously extended and enhanced by new functionalities and technologies. However, it is necessary to note that it would not be possible without support of various foundations.

Diabetes. Diabetes is characterized by elevated blood glucose level. It has a wide variety of clinical consequences. The origin of this hyperglycaemia differs according to the type of diabetes. Most common types of diabetes are type 1 and 2 (DM1 and DM2) respectively. In DM2 the leading cause of hyperglycaemia is an insulin resistance, decrease of insulin production follows later. In DM1 it is primarily insulinopenia that is the result of an autoimmune destruction of insulin producing pancreatic beta cells. DM1 has to be treated from the beginning by parenteral application of insulin. According to the International Diabetes Federation 415 million people have diabetes in the world and more than 59.8 million people in the EUR Region. By 2040 the number will rise up to 71.19 million. There were 799,300 cases of diabetes in Czech Republic in 2015. Therefore, both the medical experts and engineers try to find efficient means for better monitoring of diabetic patients.

Recently we have performed a thorough Internet and electronic libraries search focused on mobile applications linked with nutrition, diabetes and similar topics. Currently there are more than 1100 iOS and Android apps listed on the Apple App Store and Google Play specifically designed for diabetic patients and healthcare professionals to treat diabetes. Usually they have only few functions. The most frequent ones are information provided to the user, documentation, data communication to the doctor. Data input concerning food intake depends mostly on manual insertion by the user that is a very annoying property. The consequence is that the users do not insert information regularly or forget to insert some values. However, correct information about meal composition is important for the whole process of glycaemia control. The same holds for monitoring the physical activity of the patient.

One of the projects focused on monitoring of burned calories at patients with the diabetes mellitus diagnosis [31]. The application was designed for mobile phones with Android operating system. It has the following main functions, namely diary (showing list of past activities together with burned calories), recording of the physical activity (type and length), and graphs (showing burned calories in defined time interval). Currently, the project is extended with an application for patients with insulin pump and wireless subcutaneous glucose sensor. The application will allow more complex data analysis that will serve for recommendation of next meals and activities.

Selected Research Projects

In telemedicine, one of the most important issues is to prepare for the smart solutions, embedded devices and tele-monitoring applications, as user friendly as possible. This section presents several projects that were developed at universities, mostly as student research projects. All of them were discussed with medical experts and tested in real-life environment. They are based on clever ideas and mostly represent relatively simple implementations. Of course, to bring them to routine practice is not so easy.

Design and development of a **kit for experimental measurement of physiological parameters** [32] was motivated by the fact that the commercial products do not allow to acquire raw data from different steps of hardware processing. This kit allows to monitor all crucial signals and values in real time and records them to a PC for future processing. It is primarily designed for oscillometric measurement of blood pressure, but it can be a very useful tool for measurement using the auscultatoric method as well. The system is designed as modular, containing input modules for monitoring various vital signs as ECG, NIBP (non-invasive blood pressure) and oxygen saturation, control module and telecommunication modules for

streaming data using various wireless technologies like Bluetooth, GSM and Wi-Fi. The input and telecommunication modules are interchangeable. The system preprocesses acquired signals using filtration, parameterization etc. It allows to stream both raw data and aggregated data. The monitoring part is completed with the PC based part for storing data in database, prospective processing of data and sharing data with other systems. The system is modifiable for a wide range of uses. Most of the development has been done by two students during two years of their Master study within the frame of their research work and finally in their Master theses. Such kit for experimental measurement is useful for development of new applications. It is used in research environment.

Mobile CTG – Fetal Heart Rate Assessment Using Android Platform [33] has been motivated by requirements from the practice and possibilities offered by advanced technology. Cardiotocography (CTG) – measurement of fetal heart rate and uterine contractions is the prominent source of information about the fetal well-being in the late stages of pregnancy and during the delivery. With the stable increase of systematic costs of western medical systems and with the lack of trained personnel especially in the rural regions, telemedicine solutions are destined for large range of users. The project proposes a solution for mobile fetal heart rate monitoring and evaluation running on an Android platform. Additionally, the application on the mobile Android device contains viewer of the signal that enables setting of customary thresholds levels for the analysis rules and gives user full control over the settings of the recording device. The prototype was tested. However, the routine use is conditioned by existence of a mobile hardware solution for CTG measurement.

With decreasing price of mobile devices, the number of mobile applications has been growing. Especially in the field of personal health state monitoring the development of applications is very rapid. Actually, it is possible to measure many physiological parameters on a human body in a relatively easy way: electrocardiogram (ECG), heart rate (HR), breathing rate, body temperature, blood pressure, etc. Besides that, we can develop many applications that can help as guide to people with various disorders, as for example bipolar disorder or diabetes, or motivate people to activate cognitive functions. Next we show a set of student projects focused on these areas. The projects served as proof-of-concept. Their further development and implementation is planned.

The first project focuses on the issues of **bipolar disorder** (historically known as manic-depressive disorder) and examines the development of a mobile application and its integration with a web portal [34]. The mobile

application is divided into two parts. The first part consists of a ‘mood meter’. The second part is intended to serve as a support tool for monitoring the health state of bipolar patients. Current mobile devices have a built-in accelerometer, which could be used for long-term monitoring of a patient’s physical activity. This allows calculating and recording the circadian rhythmicity of patients over days, weeks or months. Almost every mobile device also has access to the Internet. This enables to upload data from the mood meter and accelerometer to the web portal, where further processing takes place. Both the patient and the doctor can view not only variables of circadian rhythmicity (IS, IV and RE) but also changes in the patient’s mood on the web portal. In this way, the doctor can check the patient’s condition without the necessity of frequent visits. This eliminates unnecessary delays between the patient’s visits to his/her doctor. In addition to actigram recordings, the patient subjectively evaluates his/her mood. The values are available both for the patient and for the doctor. With this knowledge, the doctor can propose further treatment procedures.

Two projects focus on the topics linked with problems of Alzheimer disease patients are also worth mentioning.

The topic of the first project is developing a mobile device application for Android operating system aimed to **reduce decline of cognitive functions**, especially for persons with mild cognitive dysfunction [35]. The application contains six **games**, namely N-back test; games with numbers and letters; game with sentences, which tests memorizing and understanding of sentences meaning; game with cubes that trains spatial memory, and a game with pictures aimed to find the correct picture among others. After the application was finished, tests were held. Results of testing confirmed that even a senior that has never encountered mobile phone with touch screen is able to control the application without any difficulty. The application is aimed not only at stimulation of the cognitive functions of patients with mild dementia but also for healthy persons, because the mental training can keep the persons more active in higher age. The advantage of the mobile application is that the person can use it anywhere and anytime. The mobile applications are accompanied with a web portal that serves for monitoring and evaluation of the results. The intended users are the doctors, caring for patients with Alzheimer disease. They can select a particular patient and see individual results and time series of the results.

Navi project is focused on development and implementation of an application for mobile phones with Android operating system for **navigation of persons with mild cognitive disorders** [36]. The mobile application is linked with a web interface. It can increase the safety of persons suffering from Alzheimer’s disease or another type of

neurodegenerative disease. Primarily it is a quick and timely localization of a lost patient, which can reduce both mental and physical consequences, including life threatening one. Results of testing applications and website show that the system is functional and ready for wider practical use. The application for patient localization and navigation is primarily determined for caretakers, family members and doctors, who represent an inseparable part of life of patients suffering from the Alzheimer disease. There are no increased demands on control on the side of the patient. The patient has the mobile phone with him/her and is localized using GPS. The implemented algorithm automatically connects to the internet, sends data about current position to the server and in case of alarms communications via SMS with responsible caretakers. If the caretaker has a suspicion of a lost patient, he/she can send a SMS that is evaluated by the patient phone itself. An automatically generated response is send indicating the current position of the patient.

eLearning

In the introduction, education was underlined as one of the areas where ICT and telemedicine infrastructures can be useful. During the last two decades many different applications, web pages, eLearning tools and educational content were created. It would be impossible to list all of them, yet few examples are provided below. Besides them, many web portals exist, both for professional and non-professional users, focused on different diagnoses, treatment, medicaments.

Concerning medical e-learning activities there are many events organized in the Czech Republic. One of them is a prestigious annual **Live + Video Surgery** meeting of the ophthalmologists that has been organized by the Central Military Hospital in Prague since 2001. The video conference allows the online connection of the operating rooms of other ophthalmology clinics, more specifically the ophthalmology clinics from the Faculty Hospital in Hradec Kralove, Olomouc, Ostrava, and from abroad. In 2011, eye specialists from Malta and Chinese ophthalmologists from the Medical School of Tsinghua University in Beijing were invited. Examples of refractive, vitreoretinal, cataract, and glaucoma surgeries were available for viewing, discussion and teaching of new surgical techniques.

Several e-learning tools supporting medical and life-long education and training in biomedicine and healthcare are also provided. These are **ExaME system** for evaluation of knowledge of students [37], and education by transferring medical knowledge using the internet **Catalogue of clinical practice guidelines** in the Czech Republic [38].

The **MEFANET** project (Medical Faculties NETwork) [39] aims to develop and strengthen the cooperation among Czech and Slovak medical faculties, as regards the progress in education of medical and health care disciplines using modern ICT. The primary objective of the MEFANET project is to facilitate the cooperation among teams from different faculties, and to ensure a horizontal accessibility of electronic teaching tools for both teachers and students. The MEFANET project is certainly not meant to affect or control teaching activities at individual faculties: all targets of the MEFANET project fully respect the independence of individual faculties.

The MEFANET network covers all medical faculties in the Czech Republic and Slovakia. The MEFANET Coordinating Council, which is composed of representatives of all participating members, drives it. In 2012 health care faculties have joined the MEFANET educational network and they are coordinated by the separate Health care sciences Coordinating Council.

One of the elementary goals of the MEFANET project is to advance medical teaching and learning with the use of modern information and communication technologies. As an instrument for that, MEFANET has decided to develop an original and uniform solution for educational web portals which are used, together with a central gate, to offer and share digital educational content. In this way, a unique collaborative environment, which is full of shared resources, is growing.

The educational web portal is an official publication platform of the MEFANET network, which serves for publication of electronic versions of educational works and multimedia teaching materials. Its main task is accessibility to all types of electronic didactic materials developed across the whole MEFANET network. There are currently eleven portal platforms developed within the MEFANET project covered by a central gate that allows for effective searching within the whole content available.

The local portal instances do not replace well-established LMS (Learning Management System) systems at the medical schools. Compared to the LMS, the educational portal platform provides additional e-publishing tools with well-defined rules for quality assessment. Further, it allows users federated authentication, and so they do not have to create ten separate user accounts for each portal instance.

Assistive Technologies as Inseparable Part of Care

In 2015, a detailed study on possibilities of utilization of assistive technologies in the systems of social, health and informal care was conducted [40]. The motivation for the study was the fact that no proper

survey of assistive technologies existed in the Czech Republic. Assistive technologies (AT) cover a very broad area, which is not yet fully mapped out in the Czech Republic. AT are technologies that help to provide so-called “inclusive services”. The ATIS concept (Assistive technologies and inclusion services) is used in modern states for improving provided services to clients of social and health care system. The whole concept can be utilized in social and health care services and in the environment of home and informal care.

The output is supposed to serve as one of the supporting documents for legislative, methodological and economical adjustments of the social care system in the Czech Republic. The goal is to stabilize the whole system, simplify and ensure the best-targeted distribution of required services to their users. Since AT utilization is on the border between social and health care, two ministries, namely the Ministry of Health and the Ministry of Labor and Social Affairs are involved. Moreover, two different insurance systems are involved as well: health insurance and social insurance. There is no defined guideline for simple calculation of costs of health and social services, which frequently leads to inefficient exploitation of resources. Therefore, the study suggested how to proceed when deciding about reimbursement, namely whether the provided service is health care or social care since they are paid through different insurance systems (health insurance vs. social insurance). As it was pointed out, the unclear situation until now has been the cause of many rejected payments. Therefore, many services have been offered as paid by the clients that might be a problem for handicapped or elderly persons.

The study chapter on utilization of AT in health care aims at analysis of situation in all types of health care services, including prevention, acute and urgent care, chronic diseases, and rehabilitation. It discusses relation between AT and medical devices, their utilization in telemedicine, issues of electronic health record. This chapter also contains overview of related educational programs and recommendations for future changes of curricula.

The study chapter on AT in home and informal care brings an overview of current state of AT related to their utilization in home and informal care and analysis of regulatory framework. It discusses the efficiency of AT utilization with the aim to show how to modify the relations in AT area, which legislative and economic changes have to be introduced and finally how to modify the offer of products and services in such a way that AT to become more accessible both from financial point of view and from the point of view of practical usability.

The chapter on specific AT for handicap compensation of persons with health impairment focuses on overview of technologies for compensation

and inclusion. The key issues discussed are user perception, increase of quality of life, standard devices, assessment of suitability, economic demands in relation to benefits and increase of quality of life.

The study provided a systematic and detailed overview of existing technologies, including their classification, namely to compensation aids, medical devices and other technologies. The work also focused on analysis of existing legal framework. Tenth of legal regulations that are in certain relation with development, use and financing assistive technologies were identified. The crucial issue is that there is no single and unified legal framework for assistive technologies both in the Czech Republic and in the European Union. There are also unclear relations between health and social care and services although these services are frequently provided to the same clients. Thus, the processes should be described in standard and transparent way. Clear definitions of duties, such as service and maintenance of AT, responsibilities of producers, care providers and other actors must be introduced. The authors of the research provided basic information and guide how to proceed when deciding about utilization of assistive technologies in a given situation and how to approach the question of reimbursement. For the first time, the study delivered classification of the assistive technologies in the Czech Republic.

Conclusions

The task to describe the state of eHealth and telemedicine in the Czech Republic was not easy. Until now telemedicine applications have been developed ad hoc without any central concept and support. eHealth has been supported to a certain degree, at least the part represented by hospital and ambulance information systems. Examples of various projects in each group were selected and described in brief, i.e. applications in routine use, pilot studies, and research projects, not yet finished or transformed to pilot projects. This text does not focus on current situation concerning the political decisions about future development of the health care system, including financial models for hospitals, ambulances, home care, etc. Readers interested in this topic may find relevant information on the web pages of the Ministry of Health, health insurance companies and Czech National eHealth Center.

The technological development is fast and the market offers new devices that might contribute to easier monitoring of health state of individuals, thus supporting prevention. The problem is that the health insurance companies do not motivate clients being proactive in prevention. Because of that, we come to the problem of sustainability of various projects, including many of those presented in this chapter. If the financial model is not clear, there is

almost no chance to carry through the project and introduce it in routine practice. Yet, exceptions where users pay the services, are listed in the text too.

In 2016, the Ministry of Health presented a feasibility study of the concept of electronic health care. The topics of telemedicine, m-Health, etc. were included. Finally, the requirements on standards were formulated. Although this was not mentioned explicitly when the projects above were presented, it is obvious that successful applications need coherent approach of experts from many different disciplines, i.e. information technology, electronics, communication technology, medicine. Standardization can make the way from an idea to an application much easier and faster. Thus, acceleration of standardization process represents a key issue. It is important that involved companies, researchers, and standardization bodies agree and cooperate towards the ultimate goal – defined standards. The standards go hand in hand with interoperability. Few years ago, only interoperability on the data level was considered. Nowadays the requirements go further to process interoperability and advanced knowledge representation. Especially with respect to future development and possibility to sense and store far larger volumes of heterogeneous physiological parameters, the issue of interoperability becomes more and more important. Interoperability may significantly influence efficiency of both design and development of an integrated system and of its routine operation. It will become more and more important with the development of telemedicine, home care and possibility of remote monitoring of patient state. Moreover, it will allow easier extension of existing systems without huge investments in updates. We should keep this fact in mind since it could be one of the key issues when considering ultimate sustainability.

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Evolution of Telemedicine in India

Considering varied landform and gigantic population, India is an ideal setting for telemedicine. With the country's population being more than 1 billion and approximately 72.2% of it residing in rural areas, the Indian healthcare has faced many encounters while spreading its services, particularly to those living in suburban and rural areas. Telemedicine has greater significance in India, as acceptance of the health information technology has been one of the major routes for effective medical care delivery to rural and suburban areas. Telemedicine practice was first initiated in Chennai and Lucknow in 1997. However, the telemedicine activities in the country were started in 1999. The Indian Space Research Organization (ISRO) has deployed a network of SATCOM (Satellite Communication)-based telemedicine in the form of Telemedicine Pilot

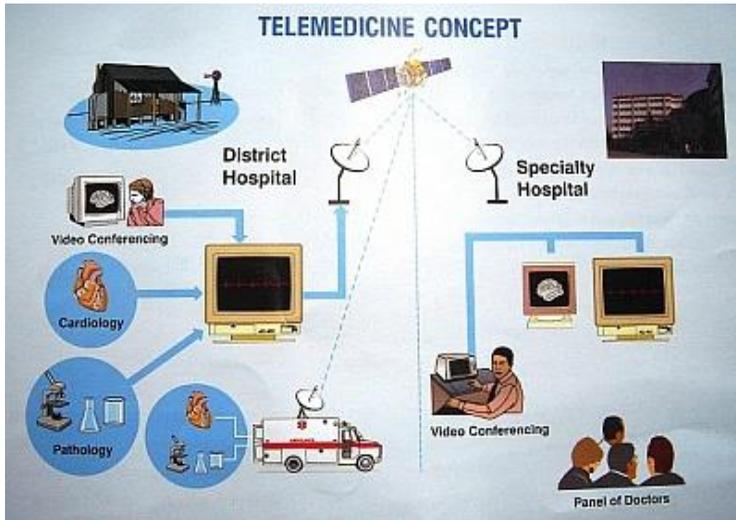


Fig. 32. Representative telemedicine structure (Adapted from Publications and Public Relations Unit, ISRO)

Project in 2001 (Fig. 32) [1]. The project was effectively linked with Apollo hospital of Chennai and Apollo rural hospital in an Aragonda village in the Chittoor district of Andhra Pradesh. However, the first unit of telemedicine was established in Thiruvanthapuram, Kerala at a medical college in 2003. Considering the common interest of the health and community welfare and to provide the quality of medical services to the poor irrespective of geographic areas, socioeconomic disparities such as remote, rural or inaccessible places, telemedicine was promoted.

Having survived an infant stage, telemedicine is now coming to an age. The first meet on telemedicine was held in 2001 in Lucknow. The meet mainly focused on rural medicine. The National Conference on Telemedicine held in Lucknow in April 2001 decided to form a scientific society dedicated to telemedicine at national level. The scientific society was dedicated to carry out a yearly scientific event requiring a formal registration and formed Telemedicine Society of India (TSI). The participants were designated as the founding members by signing a resolution. Although the efforts were started since 1996, it has been a long journey for TSI to establish telemedicine in India. TSI has also collaborated with countries including Uganda, Nigeria, Mauritius, and Netherlands to advance in the areas of telemedicine. The first official meet of TSI was held in Bangalore in 2005 after which significant development in the field of telemedicine was noted in the country. Since then, the yearly successive meets were held in Delhi (2006), Chennai (2007), Chandigarh (2008), Pune (2009), Bhubaneswar (2010), Mumbai (2011) and Coimbatore (2012), Jaipur (2013), Bhopal (2014) and Calcutta (2015). Currently, teleconsultations in several specialties have been provided to 29 countries and teleconferences have been taken place with many nations including Japan, Saudi Arabia, USA, and Hong Kong. [2] Due to severe scarcity of resources in the healthcare sector of developing countries including India, there has been an exponential increase in the accessibility of Information and Communication Technology (ICT). A unique opportunity to bridge the gap between the urban and rural has been provided by ICT. Hence, to launch telemedicine, it has to be incorporated by all the private sectors, stakeholders, government, public sectors, and entrepreneurs.

Skilled healthcare professionals who are open to new ideas, hospitals, and the healthcare centers in cities and villages have been successfully linked by the ISRO through Indian Satellite System (INSAT) satellites. This helps in connecting the patients at inaccessible areas to the specialist doctors at the urban centers. In order to deliver quality healthcare services to the rural and inaccessible parts of the country, many institutes such as a superspecialty hospital for cardiac care in Bangalore along with district hospital at

Chamarajanagar, and Vivekananda Memorial Trust hospital at Saragur in the south interior of Karnataka were linked by the Karnataka Telemedicine Project in March 2002. The specialty healthcare was provided to the rural populations by ISRO by carrying out various pilot projects in the country. Apart from the involvement of the large number of private hospitals/clinics in the country, telemedicine gained valuable experience during these preliminary projects. In India, state governments administer and manage telemedicine healthcare and few hospitals are also managed by trusts/non-governmental organizations (NGOs). This gives an assurance for the states to subsequently introduce telemedicine in the regular operational mode in hospitals with a sufficient training and experience to run the facilities of information technology. Ministry of Health and Family welfare (MoHFW), premier medical and technical institutions, and state governments of India have taken initiatives in introducing telemedicine.[3]. Numerous national level projects have been planned and initiated by the Government of India. In addition, government has also taken initiatives to spread the services of telemedicine in South Asian and African countries.

Telephone, radio, and communication through fiber optic cables were used in the early stages of telemedicine services in India. Telemedicine services presently utilize advanced diagnostic methods maintained by distributed server applications to maintain medical care at homes. In addition, video telephony has been utilized as the telemedicine has evolved. Satellite communication is developed from point to point system (one main location linked to one remote location) to point to multi point system (one remote location at time linked to many main locations) and multi point to multi point system (several remote places linked to main places in different biological locations). Medical e-learning has been the new emerging field of telemedicine with the establishments of digital medical libraries.

Telemedicine Initiatives

Indian Space Research Organization

More than 25,000 patients have been treated through telemedicine network since the launch of ISRO's telemedicine project in 2001. With this development, telemedicine is being introduced on a regular operational basis and all the district hospitals have been equipped with the facilities of telemedicine for both ambulatory and intensive care treatment. Satellite-based telemedicine facility has been initiated and established in all the district hospitals and in few trust hospitals of Karnataka, Kerala, Chhattisgarh, and Jharkhand. This service is soon to be followed by other states of the country. With this attempt by ISRO, specialty healthcare is accessible to the remote areas like Kargil and Leh in the north; offshore

islands of Lakshadweep, Andaman, and Nicobar; some of the interior parts of Orissa, Kerala, Karnataka, Jammu-Kashmir, Chhattisgarh; North-eastern states; and some tribal districts of certain other states of India.

Apollo Hospitals

Despite the challenges in establishing telemedicine, Apollo hospitals is all set to start 'Telemedicine 2.0,' which integrates new-age technology with a healthcare delivery model. This approach will make telemedicine services more accessible on mobiles and tablets. Efforts have been taken to integrate telehealth with a hospital management system, mobile personal health records, and electronic medical records in order to make healthcare more rational. Five tertiary hospitals have been launched with 'Telemedicine 2.0' by Apollo hospitals of Hyderabad and Chennai. The Telemedicine Centre of Apollo aims to launch the service across the country. Apollo accounts for 75,000 teleconsultations in 25 healthcare specialties. The Centre is also conducting surveys on attitudes and behavioral responses of the general public in accepting telemedicine as an enabler for healthcare. India is advancing in the field of telemedicine and eHealth. Most of the activities undertaken and supported by ISRO and the Department of Information Technology (DIT) are being incorporated in state governments. Apollo Telemedicine Networking Foundation has started its own network for telemedicine, which has begun operations of telemedicine since January 2000. Now, around 500 telemedicine nodal centers are in place throughout the nation.

Importance of Telemedicine in India

Telemedicine is an important step in meeting the challenges of healthcare delivery to rural and remote areas. It aims to provide healthcare to India's poorest people. The diseases that are not favorable for surgery are being encouraged by telemedicine. In order to provide healthcare services to rural India, telemedicine allows training of the healthcare professionals across the country. Telemedicine is considered as a viable technology as the complexity and cost of the technology has decreased in past 5 years. Despite infrastructural insufficiencies, telemedicine should be encouraged and be implemented to ensure the accessibility and availability to all areas.

Current Scenario of Telemedicine in India

Telemedicine has moved beyond the preliminary stage to the actual enactment stage in India. The standards for the telemedicine systems have been defined by the MoHFW by constituting national telemedicine course to encourage telemedicine activities in India. To create awareness of

telemedicine in the country, numerous government and telemedicine service providers, and few associations and societies have come forward. India is emerging as a leader of telemedicine due to its vast work force and related expertise in medical and information technology. Telemedicine capable of transforming the health statistics of remote India and medicinal practice has been proclaimed as a greater hope for healthcare in rural areas. Majority of the population has no access to healthcare facilities. Telemedicine is believed to have a potential to change lives in India, as telemedicine provides healthcare facilities to the remotest locations.

Telemedicine is considered to embrace recent technology to broaden the accessibility of healthcare in rural India and can be the explanation for healthcare anguishes. However, it would be impossible to get good and skilled doctors to work in rural India considering the present infrastructure and financial terms. It is also financially impracticable in structuring the healthcare and maintaining them. Rural India can avoid pain, suffering, and high cost of the healthcare by adopting preventive care model.

Continuing Medical Education

ISRO's Continuing Medical Education (CME) under telemedicine program aims to provide a chance to healthcare professionals at the rural hospitals to improve their medical knowledge and skills by satellite-based telelink. It enables an interaction with the experts at the specialty hospitals. As a result of these interactions, there will be advancements in the quality of the healthcare provided to rural patients. Tele-education program and the CME program are being integrated by connecting specialty hospitals and research centers with the medical institutions.[3]

Mobile Telemedicine

Various institutes across the country have established mobile telemedicine center with a mobile telemedicine unit. These units consist of a medical equipment with telemedicine software, hardware, and very-small-aperture terminal (VSAT) system installed in a bus or van.

Advantages of mobile telemedicine include:

- Mobile telemedicine has a major contribution in the field of teleophthalmology and community health
- Rural eye camps are conducted by helping the rural population to undergo eye screening for cataract, glaucoma, and diabetic retinopathy
- Mobile telemedicine units helps in disease prevention
- Mobile telemedicine units help in healthcare promotions such as conducting awareness camps and teaching hygienic practices

Village Resource Centers for Telemedicine

Pilot projects have been initiated by ISRO to outreach the rural areas of the country (Fig. 33). Efforts have been made to integrate resource information database with telemedicine/telehealth, and tele-education facilities at the Village Resource Centers (VRC) or the Village Community Centers. Tamil Nadu implemented the first pilot project connecting three remote villages to the nodal center operated by a NGO agency at Chennai. Saving the cost and effort of travelling long distances to obtain consultation and treatment is one of the biggest advantages of technology of telemedicine in the country like India. According to a survey conducted by an independent agency in Chamarajnagar district of Karnataka, it was found that patients can save 81% of the cost for consultation by spending only 19% of the money for their telemedicine consultation, which otherwise would have been spent on travelling to nearest cities to take similar treatments. Patient and the government both would be benefited with the introduction of technology of telemedicine if consultation have to be done on remote off-shore islands. In this instance, apart from cost saving, patients will also get quick and timely medical aid.

Current Usage of Telemedicine in India

Telemedicine in Special Situations

Telemedicine consultation has been provided every year since 2002 at Pampa for lakhs of pilgrims who visit the foothills of Sabrimala shrine in Kerala. The telemedicine network is provided between Amrita Institute of Medical Sciences, Trivandrum, Kochi Medical College Hospital, and the Temple Board Hospital of Pampa. As a result of this, many of the pilgrims availed telemedicine facility and some of the lives were saved. Focus is to make similar efforts on the other places too.

Telemedicine during Tsunami

Following tsunami disaster, telemedicine facilities have been provided to three hospitals—Govind Ballabh Pant hospital, Andaman Island; Bishop Richardson Hospital at Car Nicobar; Indian Naval Hospital Ship (INHS) Dhanvantari at Port Blair, and Gramsat network of ISRO at eight islands to benefit the remote population of Andaman and Nicobar islands. Efforts are made to create more of primary health centers at different islands of Andaman and Nicobar and establish telemedicine network in the states of Rajasthan, Jharkhand, Arunachal Pradesh, Uttar Pradesh, Madhya Pradesh, Maharashtra, Uttaranchal, and some other states.

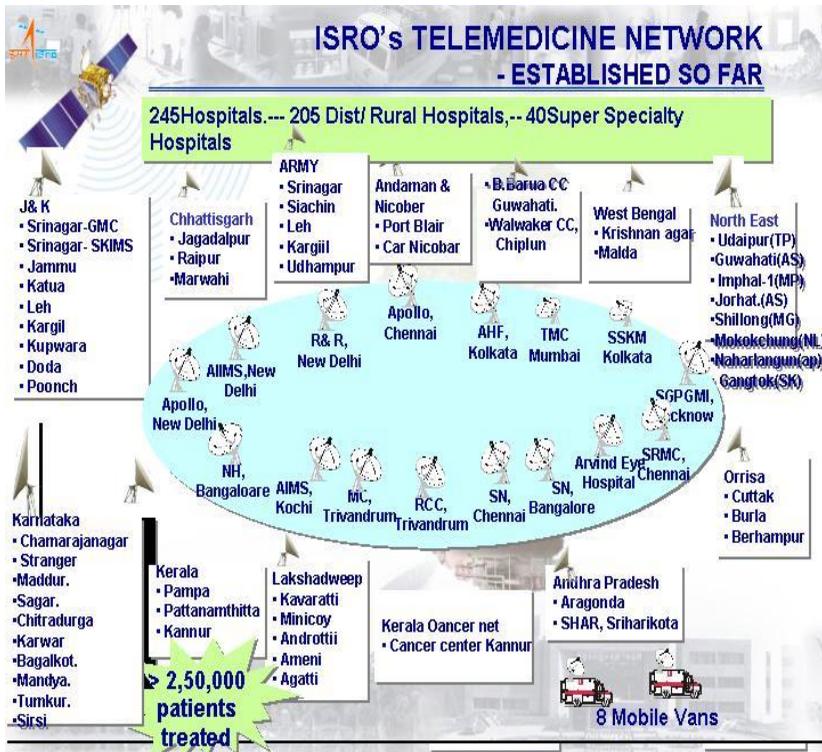


Fig. 33. ISRO's telemedicine network in India (Adapted from Publications and Public Relations Unit, ISRO)

Despite various advantages of telemedicine in the healthcare, several reasons exist. Some of them are explained below;

1. Implementation issues

Implementation issues in telemedicine are of major difficulty, as implementation of telemedicine in India requires training for Information Technology (IT) staffs, technicians, and local doctors at the village end and a lot of forceful administration and coordination at the consulting doctor's end. The major drawback of telemedicine in India is implementation.

2. Acceptance

Acceptance of high-end technology such as telemedicine might be too fundamental and inhibiting among the village doctors and

villagers. Once the benefits of the telemedicine are seen, acceptance ratio is likely to increase with the advent of rural internet services and mobile telephony.

3. Infrastructural issue

Infrastructural issues are related to poor or expensive bandwidth in different areas. Though the number of hospitals with satellite connections has been extended to 100 institutions by ISRO, connections through satellites are very expensive and the areas do not generally have the best broadband connection, there are several rural areas which are not linked to the major cities.

4. Viability issues

Telemedicine has been a free offering by larger hospital groups in India. A constant effort has been made in increasing the bed occupancy in cases of 'tele' patients turning into 'real' inpatient. Since large hospitals are in a position to deliver in-house expertise, they offer the same at no extra charge. As these in-house experts work in a busy setting such as large hospitals, there will be an issue of telemedicine consultation. There would be marked reduction in the delivery of large throughput service of telemedicine due to the fact that the consultations are free.

Telemedicine and Its Recent Developments in India

Telemedicine has brought advancements in healthcare delivery systems and improvement in quality and access. Apart from investments from private institutions, central and state governments have also shown interest to create new telemedicine solutions. To improvise healthcare services in the inaccessible parts of the country, many suggestions have been given for telemedicine solutions by The Planning Commission in the 12th 5-year plan. Efforts have been made to ensure internet access in every key healthcare centers within 12th 5-year plan period. Subcenters can extend their connectivity through cell phones. Focus is on to use software applications such as Skype for audio-visual interaction to make telemedicine available in remote and suburban areas of the countries and to enrich the professional isolation of the posted healthcare professional. Telemedicine has also been recognized as a major thrust area by the Health Ministry of India, as 25% of specialist physicians live in semiurban areas, and an only 3% reside in rural areas. An increased acceptance and proliferation of telemedicine in India has been observed, as the 700 million rural population are devoid of proper healthcare and hospital facilities

Product and Service Offerings

Multiple sectors have been involved in the development and advancement of various applications of telemedicine in India including medical device manufacturers, IT vendors, hospitals, nursing homes, pharmacies, and venture capitalists. Recently, several products, services, and models have been developed to serve the medical requirements in rural India.

To provide medical care to individuals at most inaccessible sites, Philips, and Dhan Foundation have introduced mobile health clinics. Distance healthcare Advancement (DISHA), a novel telemedicine initiative, has been taken by Apollo to provide long-distance healthcare. The secondary and tertiary procedure supports are provided to rural India since 1999 by following the lead of Apollo Telemedicine Networking Foundation (ATNF).[4] At present, approximately 100 regional hospitals and clinics are connected to 22 urban hospitals through ISRO's network. Depending upon relative specialties, different services are offered by different hospitals. For example, Narayana Hrudayalaya is supporting rural hospitals by examining electro cardio graphs (ECGs) while potential supports for the eye conditions are offered by Arvind hospitals. Individuals who cannot travel long distances to hospitals and clinics for comparatively minor health condition are offered with an alternative solution of health hotline. Due to reduced cost of mobile plans and increased usage of mobile facilities, licensed physicians can be accessed by customers with the purchased subscription plans for services of health hotline at a relatively affordable cost.

Specialty to District Hospital Model

To serve the medical requirements of India, multiple business models have been implemented to improve telemedicine market. New model have emerged to enable access to healthcare for individuals who are even more remote than the existing once can handle. This has evolved as an alternative solution for the customers who don't want to travel long distances to clinics for relatively minor health issues. Some of the significant features of these models include;

- The first telemedicine models (pioneered by ATNF) provide the secondary and tertiary care in rural India by linking small hospitals, clinics, and medical centers.
- The model connects doctors at remote centers to the experts at the large hospital chains who read ECGs, provide training for the complicated conditions, and manage complex conditions
- Telemedicine operations have been established as nonprofit entity offering free services and consultations.

- Some of the models get financial returns, but the services work primarily as a charity and are not generally profitable business models.
- The connectivity is established by linking computers to a terminal, which further links to rural district hospitals and clinics via a satellite having ISRO connectivity.

Primary Care Telemedicine

A second model for the telemedicine has been evolved in the recent years to provide primary services where there is absence of licensed doctors. In primary care models, patients in the rural areas can be connected to the basic services such as diagnostic testing and prescriptions using the combination of informal providers and telemedicine. Medical care to the rural population is provided to a greater extent by these organizations than the hospitals, which are in the ISRO network. Patients pay a small fee per doctor visit and lower if they belong to below the poverty line according to the World Health Partners (WHP)—the inventor of primary care telemedicine model. No matter what kind of services or the tests the patient requires, the fee remains the same. To enable patients for the necessary components of medical care, most of the models incorporated by WHP and eHealth Point involve developing and implementing laboratories and pharmacies near by the facility. In order to build the low-cost supply chain to spread these products, WHP supplies its own line of generic drugs to build the low cost supply chain to spread these products. The supporting profit stream is provided by the pharmaceutical sales by splitting the stakeholders. As larger hospitals take advantage of ISRO in purchasing VSAT terminals, the small rural healthcare providers cannot afford these terminals, as it is roughly eight times the upfront cost for an entrepreneur to spend for clinics in remote places. Hence, to provide telemedicine services, rural clinics generally depend on the local broadband services; however, the network has not fully reached to the remote areas where the telemedicine could actually offer value.

Narayana Hrudayalaya — Telemedicine Service

The telemedicine service of Narayana Hrudayalaya was incorporated in 2002, which was dedicated to provide services to the population of remote part of India.

Significant features of the hospital include:

- A total of 332 hospitals (299 remote district hospitals linked to 33 specialty hospitals in major cities) are covered by the Narayana Hrudayalaya through the ISRO network.

- In order to provide 24-hour support to the patients, 4–5 intensive care units and 20 telemedicine centers are established.
- Approximately 53,000 patients have been treated by Narayana Hrudayalaya—telemedicine service (NHTS) in the past 10 years in different countries including Tanzania, Nigeria, Zambia, Bangladesh, and Malaysia.
- In the past 5 years, 550 CME programs have been conducted by NHTS for cardiac conditions.
- The telephone and broadband or satellite connection provided by the ISRO is being used to exchange the analysis of the ECG reports, computed tomography (CT) scans, X-rays, audio/visual data, and Magnetic Resonance Imaging (MRIs). telemedicine ECG machine developed by Schiller India is used by the hospital for telemedicine services
- Free services of telemedicine are provided by the hospital and about 21,000 individuals have used these services.
- Narayana Hrudayalaya is a part of “The Karnataka Telemedicine Project,” which connects two hospitals in Saragur, Karnataka, Chamarajnagar district hospitals, and Vivekananda hospital with Narayana Hrudayalaya.

Some of the services offered by NHTS include:

- **Teleconsultation:** The hospital provides videoconferencing facility for the patients requiring specialist consultation at rural centers. It enables two or more individuals to interact at two or more different locations. It uses digital communications with an audio or video support and facility to transfer medical records. Narayana Hrudayalaya is the world’s largest telemedicine network, as it treats more than 30,000 patients and runs world’s largest telecardiology program.
- **Transtelephonic ECG (TT ECG):** Narayana Hrudayalaya has established more than 308 centers around India by developing indigenous software to transmit ECGs by using TT ECG machines.
- **CME tele-education:** Narayana Hrudayalaya conducts a yearly training or teaching program using telemedicine infrastructure and facility.
- **Hrudayalaya post:** Patient with any medical connections can visit district head post offices along with the medical reports (paper documents, ECG, angiogram), as all the district post offices of Karnataka are connected to the Narayana Hrudayalaya via software and internet applications. Patients can later hand over the medical report to the post office staffs for uploading. The hospital is able to

receive and review the post in 24 hours, which is sent back to the respective patients at their doorsteps.

World Health Partners

WHP was founded in 2008 by Gopi Gopalakrishnan to address the unmet requirements of the healthcare services in the remote areas. WHP model is a similar model to the Janani program but with an aim of providing larger healthcare services. The model mainly aims to match the healthcare provider with the skills close to the patients' requirements. When needed, more skilled provider is recommended to the patient. It helps to divide healthcare delivery needs.[5]

SkyCare Centers

The service model is operated and managed by local entrepreneurs at SkyCare centers. It included local rural healthcare providers equipped with basic level of care. SkyCare centers use the network of WHP under specialized care to connect the rural doctors to the central medical facilities or franchisee clinics. They offer access to the counter medications (vitamins and condoms), conduct simple diagnostic tests, and rapid pregnancy tests. They also provide referrals to more specialized clinics if required. They provide high-quality, cost-effective networks of telemedicine. WHP network provides advertising, training, brand, and scalability. Under SkyCare centers, the patient is not asked to pay for the consultations while the owner receives the referral fee for the services.[6]

SkyHealth Centers

SkyHealth centers is run by the local entrepreneurs and is a house of telemedicine communications equipment. In SkyHealth centers, the patient is generally asked to pay a referral fee of INR 50–200, or supported by the WHP if the patient is below poverty line. An electronic medical record is created and tested using a neurosynaptic product—Remote Medical Diagnostics Medical Data Acquisition Unit (ReMeDi-MDAU), which is further connected to the doctor at the central medical facility via satellite and broadband. The doctors working at the hospitals are volunteers who receive minimal pay for their time and work before or after shifts, moonlighting, and are several individuals who dedicate full time in WHP at Mumbai.

Neurosynaptic Communications

Neurosynaptic Communications is a privately held for-profit company that was incorporated in 2002 by Sameer Sawarkar and Rajeev Kumar with

the aim to deliver communications based products to help serve the health care needs of the rural population.[7]

Significant features of the company include:

- The company mainly focuses on the primary or “family” level of care rather than at the secondary or tertiary level of care.
- The delivery of components of the telemedicine is facilitated by the comprehensive tool such as ReMeDi MDAU.
- ECG, heart and lung sounds, blood pressure, and oxygen level are measured by the diagnostic kit provided by the company.
- It also enables video conferencing.
- The services are designed to lodge rural conditions such as low power and connectivity.
- ReMeDi MDAU has drastically decreased the cost per consultation by cutting down the cost to INR30–100 per visit.
- ReMeDi leads in the delivery of telemedicine and is used by WHP, Cisco, and several other public and private service providers.
- Approximately 400 ReMeDi units have been sold and installed by the Neurosynaptic Communications.

Role of the Multinational-Deployment of Cisco’s Healthpresence

In 2010, an advanced and care-at-a-distance technology platform was designed by Cisco’s ‘HealthPresence’ solution. This platform allows the patients to interact with the clinicians and doctors for the healthcare consultations.[8]

The objectives of the organization include:

- To organize healthcare solution as an important part of its vision; and improve the access to the healthcare, education, and public services to the mainstream economy; Cisco collaborated with the government of Madhya Pradesh at Sehore in November 2011.
- In order to provide medical care to the patients in Raichur, North Karnataka, Cisco collaborated with HealthPresence at Telrad RxDx—a multispecialty hospital was established in Bangalore. HealthPresence is a telemedicine product that helps in providing good quality while occupied in the low-bandwidth processes.
- To organize open healthcare IT standard, and to deploy Cisco’s technology around Asia, Cisco worked on a joint venture with Apollo Hospitals. Through this, Cisco is developing a foundational infrastructure by enabling the strong usage of telemedicine across the country.

Cisco's Health Presence solution mainly focuses on:

1. Capacity inclusive of both scarcity and productivity of the clinical expertise
2. Collaboration between clinicians, providers, and patients
3. Information exchange to share and view important health information
4. Personalization in order to make patients more active in consultations

Apollo Telemedicine Networking Foundation

ATNF is a non-profit organization, established by the Apollo hospitals to develop and promote telemedicine in remote areas. It aimed to establish communication among the medical community by the assembly of specialized knowledge of medicine with a technologically advanced network.[4]

ATNF mainly focuses on:

- To provide telemedicine at the remote parts of the country. It aims to connect patients, physicians, healthcare providers and medical institutions through medical transcripts, audios, videos, still images, motion pictures, graphics, internet, email, compact disks (CDs), and other electronic methods.
- To conduct teleconferences and obtain reviews by integrating medical and surgical expertise of medical consultants in the rural by using computer, satellite, networking technology for diagnosis, treatment, consultation, and CME.
- ATNF also aims to implement and maintain software, computers, related hardware, other equipment for the communication, and use telecommunications and technology to provide telemedicine and manage healthcare. It also develops and standardizes the techniques of telemedicine and conducts research.
- It also helps in conducting training programs, lectures and seminars of telemedicine in schools, colleges, universities, and educational institutions.

Proposed Service Delivery Model-2

Proposed service delivery model-2 is real-time patient monitoring system that is mainly focused on elderly and children (Fig. 34). The model works as follows:

- It contains a specially designed device, which is able to sense the continuous changes happening in the body of patients.

- The device is small and wearable and hence, can be carried in full time without any discomfort.
- The device can be programmed in such a way that the medical information of the patient can be transferred to the nearest hospital.
- Through the listening system implemented inside, the hospital can display the real-time information of each and every patient.
- Normal physical values set inside the device can be compared with the real-time values of the patient body. Any changes in the limit values will send an alert message to the nearest hospital and an alert signal to the ambulance service tracking the patient's current location and automatically calls on the emergency number and conveys the message to the nearest hospitals.
- Multisensor is the major part of the device and there is hardly any technology hurdles in implementing this project.

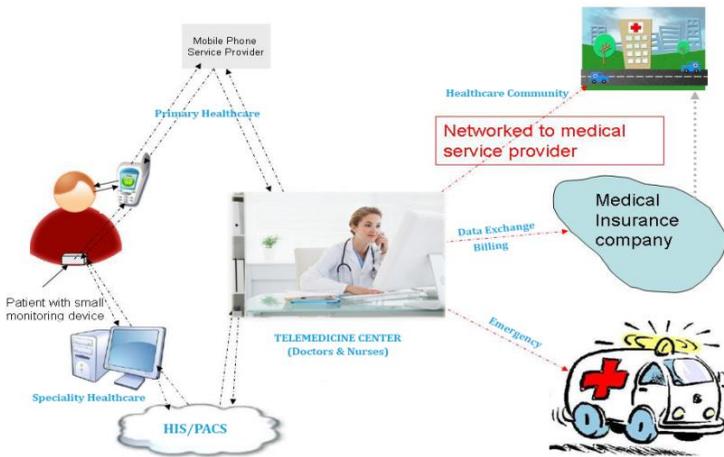


Fig. 34 Telemedicine service delivery model
(Adapted from telemedicine in India design research)

Indian Telemedicine Market

Indian telemedicine market has a size of USD 70–110 million. More than 35% high Compound Annual Growth Rate (CAGR) is expected in next 5 years in order to reach USD 314–493 million. With an appropriate

stakeholder vision and better adoption, the complete potential of the telemedicine market in India can be realized [9].

Key growth drivers in the country include:

- Lack of framework of disease management;
- Lacks of facilities of healthcare in far-off regions;
- Low cost and increased reach over fiber optic bandwidth or satellite;
- Reduced cost for technology and accessibility of skilled technical personnel;
- Shortage of skilled medical professionals;
- Increased focus of government on healthcare;
- Varied medical facilities due to division of urban and rural areas of country;
- Dedicated satellite from ISRO for health communications;
- Growth of ICT as a sector;
- National telemedicine grid to link institutions and practitioners.

The technologically advanced ICT sector is the key driver for growth of telemedicine in India, as it is sufficient in meeting the requirements of software, hardware, connectivity, and services. ICT technologies have the capacity to make healthcare affordable in India, especially in rural India (Fig. 35-36). This achievement may be further strengthened if the existing healthcare delivery systems get integrated into the ICT technologies. Though there is an active investment for development of telemedicine in India in last decade, considering its demographic range, the investment may not be sufficient for such a large country. The services of telemedicine in the country are restricted to health awareness, medical transcription, telemedicine and hospital management system, and customer services using internet. To meet the requirement for the healthcare solutions in India, the use of communication devices including conferencing solutions or mobile phones have been limited. Using wireless devices to access internet is growing steadily in India with the telecom operators finding it as growing segment. Lately, Indian healthcare market is considering mobile phones as a tool and an enabler to deliver healthcare. mHealth can be implemented in the hospitals, insurance companies, and pharmaceutical companies as mobile phones offer unlimited opportunities and challenges. Thus, mobile phones will soon become a hand-held hospital. mHealth is considered more relevant in India, as accessing to personal computers, broadband, and laptops is far less than accessing to mobile phones. Compared to 881 million of mobile phones in India, there are 85 million PCs, 24 million internet subscribers, and only 12 million broadband connections. Though mobile phones are easy to sell due to the larger scale user adaptability and

familiarity, practical mHealth still will take time. Although 881 million mobile phones have equipped the country for mobile communication, according to the recent survey, of 30 telemedicine projects, only 2 projects had intersect with the mobile phones while the other used satellite connections offered by the government initiatives. Presently, National Centre of Biological Sciences, Bangalore and Department of Health and Family Welfare have adopted text-based cell phones to improve the disease surveillance and reaction time. To demonstrate telepresentation of radiology images, the Apollo Telehealth Network foundation is collaborated with Ericsson's Gram-Jyothi Program to establish application of the telemedicine on mobile platforms at 3G networks. According to the recent study conducted by ASSOCHAM, the telemedicine market in India has been growing at 20% of CAGR. The study also says that Indian telemedicine market has the potential to cross \$32 million mark in 2020 from the current stage of over \$15 million mark [2].

Potential of ICT to improve Healthcare

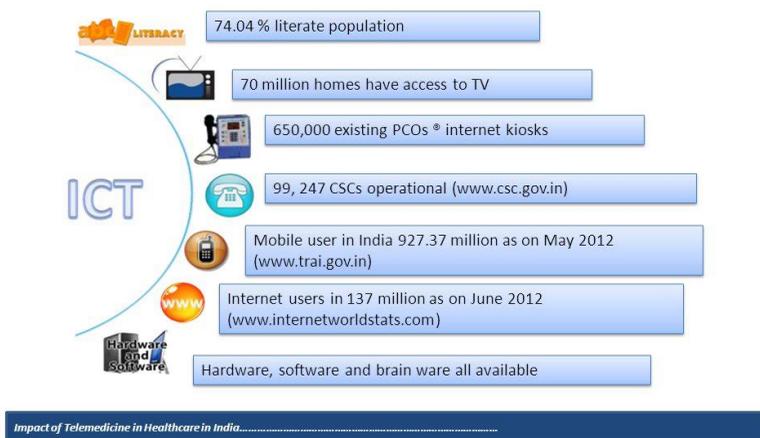


Fig. 35. Potential of ICT to improve healthcare
 (Adapted from Sanjay Gandhi Postgraduate Institute of Medical Sciences telemedicine program, Lucknow)

Effort has been taken to cover primary healthcare centers, district hospitals, referral specialty hospitals, software/hardware requirements, and fixing bandwidth and connectivity.

According to the study, the growth of telemedicine network in India depends on:

- Introduction of legal outlines
- Development of the national level eHealth policies
- Trained human resource
- Regular funding

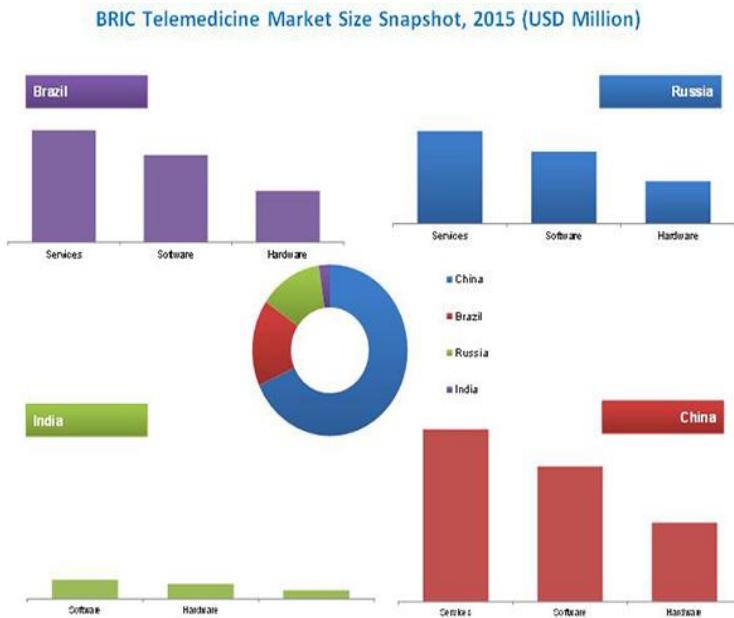


Fig. 36. Telemedicine market (Adapted from Markets and Markets, Published: March 2016)

Telemedicine is considered to have a potential to transform the status of healthcare sector in the country, as majority (68%) of the country population resides in remote and rural areas. The major challenge to the healthcare sector in India is the geographic limitations and socioeconomic conditions, which limit the access to the specialty physicians. Example a marked increase of 6,300 subcenters in India was seen during the period of 2005–

2009. Also, increase in the number of primary health centers to 1,800 and increase in the number of community health centers to more than 2,000 has been documented. This depicts the growth and progress of rural healthcare in the country. There has been shortage of approximately 32% in the number of community health centers and approximately 23% in the number of primary health centers in India. According to ASSOCHAM, Jharkhand (66%), West Bengal (58%), and Madhya Pradesh (42%) face majority of the shortage in the number of primary health centers (Fig. 37). However, scarcity in the required number of community health centers is observed in Bihar (91%), Andhra Pradesh (United) (40%), and Karnataka (41%; Fig. 38).

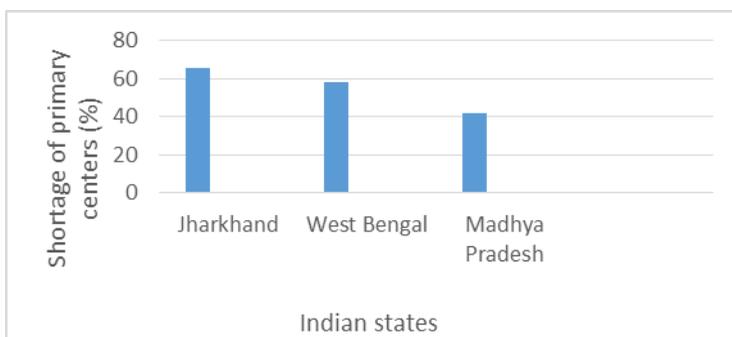


Fig. 37. Shortage of primary health centers

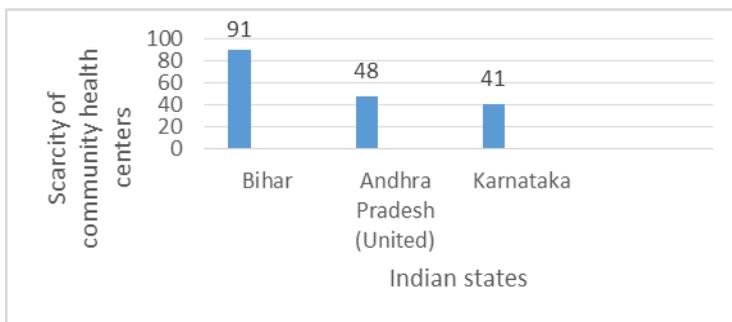


Fig. 38. Shortage of community health centers
Standardization and policy initiatives

A Typical Framework of Telemedicine in India

In India, telemedicine has gained a special significance due to its vast geographical spread and predominant rural population. With this extending application of telemedicine, the policy makers in India feel that a recommended set of guidelines and standards should be set continuously updated to advance the integrated growth of telemedicine in the country.

As a major aspect of this attempt, the DIT, Government of India, has formulated “Standards & Guidelines for the Practice of Telemedicine in India.” The main user ministry took the activity further. A category for telemedicine standards was created under the guidance of the Task Force for telemedicine in India, which was constituted by the Union MoHFW. The various members from this category were drawn from different government and private institutions that took initiatives in the form of development of generally acceptable standards and guidelines in telemedicine.[10]

Key Objectives in Defining the Standards

While constructing the guidelines and standards, following points were considered:

1. To promote the growth of telemedicine
2. To increase accessibility of quality medical services to all
3. To define the use of telemedicine technology suitable to the Indian environment
4. To identify the mechanisms for protecting the privacy and confidentiality of individual health data
5. To define processes for the scientific practice of telemedicine
6. To contribute to broad international co-operation in the scientific, legal, and ethical aspects of the use of telemedicine
7. To encourage continued support for the advancement of telemedicine and its applications globally
8. To provide a framework for interoperability and scalability across telemedicine services within the country
9. To bring down the opportunity costs to the various stakeholders (vendors, users, general public)

Framework in Defining the Guidelines and Standards

While formulating the standards the subgroups covered the major issues of interoperability, compatibility, scalability, portability and reliability.[10] The main aim is to provide a framework for telemedicine services within the country.

- Interoperability: Interoperability of the systems (computers, communication devices, networks, software and other IT

components) with the components of health system networks is necessary for effective and efficient sharing of data in real-time and delivery of telemedicine services.

- **Compatibility:** Compatibility is also crucial where equipment/systems of different vendors and different versions of the same system should be able to be interconnected.
- **Scalability:** Scalability is a significant consideration when planning telemedicine program and purchasing necessary equipment and technology. Equipment/systems inducted for telemedicine should be able to be augmented with additional features and functions as modular add-on options.
- **Portability:** The data generated by an application that runs on one system should be able to be exported to different platforms with a minimum effort.
- **Reliability:** Reliability of technology and equipment is essential for safe, effective and efficient delivery of telemedicine services. Telemedicine systems should follow relevant reliability standards of equipment/ systems of similar category to ensure availability of service with minimum system downtime.

Framework for Telemedicine in India

Considering the standards and understanding the international scenario, DIT undertook the initiative to define the framework for telemedicine in India. At the same time, a set of standards and guidelines were proposed for successful implementation and practice of telemedicine in India. The suggested framework includes clinical standards, data elements, billing formats, health identifiers, minimum data set, legal framework, and messaging standards.

Key Stakeholders of Telemedicine in India

Telemedicine, as a concept, has poised for growth with governmental focus to improve access to healthcare, reduce the cost of transportation, and enhance the convenience to patients in obtaining health care. Various possible stakeholders in India have effectively executed and promoted telemedicine network in their states. The key players in the telemedicine ecosystem can be broadly classified into three categories.[11]

A. Government and Government Bodies

This includes organizations that encourage development of telemedicine through policy initiatives and financial backing. It comprises of organization such as the MoHFW [12], the DIT, Ministry of Communication and IT

(MCIT), and the various state governments. In India, various departments have been proactive in launching initiatives and collaborating with various other organizations to promote telemedicine.

Ministry of Health and Family Welfare, Government of India

In India, a much organized approach toward telemedicine can be observed under the chair of Secretary, Union MoHFW. The ministry has incorporated members from various concerned ministries of union government for example, health, communication, and information technology and space. Technical agencies including ISRO,[13] Indian Council of Medical Research (ICMR), Medical Council of India (MCI), Centre for Development of Advanced Computing (C-DAC), academic medical institutions, and corporate hospitals are also practicing telemedicine actively. MOHFW has implemented Integrated Disease Surveillance Project networking of all district hospitals and medical colleges of the state to strengthen the public health system, especially emphasizing on disease surveillance.[14]

State Governments

Many state governments have realized the significance and benefits of telemedicine technology and collaborated with the central government in building statewide telemedicine networks to improve the healthcare facilities in their states.[15] Detailed information on state governments, which have implemented telemedicine network, is provided in Table 3 and Fig. 39.

Table 3. Statewide telemedicine network implemented in various states of India (Adapted from; Telemedicine in India: Current Scenario and the Future, 2009)

State	Funding agency	No. of telemedicine nodes	Specialty hospital
Jammu and Kashmir	ISRO	Twelve district hospitals	Sher-e-Kashmir Institute of Medical Sciences Hospital, Srinagar

Himachal Pradesh	DIT	Nineteen Health centers at district, block and tehsil headquarters	IGMC Shimla and PGIMER Chandigarh
Punjab	DIT	Twenty district hospitals	Government medical college and hospital and five polyclinics of the state
Uttarakhand	State	Two district hospitals	SGPGIMS, Lucknow
North-eastern states	DIT	District hospitals each of seven north-eastern states	Narayana Hrudayala, Bangalore
Jharkhand	ISRO	Twenty two district hospitals	Three medical colleges and hospitals
West Bengal	DIT	Twelve district hospitals	School of Tropical Medicine, NRS Medical College and hospital, Kolkata, Burdwan Medical College and Hospital, Burdwan
Rajasthan	ISRO	Thirty two district hospitals	Six State medical colleges
Chhattisgarh	ISRO	Two medical colleges	Government medical colleges at Raipur and Bilaspur that further link to premier hospitals of the country
Orissa	ISRO, C-DAC	Five district hospitals	Three medical colleges that further linked with SGPGIMS

Karnataka	ISRO	Twenty six district hospitals	Narayana Hrudayalaya, Bangalore
Tamil Nadu		Six district hospitals	Government General Hospital, Royapettah Hospital, Adiyar Cancer Center11, Chennai
Kerala	ISRO, CDAC	Fourteen district hospitals and two taluk hospitals	AIIMS, New Delhi, Amrita Institute of Medical Sciences (AIMS), Kochi and Sri Chitra Tirunal Institute of Medical Science and Technology, Thiruvananthapuram

ISRO, Indian Space Research Organization; *DIT*, Department of Information Technology; *PGIMER*, Postgraduate Institute of Medical Sciences; *SGPGIMS*, Sanjay Gandhi Postgraduate Institute of Medical Sciences; *IGMC*, Indira Gandhi Medical College; *NRS Medical College & hospital*, Nil Ratan Sircar Medical College and hospital



Fig. 39. Geographical distribution of telemedicine nodes in the India map
 Adapted from; Telemedicine in India: Current Scenario and the Future, 2009

In Orissa and Uttarakhand, secondary hospitals have now been connected to Sanjay Gandhi Postgraduate Institute of Medical Sciences (SGPGIMS), Lucknow for specialty consultation with the support of the governments. ISRO, with the administration of Chhattisgarh, has set up a statewide network linking the state government medical colleges at Raipur and Bilaspur with other premier hospitals across the country. Correspondingly, the Rajasthan state government has established a telemedicine network among six state medical colleges, 32 district hospitals, and six mobile vans with ISRO's aid. The Karnataka State Telemedicine Network Project, run by an autonomous trust, has set up 30 nodes in collaboration with ISRO. The Government of Punjab has additionally propelled a telemedicine project with state-of-the-art facilities at the Government Medical College and Hospital to link the five polyclinics set up in the state. Many state governments, along with the department of IT, have started establishing

telemedicine networks with state specialty hospitals connected with different district and smaller health centers. Some of them include the Government of Tripura, West Bengal, Himachal Pradesh, Tamil Nadu, and Kerala.

Ministry of External Affairs Projects

Progress in telemedicine is not confined within domestic networking and the Ministry of External Affairs (MEA) has embraced worldwide telemedicine activity. The MEA has undertaken initiative in Africa and South Asia to extend its services under South Asian Association for Regional Cooperation (SAARC) and Pan-African e-Network Project.

South Asian Association for Regional Cooperation telemedicine network

The SAARC Telemedicine Network project connects one or two hospitals in each of the SAARC countries with three to four superspecialty hospitals in India. The superspecialty hospitals in India include All India Institute of Medical Sciences (AIIMS), New Delhi, The SGPGIMS, Lucknow, Postgraduate Institute of Medical Sciences (PGIMER) at Chandigarh, and the CARE Hospital, Hyderabad.

B. Technology Providers

By collaborating with state governments, the DIT and MCIT have established a telemedicine network of more than 100 nodes all over India. Some of the successful telemedicine pilot projects implemented by DIT in various states are:

- West Bengal for diagnosis and monitoring of tropical diseases
- Kerala and Tamil Nadu Oncology Network for facilitating cancer care
- North-eastern and Himachal Pradesh hilly states for specialty health care access
- DIT has also established links among SGPGIMS, AIIMS, and PGIMER.

Various other technology providers incorporates the various organizations such as Ericson, Texas Instruments, CISCO Systems, C-DAC, Sony, which provide specialized hardware and software solutions for innovative telemedicine services. These group additionally include the different stakeholders that provide the sustaining infrastructure and connectivity support. In India, some of the key players are ISRO, Aircel, Airtel, and IBM. With innovation in services and enhanced efficiencies in communication and support technology, these groups of stakeholders hold the key to the long-term growth and commitment to telemedicine in India.

Indian Space Research Organization

ISRO's pilot telemedicine project was introduced in 2001 under the GRAMSAT (rural satellite) program with the aim of providing telemedicine facility to the grassroots level population. This telemedicine facility connects the remote district hospitals/health centers with super specialty hospitals in cities, through the INSAT for providing expert consultation to the rural population.

Telemedicine facilities have been made available at numerous remote rural district hospitals in many states and union territories of the country including Jammu and Kashmir, Andaman and Nicobar Islands, Lakshadweep Islands, and North-eastern states. State-level telemedicine networks have been established in Karnataka, Kerala, Rajasthan, Maharashtra, Odisha, and Chhattisgarh. Many interior districts in Orissa, Madhya Pradesh, Andhra Pradesh, Punjab, West Bengal, and Gujarat have the telemedicine facilities.

Presently, ISRO's telemedicine network has empowered 382 hospitals with the telemedicine facility. A total of 306 remote/rural/district hospital/health centers and 16 mobile telemedicine units are associated with 60 super specialty hospitals located in the major cities. ISRO's telemedicine network has supported Shankar Nethralaya at Chennai, Meenakshi Eye Mission and Aravind Eye Hospital at Madurai, and four other corporate eye hospitals to launch mobile teleophthalmology services. These administrations help in early diagnosis and treatment of ophthalmic diseases under National Blindness Control Program. Simultaneously, mobile vans are broadly utilized for teleophthalmology, diabetic screening, mammography, child care, and community health. The mobile teleophthalmology facilities provide services to the rural population in ophthalmology care including village-level eye camps, vision screening for cataract, glaucoma, and diabetic retinopathy.

The Centre for Development of Advanced Computing

The C-DAC[16] works in the area of health informatics and provides training to healthcare professionals to efficiently use telemedicine solutions with the help of telehealth equipment and training specialists. C-DAC training enables successful implementation of electronic medical records and providing technical assessments and business analyses.

C. Hospitals and Biomedical Institutions

The core of telemedicine, be it eHealth, mHealth or medical research, is the medicine. Innovation in terms of pioneering mobility in medical instrument, spreading awareness of the benefits, reliability and correct use of telemedicine techniques are just a few critical roles taken up by

organizations under hospitals and biomedical institutions. In India, hospitals and institutes across locations and size of operation are continuing to be a part of many initiatives. The most striking contributions have been seen from the Apollo group and SGPGIMS. Other noteworthy contributors include premier medical institutions such as AIIMS, New Delhi (Jammu and Kashmir, Haryana, Odisha, North East states network); PGIMER, Chandigarh (Punjab and Himachal state network); Sri Ramachandra Medical College and Research Institute (Andaman and Nicobar Islands), Tata Memorial Hospital and Sir Ganga Ram Hospital, New Delhi; The Amrita Institute of Medical Sciences (AIMS); The Asia Heart Foundation; Fortis Hospital; Narayana Hrudayalaya; and Escorts Heart Institute and Research Center.

The Sanjay Gandhi Post Graduate Institute of Sciences

Since the commencement of SGPGIMS (Fig. 40)[17], it has been actively involved in promoting telemedicine. It has helped in networking 14 national and international partner nodes and carrying out tele-education and telehealthcare activities. It has effectively participated in various research and development activities in collaboration with its technical partners. The organization is additionally credited with establishing the School of Telemedicine and Biomedical Informatics to prepare workforce in this field.



Fig. 40. School of Telemedicine and Biomedical Informatics, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India

Apollo Hospitals

In the year 2011-2014, Apollo hospitals planned to open 1,000 telemedicine centers. It also has actively participated in various other eHealth activities. Apollo hospitals, with Aircel, have additionally launched the first telehealthcare delivery on the mobile for consumers in India. In the past, Ericsson and Apollo have also collaborated for the 3-month Gram Jyothi project, which aimed at exploring benefits that can be met for rural India with the advent of internet connectivity and bridging the digital divide. Gram Jyothi covered 18 villages and 15 towns.

In September 2010, Apollo hospitals joined hands with pan-India telecom operator—Aircel to launch the first telehealthcare delivery on the mobile for consumers in India. With a subscriber base of more than 45 million, Aircel is India's fifth largest service provider, making it an ideal partner for Apollo to launch a mobile healthcare initiative initially via two dynamic products—Tele Medicine and Tele Triage.[18]

Governing Laws and Policies

World Health Organization (WHO) defined the concept of telemedicine as “The delivery of healthcare services by all healthcare professionals using information and communication technologies, for the exchanges of valid information for diagnosis, treatment, and prevention of disease and injuries, research and evaluation, and for the continuing education of healthcare providers, all in the interests of advancing the health of individuals and their communities.” However, no legislation singularly deals with the practice of telemedicine in India [19].

Therefore in the absence of defined law, as the practice of telemedicine is basically an intricate combination of “the practice of medicine” with “information technology,” all the existing laws relating to both ‘medicine’ and ‘information technology’ in India would apply to telemedicine.

Telemedicine has been recognized by the Government of India, which includes formulating schemes and policies.

National policies on telemedicine include [20]:

- National Steering Committee on telemedicine under constituted (2005);
- Budget Head by Planning Commission for eHealth including telemedicine—12th 5-year plan (2012–2016);
- National Standards on telemedicine (2003);
- National Rural Telemedicine Network (2007);
- Health education content delivery, skill enhancement and healthcare outreach services project through high speed fiber backbone National Knowledge Network (NKN);

- Draft National Standards of Electronic Health Record (EHR) on Public domain (2016) [21];
- Malawi National e-Health strategy (2011-2016) [22].

Government has taken initiative in getting specific legislation for telemedicine and the laws applicable to telemedicine in India are the laws governing the medical profession, patient-doctor relationship and information technology.

Consequently, the practice of telemedicine in India is governed by various statutes that generally relate to the practice of “medicine” in India such as the Medical Council of India Act, 1956 (MCI ACT) and the rules and regulations issued there under and state specific legislations where the business is proposed to be established. According to this MCI Act, the medical practitioner who is qualified and registered in one of the state medical registers should forward one copy of his/her registration certificate to the MCI for enrolment of his/her name in the Indian Medical register (national database).

On the other hand, for all medical treatments via telemedicine or web-based interface format, it is necessary that the issued prescriptions should satisfy the requirements of being in writing and signed by a registered medical practitioner, in accordance with the Drugs and Cosmetic Rules 1945, without which the prescription will be invalid as per the law. Telemedicine would also be governed by the Information Technology Act, 2000 that gives standards in relation to information technology.

Recommended Guidelines and Standards for Practice of Telemedicine in India

The DIT, and MCIT have issued recommended “Guidelines & Standards for Practice of Telemedicine in India” in May 2003.

The guideline outlines the necessary information in terms of introduction to telemedicine including definitions and concepts, standards required for hardware, software and clinical devices, security aspects, and finally the telemedicine process.

The guidelines also suggest that each healthcare provider should have a unique provider identifier, which will flow to all its programs and telemedicine specialty centers (TSCs). Each of the TSCs and telemedicine consultation centers (TCCs) are also recommended to have a separate unique and universal identifier code. The guideline also describes the hardware and software (including detailed configuration and specifications) required for setting up of the TCC and TCSs. This guideline for telemedicine also provides adequate risk mitigation at various stages in the

process of telemedicine and thus, must be closely consulted while setting up telemedicine organizations.

Telemedicine Initiatives in India

Telemedicine initiatives are adopted to deliver quality healthcare measures to patients existing in remote locations by the aid of medical specialists, doctors or healthcare professionals present in another site using ICT. The advanced use of ICT makes a single specialist to analyze more than one patient at a time as compared to conventional methods, and also making the prescriptions online.

The DIT, MoHFW, MCIT, ISRO, certain state governments, private hospitals (Apollo and Narayana), as well as few nonprofit organizations have played substantial role in the expansion of telemedicine in India. Few models of initiatives initiated by the government bodies, academics, hospitals, and other organizations in India are:

A. Initiatives by Government and Government Bodies

Department of Information Technology Initiatives

DIT, MCIT, and Government of India have implemented more than 75 nodes all around the country. The initiatives undertaken by the DIT are following:

- It has supported the development of many telemedicine software systems. Among them Sanjeevani® and Mercury® software by C-DAC are the prominent ones, and it also funded the telemedicine project linking three premier medical institutions such as AIIMS, New Delhi; PGIMER, Chandigarh; and SGPGI, Lucknow [11];
- In alliance with state government, DIT supported West Bengal telemedicine network for the diagnosis and monitoring of tropical diseases;
- Oncology network in Kerala and Tamil Nadu provides services for facilitating cancer care detection, treatment, pain relief, follow-up, and continuity of care in peripheral hospitals of regional cancer centers. From the boosting results obtained from the Kerala oncology network, the MoHFW led the OncoNET program in India to embrace all the states in India;
- In alliance with National Informatics Center (NIC), Community Information Centers (CICs) has been set up primarily in 30 blocks of the North-Eastern states and Sikkim using NICNET (National Informatics Center);

- It initiated specialty healthcare services to residents in remote areas of north-eastern states of India at Naga Hospital, Kohima and rural parts of Mizoram and Sikkim with support from Apollo hospital, Delhi and Marubeni India Ltd., Government of Nagaland [23].

Telemedicine Initiatives undertaken by the Ministry of Health and Family Welfare

National Medical College Network Project

MoHFW has launched National Medical College Network (NMCN) project in which 41 government medical colleges have been networked in the first phase by riding over NKN (National Knowledge Network) with high-speed bandwidth connectivity. The projected network will bestow learners and teachers to practice distance continuing medical education using various ICT-enabled educational technologies. The NKN has established connectivity between five regional resource centers (AIIMS, New Delhi; PGIMER, Chandigarh; JIPMER, Puducherry; North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences (NEIGRIHMS), Shillong; and KEM, Mumbai) for tele-education, tele-CME, telespecialist consultations, telefollow-up and access to digital library etc. Standard operating procedures (SoP) and guidelines for execution of NMCN have also been formulated. For execution of the NMCN, a technical evaluation committee and a financial evaluation committee have constituted and process of shortlisting the system integrator (SI) has been undertaken [11].

OncoNET Project

Under national cancer control program, MoHFW implemented OncoNET India, which is a network connecting 27 regional cancer centers with 108 peripheral cancer hospitals. The projected network delivers comprehensive cancer treatment facilities and accomplishes cancer prevention and research activities.[11]

National Digital Medical Library Consortium Project

The National Medical Library's electronic resource in medicine (ERMED) consortium is an initiative undertaken by the Director General of Health Services (DGHS) to advance nationwide electronic information resources in the pitch of medicine. A total of 39 centrally funded government institutions (10 under DGHS, 28 laboratories under the ICMR, and one under the AIIMS libraries) has been chosen at the early stage as

core members. The MoHFW provides funds needed for the procurement of electronic journals under this consortium project.[24]

Telemedicine Projects Initiated by Ministry of External Affairs, Government of India

SAARC Telemedicine Network

It is a pilot project, which connects one or two hospitals in each of the SAARC countries with the superspecialty hospitals such as AIIMS, New Delhi; SGPGIMS, Lucknow; PGIMER Chandigarh; and CARE Hospital, Hyderabad in India. Jigme Dorji Wangchuck National Referral Hospital, Thimphu, Bhutan; and Indira Gandhi Child Hospital, Kabul, Afghanistan have been connected to SGPGIMS, Lucknow and PGIMER, Chandigarh under this project for tele-education and telehealthcare activities. It is a prototypical model developed for implementing projects at the regional level. It has an immense potential to develop the scope of regional cooperation to other ICT-enabled areas such as education, business process outsourcing and mass communication.[15]

Pan-African eNetwork Project

The MEA implemented this project through TCIL to establish a VSAT-based infrastructure in 53 African countries of the African Union by satellite and fiber optic network that would provide effective tele-education, telemedicine, internet, videoconferencing, and VoIP (Voice over internet Protocol) services. Ten superspecialty hospitals in India were identified to provide telehealth services to 53 remote African hospitals.[15]

Telemedicine Network in Karnataka

The Karnataka State Government established an autonomous trust to run a telemedicine project called 'The Karnataka State Telemedicine Network Project' in the 2001. In collaboration with ISRO and MoHFW, the state has connected 30 hospitals in the operational phase. This network in Karnataka embraces all the district hospitals in the state, which in turn connected to five specialty hospitals in Mysore and Bangalore.[11]

Odisha Telemedicine Network

In collaboration with the DIT, Government of India, and SGPGIMS, Lucknow, telemedicine services are initiated in Odisha in 2001. Consecutively in the same year, ISRO came out to implement a telemedicine network in Odisha.

- Phase I: Odisha telemedicine network, established in 2003, linked all the three government medical college of Odisha (Situating in

three districts of Ganjam, Sambalpur, and Cuttack) to SGPGIMS, Lucknow, through satellite-based VSAT connectivity. ISRO provided all the required hardware and software along with bandwidth connectivity free of charge.

- Phase II: In 2007, network services are further extended to embrace district headquarters, hospitals of Koraput, Bhawanipatna, Baripada, Rayagada, Sundergarh, and Capital Hospital, Bhubaneswar, in collaboration with ISRO [25].
- Phase III: Odisha telemedicine network, implemented by C-DAC, Pune has expanded the existing telemedicine services, fabricated in Phase-I and Phase-II in the state. It is intended to cover the entire state under telemedicine services network. C-DAC has built telemedicine networks in numerous places covering specialty hospitals, district hospitals, taluka hospitals, and primary health center (PHC) [26]/

Sehat Initiative

The government has launched a pan-India health initiative known as Social Endeavour for Health and Telemedicine (SEHAT) in line with its Digital India vision. It runs in alliance with Apollo Hospitals. The main aim of the initiative is to connect 60,000 common service centers across the country and offer healthcare facilities to residents regardless of their geographical location. The Digital India initiative is an umbrella program, which delivers government service on internet and mobile, strives to build digital infrastructure, and digitally endow all the citizens with an investment of INR1.13 trillion over the subsequent 3–5 years. The cardinal targets of Digital India is to connect all the villages at the panchayat level through some 250,000 common service centers, which act as access points for delivery of various government services to citizens. Apollo hospitals opened India's first telemedicine center in 2000 in Aragonda, Andhra Pradesh. Sangita Reddy, the joint managing director of Apollo hospitals said "Telemedicine can provide rural population access for basic, specialty and superspecialty consultations. Since 80% of conditions do not require a doctor's physical presence immediately, they can be dealt with through telemedicine" [27].

B. Corporate Hospital Initiatives

Telemedicine Initiatives by Narayana Hrudayalaya

In 2002, Narayana Hrudayalaya initiated telemedicine services to deliver healthcare facilities to the rural population in India. Through the ISRO network, it embraces 332 hospitals—299 remote/rural/district

hospitals/healthcare centers linked to 33 specialty hospitals located in major cities. The hospital has framed a network of 4–5 intensive care units (ICU) and 20 telemedicine centers with an aim to provide 24-hour support to the patients. The network of the hospital links countries such as Pakistan, Malaysia, and Mauritius. Almost 550 CME cases have been referred through telemedicine, most of them were cardiac problems. ECG reports, audio/visual data, CT scans, X-rays, MRIs and their analysis are exchanged via the telephone line, broadband connection, or satellite provided by ISRO. The hospital uses a telemedicine ECG machine manufactured in Schiller India, a Germany-based company and with software, which is internally developed. The telemedicine services provided by the hospital are free and more than 21,000 cases have been referred using this service. Narayana Hrudayalaya is also a part of "The Karnataka Telemedicine Project," which was inaugurated on April 8, 2002 and links two rural hospitals in Saragur, Karnataka—the Chamarajnagar District Hospital and the Vivekananda Memorial Hospital [7].

Sankara Nethralaya Teleophthalmology Project

Sankara Nethralaya was established by Dr. S.S. Badrinath to deliver charitable eye care services. The hospital has gained international recognition and is admired for its quality care.

Teleophthalmology project was initiated to provide telemedicine services to the eye disorders in the remote/rural areas. A fully equipped van with all the medical and telemedicine amenities visits remote/rural areas where patients are diagnosed by a team of optometrists for various eye disorders, including diabetic retinopathy, cataract, and glaucoma. Based on the diagnosis, patients are fetched to Sankara Nethralaya for further treatment free of cost [28].

Apollo Telemedicine Networking Foundation

The main vision of Apollo is to provide a successful operating model of telemedicine, which propagates throughout India and into the developing world. It provides a channel for continuous access to the most sophisticated medical support systems at all times. Additionally, telemedicine improves patient care, enhance medical training, standardize clinical practice, stabilize costs, and unite clinicians worldwide. The Apollo telemedicine network allows the participant sites to collaborate with institutions in the country and abroad and provides patients with access to better healthcare in areas not effectively functioned by the medical community. Bill Clinton, the President of the United States of America, on his visit to India in April 2000, visited Apollo telemedicine station in Hyderabad and said, "I think it

is a wonderful contribution to the healthcare of the people who live in rural villages, and I hope that people from all over the world will follow your lead, because if they do then the benefits of the development in medicine can reach everyone and not just to people who live in big cities." Regarding mHealth initiatives, Professor K. Ganapathy, President and Head, Apollo Telemedicine Networking Foundation said, "My interest in mHealth commenced in August 2007 when Ericsson approached me to understand the feasibility of providing value-added healthcare services using 3G along with other services to a cluster of villages near Mahabalipuram. We carried out the first clinical trial using a 3G spectrum, especially obtained for the study. Clinical evaluation of 240 patients through videoconferencing, including teleauscultation and transmission of 12 lead ECGs entirely through wireless were carried out, followed by a mini master health check-up for 75 patients in a village. X-rays and ultrasound images, including video streaming of echocardiograms were transmitted through wireless. Following this, SMS texting was used to provide appointment alerts, inform doctors about admissions, lab results, etc. Home-grown mobile phone software was then deployed in the management of diabetes. In pilot projects, glycosylated hemoglobin (HbA1C) values were significantly lowered. Recently, we have initiated electronic house visits and have even provided healthcare on moving trains through existing wireless networks. To demonstrate commitment to mHealth, 24/7 medical response centers have been recently started by a sister concern Health Net Global. Accessible to mobile phone users, these cost-effective resource centers are manned by trained personnel, who use customized evaluated algorithms/triage protocols to evaluate the caller's health needs. The protocol has been tested with millions of patient encounters in UK during the last decade. All this can be availed at a cost of less than INR 40 for an initial teleconsult" [29].

Karnataka Internet Assisted Diagnosis of Retinopathy of Prematurity

In 2008, Narayana Nethralaya Postgraduate Institute of Ophthalmology, envisioned this teleophthalmology program known as Karnataka Internet Assisted Diagnosis of Retinopathy of Prematurity (KIDROP) to diagnose, screen, and tackle infant blindness caused by retinopathy of prematurity (ROP) in under-served areas of Karnataka. The team includes doctors, ophthalmologists, ROP experts, and other specialists. The pilot project commenced in 2008 with five centers. In the first part of 2011, KIDROP has grown to screen in 25 centers spread across the southern six districts of Karnataka. Most of these are in the rural or semiurban centers. None of them had ROP screening prior to being included. Since 2010, the project has collaborated with the MoHFW to include 36 more centers, which started

operating in 2012. Narayana Nethralaya foundation capitals KIDROP with a social responsibility that, “no child must go blind for want of financial resources.” Narayana Nethralaya, in collaborations with i2i Telesolutions, Bangalore has developed an internet-based hardware–software platform using a patented compression technology that allows live uploading, viewing and reporting of images from any part of the globe directly accessed by the KIDROP doctors on their PCs and smart phones. This technology was announced among the "Top Ten Medical Innovations" in 2009.

KIDROP has screened more than 3400 unique infants at more than 25 neonatal care centers spread six districts covering a radius of care of more than 350 km in the first 36 months of its initiation. Approximately 400 infants have received laser and other treatments in the peripheral centers without travelling to the city. Among them, more than 72% received treatment, which were either free or subsidized, and more than 18,000 imaging sessions were recorded and an image database of more than 200,000 images were generated [30].

Sri Ganga Ram Hospital-launched Telemedicine Centers

Sri Ganga Ram Hospital (SGRH), New Delhi, launched its telemedicine centers in 2007. With a public–private partnership (PPP), between the SGRH and government, the telemedicine technology has initiated services in three rural areas of Gohana in Haryana, Kaithun in Rajasthan, and Dasmal in Himachal Pradesh. Among these, Gohana center has diagnosed 5,000 cases in past 6 months, which revealed the success of this project. After 2 years, the government launched 15 more such centers in India. Furthermore, it soon launched teleophthalmology and mammography vans linked to SGRH by an ISRO satellite. These vans are placed in different states and visits different villages every day. The hospital has also devised an operating model called “VRC” in alliance with the MoHFW, the Department of Science and Technology, and the Department of Space. This model is utilized to provide healthcare services to remote/rural areas. The network comprises of three nodes situated at Gohana, Sonipat, and Kaithun. The VRCs will also provide a variety of services such as tele-education, telemedicine, e-governance services, information on weather services, and water management. All the three nodal centers have the medical lofts with the facilities of X-Ray unit, ECG unit, laboratory, and telemedicine unit and are connected to SGRH by video-conferencing technology [31].

Nanavati Hospital Telemedicine Initiative

National Rural Health Mission (NRHM), Maharashtra recognized Nanavati Hospital telemedicine department in 2009 as a specialist center and became a part of the esteemed project of the MEA. It is managed by TCIL to provide the best consultation services and CMEs to its district and sub district hospitals in the state of Maharashtra.

The department was made equipped with high-end communication tools, servers, studio equipment, audio–video editing systems, data storage infrastructure, and connectivity to African continent through dedicated sea fiber optic cable. This robust technical infrastructure enabled hospital to conduct teleconsultation, CME programs in 53 African countries in a systematic manner in past 5 years.

Nanavati Hospital is privileged to be the only hospital in Western India to provide such kind of international telemedicine services. The department is equipped with latest video conference equipment, computer hardware, server, camera, webcam, printer, media storage devices, and Integrated Services Digital Network (ISDN) broadband satellite connectivity. It also has software to provide an efficient technical platform to facilitate the specialist doctors and other users to access live high-resolution image quality, data transfer of voice, patient profile, and investigation reports simultaneously, enabling doctors to examine patient and guide doctors at nodal centers to start the treatment [2, 32].

C. Academic Hospital Initiatives Projects Undertaken by SGPGIMS Maha Kumbh Mela Project

SGPGIMS carried out this project during the Maha Kumbh mela held in 2001 at the Sangam, Allahabad to notice the benefits of telemedicine technology over and above the traditional healthcare delivery system. The project network was setup with 128 kbps ISDN link at five locations including the mela site field hospital, local medical college at Allahabad, SGPGIMS, public health department, and mela-monitoring cell at Lucknow situated 300 km away. Consistent interchange of healthcare related data and videoconferencing were done between these nodes. Continuous testing of water samples from diverse areas over several square km aided to stop water-borne diseases and epidemic outbreaks [33].

National Informatics Center tele-CME project for North-Eastern states through VSAT

This project was conducted in 2004, between SGPGIMS, Lucknow and NIC, Delhi. The tele-education conference of this institute was telecasted interactively with eight North-Eastern states headquarters and broadcasted

to 450 community information centers located in the same region. Various departments such as microbiology, endocrine, surgery, gastroenterology, gynecology, rheumatology, immunology, anesthesiology, and neuro-ophthalmology participated in this project. This program has helped the doctors at the peripheral, remote or rural hospitals to become conscious about the modern advances in the management of the patients. Initially, it was started as a monthly session, but after its popularity and increases demand, it was held twice in a month [33].

Project Undertaken By Amrita Institute of Medical Sciences

AIMS and Research Center, Kochi is one of the few medical institutions selected by ISRO to take part in its pilot telemedicine project. This delivers teleconsultations to residents in rural or remote locations in India such as Leh-Ladakh and Lakshadweep islands. It is an energetic department, active in medical care, education, and research. It renders tele-education programs such as CME, conferences and workshops with world-class institutions such as the University of Southern California in Los Angeles, Beth Israel Hospital at Harvard University, Johns Hopkins University, Division of Digestive Diseases, the University of Illinois, Chicago, Division of Gastroenterology, and SGPGIMS, Lucknow. AIMS has used the technology to deliver specialty medical support during times of natural disasters, including the Indian Ocean Tsunami and Bihar floods. Apart from providing consultations to the rural/remote corners of India, AIMS uses its telemedicine link to educate the doctors in rural/remote primary centers for the modern medical advancement through workshops, seminars, and teaching programs. AIMS telemedicine program is implemented successfully through its connection with an ISRO satellite [34, 35].

ISRO-PGI Telemedicine Project 2016

In collaboration with MoHFW, ISRO established three nodes in rural/remote areas. The three nodes include Community Hospital Corporation, Pooh, Himachal Pradesh; Pampa Hospital, Sabrimala, Kerala; Sheshnag, Amarnath located in Jammu and Kashmir. Memorandum of understanding (MoU) has been signed between the MoHFW and ISRO for providing tele-education to all the connected centers with the help of PGIMER. PGIMER is transmitting tele-CME services to more than 100 ISRO-linked centers.

Under the Kaya Kalp program of Government of India, inspired by the MoHFW, the Rotary Club of Chandigarh had commenced this project to augment the quality of life of children undergoing major surgical procedures, during their stay in the hospital. Renovations of the toilets,

interior decoration of the ward, creation of a recreation facility for the children are accomplished in this project at a cost of approximately INR 25 lakhs [36].

D. Other Organizations

Byrraju Telemedicine Services

It is a nonprofit organization inaugurated on 9th January 2006 in 10 villages, which had a last mile strong connectivity. After 3 months of its inauguration, these services had extended to 150 villages. The main aim of the services is to track and manage the health of thousands of people.

- In phase I, implementation of the service was enabled in registering and searching patients' history and their records, primary health details, and tracking primary health prescriptions in the areas of infant vaccination, maternal care, hypertension, and school health.
- In phase II, the solution was extended to cover areas such as dental and eye care, epilepsy, cancer detection, and health insurance [37].

Karnataka Integrated Telemedicine and Telehealth Project

The Government of Karnataka, the Narayana Hrudayalaya hospital in Bangalore, and the ISRO initiated an experimental telemedicine project called Karnataka Integrated Telemedicine and Telehealth (KITTH) project. It is an online healthcare initiative in Karnataka. With connections by satellite, the project operates in the coronary care units of chosen district hospitals, which are in turn connected with Narayana Hrudayalaya hospital. Each Critical Care Unit (CCU) is linked to the main hospital to ease the analysis by healthcare specialists once the ordinary doctors have investigated the patients. If the patient needs an operation, she/he is referred to the main hospital in Bangalore; otherwise admitted to a CCU for consultation and treatment. Telemedicine delivers access to zones that are unserved or undeserved. It improves access to specialty care and lessens both time and cost for remote, rural and semiurban patients. Telemedicine augments the quality of healthcare through timely diagnosis and treatment of patients. The most vital aspect of telemedicine is the digital convergence of medical records, x-rays, charts, histopathology slides, medical procedures, and laboratory studies piloted on patients [38].

Sehat Saathi Project

Sehat Saathi, a rural telemedicine system, developed by Media Lab Asia research hub at Indian Institutes of Technology (IIT) Kanpur, used to expand the medical care to patients in the remote parts of the country. The model provides front-end support through an aptly trained nonmedical

professional and provides back-end support from doctors, specialists, pathologists, and other healthcare professionals for mitigation and treatment. It also uses a digital technology to attain the objects and broadcast information on health and disease [39].

Health Management and Research Institute Initiatives

Health Management and Research Institute (HMRI) is a not-for-profit organization works toward enhancing the availability, accessibility, and affordability issues of health/medical services to underserved groups. It reduces the issues in the public health system through its continuous health information helpline. Health information helpline is the healthcare contact center that delivers round-the-clock-services to the citizens. These helplines have been established in collaboration with various state governments. It has worked with the Government of India and Department of Telecommunications to launch 104 as India's central number for nonemergency health services. By calling to 104, the people can access counseling services, free medical information and advices, directory information, and complaints against public health facilities. As of November 2013, the helpline services have aided 67 million callers, covering a population of 383 million people.

In addition to the above health information helpline, HMRI runs four major programs. The health information helpline is a health contact center that provides medical services round the clock.

Asara program: It was launched in 2010 to provide primary and secondary healthcare services. In partnership with MacArthur Foundation, it focuses on maternal health (antenatal and postnatal). It links patients to obstetrics and gynecology through the Asara Telehealth Center, raises awareness, trains traditional birth attendants, and eases home-based neonatal care among the people.

Dox-in-Box technology: HMRI provides services through this technology, which captures, stores and transmit eight vital signs—blood sugar level, temperature, heart and lung sounds, peripheral capillary oxygen saturation (SpO₂), images of the ear-nose-throat and skin, pulse rate, and ECG. This information is then transmitted and stored in the central database, thus enables virtual consultation, diagnosis, and treatment [40].

eSwasthya microfranchise: The model helps the patients to setup clinics at home, in which they link patients to doctors through the mobile technology, with a minimal fee.

Mobile health services: It operates mobile medical units, consisting of medicines, medical devices, and health workers who visit villages daily on a fixed basis. The units deliver education, medication, screenings and

referrals, monitoring and follow-up, and also maintain electronic health records for maternal and child health, chronic diseases, and minor ailments [28].

Balabhai Nanavati Hospital Telemedicine Center

Balabhai Nanavati Hospital telemedicine center was established as an outreach initiative of the Balabhai Nanavati Hospital, Mumbai, to address difficulties of mobility, accessibility, and availability of primary healthcare. The network delivers telemedicine services to 78 peripheral hospitals in the country. It has launched various e-clinics and telemedicine units in India. The centers deliver teleconsultation, teleradiology, mobile health consultation/education/disease prevention, and live physiotherapy sessions. Telemedicine services are given for cardiology, urology, pediatrics, neurology, dentology, dermatology, orthopedics, nephrology, oncology, obstetrics, gynecology, ophthalmology, urosurgery, and neurosurgery consultations [28].

Orissa Trust of Technical Education and Training Telemedicine

It is a nonprofit organization project, developed as a PPP (public-private partnership) between the Orissa Trust of Technical Education and Training (OTTET) and the Government of Odisha, in technical collaboration with the School of Telemedicine and Biomedical Informatics, SGPGI, Lucknow, National Resource Center for Telemedicine, and MoHFW. It uses technology to deliver high-quality healthcare services to the residents in remote/rural areas. It trains local community members to run the centers and provide telehealth services. The centers are equipped with medical equipment, telemedicine software, video conferencing, and are connected to superspecialty hospitals. The company delivers health services for a range of conditions, for example cardiovascular diseases, hypertension, diabetes, skin diseases, respiratory diseases, anemia, common ailments, eye care, chronic diseases, and nonemergency care. Each telemedicine center delivers services to a population of 20,000 to 30,000 [28].

Check on Implementation of the Initiatives

- Under National Human Rights Mission (NHRM), various state governments have started implementing a telemedicine network. States such as Andhra Pradesh, Chhattisgarh, Karnataka, Kerala, and Rajasthan have covered all the districts under telemedicine network. States such as Madhya Pradesh, Jammu and Kashmir, Punjab, Haryana, and North-eastern states have taken telemedicine in an immense way.

- Large companies such as Oil and Natural Gas Corporation (ONGC) have implemented telemedicine for their remote operations.
- Narayana Hrudayalaya telemedicine network is performing more than 350,000 teleconsultations annually. With 800 telemedicine centers across India, it has treated over 53,000 patients with heart ailments through telemedicine.
- The OTTET telemedicine project has benefited more than 205,000 patients.
- The telemedicine initiative has been implemented in the School of Tropical Medicine (STM), Kolkata and in two district hospitals including coronary care unit inaugurated in Siliguri district hospital, Siliguri, West Bengal; and Bankura Sammilani Hospital, Bankura, West Bengal. Apart from the project at STM, the second telemedicine project has been implemented by Webel ECS include two referral centers—Nil Ratan Sircar Medical College and Hospital, Kolkata; and Burdwan Medical College and Hospital, Burdwan, and four nodal centers—Midnapore District Hospital, Behrampur District Hospital, Suri District Hospital, and Purulia District Hospital. The project uses a 512 kbps leased line and West Bengal State Wide Area Network (WBSWAN; 2 Mbps fiber optic link) as the backbone.
- Sankara Nethralya teleophthalmology project has organized 4,666 teleophthalmology camps and 406,237 patients underwent complete ophthalmology examinations as of 2014.
- ISRO's telemedicine network has connected 45 remote and rural hospitals and 15 superspecialty hospitals. The remote/rural nodes include the islands of Andaman and Nicobar and Lakshadweep, the mountainous and hilly regions of Jammu and Kashmir, Medical College hospitals in Orissa and some of the rural/district hospitals in the mainland states. This telemedicine network has connected more than 300,000 people. In collaboration with ISRO, MoHFW has implemented integrated disease surveillance program network. ISRO has prepared and submitted a draft proposal for national telemedicine grid to MoHFW.
- The BNH telemedicine network has aided more than 4,000 patients in rural Maharashtra, Madhya Pradesh, Gujarat, and Daman and Diu.
- To address various issues in the telemedicine in national context, MoHFW has setup National Task Force on Telemedicine in 2005.
- HMRI's Telemedicine initiatives and mobile health services have aided 25,000 patients and 26 million people, respectively [23, 28, 41, 42].

Opportunities and Challenges

India's Vision

The ever-growing Indian population has shaped the healthcare in India in terms of both revenue and employment. Although, it has become one of the country's largest sectors, the rural population is still deprived of the healthcare facilities. High demands for healthcare and constrained resources pose a challenge for the development of the health system in India. The advancements in the field of technology provide the opportunity to create a sustainable telemedicine ecosystem in India. Regions with deprived accessibility to doctors would be a spectacular opportunity to leverage diagnosis from a distance.

Various parameters influence the rural healthcare scenario, including affordability and availability of healthcare personnel and medicine, infrastructure, social security/insurance; and viable, sustainable, and scalable business models. Telemedicine in India is more of a technological issue. India aims at delivering healthcare to the farthest of the villages by harnessing satellites, information technology, and generating large amount of information for an efficient telemedicine network system. Approximately 72.2% of Indian population resides in the rural areas challenging the extension of services [1]. The diverse landmass in India makes it an ideal setting for telemedicine.

Availability and accessibility of the healthcare infrastructure are not guaranteed to the needs of the people, especially in rural areas. Availability of transportation facilities such as ambulance services for the transport of severely ill patients to the community centers is minimal. Private transportation between PHCs and the district/state hospitals is irregular and infrequent. Most of the PHCs lack the presence of telephonic communication facilities as well. In case of emergencies, the healthcare system in the rural regions has taken a toll on the health of the patients and has become unreliable and undependable.

The presence of a diverse population in the urban and the suburban regions brings about varied expectations leading to equally disappointing health facilities. The urban population is facilitated with better healthcare and transportation services compared to rural regions. Although, it favors the urban, the slums, which constitute for half of the urban area, are left out of the frame being deprived of the facilities.

The collaboration initiated by the MoHFW between the ICT and the present health infrastructures is working toward sealing the gap between the urban and rural healthcare facility systems. ICT innovations developed by MoHFW are being utilized in the promotion of telemedicine in the

remote/rural areas in India. Some of the most important initiatives by the MoHFW include National Medical College network, National Telemedicine network and use of space technology for telemedicine. The current Director of Telemedicine Division of MoHFW, Mr. Jitendra Arora, has implemented the initiation of the telemedicine services.

Opportunity of Telemedicine in India

The specialty healthcare infrastructure, being the need for telemedicine, provides an opportunity to the healthcare providers, telecom vendors, and policy makers to offer healthcare to the masses. To address the scantiness of healthcare in India, telemedicine is receiving a huge support from the Indian Government. To create the awareness in the country, several governments, quasi-governments, and private telemedicine service workers are actively engaged. With its huge IT and medical work force with expertise, India keeps the great promise in the field of telemedicine.

India is emerging as a leader in the field of telemedicine by offering following opportunities:

- **Increase availability:** As India has low permeation for healthcare services, the primary healthcare facilities for the inaccessible parts of the India are highly inadequate. Rural and remote areas continue to strive for the healthcare quality despite the initiatives taken by government and private sectors. Since rural people have to travel long distances to obtain healthcare facilities, most of the people do not consult doctors in the early stage of the disease cycle and thus fail to meet their appropriate medical needs. Increased medical expenses are also one of the reasons why rural people do not get appropriate medical treatment. They generally visit doctors when the condition is very serious. Due to this, approximately 29% of Indian population is highly dependent on free healthcare facilities offered by the public sectors. It has been found that approximately 20 million families get dropped down to below poverty line due to the healthcare expenditure. Thus, telemedicine offers an opportunity to reach the patients in the remote areas, by locally taking advice from specialists without traveling long distances. Hence, to deliver healthcare facilities for the people of India, telemedicine acts as a key driver of public-private partnership. Telemedicine has aimed to deliver advanced healthcare to the remote parts of India, where the maximum number of diseases not requiring surgeries could be favorable to telemedicine. It also plays an important role in training majority of healthcare professionals across the country. Telemedicine is economically viable due to the

reduction in the price and complexity of the technology in the past 5 years.

- **Address shortage of medical professionals:** As the majority (80%) of physicians resides in urban areas in India, and with the 72.2% of the rural population having limited access to healthcare services, the biased healthcare delivery is evident. Although, PHCs are being constructed in the remote areas, the country is still experiencing a lack of trained doctors and nurses. In fact, India has one doctor for every 15,000 people and specialists have been found to be even rarer. Due to absence of qualified doctors and limited or no training, medical healthcare personnel in rural area become unqualified practitioners. Healthcare in rural India is largely absent or inadequate as doctors and the healthcare centers concentrates on the cities. Thus, telemedicine offers to bridge this gap in India.
- **Opportunity in a varied range of applications:** To overcome the disadvantages of distance and time, telemedicine has a potential to bridge the gap between the clinicians and patients. Telemedicine helps to establish virtual communities by interacting and sharing knowledge, improving healthcare access in rural areas, and increasing the continuity of care. Clinical applications, educational and administrative applications are the generic applications of telemedicine.

Clinical application include handling urgent consultations, remote visits of the patients, scheduled consultations and video reviews of certain studies done in advance

Administrative applications include raising and quickening the replication, updating and transfer of clinical information, which involves medical records, financial information, and examination data.

Educational applications: The process of sharing the materials of teaching and examination is facilitated in the medical field. Interesting cases from a conference rooms, auditorium and teleconference to physicians and residents scattered throughout the network are presented using this technology.

Telemedicine applications can be listed as:

- Far-off consultations and critical care monitoring;
- Diseases reconnaissance and program tracking;
- Second opinion and complex interpretations;
- Continuing medical education and public awareness;
- Disease management;
- Disaster management;

- Home care and ambulatory monitoring and telementored robotic procedures.

Extending Broadband

Without broadband internet, it would be impossible to fulfill the promise of telemedicine as the future of health IT. The biggest lift for the telemedicine is broadband. India is now becoming the searing destination for telemedicine, with the greater availability of broadband, as it is a win-win situation for both hospitals and patients. Medical information, medical services, and advices are provided by the telemedicine with the use of multimedia technology through video, voice, and data.

Delivery of healthcare to long distances has become easier with the development of technologies of video and data compression and bandwidth. Numbers of types of medical services delivered from distances, including every specialty have been increased by the improvement in the standard of video and data compression and the due to lower cost of the bandwidth. The broadband market of telemedicine is expected to move from 18th position to 6th position in the world [9].

Development of ICT Industry

One of the greatest opportunities for the telemedicine to grow in the Indian market in the next few years is through 3G services rolling out across the country. A radical change is expected to be triggered by the 3G services. A much smoother and clear picture of how to consult the doctors is expected to be given by the 3G services.

Decreased Cost of Medical Care

The prime concern about healthcare is increasing cost. The overall cost of the treatment substantially contributes to the expenses of the patient care including cost affected by travel, food, and accommodation to the relatives. The burden of care on the patient can be reduced by decreasing the cost associated with the treatment. Telemedicine seems to be the solution for reducing the cost burden on patients.

Initiatives by Government and Public-Private Sector Partnership

In order to make healthcare access to the communities of rural India, the Government of India is investing in Telemedicine. To integrate telemedicine, many public and private sectors are investing substantial money and efforts. Telemedicine seems to be the solution for the deficiencies observed in healthcare. According to government's 11th 5-year plan (2007–2012), it has allotted INR 2,000 million for telemedicine. Most

of the funding is directed by the public–private partnerships. A favorable ground for the telemedicine is already set up across the country, as required infrastructure in the form of broadband connectivity is in place in the large parts of India. The budget proposed under 12th 5-year plan (2012–2017) for telemedicine program was INR 3000 million [43]/

Government of India strategy for ICT applications in health during 12th 5-year plan (2012–2017):

- Access to CME and skill up-grade programs, as well as back-up support for telemedicine;
- All district hospitals linked by telemedicine channels to leading tertiary care centers;
- m-Health, the use of mobile phones to speed up transmission;
- The use of ICT in health education, health status analysis, and expansion of related research.

For apprehending telediagnosis, teleconsultation, and tele-education, The Ministry Information Technology is connecting three premier medical institutes—AIIMS, New Delhi; PGIMR, Chandigarh; and SGPIMS, Lucknow.

Improved and Combined Health

The delivery of integrated health and the social care has become a significant challenge, as the prevalence of the chronic and long-term illnesses have considerably increased. A new approach for the health and social care is therefore required due to lifestyle and demographic change, unmet needs of personalized care, and the increasing incidences of the chronic disease. The cost per treatment might increase, as chances of lifestyle diseases are anticipated to be more than the infectious diseases in the next 5–10 years. Telemedicine is expected to offer following advantages:

- The increasing incidence of lifestyle diseases can be reduced by targeting telemedicine wellness programs at work place.
- ICT offers a great opportunity to recognize care integration in the current scenario of prevailing health burden
- For a long-term care, to promote innovations that challenge the system to concentrate on prevention of diseases, support for self-care, and the delivery of the care closer to people’s home, there is a need for new mobile models such as telehealth and telecare.
- Long-term health conditions such as heart failure, diabetes, and chronic obstructive pulmonary diseases can be managed by growing interest in the telemedicine services.

Timely Intervention

Medical records in electronic format can be transmitted to medical specialists with the help of technology. For example, an electrocardiogram of the patient with heart disease can be immediately be sent to the expert view through telemedicine facility associated with the data and voice capability. The cost for telemedicine is also less and provides the correct diagnosis and treatment.

Beginning of the Cloud Market

Cloud marketing, also called Infrastructure and Service (IaaS) market, is at a preliminary stage in India. The interest in the capability of the IaaS services have been significantly recognized by the Indian market across the industry segments. The public or the private cloud can be applied to:

- Store pathology and other reports such as x-ray;
- Maintain patient records/billing/claims;
- Host in-house applications;
- Connect the doctors/hospitals, patients, and diagnostic companies on a community level;
- The cloud market is expected to offer 100,000 jobs in India, as it is projected to grow in coming years.

Some of the service provider segments like Tata communications, Net Magic, Wipro, evolve the more stable cloud offerings. In order to enhance the capacity, Tata communications has offered its customers an improvised virtualized environment with flexible arrangements.

Professional Education and Teaching

Telemedicine services offer networked usage of specified medical expertise depending on the skills of the medical professionals. It also provides opportunities to learn and train professionals through real-life operations or by allocating experiences with the contemporaries worldwide.

Knowledge Management and Administrative Education

The trend of virtual networking in the healthcare revelries has to be started with the latest resurrection of telemedicine in the country. Telemedicine is expected to progress from point-to-point networks to more integrated, coordinated, and interoperable systems. The provision of the development of the administrative education communities has been provided by the IT-enabled networks along with the collaboration with multiple players on multiple sites. Thus, knowledge acquisition, creation, sharing is promoted by these organizations, which permits quality

enhancement and novel perceptions in the awareness-based healthcare delivery industry.

Responsive To Precautionary Healthcare

To defend the patient and provide information for the clinicians what they require, the healthcare in India needs to be shifted from the present reactive health care to a more proactive model. This is because, preventive care could not be as effective as it would be and the health care model is built around the hospital and waits for the sick people to come to the hospitals. However, telemedicine offers following opportunities:

- To shift the focus of the organization to the person;
- To assist prevention and presents itself as a new way to use technology ;
- To recognize the risks associated and interfere before an emergency visit is needed;
- Patients get to make smarter healthcare choices, as they gain access to the required health information.

Other Opportunities

The various aspects of telemedicine include teleconsultation, telediagnosis, tele-education, telediagnosis, teletraining, telesupport, and telemonitoring by incorporating entire information of the patient in the medical record (Fig. 41).

As telemedicine is more consistent when compared to the physical system, telemedicine is therefore more appropriate for the disaster management. The telemedicine market in India is estimated to be \$7.5 million and in the next 5 years, it is expected to grow at a CAGR around 20%. It has found that every year, approximately 1.5 lakh people are benefited from telemedicine. The global telemedicine market grew from \$9.8 billion in 2010 to \$11.6 billion in 2011 and almost tripled to \$27.3 billion in 2016, growing at a CAGR of 18.6% [44].

The major player of telemedicine in the India—The Apollo Telemedicine Enterprise Ltd is the largest provider of telemedicine, Asia Heart Foundation, Narayana Hrudayalaya, Escorts Heart Institute, Arvind Eye

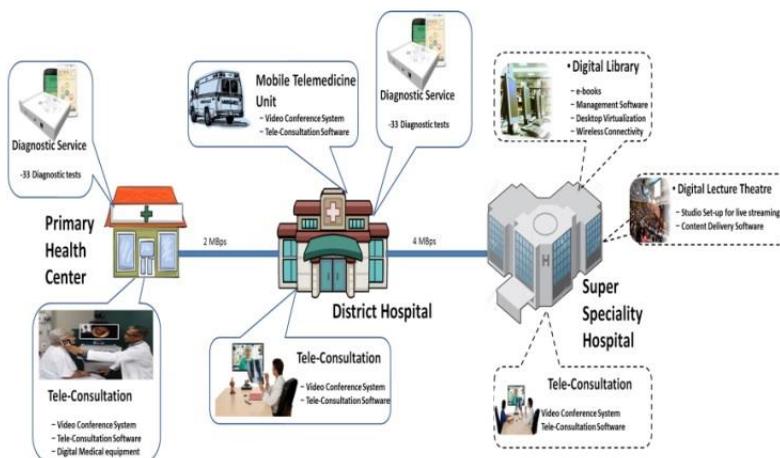


Fig. 41. National Telemedicine network (Adapted from MoHFW, Government of India)

Care etc. are the private sectors driving telemedicine in the country [1]. AIIMS, Delhi; SGPGI, Lucknow; PGIMER, Chandigarh are among the public sectors. The major reasons for the increased market of telemedicine in the country is because of the elevated usage of wireless and web-based services and acceptance of the 3G and High Speed Packet Access (HSPA). However, lack of computer healthcare personnel, the requirement of high capital (approximately \$10,000), and the reduced reliability are some of the roadblocks of telemedicine in India.

In order to implement a telemedicine delivery system in approximately 212 primary healthcare centers, 38 district hospitals and, a central unit at Patna, Ktwo Technologies has been selected by a Karnataka government-owned enterprise called Keonics. The National Rural Tele Medicine Ayush Network project was actually awarded to the Keonics by the State Health Society of Bihar; however, the Keonics was in turn partnered to KTwo in order to start deliverable solutions. At present, KTwo along with its flagship invention Kshema, Unified Healthcare System might provide and implement Telemedicine system on a Build Own, Operate, and Transfer

(BOOT) model for 3 years. To supervise the entire operation managed with video conferencing facilities, the command and the control center would be established in Patna [1].

Challenges

Despite the encouraging activity in the field of telemedicine, many observers think that there is still a long way for telemedicine to establish itself as an inescapable way of delivery of healthcare. Telemedicine has achieved the erratic levels of success, despite its promise. To deliver routine services, telemedicine has to be unswervingly engaged in the healthcare system. Very few pilot projects have the capability to endure themselves once the initial funding has made. According to SK Mishra, Head of Telemedicine project at SGPIMS, telemedicine can be made more attractive and viable with better business model. Telemedicine appears as a contradiction due to the mad rush among issues of the poor earnings. The shortage in the permanency of several telemedicine endeavors is cited by several challenges, which include;

- ***Network infrastructure:*** To meet the growing demand for the healthcare services in India, the infrastructure of telemedicine and health needs to be modified. To provide affordable and quality healthcare services, the Government of India has undertaken various initiatives by establishing PHCs across the country. However, PHCs fail to provide adequate healthcare solutions, as they are not reliable and they work with the internet speed of 33.6 Kbps, which makes the inadequate connection of the PHCs to the district hospitals. Thus, the basic online information exchange or the advanced video transmission technology would not provide instant healthcare services to patients in the rural villages.
- ***Costing:*** The application and the adoption of the telemedicine in the country are posed by the financial cost. An extra up-front investment is required to provide healthcare solutions to the large population of the country. To reduce the overall cost of the healthcare, there is an increased need to manage the cost associated with it. To provide services of healthcare to the masses not enough funds are available. There is requirement of huge cost for the equipment, maintenance, and training the staff. The weak convincing evidence for the overall cost-effectiveness of the specific telemedicine strategies and its implementation is one of the major drawbacks. One possible way is to obtain resources from the schemes of the different government and to form a fast and vigorous technology infrastructure fund, which helps in multiple

verticals like healthcare, education and financial. This would not only help in building the infrastructure, but also help in creating the synergy between different verticals.

- **Professional buy-in:** A significant challenge of telemedicine is to encourage doctors to relocate to the rural areas. It is not an easy task to ask doctors to devote part or all of their time for the treatment and support of the patients in rural areas. This challenge might increase as the telemedicine increases in scale. On the other hand, Indian doctors are also less likely to incorporate new technologies. Technologies that are offered on an opt-in basis is adopted slow by the physicians.
- **Patient buy-in:** For the financial feasibility, the models developed for telemedicine are new and depend upon the large number of patients. As telemedicine is new, there would be the short-term financial viability for the adaptation of the patient to the new and different form of healthcare.
- **With limited support from government:** Although there are financial resources available for the Indian government to provide medical care to the rural patients, an unfocused spending and the fund infrequently goes to the projects, which has an indirect benefit like the development of the infrastructure to make private enterprise to take part in the space.
- **Slow growth of infrastructure:** Though the number of hospitals with satellite connections has been extended to 100 institutions by ISRO, connections through satellites are very expensive and the areas do not generally have the best broadband connection.[6] There are several rural areas, which are not linked to the major cities.
- **Language diversity:** A webcam is used from the remotely based physician to speak directly to the patients in a primary care telemedicine clinic. Wherever communication difficulties have been encountered, pilots are launched in such locations. Since, India is a country, which has 22 official languages and hundreds of regional languages, which are common in rural areas, finding a physician in a broad range with knowledge of different languages or finding a way to overcome the language barrier would pose a significant challenge.

The additional challenges faced by the startups and public–private partnerships identified by the telemedicine society of India include:

- **Failed pilot projects:** To prepare for more than one pilot project, the cash-strapped startup does not generate the required amount of

money for the preparation. There is a challenge for the startups once the pilot fails. This is due to unavailability of funds for the product modification or to change in the business model/product market. Such issues may generally kill a viable concept.

- ***Underinvestment in research and development:*** Even after the successful completion of the pilot projects, there would be a lack of data in many startups to exhibit their undertakings to other potential customers. However, it has been found that, the benefits generated by the pilot, role of tracking the outcomes, and the benefits associated with the pilot projects to the doctors or the NGOs is done with the active role played by the startups.
- ***Complicated contracts:*** It would be difficult to keep track when something goes wrong, as the projects associated with telemedicine involve two or more parties in the delivery of care. It is difficult to be liable in such situations. This would then result in poor contracts for the startup or prevents by being signed in the first place.

Potential Solutions for Telemedicine In India

Education and Training for E-Learning in India

Open Access Bibliography

In order to gratify the information required by the Indian medical community, the Indian Medical Literature Analysis and the Retrieval System (MEDLARS) center was established by the two government agencies called NIC and the ICMR. Several web-based modules such as union catalogue of Journal holdings of medical libraries has been developed by the ICMR-NIC center of Biomedical Information Database on the Indian Biomedical Journals (<http://indmed.nic.in>) and full texts of Indian biomedical Journals (<http://medind.nic.in>) [15]/

Collaborative Knowledge Sharing

Academic medical institutions such as AIIMS, New Delhi; SGPGIMS, Lucknow; PGIMER, Chandigarh; Christian Medical College, Vellore; AIMS, Kochi, are involved toward professional knowledge sharing the academic activities on the telemedicine network.

National Digital Medical Library Consortium

To develop the resources of nationwide electronic information in the field of medicine, the Director General of Health services (DGHS) has taken an initiative of National Medical Library's Electronic Resources in Medicine Consortium. The core members of the institution include, 76 centrally

funded institutes including 10 from DGHS, 28 laboratories of the ICMR. Under this project, the MoHFW provide funds to purchase electronic journals.

Medvarsity

In order to provide an online delivery platform for continuing medical education, the Apollo Hospitals Group in collaboration with National Institute of Information Technology (NIIT) Ltd. has launched Medvarsity. They offer variety of courses for the doctors, nurses, and other paramedical personnel.

School of Telemedicine and Biomedical Informatics

The School of Telemedicine and Biomedical Informatics has been set up in the campus of SGPGIMS, Lucknow with the support from Uttar Pradesh State Government. The DIT has identified this school as the National Resource center for telemedicine. The school is also involved themselves in producing different low-cost telemedicine products and has received trainees not only from within the country but also from abroad. The objectives of the school are:

- Creation of various facilities for research;
- Organizing structured training programs;
- Research and development;
- To provide consultancy to government and private organizations in association with technical and medical institutions in the country and abroad;
- To start curriculum-based telemedicine courses very soon.

Apollo Telemedicine Network Foundation

The Apollo Telemedicine Network Foundation in association with Anna University started a 15-day certificate course on telehealth technology, which is a blend of technical, medical, and administrative skills.

RAD Gurukul

In order to provide training and to improve the skills of teleradiologists, technologists and IT personnel of the healthcare IT, RAD Gurukul was launched in Bangalore by the solutions provider of the teleradiology services.

C-DAC Mohali

To effectively use telemedicine solutions, both on the site and remotely, the C-DAC Mohali provides a training to the healthcare professionals by

using telehealth equipment and with the help of training specialists. This would be helpful in training and support of the telemedicine system,

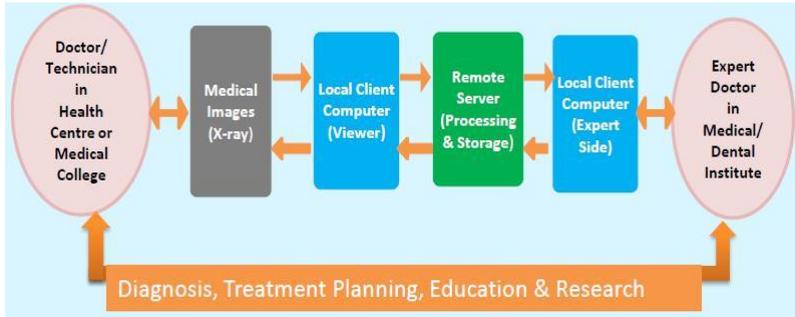


Fig. 42. Telemedicine Treatment planning (Adapted from MoHFW, Government of India)

implementation of electronic medical records, and for business analyses and technical assessments.

Research and Development

DIT initiative

DIT in association with its societies such as CDAC and partnership with many medical and technical institutions such as AIIMS, SGPGIMS, PGIMER, and the Indian Institute of Technology, has been involved in research, development, design and organization of the progressive telemedicine products and solutions. DIT also specialize in biomedical, telemedicine, electronics, and entrepreneurship development. An institution-based and application-based telemedicine software systems such as “Mercury” and “Sanjeevani” were also developed by DIT at three leading medical institutions of India.

SGPGIMS initiative

SGPGIMS in association with its technical partners has developed and included various applications in telemedicine modules apart from the mobile telehospital for rural health care, teleambulance for emergency healthcare, and movable suitcase telemedicine module for calamitous situations.

Research Publications

Numerous research publications have been contributed by India in reviewed scientific journals and chapters on book to the related fields. The telemedicine India Web portal can be used to find the compilation of these publications [15].

Though telemedicine application projects have been undertaken in many states in the country, research and development has not grown in that proportion [23]. Research projects carried out / under development till date are summarized in Table. 4.

Table 4. The summary of research projects

Sl. No	Organi- zation	Project title	Objective	Funding agency
1	SGPGIMS, (June1999)	Telemedicine in extremes of environment	Telehealth care for the Kailash Mansarovar Pilgrims	Kumaon Mandal Vikas Nigam, SGPGIMS
2	SGPGIMS (January 2001)	Application of the telemedicine technology to provide telehealthcare during mela / festival and disaster	Telehealthcare in festivals and disaster situations	DIT, Ministry of communica tion and IT, Govern- ment of India
3	AIIMS, SGPGIMS, PGIMER, C-DAC, Mohali (2001-2005)	Development of telemedicine technology and its implementation towards optimization of medical resources	Development of telemedicine software (Mercury and Sanjeevini)	DIT, Ministry of communica tion and IT, Governmen t of India
4	SGPGIMS (2002)	Development of mobile telemedicine units	Mobile healthcare in remote areas, emergencies and disaster management	OTRI Ahmedabad
5	SGPGIMS (2002)	Development of portable telemedicine units	Emergencies and disaster management	OTRI

		in suitcase		
6	IIT	Development of portable mobile rural healthcare module (Sehat Sathi)	Dissemination of information, diagnosis and treatment on health and disease	Media Lab Asia
7	IIT, Kanpur	A mobile platform (Infothela)	Designed to accommodate diagnostic equipment and other primary health diagnostic and testing equipment	Media Lab Asia
8	IIT, Kharagpur	Augmentative communications system for the speech impaired and people affected with cerebral palsy (Sanvog)	Natural language sentence generator	Media Lab Asia
9	IIT, Kharagpur	An embedded Indian language text to speech system	Provides a speech-based communication interface for speech impairments talking web browser for visually challenged	Media Lab Asia
10	AIIMS, New Delhi	A replicable model for IT-based health system at grass root level	Digital is updating of data at PHCs and CHC management of childhood diseases on handheld devices	Media Lab Asia
11	IIT Delhi	Zero configuration wireless mesh	Disaster mitigation and	Media Lab Asia

		network	management	
12	Byrraju Foundation	Ashwini centers in 84 villages of Andhra Pradesh	Specialist consultation health education and promotion of continuous medical education	Byrraju foundation

SGPGIMS-Sanjay Gandhi Post graduate Institute of Medical Sciences, AIIMS-All India Institute of Medical Sciences, IIT-Indian Institute of Technology, PHC-Primary Health Care center, CHC-Community Health Center, PGIMER-Post Graduate Institute of Medical Education and Research, OTRI-Online Telemedicine Research Institute, DIT-Department of Information Technology

National Scientific Societies

In order to develop awareness and to provide a platform to share research experience in the advancing field of healthcare informatics, annual scientific meeting is organized by The Medical Computer Society of India, The TSI, and the Indian Medical Association of Informatics [23].

Emerging Trends of Telemedicine

Various national level projects have been under the plan and implementation stage by the Government of India. In addition, mobile and telemedicine centers have been organized within the country to provide medical facilities in the remote parts of the country [15]. This includes:

- ISRO telemedicine nodes have launched a dedicated satellite, HEALTHSAT;
- To enable the national cancer control program, MoHFW has launched “OncoNET” India Project, which is expected to connect 27 regional cancer centers along with 100 peripheral cancer centers;
- Under National Rural Health's mission, another major initiative is National Rural Telemedicine Network (NRTN);
- To establish National Telemedicine Grid; all the medical colleges are in the stages of implementing the National Medical College Network Project in the emerging field of e-learning as per the recommendation of the national knowledge commission;
- Some of the tertiary care academic medical institutes of the country will be recognized as Medical Knowledge Resource Centers and linked to medical colleges in the region;

- The National Resource Centers for telemedicine and biomedical informatics are established under the DIT support at the school of telemedicine and biomedical informatics at SGPGIMS, Lucknow;
- Various other projects in collaboration with other government organizations have been under the planning stage by DIT. Some of the projects include development of a web-based telemedicine system for chronic diseases, E-health visualization and e-health associated field, advanced ICT for healthcare, proof of concept project in district by NIC state center, Hyderabad and access to quality healthcare in Tamil Nadu through a pilot telemedicine network;
- The National Knowledge Commission has launched the Indian health information network;
- To facilitate telemedicine in India, a memorandum of understanding was signed between the Government of India and Afghanistan;
- DIT has collaborated with European Union (EU) for the development of the robust grid infrastructure worldwide, to associate with EU in various fields of e-health and e-governance and to build the platform of the network to furnace alliances between industries and academics.

Road Map Ahead and Forecast on Telemedicine Market

In the past few years, telemedicine has emerged long way with the advancement in technologies and internet. It has made healthcare services more accessible to the general population, particularly in the remote areas. Using technology, hospitals and clinics has served critically ill patients by consulting them through videoconferencing. It can be observed that telemedicine has great potential to overcome various issues in current healthcare set-up such as enhancing the access to healthcare, improving quality of care, and decreasing overall healthcare costs.

In 2015, the global telemedicine market was estimated to be around USD 23,224 million and is expected to reach USD 66,606 million by 2021, growing at a CAGR of 18.8% during the forecast period (2016–2021) [45]. The global market for telemedicine is categorized depending on technology (hardware, software, telecommunications), service (remote patient monitoring, store-and-forward, real-time interactive), applications (telecardiology, telepathology, teleradiology, teledermatology, teleneurology, emergency care, and home health), delivery mode (web-based, cloud-based), and end user (Tele Hospitals, Tele Homes). The largest segments of the Telemedicine market are telepathology, teleradiology,

tele dermatology, teledermatology and telepsychology. Although, telemedicine represents a small share in the healthcare market, it is one of the fastest sectors in healthcare market.

As we know, the tremendous growth in telemedicine is predicated, especially due to its potential to revolutionize healthcare delivery. Increasing population, emerging number of chronic diseases and rising cost of healthcare services are the predominant key drivers for the growth of telemedicine market in India. Along with this, enhanced use of technology in healthcare conveyance, shortage of physicians in rural areas is foreseen to provide new prospects for growth of telemedicine market. Despite the great scope for telemedicine growth, there are certain major factors such as legal issues, high cost of advanced technology, lack of physician support, and lack of infrastructure, which are affecting the telemedicine market in India. In addition, inadequacy of trained and skilled professionals in the remote areas, lack of consumer awareness about new technology, and uses are some of the other aspects that are inhibiting the growth of telemedicine market.

Although, India is facing these issues, the Ministry of Information Technology has developed “Recommended Guidelines & Standards for Practice of Telemedicine” with the aim of standardizing digital communication in telemedicine. Simultaneously, the government has also focused on enhancing telemedicine capabilities in India. The 11th 5-year plan (2007–2012) allocated approximately INR 2,000 million to telemedicine, which is channeled through public–private partnerships. The 12th 5-year plan (2012–2017) allocated INR 3,000 million to telemedicine. The necessary infrastructure (satellite and broadband connectivity) is also in place in most parts of country as per the MoHFW.

Attempts are also taken in other fields of telemedicine, such as medical e-learning by developing digital medical libraries. Various government bodies, private telemedicine solution providers, and few associations are also effectively engaged to create more awareness about telemedicine in the country.

Telemedicine players have focused on enhancing their technology offerings in terms of hardware, network, and software. Some of the key participants in the global telemedicine market include Philips, Aerotel Medical Systems, InTouch Technologies, Medtronic, HoneyWell Life Sciences, LifeWatch, AllScripts Healthcare Solutions, Mckesson Corporation, BioTelemetry, SHL Telemedicine Ltd., AMD Global Telemedicine, Cardiocom.

However, various challenges remain in the telemedicine market in India, despite the fact that telemedicine is gaining popularity in India.

Conclusion

In a developing country like India, where 70% of population resides in rural villages, there is a great inequality in healthcare distribution with major healthcare issues such as inadequate infrastructure of rural health centers, poor access to healthcare services, and high cost of healthcare services. Such issues make a daunting challenge for India in providing quality healthcare to its citizens, especially in remote areas.

Telemedicine, the use of telecommunications to improve patients' health status by exchanging medical information from one site to another, is an emerging field in healthcare, which has enormous potential in meeting the challenges of healthcare delivery to rural and remote areas. Telemedicine has provided an impetus to the government's vision of quality for all by helping in delivering quality healthcare and in controlling medical costs. As telemedicine can bring positive changes to the healthcare systems, this chapter focusses on "*Telemedicine adoption in India*" to give us a clear picture of the current state of telemedicine adoption in India.

To promote telemedicine and to create awareness in the country, various government telemedicine service providers and associations have come forward. In India, telemedicine programs are actively supported by:

- DIT;
- ISRO;
- Apollo Hospitals;
- North Eastern Council-Telemedicine program For North-Eastern states;
- State governments;
- Asia Heart Foundation;
- Other private organizations.

As a part of this attempt, the DIT, Government of India, under a high-level committee formulated a set of "*Standards & Guidelines for Practice of Telemedicine in India.*" The main user ministry is taking the initiative further. A subgroup for telemedicine standards was constituted under the aegis of the Task Force for Telemedicine in India, which was constituted by the MoHFW. The various members from the subgroup were drawn from different government and private agencies/institutions that took initiatives in the form of development of generally acceptable standards and guidelines in telemedicine.

Over the years, telemedicine has progressed from the preliminary stage to the actual enactment stage in India, where it has emerged as leader of telemedicine due to its enormous work force and related expertise in medical and information technology. Although, telemedicine has brought

advancements in healthcare delivery systems, various challenges such as legal issues, high cost of advanced technology, lack of infrastructure etc. exist, which need to be addressed for effective implementation of telemedicine.

To conclude, until these issues remains in India, adoption of telemedicine will continue to lag behind when compared to countries such as the United States of America, Australia, and the United Kingdom.

This chapter concludes that the widespread adoption of telemedicine projects in healthcare system is increasing, which eventually will become a very essential tool among healthcare providers nationwide. This effective implementation of telemedicine projects in the country will enable comprehensive and effective diagnosis and treatment of patients, providing better healthcare access.

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Logos of Indian Organizations

<i>Indian Space Research Organization (ISRO)</i>	
<i>Apollo Hospital</i>	

<p><i>Telemedicine Society of India (TSI)</i></p>	
<p><i>Ministry of Health and Family welfare (MoHFW)</i></p>	
<p><i>Apollo Telemedicine networking foundation (ATNF)</i></p>	
<p><i>Narayana Hrudayalaya Hospitals</i></p>	
<p><i>Arvind Hospitals</i></p>	
<p><i>World Health Partners</i></p>	
<p><i>Indian Council of Medical Research</i></p>	
<p><i>Medical Council of India</i></p>	

<p><i>Centre for Development of Advanced Computing (C-DAC)</i></p>	 <p>CENTER FOR DEVELOPMENT OF ADVANCED COMPUTING</p>
<p><i>Postgraduate Institute of Medical Sciences (PGIMER)</i></p>	
<p><i>Indra Gandhi Medical College (IGMC)</i></p>	
<p><i>All India Institute of Medical Sciences (AIIMS)</i></p>	 <p>शरीरमात्रं खलु धर्मसाधनम्</p>
<p><i>Sanjay Gandhi Postgraduate Institute of Medical Sciences (SGPGIMS)</i></p>	
<p><i>Ministry of External Affairs</i></p>	
<p><i>South Asian Association for Regional Cooperation</i></p>	
<p><i>Telecommunication consultant India</i></p>	

<i>Airtel</i>	
<i>Aircel</i>	
<i>Sri Ramachandra Medical College and Research Institute</i>	
<i>Tata Memorial Hospital</i>	
<i>Sir Ganga Ram Hospital</i>	 <p>Sir Ganga Ram Hospital web: www.sgrh.com</p>
<i>The Amrita Institute of Medical Sciences (AIMS)</i>	
<i>Fortis Hospital</i>	
<i>National Informatics Center (NIC)</i>	 <p>Driving the Next Generation Government</p>
<i>The Indian Council of Medical Research (ICMR)</i>	
<i>CARE Hospital</i>	

<i>Sri Ganga Ram Hospital (SGRH)</i>	
<i>Nanavati Hospital</i>	
<i>Federation of Indian chambers of Commerce and industry</i>	
<i>National Institute of Mental Health and Neurosciences</i>	
<i>Vidhya Pratishthan's Institute of Information Technology</i>	



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He has been invited by global organisations like the United Nations, World Health Organization, World Economic Forum, ITU, Embassy of the United States

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He currently chairs; Continua India, HIMSS Asia Pacific India , Personal Connected Health Alliance – India , Innovation Working Group-Asia, amongst others .

Rajendra has traveled extensively and delivered lectures across the globe and has written articles in leading publications and is an author of a popular book, ‘Healthcare Reforms in India’, and also serves several advisory boards across USA, Europe, U.K. & India, and divides his time between public policy work and corporate boards.

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Introduction

Geography

The Federal Republic of Nigeria is located along the west coast of Africa between latitudes 4°16' and 13°53' north and longitudes 2°40' and 14°41' east. The land size is about 923,768 square kilometers. It extends from the Gulf of Guinea on the Atlantic coast in the south to the fringes of the Sahara Desert in the north. Nigeria shares boundaries with the republics of Niger and Chad in the north, the Republic of Cameroon on the east, and the Republic of Benin on the west. The Population of Nigeria was 140,431,790 by the 2006 census. The current population is about 173,610,000. In Africa, it is the most populous country and the 14th largest in land mass. Nigeria topography is composed of two main landforms: lowlands and highlands. “The uplands stretch from 600 to 1,300 meters in the North Central and the east highlands, with lowlands of less than 20 meters in the coastal areas. The lowlands extend from the Sokoto plains to the Borno plains in the North, the coastal lowlands of western Nigeria, and the Cross River basin in the east” [1-4].

The Nigerian climate is tropical, because of its location in the tropics characterised by two seasons - wet (raining) and dry. The wet season starts from April to September, while the dry season occurs from October to March with dusty Harmattan wind felt mostly in the north of the country in December and January. The temperature in Nigeria oscillates between 25°C and 40°C, and rainfall ranges from 2,650 millimeters in the southeast to less than 600 millimeters in some parts of the north, mainly on the fringes of the Sahara Desert [1].

History

Nigeria exists since 1914 and is a result of the amalgamation of the



Fig. 43. Map of Nigeria Showing different states and six geopolitical zones of administration. Source: 2013 Nigeria Demographic and Health Survey

Northern and Southern protectorates. Before that the following cultural, ethnic, and linguistic groups, such as the Oyo, Benin, Nupe, Jukun, Kanem-Bornu, and Hausa-Fulani empires, existed with their own system of governance. Other very strong ethnic groups were also the Igbos, Ibibios,

Ijaws, and Tivs. The introduction of British rule by the then colonial master resulted in the amalgamation of the protectorates of southern and northern Nigeria in 1914. They establish their own system of governance after the amalgamation known as crown colony type of government. The British administered the country until few Nigerians were involved in 1942. In the early 1950s, Nigeria achieved partial self-government with a legislature in which the majority of the members were elected into an executive council of which most were Nigerians. Nigeria obtained her independence from the British rule in October 1960 as a federation of three regions (Northern, Western, and Eastern) with a constitution that provided for a parliamentary system of governance. The Federal Capital Territory (FCT) was located in Lagos area [1].

Nigeria became a republican state on October 1, 1963, with a different administrative structure. Today, about 478 identifiable ethnic groups exist in Nigeria. The major groups are the Hausa, Yoruba and Igbo. The country is currently made up of 36 states and a Federal Capital Territory located at the center Abuja, grouped into six geopolitical zones: North Central, North East, North West, South East, South, and South West as shown in figure 43 [1-2].

Economy

Nigerian economy depended on agriculture until the discovery of oil in January 1953 [1]. Presently, the volatility in global commodity markets, “witnessed in the second half of 2014 brought their full weight to bear on the Nigerian economy in 2015”. The country revenue is mainly from oil for both exports and government revenues, and therefore fall in the oil price have slow down the growth of the economy. Oil prices fell 66.8% from \$114/barrel recorded in June 2014, to \$38.0 by December 2015. Prices fell even further in 2016, to \$32.6 as at 3rd February, 2016 [5]. The economic growth is slow as compared to previous years. This is due to fall in the oil price as well as non-oil sectors. The World Bank reported the Gross Domestic Product (GDP) per capita for Nigeria to be 5638.89 US dollars in 2015, when adjusted by purchasing power parity (PPP). The Nigerian GDP growth is lowest in the last 15 years [7-8]. This certainly affects government spending on health. Nigeria spent 3.7% of GDP on health in 2014 and public health expenditure per GDP was 0.9% [10-11]. What percentage of the GDP will the government be able to spend on eHealth?

Population Health and Demographics

Nigeria is one of the most populated and fastest growing countries in Africa and in the world. 49.5% and 50.5% of the Nigerian population are

women and men respectively. The annual growth rate is 3%. The population has been growing steadily since the last census in 2006. However, the gender ratio dropped from 103 men per 100 women in 2006 to 102 men per 100 women in 2013 [6]. The “four special and specific population categorization namely: children less than 15 years; youth 15---39 years; adult 40---59 years; and the elderly 60+ years showed that the trend for these categories generally remained constant throughout the periods 2006--2014’ [6].

Figure 44 shows the projected population of Nigeria from 2006 – 2014. Government has to harness all resources possible to meet the health demands of Nigeria’s growing population.

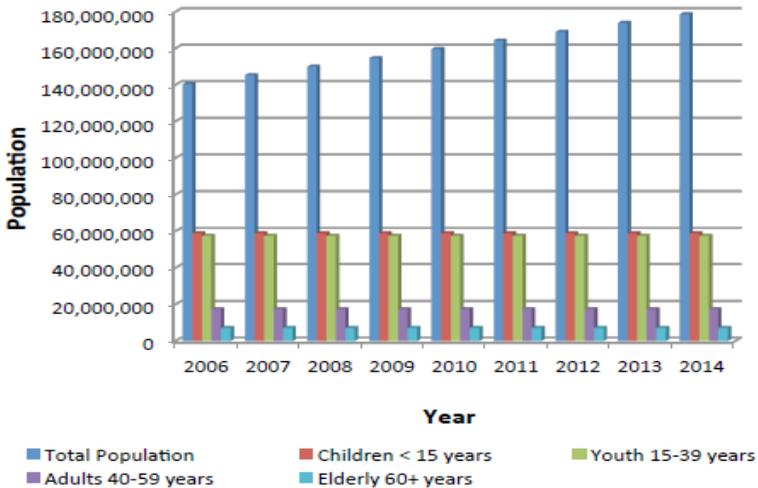


Fig. 44. Nigeria Population and Specific Population Category (2006---2014). Source: National Bureau of Statistics (2013) Demographic Statistics Bulletin

The Life expectancy at birth male/female (years, 2015) is 53/56, Probability of dying between 15 and 60 years m/f (per 1 000 population, 2013) is 357/325 and total expenditure on health per capita (Intl \$, 2014) is 217 [12]. The data above plus the distribution of diseases, injuries and disabilities in the population coupled with low government spending on health, implies the need to rethink how health is organized and delivered in the country.

Indicators	Statistics		Year
Population (thousands)	173615		2013
Population aged under 15 (%)	44		2013
Population aged over 60 (%)	5		2013
Median age (years)	18		2013
Population living in urban areas (%)	46		2013
Total fertility rate (per woman)	6.0		2013
Number of live births (thousands)	7173.0		2013
Number of deaths (thousands)	2071.4		2013
Birth registration coverage (%)	30		2013
Cause-of-death registration coverage (%)	...		
Gross national income per capita (PPP int \$)	5360		2013
WHO region	African		2013
World Bank income classification	Lower middle		2013

... Data from 2007 onwards not available.

Fig. 45. Basic Statistics. Source: Country statistics and global health estimates by World Health Organization (WHO) and United Nations (UN) partners

Indicators	Statistics	
	Baseline*	Latest**
Under-five mortality rate (per 1000 live births)	213	117
Maternal mortality ratio (per 100 000 live births)	1200	560
Deaths due to HIV/AIDS (per 100 000 population)	102.2	128.7
Deaths due to malaria (per 100 000 population)	205.6	106.9
Deaths due to tuberculosis among HIV-negative people (per 100 000 population)	103	94

*1990 for under-five mortality and maternal mortality; 2000 for other indicators
**2012 for deaths due to HIV/AIDS and malaria ; 2013 for other indicators

Fig. 46. Millennium Development Goals (MDGs) in Nigeria. Source: Country statistics and global health estimates by WHO and UN partners

Nigerian Health System at a Glance

A WHO report in 2000 ranked the national health system overall performance 187th among the 191 Member States of the WHO [13 - 14]. As at that time, most of the disease burden was due to preventable diseases complicated by poverty. The maternal mortality rate was very high and other health status indicator like under-5 mortality rate and adult mortality were higher than the WHO average for the sub-Saharan Africa [13]. The capacity for policy / plan / programme formulation, implementation, monitoring and evaluation at all levels was limited with no health act in place describing the national health system and functions of each of the 3-tiers of government [13]. The bedrock of the national health system remains Primary Health Care (PHC). “The poor performance of Nigeria’s health system can therefore also be primarily attributed to poor financial resourcing of health services” [13 - 14]. A national health plan was put in place by the Federal Ministry of Health (FMOH) in 2010 to “meet the challenges of achieving improved health status particularly for its poorest and most vulnerable population, the health system must be strengthened; proven cost-effective interventions must be scaled up and gains in health must be sustained and expanded” [14].

It was inspired by the 36 states of the federation and the Federal Capital Territory (displayed in figure 43). The National Strategic Health Development Plan (NSHDP) has driven a purposeful reform of the national health care delivery system; strengthen the weak and fragile national health care delivery system and improving its performance over the years. The plan focused on eight building blocks of the national health system that are Leadership and Governance for Health, Health Service Delivery, Human Resources for Health, Financing for Health, National Health Management Information System, and Partnerships for Health, Community Participation and Ownership, and Research for Health [14]. The NSHDP proposed a national health bill and was signed to Law in 2014. The National Health Act provides the legal framework for the regulation, development and management of the National Health System [15 - 16].

Historical Perspective on eHealth Development

Historically, eHealth related development efforts at national level started in Nigeria when health informatics took off around 1988-89 through a collaborative research project between the Computing Centre of the University of Kuopio, Finland and Obafemi Awolowo University, and the Obafemi Awolowo University Teaching Hospital (OAUTHC). It was organized as a component of Informatics Development for Health in Africa

(INDEHELA) and supposed to be a long-term strategic arrangement [17]. More details on this initiative are available at <http://www.uku.fi/indehela/>. Several interested individuals and groups made efforts towards telemedicine and eHealth development in 1994 after the Kuopio project but there was lack of political will to support the initiatives. The department of planning, research & statistics of the Federal Ministry of Health took steps as part of strengthening national health information system to plan for eHealth development and deployment in 1996, but suffered from lack of political support [18 - 19].

In 2001, professional bodies including the Computer Association of Nigeria (COAN) now Nigeria Computer Society, Information Technology Association of Nigeria (ITAN), Institute of Software Practitioners of Nigeria (ISPAN) submitted a draft policy on Information Technology (IT) at the national workshop on National Information and Communication Infrastructure, held in Abuja in 2000. This led to the development of a National Policy on IT with sectoral application for health. The government planned to invest in IT based healthcare systems to ensure that Nigerians have access to good healthcare delivery [20]. eHealth became a national development agenda in 2002, it was mentioned in the National Economic Empowerment and Development Strategy (NEEDS-2) to be launched as a component of eGovernance [19]. Notably, other groups began to emerge such as the Nigerian Telemedicine Development Alliance (NTDA) an online advocacy network founded in 2003 to propel a critical mass of professional aware and advocating for the growth of a national telemedicine infrastructure [21]. In 2004, National eGovernment Strategies, NeGSt, a “Special Purpose Vehicle (SPV) was launched by the Federal Government through the National Information Technology Development Agency (NITDA) with the mandate to facilitate, drive and implement the Nigerian eGovernment Programme under a Public Private Partnership (PPP) model. eHealth was part of the eGovernment Programme of NeGSt [19, 23].

The Society for Telemedicine and eHealth (SFTeHIN) was founded in April 2005 by Dr. Olajide Adebola (formerly Awolola) and became a national member of the International Society for Telemedicine (ISfTeH) in July 2005. The SFTeHIN members were individuals that felt there was a need to keep well-informed on what is happenings in the field of telemedicine / eHealth. They believe that the use of telemedicine / eHealth technology will improve national



health. The Society became the national eHealth association and strong advocate for the development of telemedicine and eHealth in Nigeria since its creation [24].

The Society was born with the vision of introducing Telemedicine and creating an eHealth network in Nigeria. In partnership with the WHO collaborating center on Telemedicine in Norway (Norwegian Telemedicine Center), the National Information Technology Development Agency (NITDA), the National e-Government Strategies (NeGSt), the Federal Ministry of Health and Communications, the Society organized its first national stakeholders meeting on developing sustainable telemedicine and eHealth program for Nigeria. The premier telemedicine workshop was held in 2005 and the first Pan African conference on telemedicine and eHealth was organized in 2006. The latter recommended to the Federal Government of Nigeria the need to develop eHealth in Nigeria and to create a national coordinating mechanism to carry out the task on developing telemedicine in Nigeria [25 - 26].

The Federal MOH created its ICT committee in 2003. The Society for Telemedicine and eHealth was nominated to function on the committee with a view to helping the FMOH achieve its ICT related reform goals. Proposed activities of the committee then included:

- Electronic linkage of the FMOH with its hospitals with the aim of creating something similar to a Wide Local Area Network (WLAN) whereby all tertiary hospitals can access each other, exchange information and create a reliable central database;
- Creation of an e-Library /e-Learning center for increasing the level of information dissemination concerning common health problems, the activities of the ministry and its programs and
- Training medical and paramedical personnel.

Since inception in April 2005, the Society for Telemedicine and eHealth in Nigeria has moved in leaps and bounds with the two-ground-breaking meetings mentioned above. “Its incorporation into the ICT committee for the Federal Ministry of Health is in recognition of the importance of Telemedicine and eHealth to the development and improvement of existing healthcare delivery systems in Nigeria and the immense International support from the parent body is a great bonus” [24 - 26].

These activities led to a meeting of the Society for Telemedicine and eHealth with the Nigerian President then, Chief Olusegun Obasanjo in October 17, 2006. In attendance were the Minister of health, key ministry staffs and government agencies. The target was to support telemedicine and eHealth development at national level. In that meeting, the president approved a national eHealth committee but unfortunately the committee was

never inaugurated due to paucity of fund at the FMOH [19, 27 - 28]. With strong advocacy by the Society, Nigeria began to witness several projects in space. By 2007, the Federal government through the National Space Research and Development Agency (NASRDA), initiated a telemedicine pilot project. The project aimed to prove the telemedicine concept in Nigeria, tune the program to meet the people's needs, find the best operating model for telemedicine in Nigeria, discover effective public relations mechanisms for telemedicine to drive the larger deployment, realize the vision of the Government to deliver Health according to the indices of the Millennium development Goals. The project could not scale up to second phase mainly due to lack of stakeholder collaboration and means of financing the project beyond pilot [19, 29]. In 2007, the FMOH created a national programme for Telemedicine as a result of the meeting with the president [19].



Fig. 49. Showing the mobile components of the NASRDA telemedicine project

The mobile unit in figure 49 is presently not in operation due to maintenance difficulty as a result of lack of funds. In addition, as a result of its size, this mobile unit has not been able to reach out to people in some very remote and isolated places [19].

In 2009, at the end of the 3rd Nigerian Conference, organized by the Society for Telemedicine and eHealth, a policy recommendation paper was published. Its strategic goal was to transform the healthcare situation in Nigeria using telemedicine / eHealth [30]. Again, stakeholders learnt from

the NASRDA pilot projects and this led to several developmental efforts at creating enabling environment for telemedicine / eHealth development in Nigeria such as:

- The National Space Research Development Agency developed a road map for telemedicine in 2009 in collaboration with FMOH.
- The National Information Technology Development Agency Developed ICT4D for health in 2008, revised in 2011 and adapted as the Nigerian National eHealth Strategy.
- The eHealth Division of the department of Hospital services of the FMOH produced a draft national policy on eHealth in 2013.
- Several projects have been identified in the country by 2014 that can be leveraged upon based on ICT4SOML initiative baseline assessment report and some are not sustainable. The ICT4SOML initiative with their technical partner initiated an ICT for Health framework development process in November 2014 [31].

All of these efforts and projects lacked stakeholder collaboration and coordination of different actors, which led to the creation in parallel of several national documents. They all have to guide eHealth development. The lack of a national coordinating mechanism and eHealth pilots was quite evident [19]. The 58th National Council on Health approved a National eHealth Strategy in March 2016 and the honorable minister of health inaugurated a national steering and technical committee on eHealth in August 2016 [32]. The two achievements by the FMOH put eHealth in the health development agenda of the country, resolving many of the challenges in the past toward telemedicine / eHealth development in Nigeria.

Highlights of eHealth foundational Activities in Nigeria by the Federal Government

1. Very limited ICT, eHealth development prior to 1999.
2. FGN adopted the National Policy on ICT in 2000 to guide the development of the telecommunications industry in Nigeria.
3. Based on the National Policy on ICT, the National Information Technology Development Agency (NITDA) was established in 2002 to serve as a national agency for coordinating Nigeria's Information & Communications Technologies for Development (ICT4D)
4. Nigeria Telecommunications Act was enacted in 2003 to give legal effect to the National Policy on ICT and NCC was set up as an independent regulatory body
5. FGN embarked on the construction of a government portal on the internet to facilitate the development of government-to-

- government, government to commerce and commerce to government interactions on the web.
6. FGN launched data and research satellite in 2003 and approved plans to launch communications satellite in 2006.
 7. In 2004, the Nigerian Government adopted Public-Private Partnership of a tripartite Joint Venture registered as National eGovernment Strategies Ltd (NeGSt) comprising government, consortium of banks and a strategic partner with mandate to drive the development of Nigeria's eGovernance initiatives.
 8. A policy on eGovernment was launched in 2006 under the implementation mandate of NITDA.
 9. FMOH established national programme for Telemedicine under the department of hospital services in 2007
 10. Development of Nigeria's ICT4D strategic action plan started in 2003 and the first ICT4D which covered the period 2008 to 2011 was revised in 2011 (the health sector was one the key sectors with planned activities on ICT).
 11. National Space Research & Development Agency (NASRDA) formulated a National Roadmap towards implementing e-health in 2009 with the support of the National Planning Commission.
 12. Creation of a new Ministry of Communication Technology to supervise the activities of all ICT agencies in Nigeria took place in 2011.
 13. Establishment of eHealth division under hospital services in 2011 and developed a national eHealth policy in 2013.
 14. 58th National Council on Health approved a National Strategic Health ICT Framework as national eHealth strategy in 2016.
 15. The honorable minister of Health inaugurated a national steering and technical committee on eHealth in 2016.

Some of the eHealth projects at National level are listed below:

1. A pilot project initiated by National eGovernment Strategies Ltd in 2006 to provide teleconsulting in cardiology with the use of video conferencing equipment and digitalized electrocardiography machine to Abuja communities.
2. A pilot project initiated by the National Space Research and Development Agency (NASRDA) in collaboration with FMOH in 2007 through provision of services by tertiary institutions – mobile health unit set up to shuttle across 8 states for a period of 2 months

3. India Pan African eHealth Network project at the Universities of Ibadan and Lagos Teaching Hospitals to help provide trans-border teleconsultation and training of workforce.
4. Intel telemedicine/eHealth project between Federal Medical Centre, Bida, and the National Hospital, Abuja, for critical pediatric care as well as surgical cases.
5. FCT eHealth pilot (the FCT eHealth web Portal Initiative) – an online portal that seeks to manage patient data/statistics and to close any existing gap between primary and secondary health systems by linking data across health facilities.
6. mHealth project with the National Primary Health Care Development Agency (NPHCDA) used in the Midwives Service Scheme(MSS).
7. Mobile Community Based Surveillance (mCBS) project designed to give traditional birth attendants the ability to report vital MCH events in real time using mobile phones
8. UNICEF supported an mHealth initiative which involves the implementation of Rapid SMS to track the supply of malaria bed nets as well as using Rapid SMS to pilot a child nutrition monitoring system
9. The application of developed in Nigeria Primary Health Care and Hospital Information System (MINPHIS) that keeps patient records and generates various reports for health management and research purposes.
10. Adoption of District Health Information System (DHIS) as a national tool for reporting aggregate data from the lowest to the highest level.
11. Establishment of a national eHealth data/documentation center to provide central coordination for national health data/information warehousing and management and hosting databases for all health programmes of FMoH in 2008
12. Lagos State Government's implementation of eHealth in 13 General Hospitals in the state enabling the hospitals to practice health care system supported by electronic processes and telecommunications technology.

Global Reports on eHealth Development in Nigeria

A WHO publication, Building foundations for eHealth: progress of member states; report of the Global Observatory for eHealth (GOe) on Nigeria in 2006 noted that actions to promote enabling environment for eHealth took place between 2000 and 2005. This is supported by the

historical account narrated above. The Lack of policy, technical issues, human resources and funding were the major challenge to eHealth development in Nigeria [33]. The infrastructure at all levels of health care delivery posed a challenge and public-private partnership is encouraged to promote access to electronic health content to address the lack of funds [33].

eHealth policy/strategy			
Status of eHealth and women's and children's health policy/strategy			
National eHealth policy/strategy exists		No	
Year adopted			
Implementation status			
Refers to the use of eHealth in women's and children's health policy/strategy			
Special funding allocated for implementation		Yes	
Women's and children's health			
National policy/strategy for women's and children's health exists		Yes	
Policy/strategy refers to the use of eHealth, mHealth or social media		Yes	
eHealth systems			
An overview of the types of eHealth systems in place, their purpose and level			
Electronic information system collects and reports births, deaths and causes of death data		Yes – partial coverage	
Year introduced		2011	
At least one electronic information system exists at the district level to collect and report health data		Yes	
Resource tracking system in place to report total health expenditure by financing source, per capita		No	
Type of resource tracking system			
Resource tracking system level			
Resource tracking system in place to report total reproductive, maternal, newborn, and child health (RMNCH) expenditure by financing source, per capita		No	
Type of resource tracking system			
Resource tracking system level			
Monitoring the status of women's and children's health			
An overview of the measurement of the 11 CoA indicators by monitoring frequency and format			
Indicator measured	Monitor	Frequency	Format: Paper, Electronic, or Both
Maternal mortality ratio	Yes	Every 5 years	Both
Under 5 child mortality with the proportion of newborn deaths	Yes	Every 2 years	Both
Children under 5 who are stunted	Yes	Every 2 years	Both
Met need for contraception	Yes	Every 2 years	Both
Antenatal care coverage	Yes	Every 2 years	Both
Prevention of mother-to-child HIV transmission (PMTCT)	Yes	Every year	Both
Skilled attendant at birth	Yes	Every 2 years	Both
Postnatal care for mothers and babies	Yes	Every year	Both
Exclusive breastfeeding for six months	Yes	Every 2 years	Both
3 doses of the combined diphtheria, pertussis and tetanus vaccine	Yes	Every year	Both
Antibiotic treatment for pneumonia	Yes	Every 3 years	Both
eHealth initiatives – national overview			
eHealth supports major women's and children's health initiatives		Yes	
Funding sources		Public funding, Private funding, Donor funding, Public-private partnerships	

Fig. 50.1. eHealth and innovation in women's and children's health – Goe 2013 survey. Source: WHO GOe Survey Country profile Nigeria 2013

The GOe country profile 2009 described the eHealth foundation actions in Nigeria towards building an enabling environment for the use of eHealth. These include policy, legal and ethical frameworks, adequate funding from various sources, infrastructure development, and developing the capacity of

the health work force through training. The report revealed that Nigeria had no national eHealth policy but have eGovernment policy. A legal and ethical framework for eHealth is not available. It shows that current eHealth expenditure is mainly by government, donor bodies and public –private partnership arrangements. Barriers to telemedicine

Possible barriers to implementing eHealth services	
The most important barriers hindering the implementation of eHealth services	
Infrastructure - not yet adequate, accessible, or cost-effective to support desired services	Yes
Standards - lack of nationally adopted standards (e.g. ICD, DICOM, HL7, SNOMED) for the systematic adoption of eHealth services or health information systems	Yes
Human resources - lack of suitably qualified or experienced professionals who can develop and implement eHealth projects and promote their use	Yes
Financial - limited or no reimbursement by insurance companies for services; business models not yet developed for broad and sustainable eHealth delivery	Yes

ICT training	
Tertiary institutions offer ICT training for students of health sciences	Yes
Continuing education in ICT for health professionals	No

Internet health information quality	
Approaches taken to ensure quality of health-related content on the Internet	
Dedicated website(s) - concerning women's & children's health	No

Online safety for children	
Approaches taken by government to protect children in the online environment	
Government provides information and education to citizens on internet safety and literacy	No
Some initiatives are aimed specifically to protect children	No
Safety tools and security technologies are required by law for schools, libraries and other public places where children have Internet access	No
ISPs are legally mandated to provide online safety tools to protect children	No

Privacy and security of personal and health-related data	
Legislation to protect women and children	
Privacy laws exist to protect citizens' personal identifiable data irrespective of format (paper or digital)	No
Privacy laws exist to protect citizens' health data held in digitized format in an Electronic Medical Record (EMR) or Electronic Health Record (EHR)	No
Parental consent required for the creation of a child's EMR/EHR	No
Parental access to a child's EMR/EHR is possible	Yes
Correction of errors in a child's EMR/EHR is possible	Yes
Legislation exists enabling the sharing of EMR/EHR between health care entities within the same country	No
Parental consent is required	
Legislation exists enabling the sharing of EMR/EHR between health care entities in other countries	No
Parental consent is required	
Legislation exists which grants a child the right to control over its EMR/EHR	No
From age (years)	

Social media	
Countries are recognizing the benefit of using social media for health	
Some health programmes use social media (eg, Facebook, Twitter, YouTube)	Do not know

Fig. 50.2. eHealth and innovation in women's and children's health – Goe 2013 survey. Source: WHO GOe Survey Country profile Nigeria 2013

development include lack of policy and organization readiness. There was

no data on mHealth and eLearning programme exist that targets medical and allied health professionals [34].

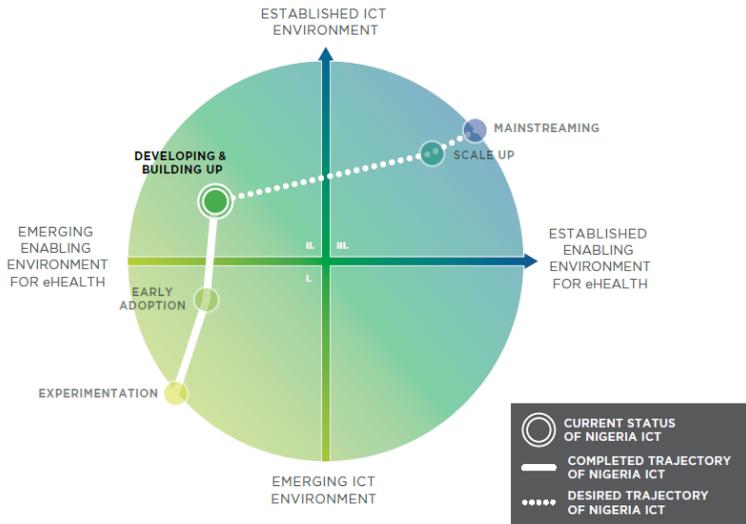


Fig. 51. Current State of Nigeria’s Enabling Environment for Health ICT. Source: National Strategic Health ICT Framework

The reports displayed in figures 50.1 and 50.2 show that Nigeria is still at experimentation and early adoption stages of a national context for eHealth development according to the national eHealth strategy toolkit developed by WHO and International Telecommunication Union (ITU) [35]. This position taken by the authors contradicts figure 51 above extracted from “The report, Assessing the Enabling Environment for ICTs for Health in Nigeria” in 2004 cited in the National Strategic Health ICT framework 2016 that Nigeria is transitioning from ‘experimentation and early adoption’ to ‘developing and building up’ national context for eHealth development [32] [35]. Nigeria still lacks the fundamental policies that enable eHealth to thrive. We have thousands of projects across the landscape, yet most are not evaluated scientifically as to determine if they can scale up which does not necessarily imply a proper transition towards the development and build up of the eHealth environment. With the development of a national eHealth strategy and establishment of national coordinating mechanisms (national steering and technical committee on eHealth) and subsequent

implementation of the strategy, Nigeria should be transiting from the ‘experimentation and early adoption’ to ‘developing and building up’ national context for eHealth development.

National Health ICT Strategic Framework 2015 - 2020

The framework was developed by stakeholders with the support of the leadership of the Honorable Minister of Health and Honorable Minister of Communication Technology. This is a clear departure from the development efforts in the past that lacked political will and support. They recognized the need for both sector to collaborate and provided the much-needed inter-sectoral collaboration that ensures high success of any eHealth initiative. The framework is built upon the Universal Health Coverage principles and Nigeria’s commitment to achieving the Sustainable Development Goals (SDGs) [31]. It is a high-level plan yet to be costed.

Health ICT Vision

“By 2020, health ICT will help enable and deliver universal health coverage in Nigeria.”

The Nigeria eHealth vision will be delivered through the enabling of the environment structures outlined in the national strategy toolkit which are Leadership and Governance; Strategy and Investment; Architecture, Standards and Interoperability; Legislation, Policy and Compliance; Capacity Building; Infrastructure and Solutions (Services and Applications) taking into consideration the needs of the health system and stakeholder inputs [31].

Action and M&E Plans

The action plan was used to develop the roadmap and directs prioritized eHealth activities. “It informs the steps that those governing and involved with the achievement of the Health ICT vision will need to make”. “The monitoring and evaluation (M&E) plan and budget build on activities outlined in the action plan. The M&E plan provides a link between the vision, action plan and desired results and the budget estimates the resources needed to attain the vision” [31]. The implementation plan is in three phases over the next five years.

1. PHASE 1: Set-up (Year 1)
2. PHASE 2: Deploy, Maintain and Support (Year 2 and Year 3)
3. PHASE 3: Consolidate and Continuous Review (Year 4 and Year 5)

The National Council on Health through the national steering and technical committee is responsible to see to the implementation of the strategy and ensures the vision is achieved [31].

Conclusion

The national eHealth journey in Nigeria has spanned over two decades. This write up was not be able to capture all that happened in twenty years but certainly the next twenty years looks great for eHealth in Nigeria. If your activities or projects in eHealth were not mentioned here, be assured the authors acknowledged your contributions to eHealth development in Nigeria.

The National Health Council and National Steering and Technical Committees on eHealth must ensure that the lessons of the past developmental efforts are not thrown away but serves as the pedestal for providing the needed national health sector leadership to drive eHealth development in Nigeria. All stakeholders must align themselves to the strategic direction of the government on making eHealth a health sector development agenda by ensuring their projects integrates into the overall national eHealth architecture.

If there is any further step to be taken to ensure that eHealth tools and services becomes part of the fabrics of our national health system, the healthcare professionals (providers of health services) and counterparts in the ICT sectors and consumers of health services (the citizens) must be considered as a critical stakeholder by government, whose contribution or lack thereof to the eHealth development process may hinder the achievement of the national eHealth strategy vision. The National Health Council and National Steering and Technical Committees on eHealth should ensure that certain percentage of the national health budget is set aside for eHealth implementation. Public-private partnerships must be encouraged and solutions deployed should meet national health system goals and objectives as outlined in the national health plan. This chapter is an outline of the telemedicine activities in Nigeria and for information visit www.sftehin.ng and Global Knowledge Resources for Telemedicine and eHealth Med-e-Tel website (http://www.medetel.eu/?rub=knowledge_resources&page=info).

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His passion for the use of ICT in Health care originated early in his medical school days. He pioneered the development of the first professional online medical portal in Nigeria in 2007 with the development of the TheNigerianDoctor.org website then known as Nigerianphysician.com.

He was a pioneering member of the Lagos State Government's eHealth project and has provided numerous technical support to the government towards the development of eHealth in the State.

He was also a member of the team that developed the first Nigerian eHealth policy draft document for the Federal Capital Territory, Abuja. Dr. Arogundade has been a serving Board member of the Society for Telemedicine and eHealth in Nigeria since 2009 until today. He has also served on the Board and or as Technical Advisor to other private organizations in Nigeria including Sugilite Health Services, Synapsis Medinet and Restore Global Projects.

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RUSSIA

Telemedicine History 1900-1990

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Early Times, Basic Technologies

During the start-up of telemedicine, telegraph, telephone and radio connection were the main available telecommunication technologies for its implementation.

In Russia during the first half of the XXth century, telegraph communications were used during war conflicts both for organizational issues of medical help and for teleconsultations. There is an excellent descriptions of such episodes from the Russian-Japanese War (1905), the First World War (the German War, 1914-1918), and the Second World War (The Great Patriotic War, 1941-1945) in the memoires of a famous medical officers and talented writers Vikenty V. Veresaev and academician Aleksander A. Vishnevsky.

There is another interesting fact about distant medical care via telecommunications that occurred in 1914.

That year a special marine expedition to the Kara Sea took place. The main aim of this expedition was the establishment of radiostations at extremely isolated places in the North. For each station, trained crew, special sets of supplies and provisions were prepared. There is a quote from the paper of a radio engineer V. A. Tarasoff [1, 2] concerning the medical issues: "For the purpose of giving medical aid, a trained hospital assistant was left on the Yugor station, who had also, in case of necessity, to visit the Vaigatch radio station. In addition all the stations are supplied with pharmaceutical stores containing a sufficient quantity of drugs and popular text-books on medicine, and in severe cases the use of the radiotelegraph for communication with Archangel Physicians is allowed to all, free of charge". Thus, the radio was used for medical advices in the Northern territories of Russia since 1914.

In the 20th century, radio amateurs from all parts of the world made a certain contribution to the development of medical telecommunications. A number of episodes are known where in cases of natural or technologic disasters, some territories practically lost communication with the outside

world. The simple voice communications (via amateur, so-called “ham”, radio stations) were used for spreading information, coordination of rescue teams, simple teleconsultations and management of emergency care (including the evacuation of victims). The earliest episode of amateur radio use in an emergency in Russia happened in 1929 during terrible snow winds in the Tula region (in winter) and floods in Leningrad (in July). Huge number of Russian radio amateurs (Karen Karapetian, Gennadiy Shul’gin, Constantine Khachaturov, Viktor Jirnov, Valeriy Bazhenov, Anatoliy Bayakin, Georgy Chliyants, etc.) took part in emergency communications after an earthquake in Spitak and Leninakan, Armenia/USSR (07.12.1988). In the second half of the 20th century, radio amateurs founded a lot of associations and societies for emergency communications. Medical doctors organized some of them.

Thus, telegraph and radio communications were a basic telemedicine tools in the late nineteenth century and in the first half of the twentieth century, especially during war conflicts.

Telecardiology

Among all clinical disciplines, the widest use of telemedicine in the XXth century has been in cardiology. The main reason for this is the necessity of urgent diagnosis of acute pathology of the cardiovascular system, involving high-level experts. At the other hand, telemetry of electrocardiosignals (ECS or ECG) for the remote interpretation and analysis was most consistent with the technical capabilities of electrical engineering.

Between 1963-1966, studies on transtelephonic ECG transmission and telemetry of phonocardiographic research were carried out at the Kaunas Medical Institute under the supervision of Zigmas Ippolitovich Yanushkevichus (3(16).10.1911-26.05.1984, Fig. 1) [3-5]. Under him, one of the first ECG automated analysis systems using a first generation computer was developed. There is one more notable fact in the above mentioned publication by Yanushkevichus et al. «Tele-transmission of phonocardiograms» (1966), which is that for the first time in the Russian language the term «teleconsultation», and more specifically «teleconsultation centre», was used. As a result of long-lasting work, Zigmas Yanushkevichus created a new section and his own school of telecardiology and medical cybernetics.

A large-scale formation of telecardiology in Russia/USSR was associated primarily with the name of Professor Emmanuil Shevakhovich Halfen (b.26.06.1923, Fig. 52) [6-9]. As early as 1967, Prof. Halfen and a team of engineers, headed by Oleg Mikhailovich Radyuk (1931-9.10.2013, Fig. 53), designed and manufactured a biological information telemetry device

(including ECG) transferring data via telephone and radio. Later the device was named «Volna» («Wave») transtelephonic ECG transmission system. Based on this system, in 1971 in Saratov, at the Introductory Course of Internal Diseases (Propaedeutics) Department of the Saratov State Medical Institute, the first remote consultative and diagnostic center in the USSR was established.



Fig. 52. Emmanuil Sh. Halfen

At the time of the system development, Prof. E. Halfen was Chairman of the above-mentioned Department, and O. Radyuk was Director General of the Scientific Research Institute

«Almaz» (State Scientific Industrial Enterprise) in Saratov. The author's description of the tele-ECG system operation is given below:

«...the device - electrocardiotransducer, by receiving weak heart biosignals, amplifies and

transforms them into signals that can be easily transmitted via telephone or radio to the control panel of the attending cardiologist in the consulting and diagnostic center. This control panel is connected with an electronic computing machine, which instantly processes the cardiogram and automatic typewriter ... prints diagnosis outcome... All the control panels of the center have a direct communication with the head of the clinic via an intercom system, and in the professor's room a monitor is installed on which any information from the control panel is transmitted, if necessary».

In 1974 the serial production of the «Volna» telemetry system started, which included electric cardio-transmitter (ECT), a



Fig. 53. Oleg M. Radyuk



Fig. 54. Prof. Halfen receives ECG at the remote cardiological centre control panel. There is a consultation and diagnostic control panel of «Volna» system (early-middle 1980s)

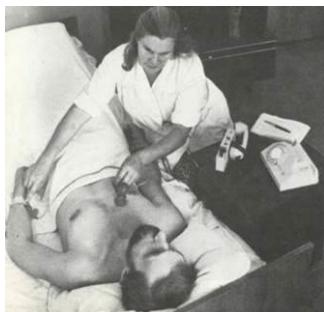


Fig. 55. Work of mobile ambulance unit: ECG transmission from a patient's apartment (early-middle 1980s)

consultative and diagnostic control panel (CDCP) and the communication line (telephone or radio). ECT was a portable device consisting of three units: a transducer, a power supply unit and an acoustic set-top box. Early transmitter models had dimensions of 11x12x4 cm weighing 1 kg, later on the size was reduced to 3x8x14 cm and 400 gr. CDCP was intended for the ECG reception by telephone and radio, «ink recording on paper tape», consultations with specialists, the transfer of the ECG results and recommendations to the attending doctor. There was an «integral or remote long-term memory» on the panel, which recorded on a magnetic tape all of the transmitted information and ECG. The

archive of the performed tele-ECG consultations was created in an ad-hoc way. CDP provided the possibility to transmit ECG to the computer memory for the subsequent automated analysis. It also was equipped with a loud-speaking communication system and an additional telephone to communicate with a third party (for example, a qualified specialist). In general, the system allowed remotely transmitting 12 ECG leads, taking only 3-4 minutes. Telephone communication was generally for data transmission and when connecting to ambulances, data were transmitted by radio (Fig. 54-55).

Tele-ECG network covered treatment and preventive health care facilities in Saratov, in rural hospitals in 35 districts, as well as outreach brigades of Emergency Health Service formed quickly around the first remote diagnostic center. The network consisted of 125 transmitters in the hospitals, 10 transmitters for outpatients and 6 ECG receiving panels (five panels operated regularly, and one more was connected additionally during wide-scale preventive examinations). Over time, multi-channel telephony was organized, which simplified and speeded up considerably the communication between health care workers, subscribers and the expert center.

Prof. Halfen determined three main lines for tele-ECG application:

- Clinical medicine (including rural health care, emergency medical service, large enterprises, sanatoria, etc.);

- Mass preventive onsite screening examinations (combined with automated ECG analysis);
- ECG patient-activated transmission (auto-transmission) during outpatient treatment.

Between 1972 and 1979 about 250 000 ECGs were transmitted in the Saratov region via «Volna-1» system.

Between 1974 and 1978 the «Volna» system operated in 74 cities and towns of the USSR, and by 1980 – already in one hundred. It was presented at the Exhibition of National Economy Achievements and the International Exhibition «Healthcare-74». The «Volna» creators were awarded medals and diplomas. The technical upgrading of the systems continued constantly. In 1980 under the supervision of Prof. E. Sh Halfen, tele-ECG systems were further developed, as a digital data transfer method was used instead of the analogue one. In addition, the «Jaguar» three-channel tele-ECG system was created enabling direct remote ECG transmission to an early generation computer machine.

In the late 1970s, Prof. E. Sh. Halfen suggested the idea of ECG autotransmission by the patient. This is one of the first home telemedicine technologies in Eastern Europe.

«In recent years, in some cases, we hand out EPCs to the patients who were discharged from our clinic for outpatient observation... Being at home, the patient, if necessary, quickly calls the remote cardiac centre, transmits the ECG... and gets the relevant recommendations from the centre...



Fig. 56. “Volna” system usage: ECG autotransmission in home conditions - ancestor of modern home telemedicine (Saratov, USSR, 1980s)

Telemetry information allows the consulting physician to diagnose the nature of the attack immediately and to apply the urgent treatment».

ECG in one deflection was used for autotransmission. It should be emphasized that as far back as in the 1970s, through its work, Professor E. Sh. Halfen laid the conceptual foundations of modern telehealth (home telemedicine) (Fig. 56).

By 1980 tele-ECG operational outcomes, technical and diagnostic aspects and potentials had been analyzed



Fig. 57. ECG “Volna”
telecardiological system was
successfully run for 30 years
(Regional Remote Centre of ECG
diagnostics of the Novosibirsk

carefully. Some statistical analysis and efficiency evaluation had been made. In general, Prof. Halfen carried out considerable scientific work, having analysed and generalized experience of tele-ECG service rules and use. He formulated the general methodological principles of remote diagnostic centers operation, developed a model of territorial tele-ECG network, described the organizational and personnel details, the necessary documentation, etc. In fact, for the first time a substantiated concept of telecardiology service was presented (Fig. 57).

During the described period, another specific development in telecardiology took place in

Saratov - a telemetry monitoring of patients under hospital conditions. Approximately, in 1980, Professor B. M. Temkin deployed the system for automated interpretation of telemetrically transmitted ECG of patients undergoing rehabilitation treatment after myocardial infarction in the Saratov Medical Institute Clinic. The following equipment was used: «Saratov» computer machine, 21 RTN radio-based transducer and N-338 self-recorder. Intra-hospital telemetry provided great reception security and accurate load dosage on at least 120 patients.

Long lasting experience and a proven transtelephonic electrocardiography system performance led to the recognition at national level. On May 27, 1977, the Ministry of Health of the USSR issued Ordinance №495 «On carrying out an experiment for operation of ECG remote transmission systems». Following the results of this work Eugeniy I. Chazov and Rustam I. Utyamyshev [10] published a methodological guide under the same name.

A few years later telecardiology reached a new level. On August 19, 1982, the related resolution of the Central Committee of the CPSU and the USSR Council of Ministers (№773) and on January 20, 1983 the Order of the Ministry of Health (№72) «On the organization of remote diagnostic offices/centres (RDC)» were published with the Regulation for such unit

and special forms of medical documentation. Provision was made for the arrangement of remote diagnostic offices (centres) in the state, provincial and regional hospitals and equipping them with the appropriate equipment to improve the quality of diagnosis and treatment of cardiovascular diseases.

Within 2 years (1985), there were 180 remote diagnostic centres in all major cities and towns of the USSR, implementing tele-ECG consulting, 185 RDC in 1987 and 354 RDC by 1991 (Fig. 58-60).

Prof. Halfen, in addition to tele-ECG, also carried out extensive work on the automation of diagnostic and treatment processes in cardiac institutions. Under his supervision, algorithms and programs were implemented «enabling computers to record and evaluate in real time the electrocardiogram and other basic parameters of the cardiovascular system functional state, in the on-line mode» (i.e. the direct patient - computer communication without intermediate carriers). Since 1970 computer-based automated constant supervision system for myocardial infarction patients, cybernetic methods for determining the optimal dosage of medications, mathematical methods for predicting outcomes of pathological processes were developed, operated and continuously improved. In general, Prof. Halfen created and put into practice the concept of automated control over diagnosis and treatment of patients with cardiovascular diseases.



Fig. 59. ECG Work of Remote Diagnostic Centre (RDC) in the Orenburg Regional Clinical Hospital in 1979

Fig. 58. Remote ECG-diagnostics Centre (Barnaul, 1982), headed by Lyudmila V. Kolomiets





Fig. 60. Telemetry Remote Diagnostic Centre in Kiev. Teleconsultation using telephony and the «Volna» telemetry system (cardiologist A. I. Belokur) (1980s, USSR). Photo from the collection of Dr. G.D. Kirzhner

Since 1994, Professor Pavel Dovgalevsky (b. 26.11.1947) has been heading the Saratov Research Institute of Cardiology. Dovgalevsky was a student of E. Sh. Halfen and is a Doctor of Medical Sciences. He continued the investigations of his teacher and promoted in priority the development, of new medical technologies in cardiology using telemetry and local computer systems. Further improvements and changes of the individual telemedicine concept, the «ECG autotransmission by patients», were particularly intensive. In 1995, the scientific base was developed, the work analysis was performed and the methodical approaches to the organization of the RDC work with patients were offered and standardized. In other words, the scientific and methodological basis of individual telecardiology was developed. The following results prove the effectiveness of this concept: «Comparative effectiveness of the ECG autotransmission method at a stage of follow-up of post infarction patients showed that in 57% of the patients using autotransmission, rhythm and conduction disturbances were detected as compared with 14% in the control group. The time of patients' return to occupational activities was reduced significantly (on average by 40 days). Among patients using autotransmission, the total number of recurrent myocardial infarction within 12 months was only 7.8% compared with 13.8% in the control group. Within a year, the mortality in the control group was 13.9%, of which 40% were sudden death cases. Accordingly, mortality of patients, who used autotransmission, was only 10.7%, and sudden death was observed in 27.2% cases».

A special mention in this regard should be made of the tele-ECG experience in the Gorky (today Nizhniy Novgorod) Region, USSR. Since 1962, a group of engineers and doctors in the city of Gorky was actively working on the issue of automation in cardiology. Professor Aleksandra P. Matusova (17.05.1919-26.03.2010, Fig. 61) headed the group of doctors and Professor Yury I. Neymark (24.11.1920-11.09.2011, Fig. 62) headed the group of engineers.

They developed and implemented unique methods of automated diagnostics of various cardiovascular system diseases, based on the

proprietary algorithms of medical information detection and analysis, methods of mathematical outcomes predictions, automated pre-medical screening procedure, etc.



Fig. 61. Aleksandra P. Matusova



Fig. 62. Yury I. Neymark

Because of the huge theoretical and experimental work, they managed to create new methods of initial data processing and additional approaches addressing feature selection and construction of decisive classification rules. They also succeeded to design algorithms of feature recognition, selection and formation, as well as to specify complete systems of machine features of medical curves, cardiograms in particular. With the help of the developed methods, a number of specific issues of medical diagnosis, prognosis and treatment method selection were successfully solved. The results obtained in this field were published in 1972 under the editorship of Yu. I. Neymark in the book «Pattern recognition and medical diagnostics».

In the mid-1970s, at the Internal Diseases Department of Gorky State Medical Institute and Municipal Hospital No.38, the Cardiological Remote Diagnostic Centre was established. Its goal was to receive information from the municipal medical institutions. Professor Aleksandra P. Matusova founded the centre and her students worked actively on the issues of remote ECG diagnostics for 15 years. Their research and applied works were award-winners at the Exhibition of National Economy Achievements.

Within 15 years of active work, the Gorky tele-ECG centre held over 31.000 teleconsultations, including, 27.384 teleconsultations between 1977-1987, where myocardial infarction was diagnosed in 1.3% of patients, angina pectoris in 37.2%. Based on the experience gained, a special model was developed for remote ECG diagnostics application on outpatients, and methodology and specific features of RDC establishment based on polyclinic facilities were defined.

By 1986, two Centers performed ECG and clinical data reception from 15 outpatient clinics and medical units in Gorky. Clinical teleconsultations with a mandatory transmission of complete information about the patient were held. In total about 12.970 teleconsultations were given in the outpatient telemedicine network, myocardial infarction was detected in 2.1% (270) patients. Scientific analysis of diagnostic errors was carried out, the leading role of the tele-ECG was determined for infarction prevention.

The team headed by prof. A. P. Matusova used the most advanced concepts in their work, combining remote ECG interpretation as such and full-fledged cardiac teleconsultations, accompanied by the transmission of detailed information about the patients. To unify this transmission, special coding schemes were developed, which formalised the description of a clinical case. The schemes included complaints, a brief history of life and disease, minimal information on the results of physical examination. These data were transmitted into the RDC and submitted for computer analysis:

«Three linear formulas were developed which helped to perform a mathematical diagnosis of the main forms of ischemic heart disease on the basis of the codified clinical information in the DC [Diagnostic Centre - *author's note*]».

Between 1977-1987, 13.950 teleconsultations were carried out according to this procedure. However, the described scheme was not effective enough due to mandatory medical examination of the remotely consulted patient. That is, medical attendants and nurses could not refer patients for teleconsultation though the need for such services was very high. Therefore, a few years later the schemes were replaced by scientifically substantiated «single program for thoracic pain syndrome diagnostics», which was based on the patient questionnaire. Thanks to this innovation, «clinical remote consultations... became available to any paramedic centre. The time spent on remote consultation was reduced (mean time did not exceed 15 minutes). The authors conducted a simple economic calculation and stated that the cost of one tele-ECG consultation was «1 rouble 70 kopecks».

An important methodological moment was the standardization of the variants of the most common RDC recommendations for patient surveillance. In total seven unified answers remained. The team of Prof. A. P. Matusova also studied the tele-ECG diagnostic value by comparing the «centre and hospital diagnoses in hospitalized patients»; the coincidences were observed in 70-97.6% of the cases. The accumulated experience of the tele-ECG centres was summarized in a number of articles and methodological guidances for the RDC organization based on outpatient clinics. In the mid-1990s, the team of Prof. Matusova studied and mastered

the techniques of ECG autotransmission by the patients at the outpatient treatment stage [11].

Thus, during the late 1970s-1980s the extensive tele-ECG network was established at the national level in the Soviet Union. The tele-ECG networks operated efficiently: «The average hospital stay... was shortened by 1.5 - 2 hrs., which significantly reduced the number of complications and adverse outcomes ... The number of patients, receiving qualified cardiac care at the prehospital stage increased daily on average by 2.5 times... ECG transmission by phone enabled to reveal a number of patients with periods of brief transient myocardial ischemia». Remote Diagnostic Centres worked around-the-clock as well in the interactive mode as asynchronously, reporting the results of ECG interpretation during the second communication session. In some cases, teletype machines were used to share the opinions.

Special mention should be made of the widespread telecardiology use for preventive purposes, i.e. for the implementation of telemedicine screening. Many publications at that time focussed precisely on the importance of mass screening prevention, using ECG transmission by telephone. In the late 1980s, the procedure of using remote diagnostic centres for mass screening in groups was developed and implemented under the supervision of Professor Vladimir A. Almazov.

Thanks to tele-ECG screening, rather considerable risk groups (14.01-20.7%) were revealed in large cohorts (n = 5 653; n = 1,102). Leningrad cardiologists played a significant role in the development of scientific and practical aspects of telecardiology and work methodology of remote diagnostic centres. In 1978, RDC were established in the Leningrad Scientific Research Institute of Cardiology, (now Almazov Federal Heart, Blood and Endocrinology Centre, Sankt-Petersburg, Russian Federation) and in the Regional Clinical Hospital. The deployed tele-ECG network covered 17 central district hospitals and 4 municipal healthcare facilities. Between 1980 and 1985, the Centre carried out over 20.000 tele-ECG consultations and at least 6400 tele-ECG screening examinations.



Fig. 63. Lev V. Chireykin (self-portrait)

At the Leningrad First-Aid Station a RDC established under the auspices of the Institute of Cardiology. Between 1978 and 1980, the staff carried out preparatory and organizational work and

arranged special 4-hour training courses for medical personnel (400 people, mostly doctors) on the tele-ECG usage procedure. It should be underlined that this bibliography source contains one of the first references of specialized training on telemedicine. In addition, the authors made a simple economic analysis, which showed a quick payback and high efficiency of telecardiological systems. Over the 4 years of operation, the RDC provided more than 4 000 tele-ECG and up to 1 500 clinical remote consultations annually, with a daily average load of 20 teleconsultations.

Telecardiology development from the level of routine tele-ECG ~~use~~ to the level of full-fledged clinical telemedicine consultations, scientific analysis and usage methodology validation resulted from the work of Professor Lev V. Chireykin (10.02.1931-27.10.2002, Fig. 63), who supervised the work of tele-ECG network in the Leningrad Region at that time. Professor Chireykin was the first in the USSR to carry out scientific analysis of clinical telemedicine. The structure of tele-ECG consultation appeal was defined quite clearly: «On the total number of clinical consultations, 79.7% of patients were consulted in urgent indications, including 31.2% of patients with acute macrofocal myocardial infarction (MI); 8.3% with other forms of acute ischemic heart disease; 20.2% of patients with complex arrhythmias and conduction. In 19.6% of cases the «masks» of acute ischemic heart disease» were a reason for consultations.

Lev V. Chireykin investigated the tele-ECG diagnostic value in the myocardial ischemia syndrome, having studied opinion concordance of five experts over 300 tele-ECGs. It was determined that a full match of treatments occurred in 69.8% of the cases, whereas in 13.4% - responses were completely different. It was found that «more similar results were observed in the evaluation of ECG with macrofocal MI, and evaluations of all specialists matched most during the analysis of the ECG with “His Bundle Branch Block” (ibid). Further study referred to clinical efficiency resulting from tele-ECG consultations (CDH-RCH):

- More than 30% of electrocardiographic findings were just corrected and 5.5% were completely revised;
- Treatment regimen was corrected in 60% of the cases; the nature of treatment was fundamentally changed in 12% of cases.

In 14.2% of the cases, teleconsultations resulted in conducting urgent health interventions or resuscitation. Moreover, «the centre consultants newly diagnosed focal myocardial changes in 12% of patients that had been previously regarded wrong».

For the first time within the frame of the national Telecardiology, Lev V. Chireykin determined that «there are two main lines in RDC work, which, though not excluding each other, are considered by us as equally important

to improve cardiac diagnostics, especially in patients with ischemic heart disease: remote ECG analysis and implementation of remote clinical consultations. And both, in the first and in the second case, depending on the tasks assigned to RDC and the list of its «users», consultative assistance can be rendered at the prehospital stage (for polyclinic general practitioners and cardiologists, «emergency care» teams) or in case of sufficiently qualified cardiologists available - consultations of specialists on the functional diagnosis regarding ECG being difficult to interpret or consultations of CDH cardiologists, physicians and resuscitators in the diagnosis of obscure cases».

As such, for the first time it was shown that remote ECG interpretation was only one element of a comprehensive cardiac teleconsultation, which should include a full exchange of all available information about the patient's condition to determine not only the diagnosis, but also the therapeutic approach and patient monitoring. Full-fledged «remote clinical consultations» began in the Leningrad RDC already in 1978. Fact is that annually their number and importance increased to reach at least 6 thousand (annual statistics look as follows: 1979 – 582; 1980 – 1 135; 1981 – 1 448; 1982 – 1 352; 1983 – 1 882 consultations). Moreover, Chireykin formulated the «additional conditions for remote health care with regard to the general ones», i.e. the requirements for clinical cardiac teleconsultation, which are quite relevant up to now. Here they are:

- To provide methodologically correct, systematic, fairly complete collection of information about the patient (data history, physical, laboratory and instrumental examinations);
- To minimize the distortion during the information transmission to the RDC;
- To use the conversational mode to clarify information about the patient;
- To carry out dynamic monitoring of patients by active calls and repeated consultations;
- To record precisely the transmitted information and recommended data, preferably with dictaphone devices;
- To provide peer review of errors committed and accurate diagnosis cases.

Prof. Chireykin emphasized that «compliance with these conditions shall be enhanced by the development of formal documents both to enable the information transmission and to form opinions by the centre. This also allows creating a reference system for most common emergency conditions allowing the consultant to immediately obtain information on the amount of

aid, the procedure for urgent activities, pharmacodynamic properties of essential medicines».

Thus, L. V. Chireykin formulated the general methodology of telemedicine consultation: requirements for the quality and quantity of health information interactivity aspects, reporting, resources for evidence-based decision-making, as well as regulatory issues. He proclaimed: «physicians directly supervising the patient are legally responsible for the correct diagnosis and first aid rendering to the fullest extent». This is fully in line with modern telemedicine. The description of the «human factor» is rather interesting: «The authors encountered a «paradox»: experienced and qualified cardiologists resorted to consultations more often than admitting resident physicians or other medical specialists, mainly due to an incorrect assessment of patients' condition by the latter».

L. V. Chireykin presented an evidence-based methodology of telemedicine in cardiology in a series of articles, patents, monographs and guidances in collaboration with such leading figures as V. A. Almazov and P. Ya. Dovgalevsky (Fig. 15) [12-13]. Researchers from the Leningrad Scientific Research Institute of Cardiology prepared special methodological guidance for the establishment and work management of remote cardiac diagnostic centres. This was a comprehensive document containing general provisions on the RDC, load and mode of operation, organizational structure, tasks and features of the work depending on the health facility served (rural, ambulance, etc.), the deployment procedure, etc. It was assumed that, based on one shift, RDC could hold up to 4 thousand tele-ECG consultations, and in case of an around-the-clock operation they could provide 20-25 thousand consultations a year. At least two reception centres with 30-40 transmitters should be established for a district with a population of 250 000 inhabitants.

It was recommended to install computers for automated ECG analysis in the large hospitals. In this case, the organization and operation of the ECG interpretation centre (ECG-RDC), «full-fledged» remote cardiology consultation centre (C-RDC) and wide-scale preventive examination centre (P-RDC) were considered separately (ibid). Special sections of methodological guidance were devoted to the multifunctional RDC and the creation of telecardiological network. Perhaps for the first time in clinical telecardiology, the requirements for information security provision and the fight against distortion and loss of data during teleconsultation were formulated and the criteria for evaluating the effectiveness of telecardiological activity were proposed (ibid). In terms of evaluating efficiency, many researchers compared the results of ECG interpretation by physicians of district and regional hospitals where RDC were located [14-

15]. An interesting positive factor in the tele-ECG use provided by Prof. Tamara S. Vinogradova: «It [remote ECG diagnostics] allows ... psychologically preparing a regional service of functional diagnostics for automatic remote ECG analysis with the use of computers».

In addition to the «Volna» system, other technical solutions for ECG telemetry were developed at the same time.

For example, in the mid-1970s a group of employees of the Volgograd Medical Institute - Professor Anatoly G. Konevsky (b.30.01.1921) [16], Professor Konstantin V. Gavrikov (23.08.1928-21.10.2010) [17], Professor Yekaterina V. Tsybulina, and team of engineers developed their own physiological information and ECG telemetry system «Kovyl», approved by the Ministry of Health of the USSR. Data were transmitted over the telephone line. The first version of the system performed consecutive telemetry recording of leads (all 12 leads, one after the other) and was tested by remote consultations on 1 204 patients.

Then, within 2 months, a second version of the system was developed that allowed simultaneous transmission of two leads, which, of course, reduced the time tele-ECG consultation (the practical approval involved 120 patients). The diagnostic value of «Kovyl» system was verified by an independent assessment of ECG before and after the transmission by the qualified cardiologists (as tested on 34 patients).

After some time a telemetry centre of functional diagnostics of the cardiovascular system diseases was opened in the region. It collaborated remotely with 32 rural district hospitals and 10 hospitals in Volgograd, and with the medical units of industrial enterprises. During the first 2 years, about 1 324 patients were remotely consulted; abnormalities were detected in 79.2% of them. During 10 years of active service, the centre held about 150 000 tele-ECG consultations. The scientific contribution of Professor Yekaterina V. Tsybulina to the «Kovyl» system operation study should be noted separately. Within a few years of active use of clinical telemetry in the Volgograd Region, in 1977, she pioneered the development of clear and well-founded indications for tele-ECG consultations, focusing on the wide-scale preventive examinations. On basis of the experience gained, the team developed the concept of diagnostic service centralization to manage the patients with ischemic heart disease.

The «Salyut» system was another technical solution for tele-ECG transmission in the Soviet Union. Since 1970, Izhevsk Motor Plant (now JSC «Aksion-Holding») has start producing single-channel electrocardiograph ECG-N-«Salyut» (developed by «Salyut» Design Bureau, Moscow). By 1976, more than 10 000 units were made. It was a self-powered transistor device, using printed-circuit board. It is remarkable

that in the 1970-1980s the ECG-H «Salyut» system was constantly used in the orbital space station «Salyut», and participated in two famous expeditions: the one of Yuri Senkevich with Thor Heyerdahl and the polar expedition of the «Komsomolskaya Pravda» to the North Pole. The tele-ECG networks operated on basis of the «Salyut» system in the cities of Gorky, Saransk and Kiev.

In 1980, in Gorky, a model was introduced for screening and clinical examination of patients with cardiovascular pathology, developed by a team headed by Professor Evgenia P. Kamysheva (b. 28.12.1925) [18]. At the so-called «second pre-hospital» level, the model implied ECG recording with further transtelephonic transmission «into the computer system of the clinic through the «Salyut» cardiophone system». The doctor transmitted conclusions or ECG coding was carried out directly by the operator of the computer centre with its subsequent automated analysis and conclusion delivery. The proposed concept of «computing tele-diagnostics» was successfully used in nearly 1 700 examined patients with a diagnostic accuracy of 70-85%.

In 1979-1980 at the Department of Hospital Therapy of the Medical Faculty of Moldova State University, RDC was organized (on basis of the «Salyut» system) to provide teleconsultations for district hospitals (Department of Hospital Therapy of MSU NO im.Ogareva, 2016).

Between 1971 and 1976, many scientists around the world worked on the problem of automated ECG analysis for mass screening, developing and using «information-diagnostic systems for automated ECG analysis of various complexities». Among them, Professor Lev V. Chireykin said: «systems have electrocardiological data collection devices that allow... entering the converted ECG into the computer machine or transmit it over the telephone or other communication lines. The presence of such devices enables to subject ECG obtained by ambulance brigades at home, when examining patients in the outpatient clinic and in-hospital departments... to automated analysis... They are also used for multiphase screening surveys of the population ... The above systems allow serving the entire administrative districts».

Professor Chireykin (or rather, the team under his supervision, including Professor Dorofei Y. Shurigin (18.06.1923-20.07.1982) and engineers also proposed a proprietary system based on a specialized device for mass cardiological examination of the population. With its help a «real-time ECS [electrocardiosignals] are analyzed and all the examined persons are divided into two categories: persons who are recognized as «healthy» on the basis of the ECS analysis (Class A) and those found «sick» and being in need of physical examination (Class B)». System capacity was up to 20 (on average

14-15) patients per hour (ibid). Telecardiological screening sensitivity was 85-90%, specificity being 85-87%. In this case, the element of ECG remote transmission was the key one – «research conducted during ECG transmission to a distance via telephone communication channels provides an opportunity to create multi-path information and diagnostic systems that will enable to achieve a significant improvement in the operating quality of ambulance stations, outpatient network, industrial health centres». In this paper L. V. Chireikin also described the line of activity in the telecardiology, which could be called the computing one.

Thus, in the 20th century, the most widespread form of telemedicine in Russia/USSR was telecardiology - a comprehensive use of telemedicine procedures (biotelemetry and telemonitoring, remote interpretation of diagnostic data, teleconsultation, home telemedicine) for the prevention, emergency and routine medical care for patients with disorders of cardiovascular system. During that period, the main component of telecardiology was precisely the tele-ECG, the process of transferring of the electrocardiography data over telecommunication lines for the purpose of remote interpretation, telemedicine consultation and distance learning. The significance of this technology is confirmed by the fact that it still is a common and widely spread practice since its creation. During the 1970s a few engineering solutions for tele-ECG were developed in parallel, and the relevant networks were successfully implemented. The concepts of telemedicine use for emergency support at primary-level health care were fully developed, and the foundation for an individual telemedicine (telehealth) was established to provide long-term medical care for patients in everyday life.

Biotelemetry

The development of physiology and related disciplines in the 20th century led to new specific tasks for biomedical engineering - the development and implementation of systems, which allowed performing distant recording and transmission of physiological data of motor activity. Special attention was dedicated to records in extreme conditions - underwater, underground and in microgravity. The "Dynamic Biotelemetry" concept was formed. Physiologists A. A. Yushchenko and L. A. Chernavkin in the USSR laid the basis for this concept as early as in 1930-1932. In 1938 the following team: K. Zemlyakov, D. Ivanov and T. Fedorov (USSR), suggested a telemetry system - "tele-radio station", enabling to record remotely the cardiac function. A phonocardiogram of a person placed in an altitude pressure chamber was transmitted over the radio.

The period 1960s and the early 1970s can be called "the Golden Age" of bioradiotelemetry. The famous Russian scientist Vladimir V. Rosenblatt proved this as follows:

"Between 1948-1965, several dozens of laboratories and design-engineering departments both in the USSR and abroad (USA, England, Bulgaria, Czech Republic, France, German Democratic Republic, Federal Republic of Germany, The Netherlands, Hungary and others) published information about the first developments of miniature devices for radio-telemetry of physiological information from unrestrained human or animal subjects".

In the middle of the 20th century, physiology or more precisely the dynamic study of body reaction to external and internal physical, psychoemotional and other factors became a special sphere of biotelemetry application.

In the late 1950s, electronic engineer Lev P. Shuvatov (USSR) developed an ingenious set of biotelemetry devices for application in physiology. They gave the possibility to study physiological parameters under dynamic conditions, such as at sport and occupational loading [19]. This work was highly appreciated by Academician and outstanding physiologist P. K. Anokhin, though later it faced definite criticism on the part of engineers and radio electronics specialists (Fig. 64-65).

In 1960, T. E. Timofeeva and V. A. Antselevich (1960) (All-Union Scientific-Research Institute for Medical Instruments and Equipment, Moscow, Russia) developed a telemetry electrocardiograph designed for physiological studies in sports, occupational medicine, and during functional testing.

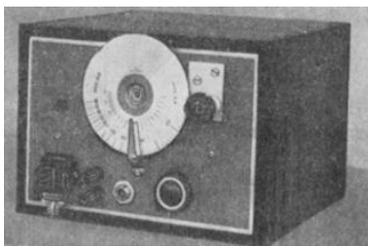


Fig. 64. The receivers of single- and two-channel biotelemetry system



Fig. 65. External view of six-channel biotelemetry system and mechanogram sensor location and radio helmet

The device called "Telecardiograph" was tested and approved at the Central Research and Development Institute of Physical Education and V. A. Obukh Institute of Occupational Hygiene and Occupational Pathology. Telemetry of 2-lead ECG was performed, according to W. Nehba, on sportsmen. The device was tested on workers during machine operation on shopfloors. A Moscow Plant of Electromedical Equipment started serial production of TEK-1 teleradiograph (Fig. 66-68).

In 1967-1970, many biotelemetry devices were developed by teams of scientists, medical doctors and engineers in different part of a country. Such inventions were meant for sport medicine and physiology researches. However, the so-called Sverdlovsk Biotelemetry Group achieved the most advanced results.

Sverdlovsk Bioradiotelemetry Group

Professor Vladimir V. Rosenblat (09.12.1927-30.04.2000, Fig. 69) - who organized and headed the Sverdlovsk Bioradiotelemetry group played an important role in the start up of dynamic biotelemetry, including sports biotelemetry, in the middle of the 20th century. Vasily I. Patrushev, Director of Ural branch of Russian Academy of Sciences, performed the first biotelemetry experiments in Sverdlovsk. Using a radiotelemetry system, i.e. a receiver, a transmission unit, a heart bioelectric current amplifier, created by Lev S. Dombrovskyy [20-22], an electrical engineer and radio amateur, an attempt to record ECG of a running horse was made.

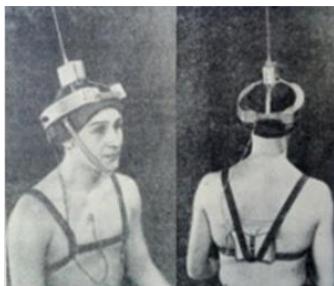


Fig. 66. TEK-1 telecardiograph - transmitter

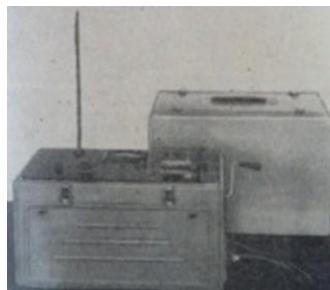


Fig. 67. TEK-1 telecardiograph - receiver



Fig. 68. TEK-1 telecardiograph advertisement in the journal "Novosti meditsinskoy tekhniki", 1960

In 1947, the same system was applied for a transmission of human ECG (of Dombrovskyy). Unfortunately, the quality of the transmission was very poor. In 1948, Professor V. I. Patrushev was removed from his post of Director and the biotelemetry experiments were stopped. Only in 1955, L. S. Dombrovskyy began collaborating with Vladimir V. Rosenblat, who at that time was an employee of the Sverdlovsk Municipal Medical Dispensary of Physical Education. A new team, together with radio technician Georgiy L. Karmanov, created a radiopulsephone, which on April 29, 1957 for the first time ever allowed recording over the radio the heart rate of an ice-skater during the training on rollers [23]. This was the pulse of Ivan V. Zykov, an outstanding sportsman and a famous coach. The device was described in a journal, won the first prize at the regional radio exhibition in May 1957, and afterwards it became an exhibit of the A. S. Popov Museum of the Radio in Ekaterinburg.

Using the first model, V. V. Rosenblat and L. S. Dombrovskyy studied the pulse of several sportsmen in a stadium, but the device was technically unreliable. In 1958, a new transistor model was designed. The weight of the device was reduced from 1300 g to 350 g, and the operating range was considerably enlarged. On January 20 of the same year, a successful biotelemetry of sportsmen during regular competition was performed.

The next model was created in 1969 with the participation of the engineer R. V. Unzhin, E. I. Rimskikh, V. M. Forshtadt and others. Unzhin designed a range of basic transistor circuits. The device was a multipurpose combined indicator ("KRP"), weighing 150 g, including the miniature storage battery. Pulse and respiratory rates were telemetered. Unzhin succeeded in developing a special amplifier, which enabled to telemeter ECG.

Here is the description of pulse telemetry given by Professor V. V. Rosenblat himself:

"In the late 1950s, a group of enthusiasts, brought together by the author of this book (L. S. Dombrovskyy, G. L. Karmanov, R. V. Uzhin, A. T. Vorobiev, etc.), developed and began to widely use radiopulsemetry, i.e. the pulse rate measurement of an unrestrained human, which was conducted over the radio. Special electrodes were stuck to the chest of a sportsman or worker. An amplifier with a transmission unit was placed on a cap. The sportsman was a football player, the worker was felling trees, and a researcher, holding a portable radio receiver set in his hands, was counting the heart rate. In this case ECG was the signal source".

Working thoroughly on biotelemetry equipment, the group of Rosenblat was constantly upgrading the sensors [24-25]. The experimental phase of the needle options application is well known. V. Demidov describe this episode in the book "77 Electrical Feelings" (2012):

"You know, Dombrovskyy told me, at that time Vorobyov and Rosenblat were all stuck with needles. The idea that it was all because of the high resistance of the skin crossed somebody's mind. So they stuck their arms with needles to get a good contact..."

Thanks to the initiative and work of Vladimir V. Rosenblat, the so-called "Sverdlovsk Biotelemetry Group" was organized, which united two teams of enthusiasts under his supervision: the specialists in the field of radio electronics (L. S. Dombrovskyy, R. V. Uzhin, G. L. Karmanov, B. A. Katsnelson, B. D. Kedrov, K. M. Kozlovskyy, E. I. Rimskikh, V. M. Forshtadt, Ya. V. Freidin and others) and the representatives of the biomedical field (Dr A. T. Vorobyov, Yu. G. Solonin, S. S. Gofman, B. M. Stolbun and others). The group was formed, mainly around two institutions - Sverdlovsk Municipal Medical Dispensary of Physical Education and Sverdlovsk Research and Development Institute of Industrial Hygiene and Occupational Pathology.



Fig. 69. Vladimir V. Rosenblat

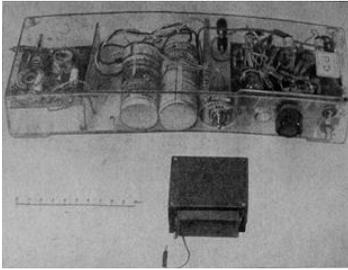


Fig. 70. Radiopulsephone (RP-1), radiopulsephone & electrocardiograph (REC-1)

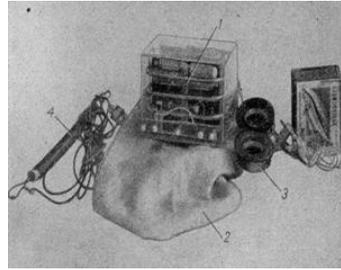


Fig. 71. Combined radiotelemetry device (CRD-1), fixed on cap-helmet

Vladimir V. Rosenblat wrote about the work of the group:

"In 1955-1964, attention was paid to the technique of radiotelemetry registration of pulse rate and heart bioelectric current. At the same time, we were looking for the approach to the research of some indicators of external breathing and other functions. More than 50 devices, including 16 types of transmitting units, were developed over a period of 9 years".

It should be noted that optimal procedures of bioelectric current and biosignals were developed; unique sensors and transmission units were designed, specially intended for various operating conditions.

There are most advanced radiotelemetry facilities developed by the group of V. V. Rosenblat (Fig. 70-71): Radio pulsephone (pulse rate), Radio pulmonograph (pneumogram), Radiopneumometer (respiratory rate), Combined radiotelemetry devices – CRD (pulse rate, pneumogram and others), Radio pulsephone-electrocardiograph – REC (pulse rate, ECG), Multi-purpose radiotelemetry device – MRD (10 parameters). The Integrated decoder (ID) should be mentioned separately, as it was designed to record radiotelemetry data with the elements of automatic analysis (Fig. 72). The ID prototype was a semiconducting pulse rate meter, developed by L. S. Dombrovskyy in 1963. In general, it was designed to work with CRD system, and the analysis of heart rate was a possible. It was a portable device sizing 360x200x160 mm and weighing 7.6 kg. V. M. Forshtadt and



Fig. 72. The integrated decoder (ID)

B. M. Stolbun (1964) developed a radio sphygmotachograph, a telemetry device for pulse wave velocity registration, and radio respirometer (RRM-1), which registered the basic parameters of external breathing. It was based on CRD-2M in 1963.

From 1957 until 1964, the researchers of the Sverdlovsk Biotelemetry Group carried out more than 100 000 radiotelemetry supervisions on sportsmen, workers and patients (precisely at functional tests).

The team of Rosenblat was the first in the world to register a total ECG curve over the radio on skaters during competitions. Many sports doctors, coaches (L. M. Sanachev, in particular) and sportsmen took part in this research. On March 7-8, 1962, the first Winter Spartakiade of the Peoples of the USSR was held. Seven masters of sport, champions and record-holders of the USSR took part in the biotelemetry experiments. Two days before the competition V. V. Rosenblat and his team recorded 132 ECGs of sprinters and long-distance runners. After that, more than 3 000 heart operating cycles were deciphered and analysed. Two days later the information about the experiment appeared in the "Medical newspaper", and furthermore in the "New-York Times" (USA). In addition, for the first time in the world, pulse rate (220 strokes per minute) of ski jumpers during the jumping itself was recorded remotely. The following quantitative data of radiotelemetry usage in sports medicine by Rosenblat are known:

- Observation on sportsmen during trainings: skating – 50, skiing – 2, ski-jumping – 6, track and field events – 3;
- Observation on sportsmen during competitions: skating – 28, track and field events – 7, table tennis – 5;
- Observation on elderly people: in the process of therapeutic physical training – 14, at functional tests – 4.

The investigations in weightlifting (A. T. Vorobyov, M. B. Kazakov, N. M. Khodakov, V. P. Khudorozhkov), in rhythmic-sportive gymnastics (R. N. Karelina) and in therapeutic physical training (F. M. Bakirova, A. P. Berseneva) are the most systemized data.

The group of Rosenblat also telemetered the ECG during the first performance of opera singer Yan Khtiras on the stage, after a myocardial infarction.

The monograph of Rosenblat "Radiotelemetry research in sports medicine" published in 1967 became a significant conceptual work. It summarized the methodology of "non-cosmic" dynamic biotelemetry in the middle of the 20th century and represented the basic physiological aspects of sports medicine. Thanks to Rosenblat, Sverdlovsk became the so-called capital of biotelemetry. Four All-Union meetings of the specialists in this field were held there (1959, 1963, 1968 and 1976).

Based on the achievements of the Sverdlovsk Biotelemetry Group, a few researches independently studied the physiological parameters of copper miners in the Urals and Donetsk.

The fact of using "computerized biotelemetry" by the representatives of Sverdlovsk Group in the middle of the 1970s is known: telemetry of ECG, EEG, EOG was conducted by means of 5-channel system with the data input to ECM ("Promin-2", "Mir-1", BECM-6M") and automatic analysis. The technology was used for physiological examination of work activities of operators, students and sportsmen.

Radiotelemetry became a reliable routine diagnostic technique in physiology, sports and occupational medicine thanks to the work of the Sverdlovsk Group. The methods of dynamic biotelemetry of Rosenblat's group became frequent practice all over the world. Vladimir Rosenblat (1967) saw its future in computerization and wrote:

"...Interpretation of vast factual material, gained by dynamic biotelemetry, can be favourable only on condition of data processing with the help of computing machines... By programming the data processing, thinking over the results and specifying programs of data reprocessing or its further steps, only in this way, we will be able to provide fruitful development and further succession and will be able to cope with the physiological data flotation, which is rather large even nowadays. Soon, the latter will become larger by volume and content in case of multichannel dynamic radiobiotelemetry of different functional parameters under natural conditions of muscular activity".

Clinical Biotelemetry

In the USSR, ECG telemetry ("radio-electrocardiography") was actively used in the early and mid-1970s in rehabilitation medicine (for walking exercise tolerance assessment, during manipulation treatment, therapeutic physical training of patients with cardiological pathology, and during insulations (telemetry seismocardiography)).

In 1973, at the V. M. Bekhterev Scientific Research Institute of Psychoneurology (Leningrad/St. Petersburg) an original technique for EEG registration and telemetry was developed. Its authors were Professor Rem A. Kharitonov, head of the paediatric neuropsychiatry development, and M. L. Nechaev. For more than 10 years, this method was used for differential diagnostics of epilepsy in children and determination of summarized seizure time duration. In 1979, at the Institute of Clinical Experimental Neurology (Tbilisi) under the supervision of Dr Tina Sh. Geladze [26] the telemetry of ECG and stereo-electroencephalometry by means of 4-channel "Televar" system were widely applied. The biotelemetry was carried during free

movement, natural sleep, and voluntary activity of the patients. It provided qualitative detection of focal alterations of the brain bioelectrical activity in patients with generalized seizures, precise topical diagnostics and localisation of trigger locus for the further treatment.

Therefore, the intensive development of physiology in the 20th century required new approaches and methods for assessment of body functions under various activities. This stimulated the appearance of dynamic radiotelemetry, which enabled to record and monitor the parameters of life-sustaining activity of a free-moving subject. Bioradiotelemetry was mostly valuable for man-in-space programs and for physiological study of sportsmen. Due to this technology, two new fields in science were developed - cosmic medicine and physiologically based training system for sportsmen.

Computational Telediagnosis

In the late 1970s, a new line of research was formed that can be called conventionally as "computational telediagnosis". It was supposed to use the remote transmission of certain medical information for its automated analysis by a computer machine for the purpose of diagnosis, screening and monitoring. This idea was successfully realized in the field of telecardiology and partly in tele-EEG (as specifically described in the relevant sections), but there were some achievements in other disciplines as well. In the USSR, a number of research teams developed computer systems with data entry over telephone communication channels, and feedback (formalized conclusion) sent by teletype. Such tools of "computing telediagnosis" were developed a lot of scientists, medical doctors and engineers in the fields of clinical genetics, traumatology, emergency, surgery, paediatrics, neurosurgery and laboratory diagnostics. The extent of implementation varied from conceptual ideas to entirely working systems with fully proven efficiency. The most striking practical implementation of the "computing telediagnosis" concept was recorded in Yaroslavl. In 1979, the team of Yaroslavl Medical Institute, consisting of Mark P. Vilyansky, Aleksandr A. Chumakov and Aleksandr N. Khorev [27], developed the remote acute abdomen diagnosis system based on the automated analysis of data transmitted from remote hospitals. The system was approved successfully by treating of 470 patients. An around-the-clock "consultative remote diagnosis centre" was established at the Institute clinic. The "Nairi-K" computer was used applying software for recognition of acute abdomen diagnosis in patients with unclear clinical picture. Nurses operated the system. The above-mentioned system supported a telemedicine network that included municipal and rural hospitals connected by telephone lines. The

number of successful teleconsultations increased to 874, including 122 consultations on patients admitted in the the rural hospitals. The diagnostics accuracy was about 89%. The system was found to be effective and promising. It was planned to equip the network additionally with teletypes and implement similar networks in the remote areas.



Fig. 73. Suren A. Gasparyan

In the USSR, between 1978-1982 and 1983-1990 the targeted comprehensive program "Development and introduction of automated systems for consultative diagnosis, prognosis and treatment policy selection in case of medical emergencies" was implemented. The program applied the main achievements in the field of clinical telemedicine at that time. Professor Suren A. Gasparyan (10.02.1932 – 4.11.2005) was the head of the program (Fig. 73). The description of the program and system is quoted as it stands in Gasparyan [28] and Pashkina and Zarubina [29]:

"The program brought together 12 research institutes, 3 universities and 3 computer and information centre. The system of remote computing emergency diagnostics functioned based on formalized cards. Consultative diagnostic centres were established at the medical aviation service stations of regional, territorial and national hospitals. Their work was carried out continuously 24 hours a day. A user dictated the numbers of diagnostic signs, specified in the clinical standardized card, over a direct telephone line. An attending physician uploaded the numbers on the computer. Within 20-30 seconds, a possible diagnosis was issued. Sometimes clinical or laboratory data were offered that had to be added for more precise differential diagnoses.

Analysis of the results of 39 000 consultations in the course of two-year work of three consultative centres showed that the overall quality of diagnosis by doctors in rural and district hospitals was 63%. When addressing the computing consultative diagnosis centre for consultation, accuracy rose up to 86%. Repeated consultation, including additional data for computer accuracy, increased the diagnostic accuracy up to 96%".

The system solved a critical economic problem by improving the quality of diagnosis in case of emergency conditions in the countryside, in remote areas and on ships at sea".

Medical Television and Videoconferencing

Television expanded the range of telemedicine tools and resulted in the formation of a new trend – medical videoconferencing. As many other technologies, television was not an exclusive invention of one person or a group of people. Many scientists all over the world had been gradually developing more and more efficient means of audio and video information communication. However, two specialists, Semyon Katayev (USSR) and Vladimir Zvorykin (Russia-USA), are globally recognized. In 1931, within an interval of one and a half month both scientists patented in the USSR and the USA respectively an electronic television technology that became the main one for decades.

“Medical television” (as an earliest form of medical videoconferencing) was developed in the USSR. However, there was no remote broadcasting as such. Interactive videoconferences were held within one medical establishment at a physical distance of about 100 meters between the transmitting and receiving equipment. There were also experiments with black and white broadcasting of surgical operation and significant achievements in color educational telesurgery (Fig. 74).

In general, a medical television was not widely spread in the USSR. The real growth of medical videoconferences began in Russia much-later, after 1995. However, there are a few very interesting episodes of videoconferencing when telemedicine for the first time ever allowed to bridge not only the geographical distance but political barriers as well.

On December 7, 1988, a disastrous earthquake happened in Armenia. 21 cities and 350 villages were hit, 25 thousand people died, hundred thousand people were injured. Within 2 weeks after the catastrophe, the USA and the USSR launched the joint project to carry out telemedicine consultations for survivors via satellite communication. Four medical centres provided experts to participate in telemedical sessions with the national diagnostic centre in Yerevan.

An unexpected follow-up took place after the industrial disaster in Bashkiria. On June 4, 1989, in the region Asha-Ulu-Telyak two passenger trains collided and a powerful explosion of light hydrocarbons gases occurred in the nearby oil pipeline. 575 people were killed; more than 600 were injured. Immediately, another telemedicine terminal was added to the Ufa medical centre. During 3 months, 51 telemedicine sessions were held, in which more than 400 doctors and nurses from both hemispheres took part. 253 patients were consulted at a distance. The sessions were organized as bilateral audio-, video and facsimile information exchange (Fig. 74). Later on, the project was named “Telemedicine Spacebridge to Russia”.

Before 1993 as part of its strategic framework, store-and-forward teleconsultations via the Internet were performed. Specially developed dynamic web-applications were tested and various types of medical multimedia information channels were employed (Fig. 74).

Fig. 74. “Medical Television” across different medical centers in USSR (1950-1960s)



The color television system of Professor P. Kupriyanov, dr. B. Aksyonov and engineer B. Kuzmin in the Kirov Military Medical Academy (Leningrad/St. Petersburg, 1958)



The single channel color television system of dr.A. Voronov and engineer R. Bykov in the Pavlov First Saint Petersburg State Medical University (Leningrad/St. Petersburg, 1957)



Surgery - operative field reflected in the mirror (the same place)



Lecture hall with receivers(the same place)



“PTU-3/ Rubin” television system by professor A. Karavanov and dr. V. Revis in Kalinin Medical Institute (Kalinin / Tver, 1961)

Fig. 75. Telemedicine “Spacebridges” (1980s)

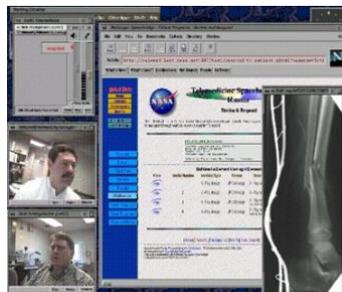


Episodes of transatlantic “spacebridge” Armenia/USSR – USA (1988)



Medical transatlantic (slow scan) videoconference: transmission of static images and sound (Bashkiria, USSR, 1989)

Screenshot of telemedicine consultation project “Telemedicine Spacebridge to Russia”



The potential offered by desktop-videoconferences also enabled the usage of this technology for real-time teleconsultations and distant lectures.

The experience of disaster telemedicine was successfully used for “peaceful” purposes also. The “Medicom’85” event took place on 16.12.1985. It was a 2-hour videoconference (via satellite communications) between teams in Moscow and Washington. The cardiologists (five from the USSR and seven from the USA), gathered in audiences, discussed topical issues of prophylaxis and treatment of coronary heart disease. The action was organized at the initiative of academician Raphael G. Oganov and Professor Eliot Corday (Fig. 75-76)



Fig. 76. Cardiology videoconference USSR-USA 16.12.1985

In conclusion, telemedicine in Russia has a wonderful history. A lot of interesting and valuable ideas, projects and networks were developed and successfully worked for years during the XXth century [30-31].

Regarding further stages of telemedicine evolution in Russia linked to Internet and personal computing growth, please refer to the next sub-chapter that is dedicated to this topic.

Recent Telemedicine History

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This part is devoted to the systematization of the recent telemedicine history in Russia. We have tried to highlight its key points: from performing the first, just some federal projects, to creating a well-structured and extensive national telemedicine system. As the upcoming of the computer provided the impulse for creation of automated diagnostic tools and new methods of medical data analysis, so, the Internet and satellite communications were the start of the creation of national telemedicine networks in all countries, including Russia.

The second part relates to the use of modern telemedicine technologies in manned space flights, as all the main approaches of modern telemedicine in Russia were first applied in space medicine. It relates, first, to technologies of remote medical monitoring. The experience from the first telemetry application in space medicine was transferred in the 70's to the state project of trans-telephonic ECG monitoring and remote ECG diagnosis in clinical practice. Medical teleconsultations were organized in Spitak (1988) and Ufa (1989) at the initiative and with the participation of space specialists. In more recent history, we can see a significant contribution of space medicine to the formation of Earth telemedicine scientific basis (occurrence of the concept "health of healthy" in government programs), in telemedicine professionals training and even in initiating the creation of the Russian National telehealth system at the state level.

The Period of Federal and Departmental Projects (mid 1990's - 2000)

Telemedicine in the modern meaning has become possible with the upcoming and growing availability of the Internet, network technologies to ensure the exchange of information between remote computers.

In the mid-1990's, first Russian health care institutions were connected to Internet, which created a crucial precondition for the technological development of the national telemedicine. Russia became one of the steadily

developing network domains, allowing it to increase quickly the number of users [32-36].

The greatest successes have been achieved in matters of special medical information input, medical Databases organization, sharing data over networks of various architecture, the automation of remote access to different types of medical information. Since 1997, the Faculty of Fundamental Medicine of the Moscow State University teaches students the fundamentals of telemedicine, which was the first experience of this kind in Russia [37].

Referring to the earlier history, the first experience of international telemedicine and "space" teleconferences took place in Spitak (1988) and in Ufa (1989) involving IBMP and NASA. Based on the success of these projects, in 1995, at the initiative of the Ministry of Science of the Russian Federation, the Russian Space Agency (RSA) and the National Agency for Astronautics and Space Exploration - NASA (USA) within the framework of the Intergovernmental (Russia - USA) agreement the Space Biomedical Center for Training and Research (SBC TR) was created. Developments of the Center in the field of telemedicine technologies have enabled to begin the actual provision of telemedicine services. The opportunities of telemedicine technologies in training and information support of health practitioners were shown. The center carries out the international cooperation of Russia in the field of telemedicine, interacting with medical centers in Europe, Asia and the United States [38-39].

Mastering the international experience and its development in relation to the actual Russian conditions, the introduction of telemedicine techniques in a number of regions has prepared a methodological basis for wide introduction of telemedicine.

Successful experience in space has allowed beginning systematic work on telemedicine in various directions. It has become one of the main tasks of the Educational Research Center of Space Biomedicine, established in 1995 and the Chair of Environmental and Extremal Medicine at the Faculty of Fundamental Medicine, Moscow State University.

Since 1996 the Chair is headed by A. I. Grigoriev, Academician and Vice President of RAS, MD, Professor, Chief Medical Officer of the Russian Space Agency, director of IBMP from 1988 to 2008, since 2008 - its scientific supervisor (Fig. 77). Grigoriev, as one of the first, developed the concept of distance education based on experience available in space medicine. It is thanks to his works that telemedicine technologies were implemented in the teaching process.



Fig. 77. Academician A. I. Grigoriev and staff of ecological and extreme medicine Chair in Moscow State University

In the early 1990's, together with Prof. O. Medvedev, he organized the permanently functioning teleconference bridges with foreign medical universities. It was a real breakthrough in the use of modern computer technologies for the purposes of medical education on the territory of the former USSR. The courses "Space Physiology and Medicine" and "Telemedicine" were created for students of the Moscow State University. The last one is also read for practitioners.

A. I. Grigoriev generalized his unique experience in two monographs on telemedicine (jointly with Academician O. I. Orlov and Professor S. V. Buravkov) [38-39]. For a long time these books were the textbooks for senior students and postgraduates to study the experience of telemedicine technologies in clinical applications.

In 1996-1997, the Space Biomedical Center for Training and Research (SBC TR), in cooperation with the Russian State Research Center "Institute of Biomedical Problems" (IBMP) developed the first draft of the federal program for the development of telemedicine services system in Russia ("Telemedicine"). The Ministry of Science and the Ministry of Health of the Russian Federation approved the latter. The program shaped as a concept and many of its provisions were used in subsequent program documents [40]. It aims to increase the level of health services through the implementation in healthcare practice of the remote techniques of consultative medical assistance and the exchange of specialized information based on modern information technologies.

The "Telemedicine" Foundation

The "Telemedicine" Foundation, established by a number of ministries and departments, as well as academic and industrial institutions, was created for the realization of the Program in 1997. Academician O. I. Orlov headed it until 2006. In 1997-1999, the Foundation has developed and realized the

project of priority measures to implement the "Telemedicine" program. The test zones of telemedicine systems were Moscow, Nizhny Novgorod and Tyumen. The Foundation has organized teleconsultations of patients in leading Moscow clinics [40]. In 1997, the first training course for future leaders of telemedicine centers "Fundamentals of telemedicine" (Fig. 78). The organization of a pilot segment of the network" took place. Twelve students from Moscow and other Russian regions have received certificates. Cooperation with the regional telemedicine centers has been initiated [41].



Fig. 78. Training of personnel of Nizhny Novgorod regional telemedicine center (NRTMTC) in Space Biomedical Center for Training and Research (Moscow), 1997

Moscow Telemedicine Project

The Moscow telemedicine project, carried out under the Moscow Government and the Russian Academy of Medical Sciences (RAMS) patronage, aimed at creating a network linking federal health care institutions and regional medical institutions to ensure their cooperation. Thirty two leading research institutes and clinics in Moscow were connected in 1996 to the "Comcor" corporate optical fiber network. Information about patients (X-rays, test results, data tomography, endoscopic images, angiography, histopathological and cytological data, etc.) was transmitted to obtain qualified opinions on the diagnosis and optimal treatment of patients. Teleconsultations were carried out through this Network with the use of teleystems developed by the company "Digital videosystems". It allowed transferring images between MNIOI Hertsen Moscow Oncology Research Institute and City Clinical Hospital №33, Vishnevsky Institute of Surgery, Sklifosovsky Institute of Emergency Care and Altai Cancer Center [42].

Some Other Projects

In 1997, with the assistance of Russian and US governments the international telemedicine project was implemented. It was attended by the Russian Military Medical Academy (St. Petersburg) and the Walter Reed Army Medical Center (Washington). The project used the equipment for videoconferencing made in the USA, Finland and Sweden, telecommunications via the Internet on a TCP / IP and high-speed digital channels ISDN and ATM. The exchange of diagnostic images of ECG, CT scans, electroencephalograms were conducted. The Kupriyanov Clinic of Cardiovascular Surgery, with its computer network, was the leading provider. A hardware-software system, created in 1991 in cooperation between St. Petersburg and American scientists has been used. The complex allowed entering and archiving medical information related to cardiac surgery, including text data, assessment of hemodynamic parameters and gas exchange during operation. It also allowed to adjust promptly treatment tactics as well as to predict patient condition in the postoperative period on the developed mathematical algorithms [40, 43, 44].

Among the first Russian telemedicine project is also a program of advisory videoconferences, conducted between the health care unit, children's rehabilitation center in Krasnoyarsk-26 and specialists of a number of medical centers in Moscow.

The Novosibirsk State University and the Institute of Medical and Biological Cybernetics have developed software for processing visual medical data and created a digital X-ray system that operated based on a corporate computer network.

Arctic and Antarctic Telemedicine

In 1998-99 according to the "Program of Development and Introduction of New Tools and Methods of Medical Ensuring of Human Security", the transmission of clinical information was organized from the "Vostok" station to the mainland during the 44th Russian Antarctic expedition. The PC based "Ambulance-071YS" complex was used, which included a cardio recorder, scanner and video camera. It allowed the input and transmission to the computer of electrocardiograms and X-rays, over switched channels. Twenty polar ECG, X-rays and photographs were transmitted.

At the same time, the work on the territory of the Yamal-Nenets Autonomous District was carried out to provide the advisory support to local health facilities. Scientists from the Center of Polar Medicine of Arctic and Antarctic Research Institute and other centers were involved in teleconsultations. Data were transmitted through a satellite system "Inmarsat-B" via Internet.

A set of devices was transformed for the 45th Antarctic Expedition to a portable version, increased with the registration of electrical brain signals and a device for carrying out the Akabane test. It performed the medical data transmission to the expedition ship. Telemedical complex was applied at the stations, "Mirny", "Progress", "Novolazarevskaya" [45-46].

Despite the short duration of the first telemedicine projects they have performed an important task - to prove the prospects of application of these technologies. On the agenda, there was a question of systematic work on the development of telemedicine, wide introduction of information and telecommunication techniques in practical Russian healthcare.

Federal and Departmental Telemedicine Activities

During these years, a number of federal and departmental telemedicine projects were organized such as the "Moscow - Russian Regions" (Fig. 79-80), a project of the Ministry of Foreign Affairs, of the Ministry of Railways, the basic system of hospitals and others.

One of the most vibrant and successful federal telemedicine projects in the 90s was the project "Moscow - Russian Regions." The initiator of the project was the Bakulev Scientific Center of Cardiovascular Surgery (NTSSSH). The project involved the largest Russian scientific centers such as the Vishnevsky Institute of Surgery; Moscow Research Institute of Pediatrics and Pediatric Surgery; Urology Institute of RAMS; Burdenko Research Institute of Neurosurgery; Petrovsky Russian Scientific Center of Surgery of RAMS; Clinic of Foreign Ministry; the International Centre for the protection of vision and a number of regional medical institutions, universities and research institutes.

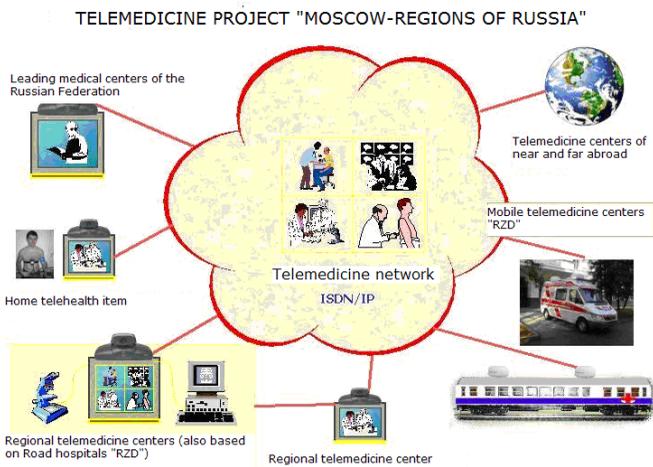


Fig. 79. Telemedicine project "Moscow - Russian Regions (the scheme by V. L. Stolyar)

Since the autumn of 1997, NTSSSH began teleconsultations using videoconferencing for patients with cardio vascular diseases from Saransk, Tula, St. Petersburg and other cities. Much of the success of the project is due to the role of its coordinator – V. L. Stolyar, the head of the laboratory of automated medical history [47-50].



Fig. 80. Valery Leonidovich Stolyar, PhD, Coordinator of the telemedicine project "Moscow - Russian Regions," since 1997. He is also a Head of the Laboratory of automated medical history in Bakulev Scientific Center of Cardiovascular Surgery (NTSSSH) and Executive Secretary of the Russian Telemedicine Association, director of the International School "Modern Aspects of Telemedicine". At the moment he is the Head of Chair in Telemedicine in "Moscow State Medical and Dental University".

At the initial stage in the process of medical videoconferencing the entire spectrum of medical information has been analyzed virtually: the text fragments of case histories, static images (X-ray, echocardiogram, electrocardiogram) and drawings (schemes of malformations and surgeries), video (fragments of surgeries catheterization of heart cavities data). Leading scientists of the Center, headed by its Director Academician L. A. Bokeria [51-52], attended the teleconsultations.

In the course of the project, the priority directions of teleconsultations were formulated. The economic aspects of medical videoconferencing have been studied. An attempt to standardize a set of equipment required to perform a full medical videoconferencing was fulfilled.

The authors of the project have developed a concept of decentralized network (reminiscent of the Internet). Three levels of counseling by the authors plan must include telemedicine points in regional/rural hospitals, in the regional hospitals or in specialized medical regional centers, a telemedicine center of the Ministry of Health. By 2001, the number of teleconsultations made in the project were about 1600. Thus, the project "Moscow - Russian Regions" became the most successful eventful as far as practical activities were concerned.

The second focus was the holding of video lectures cycles on various clinical specialties. In one of the papers, the authors [51] reported about 312 lectures in neurosurgery, cardiology and cardiac surgery, pediatric and other disciplines, conducted from Moscow telemedicine centers to regional specialists. As a part of the project since 2000, annual International Training Schools for telemedicine doctors were organized.

The telemedicine Center of the Moscow Research Institute of Pediatrics and Pediatric Surgery (MNIIPiDH) was established in 1998 [43, 46, 53]. Following main work topics were identified: videoconferencing to consult patients in the regions of Russia and the deferred consultation, distance learning and training, including the development of new diagnostics and therapies, providing access to reference databases, etc. As directed by the Ministry of Health of the Russian Federation from 11.01.1999 onward, the Advisory Council on telemedicine in pediatrics and pediatric surgery was created. Its technical coordinator became the head of the Medical Center of New Information Technologies professor B. A. Kobrinsky (Fig. 81).

Medical videoconferencing was based on the 128-kbit ISDN line and TCP / IP protocol, which is used for optical fiber communication with a capacity of 2 Mbit/s. It ensured the connections with those hospitals that were equipped with satellite channels. Consultation through the telemedicine Center of the Moscow Research Institute of Pediatrics and Pediatric Surgery

was extended to pediatric hospitals in 39 cities of the Russian Federation and CIS countries.



Fig. 81. Boris Arkad'evich Kobrinsky, MD, director of the Medical Center of New Information Technologies, Moscow Research Institute of Pediatrics and Pediatric Surgery (MNIIPiDH), Professor of Medical Cybernetics and Informatics of the Russian State Medical University

Among the center's activities is the application of telemedicine technologies in emergencies. A mobile system based on HeliosNet satellite system for combined access was developed and deployed in the pediatric field hospital in Gudermes, the Chechen Republic. The work was done in collaboration with the Russian Center of catastrophes medicine "Zaschita" and the State central airmobile rescue squad "Centros pas". The system provided the effective telecommunication exchanges of medical data in interactive mode by using satellite channels. This allowed doctors working in extreme conditions, to receive real-time teleconsultations from leading medical centers. The exchange of information was performed daily and 6 up to 10 consultations were conducted.

In the following years, there was a geographical expansion and changes in the structure of nosology [46]. At the same time, the referral of patients to hospitalization in Moscow, following the consultations results, was required in less than in 20% of the cases. Thus, telemedicine technologies, which provided audiovisual contact between the consultant and physician, allowed moving on to a qualitatively new level of medical care while reducing the amount of air ambulance flights.

Telemedicine technologies, including tele-surgery, tele-anesthesiology, medical training, intraoperative monitoring, are used in the laboratory of telemedicine of the "Russian Scientific Center of Surgery", named after Academician B. V. Petrovsky. The head of the Laboratory is E. A. Flerov, PhD (Fig. 82).

In 1994, all automated workplaces (AWP) in the cardiosurgical building were connected to a local computer network and a unified database of cardiac surgery department was created. It allowed viewing monitoring data from any networked computer in the process of surgery operations, storing data in a central database and examining it for educational purposes. As a result, the unique anesthesiologist AWP was created and repeatedly refined. It provides the collection and processing of data about dynamics of the major indicators of the patient's condition and their accumulation in the memory; mapping the dynamics of indicators of the patient in graphic trends; creating a database of all monitoring, remote viewing data on all monitors, their listing and the possibility of remote comments.



Fig. 82. Evgeny Vsevolodovich Flerov, PhD, Head of telemedicine laboratory in Petrovsky Russian Scientific Center of Surgery

At the end of the 90's, a number of departmental telemedicine projects were carried out. The "Telemedicine MPS" program (later - "Telemedicine Railways") [42, 54] became possible thanks to the availability of the telecommunications network and debugged departmental system of medicine from the Moscow Central Clinical Hospital, clinical hospitals in each center of the regional offices of the railways, and up to a network of district hospitals, as well as health centers of linear units. In the 90's, the Ministry of Railways was actively developing its data transmission system and at the beginning of the project had 45 000 km of fiber-optic networks with a capacity of up to 300 Mbit/s all over Russia, laid along the main railways, as well as duplicative satellite channels.

The fundamental decision to start the project was made in October 1999, and the first phase of the project was completed in the summer of 2000, when the Centre of telemedicine consultations was opened in Moscow. At this time, the medical and technical personals were trained in to work with the telemedicine system in Moscow and in the regions. At this point, the railway hospitals in Voronezh, Yekaterinburg, Nizhny Novgorod,

Yaroslavl, Rostov-on-Don and Novosibirsk were connected to a telemedicine network. Further steps were accompanied by connecting the hospitals of St. Petersburg, Samara, Saratov, Chelyabinsk, Irkutsk, and later - Kaliningrad, Yuzhno-Sakhalinsk, Khabarovsk, Chita, Krasnoyarsk.

Railway Hospitals were connected to the data network of Ministry of Railways, local area networks were being deployed, telemedicine equipment and software were installed. Emphasis was laid on the most difficult areas of medicine, requiring the use of the most modern research methods.

The work was conducted in two directions: teleconsultations and tele-education. It reached a sufficiently high intensity of work - one-two consultations and two lectures were carried out weekly. Demonstrations of surgeries and telemedicine consultations on cytology, laparoscopy, psychological rehabilitation of drivers for railway hospitals were organized in different cities of Russia.

Later on, the project was developed further with special medical trains "Therapist Matvey Mudrov", "Surgeon Nikolai Pirogov" and others (Fig. 83). The trains included telemedicine cabinets and satellite communications systems to provide video conferencing and consultations with specialists of the leading Russian clinics. The trains carry out consultative-diagnostic help to the population of the Northern, Siberian and Far Eastern regions. The structure of the diagnostic center includes department of ultrasonic and functional diagnostics, X-ray, ophthalmology and endoscopic studies, laboratory, surgeon, gastroenterologist, neurologist and other specialists, a total of 55 health care workers. Two teams of specialists work in the shift mode [55].

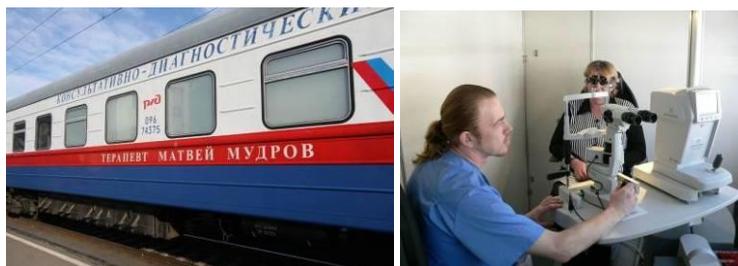


Fig. 83. The train "Therapist Matvey Mudrov" with telemedicine facilities

A similar project linked in 1998 the Russian Basin network of hospitals in Moscow, Arkhangelsk, Vladivostok, Nizhny Novgorod, Novosibirsk, Rostov-on-Don, Lena and Ob. The project also included teleconsultations and tele-education.

One of the thematic projects is the telemedicine consultative and diagnostic network in 27 northern regions in the framework of Federal Target Program "Children of the North". Seventy computer workstations based on "DiaMorph-Cito» hardware-software complex have been installed since 1995 in the district and regional health facilities to provide operational consultative medical and diagnostic care to children. An extensive area of telemedicine service included the Republic of Buryatia, Karelia, Komi, Krasnoyarsk and Primorsky Territories, Amur, Irkutsk, Kamchatka, Chita region, Taimyr and Yamal-Nenets and Chukotka autonomous regions and other territories. Health facilities got an opportunity to address directly inquiries to the leading scientific and clinical institutions in Russia, presenting to consult excerpts from case histories, the results of laboratory and instrumental studies. In 2002 the Research Center of Children's Health have made 1236 consultation of children from remote northern areas via the telemedicine network "Children of the North" and more than 1200 consultations were carried out by regional stations in the cities of Arkhangelsk, Apatity, Syktyvkar, Krasnoyarsk, Kyzyl and Chita. In addition, measures to provide emergency assistance, tele-monitoring and exchange of statistical information were taken.

The "International Centre of Telemedicine" implemented an interregional project. It included the regulation of telemedicine consultations accompanying the expensive types of medical care. This project involved the coordination of telemedicine networks development in some regions, mainly in the Siberian Federal District.

A number of international telemedicine projects were implemented. It had a stimulating effect on the development of telemedicine in Russia. In addition to the projects "Space Bridge in Armenia" (1988) and "Space Bridge in Russia" (1989), a project under the guidance of the Working Group on Space Biology and Medicine was realized in 1993. Twenty two videoconferences on 20 medical specialties were carried out, including consultations for cardiac surgery, neurology, orthopedics [34, 46]. The project involved 4 US and 15 Russian medical centers. The Clinical Hospital of Moscow Police department was equipped with a TV studio, connected to a television satellite communications. Hardware and software systems were equipped with multimedia computer-based workstations.

The active cooperation in the field of telemedicine between health institutions in Arkhangelsk region and Norway's health centers within the project "Barents Regions" [56] belongs to the same period. The telemedicine center on the base of the regional hospital and 13 studios in three cities, five regional hospitals and four outpatient clinics were opened. These telemedicine points, using relatively inexpensive telephone lines and

the Internet, are located at distances from 20 to 700 km from the regional center. 351 teleconsultations in 299 patients were performed between 1996-2001. A significant reduction in the use of air ambulance was the result of the telemedicine technologies application. More than 100 lectures for doctors via electronic communication channels were performed, too.

The Russian-Japanese telemedicine project was carried out in 1999-2000 between epy medical center RF President Administration in cooperation with the clinics in Moscow, St. Petersburg and the Far East. It was intended to counseling patients and remote training of physicians.

The development of telemedicine at this stage took place in close connection with the decision of general issues related to digitalization programs and other documents of the Ministry of Health, which became the first step in creating a regulatory basis of telemedicine.

A special section dedicated to telemedicine appeared for the first time in the order of the Ministry of Health of Russian Federation from 07.14.99, № 279, which approved the "Basic trends of developing digitalization of Russian population health care for the 1999 - 2002 period".

The section "Telecommunication Technologies and Global Corporate Networks" included the development of the following directions:

- Consultative telemedicine systems, including systems to support teleconsultation and expert consultative telemedicine systems;
- Telemedicine system in education and training;
- Information support of scientific and methodical literature with the use of the Internet;
- Reference and information systems for use in remote access mode;
- Specialized distributed medical databases.

The first official "telemedicine" Health Ministry document was the Notice from 11/01/99, №10U on "Creation of the Advisory Telemedicine Board in Pediatrics and Pediatric Surgery". Also were approved the Regulation related to an Advisory Board on the program of medical videoconferencing "Moscow - Russian regions" and the composition of this Advisory Board.

To coordinate and optimize the work upon creation and implementation of telemedicine technologies into the system of health care and public health management in Russia, a Coordinating Board of the Ministry of Health of Russia for telemedicine in the Russian Federation health care system (Russian Ministry of Health Order from 20.12.2000, № 444) was established.

Already in the course of initial telemedicine projects, along with teleconsultations, the most accessible tele-educational events - video lectures, started. Video lectures and seminars, scientific-practical videoconference on current medical problems were held initially, and later

they merged gradually into distance learning courses. The formation of educational telemedicine trends was affected not only by the development of telemedicine, but also by the formation of distance learning technologies in the non-medical education segments.

One cannot ignore the role of scientific conferences in the formation of telemedicine centers and projects. It has initiated discussions on topical issues of telemedicine, analysis of trends, elaboration of concepts and recommendations. All this became the prototype for the later official documents regulating the development of telemedicine.

The first of these forums was the International Symposium on Telemedicine that took place in Moscow on 24-26 June 1998 in the framework of the XI Conference on Space Biology and Aerospace Medicine. Officers from federal health agencies, scientists from Belgium, Germany, Norway, USA, Singapore, Ukraine and members of the International Telecommunication Union, prepared most of the reports. It is indicative that already at this first symposium, among 33 reports there were presentations from regional centers (Far East Medical Center, Arkhangelsk State Medical Academy, Ural Institute of Traumatology and Orthopedics (Ekaterinburg), Russian Scientific Center "Restorative Traumatology and Orthopedics" (Kurgan) and others).

One year later, at the sub regional workshop on telemedicine for the CIS and Baltic countries, which took place in December 1999 and was organized by the Telemedicine Foundation and the International Telecommunication Union, the emphasis has shifted from assessing the prospects, descriptions of information technologies to reports about carried out projects, practical aspects of telemedicine. The concept of creating a unified Russian information network, developed by the Telemedicine Foundation, was presented. The ways of solving the economic, technological, legal problems of a new direction, standardization of various types of telemedicine services, the possibility of providing them through health insurance programs were discussed.

Foreign scientists presented a number of interesting reports such as portable home telemedicine systems in Bulgaria; the use of telemedicine in the extensive prevention programs in Malaysia and ambulance service in Sweden; the creation of a telemedicine network in Baltic countries; thematic projects in CIS countries (Uzbekistan, Georgia and Ukraine). There were reports on the practical experience in telemedicine technologies in Russian regions (Arkhangelsk, Nizhny Novgorod and Sverdlovsk regions, the Altai Territory, Karelia).

Moscow hosted the Third International Symposium on Telemedicine in 2000. Its organizers were the Foundation "Telemedicine" and the medical

center of Administrative Department of the Russian Federation President. The development of telemedicine has allowed organizing its work on sections, dedicated to some specific directions of telemedicine: tele-pathology, tele-cardiology, tele-radiology, space medicine. Scientists from UK, Germany, Canada, Norway, USA, France, CIS countries and 19 Russian regions attended it.

In the same years other federal and international forums on telemedicine were carried out: a seminar on "Telemedicine - the formation and development" (St. Petersburg, 1999), the International Symposium "New Information and Computer Technologies in Medicine" (Moscow State University, April 2000), the International Conference "Actual Problems of Telemedicine" (Moscow, Bakulev NTSSSH, May 2000).

The Russian Telemedicine Association was founded in 2000. The permanent chairman of the association is Oleg Atkov, MD, professor, doctor-cosmonaut, well-known expert in the field of space physiology and medicine, cardiology, ultrasound diagnostic and medical imaging (Fig. 84).

The main goals of the Association are:

- Development of regulations and technologies of planned and emergency video consultations;
- Development of technologies for remote interactive training of doctors, including master classes leading surgeons and diagnosticians, including the transfer of a stereoscopic image of the surgical field;
- Creation of mobile telemedicine complexes with an interactive decision support system for distant regions or at accidents;
- Development of home telemedicine technologies for remote monitoring of patients;
- Staff training for telemedicine centers in the framework of the international school of telemedicine and creation of training courses on the basics of telemedicine for medical students and physicians in the framework of after-graduation education.



Fig. 84. Oleg Atkov, MD, PhD, Soviet cosmonaut, president of the Russian Telemedicine Association since 2000, project manager of "Telemedicine MPS" and "Telemedicine Russian Railways", chief editor of the scientific journal "Visualization in the Clinic"

A number of telemedicine projects and centers was opened with the participation of the Association of the regions (Kazan, Saransk and Smolensk). The annual International School of Telemedicine allows preparing experts for telemedicine centers.

Creation Regional Telemedicine Systems (2001 - 2010 years)

To mark the starting point for the next stage of Russian Telemedicine we can consider some official documents, which stimulated the development of regional telemedicine centers and projects.

The first draft of the federal program "Telemedicine" was worked out in 1996-1997 with participation of the Space Biomedical Center for Training and Research jointly with the IBMP. The program was shaped like a concept, and many of its provisions were used in subsequent program documents [40]. First, it is the concept of telemedicine technologies in the Russian Federation (2001) and the materials of Parliamentary debates "On Telemedicine and Information Policy in the Field of Russian Citizens Health", held on 20 May 2002 in the State Duma. The development of telemedicine has been put among the priorities of health care for the first time. The high potential of its influence on the reform of the health care system has been recognized.

The concept of telemedicine technologies in the Russian Federation and its implementation plan were prepared by the Expert Board under the Ministry of Health and approved by the Order of the Ministry of Health and RAMS from 27.08.2001, № 344/76. The concept became a powerful catalyst for telemedicine activities and brought to life many regional telemedicine centers, projects and programs.

The importance of telemedicine was stressed by the creation of the Advisory Board in the Health Committee of the State Duma of Russian Federation in 2001 for legislative support of telemedicine technologies. In 2002, the Board worked out the draft of a Federal Law "On Telemedicine Services". It also prepared the Federal Program of telemedicine development and discussed the documents at Parliamentary debates.

Mostly, telemedicine centers were organized based on regional and public hospitals. Some examples are Nizhny Novgorod (1999), Voronezh (2000), Irkutsk (2000), Saratov (2001), Smolensk (2001), Yaroslavl (2001) region of the Republic of Bashkortostan (2002), Sakha (2002) and Mordovia (2003). Clinical and diagnostic centers (Altai region (1998), Bryansk region (2000), RT (2001), Udmurtia (2007, Fig. 85) have become the basis of telemedicine centers. In some regions, telemedicine centers were organized in medical departments of catastrophes centers (Orenburg region - 2001); perinatal centers (Chuvash Republic - 2003); Basin hospitals (Rostov region - 2000); Information and Analytical Center (Samara region - 1998). Other telemedicine centers were based in medical universities and research institutes (Ural Research Institute of Traumatology and orthopedics (Ekaterinburg - 1999), Ulyanovsk (2001) and Mordovia (2003) State University, Omsk medical Academy (2002).



Fig. 85. Teleconsultation in Izhevsk, Udmurtia

A number of centers were opened for direct participation in federal programs such as "Moscow - Russian Regions" (in Tatarstan, Smolensk, Penza Region, Sakha-Yakutia), "Children of the North" (in Petropavlovsk-Kamchatka, Khabarovsk).

Because of the decentralized nature of telemedicine development a rather broad range of legal forms exist - from initiative groups, matrix structures, departments of health facilities and universities to commercial ("Interregional Center for Telemedicine", Tatarstan, 2001; "Medical engineering center OSS", Kaliningrad region, 2002) and non-profit (non-

profit partnership "Medical computer technologies", Altay, 1998) organizations.

Besides using e-mail and video conferencing, the original software and devices for telemedicine were developed in a number of regions. For example, the Bryansk regional medical-diagnostic center in conjunction with the Hematology Research Center developed and implemented a system of teleconsultation for patients with blood diseases in 2000. The original form of electronic medical records was created with the interface in the form of a temperature sheet to view text and image data of the patient for the period of hospitalization [57]. The original software for the regional telemedicine system [58] was developed in Barnaul.

The projects of Voronezh universities - Technical University and Medical Academy, "Telemedicine System for the Registration and Transferring of Patient's Physiological Data" and "Microprocessor Temperature Recorder of Biologically Active Human Points" allowed carrying out operative remote monitoring of the human condition in a variety of environment, including the monitoring of risk patients in intensive care and in everyday life.

A "virtual family clinic" based on academic consultation and diagnostic center and polyclinics of Medical Academy was developed in the Omsk State Medical Academy.

The information system "Kardinet-Online" (Fig. 86) was created in Saratov region. It provides a joint work of medical institutions with medical information. The system enables remote operational description of instrumental examinations from the medical institutions and sharing of medical information through telephone channels.



Fig. 86. Storage and transferring data of instrumental examinations in "Kardinet-Online" system, Saratov

The Saratov Institute of Cardiology, experienced in developing tele-cardiology ECG transmission systems by phone, created a number of new systems with computer data processing.

The Ural scientific and industrial enterprise "Altair" designed a distributed information-counseling system "virtual clinic" for consultations from specialists located in Russia and abroad.

The Ural Institute of Traumatology and Orthopedics (Ekaterinburg) studied the effectiveness of medical information placement on a dedicated server, which allowed physicians and scientists who live on different continents to participate in the electronic trauma forum.

Deferred teleconsultations with ultrasound transfer, morphological and magnetic resonance imaging in the modern international DICOM 3.0 standard were carried out in Altai region in 2000.

Significant scientific and methodical advances in the development of specialized technology solutions for telemedicine, adapted to the conditions of the Russian regions were created during this period.

While the first centers were based on the initiative or were opened as a part of federal projects, since 2001 the programs of digital health care, including the development of telemedicine, have been adopted in a number of regions (Arkhangelsk, Nizhny Novgorod, Penza regions, the Republic of Udmurtia, Bashkortostan and many others). In some regions, they have received the status of regional laws, the first of which, accepted in St. Petersburg in 2001, approved the target program "Telemedicine Network of St. Petersburg."

According to the data of the Russian Ministry of Health, in the middle of 2002, more than 40 of the 89 Russian regions were involved in telemedicine activity [42].

The distinctive feature of this stage is that apart from single centers, the regional telemedicine networks that involved regional, city and specialized regional institutions was created. For example, the joint telemedicine activities were carried out in the Penza region in 26 health facilities, in Nizhny Novgorod – in 17, in Bashkortostan - in 18, in the Udmurtia - in 19 [59-64].

The Project "Unified Diagnostic System of the Republic of Bashkortostan" was implemented in the Republic of Bashkortostan in 2001-2005. It aimed at creating a network of 10 regional medical centers. A Telemedicine Center, at the Republican Clinical Hospital №2 was created in 2001, consultations of patients and remote teleseminars and tele-lectures for physicians of various profiles began [65].

The cities Bratsk, Angarsk, Sayansk, Usolye-Siberian, Taishet, Slyudyanka were integrated in a unified computer network in the Irkutsk region [66-69].

The telecommunications infrastructure was formed in the Khabarovsk Territory. It included the Far East Medical Center (Khabarovsk), Far Eastern Regional Center for Disaster Medicine; city hospital №2 in Komsomolsk-on-Amur, Central District Hospital in Pereyaslavka and Central District Hospital in Nikolaev region [70].

The intra-territorial telemedicine network has been created in 2002 in the Republic of Sakha (Yakutia), including Mezhusny Children's Center in Viliuisk, Lena Central Basin Hospital and Alekseevskaya linear hospital [71-72].

There has been an expanding range of telemedicine services, which along with deferred and synchronous teleconsultations included video-educational events, webcasting scientific conferences, conducting administrative videoconferencing.

The regional telemedicine projects are currently the most dynamically developing telemedicine systems, but plans for the development of regional systems largely depend on available funding, which significantly affects their realization. Speaking about the mechanisms of telemedicine financing we must admit that along with the unfinished normative base, this is the most vulnerable link in the widespread introduction of appropriate technologies and services [67-68, 73-74].

In practice, we identify the following options for funding of telemedicine projects and programs:

- International grants (for example, the project "Samara - Iowa" in the Samara region, the grant of the American International Health Alliance in Khabarovsk);
- Federal telemedicine projects, including the previously viewed program of the "Telemedicine "Foundation, "Moscow - Russian regions", "Children of the North" and others;
- Regional programs of Health Care digitalization;
- Own funds of health facilities, research institutes and universities.

The examples of incorporating telemedicine services in the payment program of mandatory or voluntary health insurance, which could become the basis of their economic development, are very few. There is the experience of a telemedicine lab in the Perm region and some other regions of the Ural and Volga federal districts, of including telemedicine in programs of insurance companies "Rosgosstrakh", "Kane Assistance", Rostov insurance company "AsStra".

Another trend of the described stage is the appearance of the interregional telemedicine projects. A limited number of telemedicine centers at leading medical institutions in the region have been opened in most districts up till 2001-2003, while the district level of telemedicine systems have not yet received a tangible development [67, 70, 75-78]. Therefore, there was a tendency to establish cooperation between the regional telemedicine centers. The objective reasons for this were the need for exchange of experience in telemedicine activities under a normative and methodological base deficit, a desire to establish dialogue between centers, to create a system providing consultative medical care at the interregional level using the leading regional medical institutions capacities [60, 79].

Mainly, the coordination of telemedicine was organized as follows:

- Conducting scientific district telemedicine forums (Fig. 87);
- Carrying out interregional initiative telemedicine projects;
- Acceptance of conceptual documents on the development of telemedicine in the regions by the Coordination Councils.



Fig. 87. The first scientific and practical conference of the Volga Federal District "Telemedicine and modern medical technologies", Nizhny Novgorod, 2004.

As a specific result of the development of telemedicine technologies in Russia in the first decade of the twenty-first century we can consider the materials of the Round Table "Legal Aspects of the Introduction of Telemedicine Technologies in the Russian Federation", conducted by the Health Care Committee of the State Duma in 2009 (Fig. 88). The analysis was conducted by federal districts.



Fig. 88. The Round Table "Legal Aspects of the Introduction of Telemedicine Technologies in the Russian Federation", State Duma, February, 2009

Data analysis from 38 federal medical centers and 74 regions of Russia reveals the presence of telemedicine organizations in 19 federal specialized medical institutions (federal level), 98 telemedicine centers and offices in 50 subjects of the Federation (regional level) and 107 telemedicine centers and settlements in district hospitals and clinics (municipal level). In total, information about 224 telemedicine centers and offices operating on the territory of Russia was received. Thus, the experience of telemedicine activities was available in 56.1% of the regions. In some areas (Arkhangelsk, Voronezh, Irkutsk, Nizhny Novgorod region, the Republic of Altai, Bashkortostan, and others), the regional telemedicine networks, numbering from three (Khanty-Mansiysk district) up to 26 (Penza region) stationary and mobile telemedicine offices have been developed.

The concept of telemedicine development in the Far East discussed at the symposium "Actual Problems of the Implementation of Telemedicine in the Far East" in 2001. The discussions results from the Symposium program were presented at the meeting of the Coordinating Health Care Board in the Far Eastern Federal District [70, 80]. Nineteen telemedicine centers were already in operation in 2009.

The district telemedicine project "Volga Telemedicine" was on the agenda of the first meeting of the Health Care Coordinating Board in April 2001 in the Volga Federal District. It was approved and found embodiment in the health informatics programs of number of regions of the Volga Federal District. In October 2002, it was decided to establish a Section of telemedicine technologies. The coordinating functions in the regional telemedicine development have been assigned to the Nizhny Novgorod regional telemedicine center, based at the State Health Care Institution

"Semashko Nizhny Novgorod Regional Clinical Hospital". The Concept of development of telemedicine technologies in the Volga Federal District was developed somewhat later [60, 76-77, 79, Fig. 89].

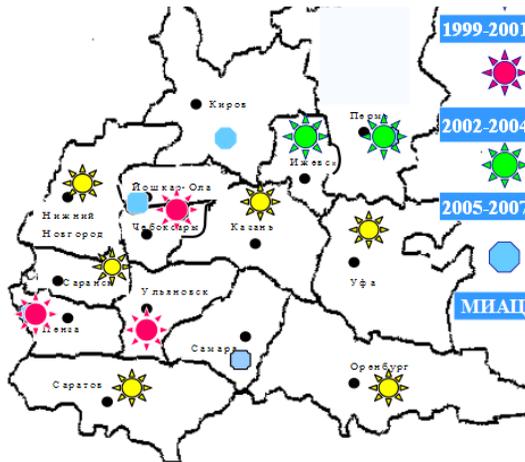


Fig. 89. Telemedicine centers in the Volga Federal District in 90's
 During the implementation of the health care modernization program the number of centers doubled. The most actively working telemedicine systems are in Bashkortostan, Tatarstan, Udmurtia and Chuvashia. 71 telemedicine centers and offices were operational in 2009 in the district, which was the highest rate in Russia.

An interregional meeting on developing telemedicine in the Siberian Federal District was held in 2002 at the Irkutsk diagnostic center. The model of telemedicine technologies implementation in the regions of Siberia was worked out [66]. 2280 telemedicine activities, including 2197 teleconsultation at the federal and inter-regional levels were conducted in the district during the period from 2000 to 2004. The number of different types of events increased 7-10 times over the 5 years. In addition to conducting teleconsultation by federal clinics, the potential of other eight medical regional institutions in the district was also exploited [69, 80].

The Board of the Interregional Association "Public Health Services of the North-West," decided in July 2002 to create a website within the interregional program "Information Interaction" to help health authorities and medical institutions in the region in the development of the possibilities offered by modern informatics science to medicine. The practical issues of the organization of telemedicine center occupied a prominent place in

section "Telemedicine in North-West Region", in addition to the overall concept [81-82]. 44 telemedicine centers and offices were opened till 2009 in the regions of the North-West District.

The meeting of the Academic Council, which has approved the "Concept of Development of Telemedicine in the Ural Federal District", was held in November, 2002, in the South-Ural Scientific Center of RAMS (Chelyabinsk). The implementation in pilot projects of the structural-functional model of comprehensive information and telemedicine district system started in 2006. It provided a transition from the "point" to the "through" digitalization. The district had 19 telemedicine centers and offices, several specialized centers at scientific research institutes and clinics in 2009, as well as mobile telemedicine laboratories, effectively working in the northern district territories.

A video conference to discuss the telemedicine issues with the cities of the Southern Federal District, Krasnodar, Stavropol, Nalchik, Maikop and Makhachkala was held in September of 2002. The District Coordination Board on Health Care determined the development of telemedicine networks as one of the priority directions of public health in the regions. The coordination of this work was mandated to the "Southern District Medical Center" (Rostov-on-Don). Initially, the system consisted of three centers in Rostov, Astrakhan, Volgograd, in 2005 there were already 9 telemedicine centers and offices, and in 2009 the number of telemedicine facilities increased up to 19 [75, 78].

Thus, the creation of district telemedicine systems had a definite impact on the development of telemedicine at in the regional health care level. The prevailing telemedicine technology was the data transmission via e-mail and video conferencing, 30% of the regional centers had access to telecommunications via ISDN protocol, and others - only via Internet Protocol (TCP / IP). The project "Moscow - Russian Regions", coordinated by the Bakulev Scientific Center of Cardiovascular Surgery remained the most intensively functioning project, in which more than 1200 teleconsultations were conducted annually.

The mutual commitment to broad international cooperation in the field of telemedicine was fixed in the "Memorandum of Cooperation of States - Participants of the CIS in the Field of Creation of Compatible National Telemedicine Consultation and Diagnostic Systems", signed in Kishinev on November 11, 2008. In the agreed definition of telemedicine, it is understood as:

"a complex of organizational, financial and technical measures to ensure the operation of the remote consultative and diagnostic medical services system, in which the patient or the doctor who performs the medical

investigation or treatment of the patient receives a remote consultation with other specialists, using modern information and communication technologies".

The wider concept of "e-health", accepted in 2005 at the WHO session (WHA 58.28) [83], was introduced in this document. It was understood as a "cost-effective and reliable use of information and communication technologies for health and related fields, including health care, medical oversight, the medical literature, medical education, knowledge and research in the field of health.

So, the described stage was characterized by improving the technological base of telemedicine, including informatics, telecommunications, medical and diagnostic components, expanding the range of services, diffusion of relevant technologies from the federal to the regional and municipal levels, the development of normative base components, the search for effective organizational and financial functioning mechanisms, work on the creation of methodological support of telemedicine systems.

The transition to the concept of "e-health" marks the next stage in the development of telemedicine technologies in Russia, the main features of which will be the diversification of services.

Period of Telemedicine Services Diversification (Since 2011)

The current period in Russian telemedicine is characterized by transition to the systematic application of its technologies, including regulatory-legal economic, methodological, personnel and organizational support.

Telemedicine, which had appeared inside the medical informatics, and then developed as a relatively independent branch, now is re-integrated into medical informatics already at a new stage – within the framework of the e-health concept.

A distinctive feature of the present stage is that Russian telemedicine is more and more reflected in government programs. Digitalization of health care and telemedicine development were classified as one of the main tasks in the Federal Healthcare Modernization Program (2011 - 2012).

Following the report of the Russian Ministry of Health on the results of the program, more than 11,000 state and municipal medical institutions in 83 Russian regions and 1955000 health professionals are covered by digitalization in health care. The costs for realization of measures on digitalization in 2011-2012 amounted to about 39 billion rubles. About 600000 workstations are connected to the unified state information system in the health sector.

The principle for the subsequent stage of development of telemedicine and e-health is their integration into the unified state information system in

the health sector (EGISZ), the creation of which is carried out step by step since 2011.

The general architecture of the system consists of two segments - the centralized system-wide components, a unified information space in Healthcare and application components. The central element of the infrastructure is the Federal Data Processing Center (Federal DPC).

The functions of the applied information systems are divided into transactional, management and referral.

The following System components are introduced at the first stage:

- System for keeping the experts schedules,
- System of electronic record for the doctor,
- Management accounting system,
- System of interactions with health insurance organizations,
- System of conducting electronic medical records and access services,
- System of conducting the registry of medical devices (the database),
- Procurement system,
- Regulatory and reference information system,
- System of monitoring the realization of programs in public health,
- The Federal electronic medical library,
- Specialized registers for individual categories of nosologies and citizens.

The system involved 8300 medical organizations all over Russia and to 3 million healthcare professionals.

Telemedicine technologies played an essential role to ensure the availability and efficiency of high-tech medical care for the population, including those in remote areas. To the organization of high-tech assistance elements of its translation in telemedicine technologies were added.

Currently, the federal state budget for health care institutions covers 21 telemedicine consulting centers for planned and emergency counseling.

Among the numerous directions of health informatics, the important role belongs to the most massive, socially oriented health services, one of which is remote entry of patients from rural areas to the consultative polyclinic of regional medical institutions.

The receipt of applications (entry) to the doctor in the State Health Care Institution is included today in the Register of state and municipal services provided in electronic form.

In recent years, the remote recording became popular among the population. For example, in 2016 more than 2.4 million patients of the Moscow region (every third inhabitant of the region) made an appointment to see a doctor through an Internet portal.

The Remote Medical Education

The modern stage is characterized by the systematization of distance education (DE) methods, in a variety of forms, with an expanding range of specialties.

Formal requirements for distance education in health care have been set. It was determined that DE should include training of students; training and retraining of doctors and nurses; tele-mentoring; work with the post-graduate student and doctoral students; scientific-practical seminars for the efficient exchange of information on new methods of diagnosis and treatment; training while developing of new medical techniques [84].

The DE system has been developed in a number of medical universities in Russia: the Sechenov First Moscow State Medical University, Pirogov Russian National Research Medical University, St. Petersburg, Rostov, Northern State Medical Universities and others.

The Law "Education in the Russian Federation" [85] establishes the concept of distance learning technologies and e-learning. The method of application of distance learning technologies in the educational institutions of higher, secondary and supplementary professional education of the Russian Federation has been developed and validated in 2002 by the Order of the RF Ministry of Education.

The standards of e-learning have been detailed in departmental normative base [86]. For the most part, the advantages of distance learning are present in education of humanitarian disciplines [87]. Distance learning took place for 48% of all students in public and 79% of pupils in private high schools at the end of the first decade of the 21st century [88-89].

Among the various models of distance education, the most accessible and independent is the self-obtaining knowledge by doctors using Internet resources. In recent years, electronic libraries have been developed, allowing receiving a huge amount of medical information previously posted on vast number of websites.

The largest Russian multi-disciplinary resource is the Scientific Electronic Library (www.elibraty.ru; Fig. 90) [90] - an information portal in the field of science, technologies, medicine and education that contains abstracts and full texts of more than 18 million scientific articles and publications. On the platform eLIBRARY.RU electronic versions of 3200 Russian scientific and technical journals, including more than 2,000 journals are available in open access. Among the journals, 1240 cover the field of medicine and public health.

The search of available scientific publications via author index leads to more than 4,8 million authors, including more than 590 thousand Russian ones. The national information-analytical system - "Russian Science

Citation Index (RSCI)", accumulating more than 4,7 million publications of Russian authors, as well as information about the citation of these publications from more than 4,000 Russian journals, was implemented in the Scientific Electronic Library.



Fig. 90. Web service eLIBRARY.RU

KiberLeninka (<http://cyberleninka.ru>; Fig. 91) project [91] is another Scientific Electronic Library. It is built on the Open Science paradigm, main objectives of which is to promote science and research activities, public control of quality of scientific publications, the development of interdisciplinary researches and of modern institute of scientific reviewing, improvement of Russian science citations. Russia is among five European countries with the largest number of articles published in open access.

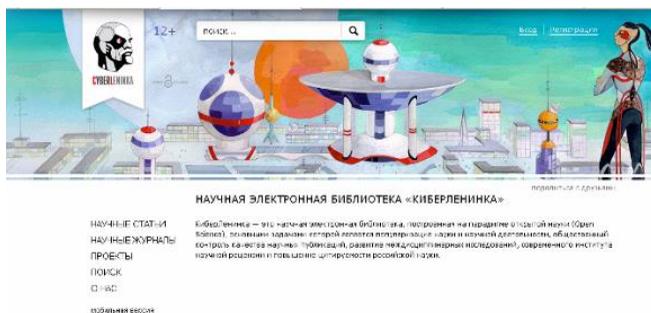


Fig. 91. Scientific Electronic Library KiberLeninka

The largest Russian medical electronic repository is the Federal E-Library of Medicine (FEMB), which is a part of the unified state information system in the health sector as a reference system [92]. FEMB updating is funded by

the Central Scientific Library of Medicine of the Sechenov Moscow State Medical University, numbering three million copies. The amount of electronic publications FEMB in open access is constantly growing. FEMB should provide fundamental modernization of health information, as a result of which the most important information in digital form will be available in all clinical, educational, scientific and medical institutions of the country via the Internet. It is shaped as a library complex, consisting of a distributed collection of electronic documents and distributed catalogue with a common architecture, conventional protocols and standards. Many state medical universities in the regions also have their own digital libraries: Altai (<http://www.agmu.ru/biblioteka>), Volgograd (<http://lib.volgmed.ru>), Far East (<http://www.fesmu.ru/elib>) and others.

Today, many medical schools have accumulated extensive experience in the use of e-learning in teaching doctors of various disciplines, which is a true need in studying, generalization and unification [93-99]. For example, at the Faculty of Postgraduate Education of the Stavropol State Medical Academy teleconferences, video seminars, live video from surgical operations and consultations of difficult patients in federal institutions are regularly held for surgeons (Fig. 92) [100]. The laboratory of innovative learning technologies was opened in the Stavropol Medical Academy in 2010. The basis of the laboratory is a virtual training system, which allows imparting practical skills in conditions close to real. The Concept of additional professional education development has been elaborated in the Irkutsk State Academy of Postgraduate Medical Education [101]. In the Bashkir Medical University modern and effective teaching methods as multimedia demonstration of educational material within the mandatory program, demonstration of videos on topics of ophthalmology, of surgical treatment of patients with ophthalmopathy (cataract, glaucoma, etc.) are widely used [102].



Fig. 92. Master class on laparoscopic surgery of hernia in Stavropol

The State Organization "Institute of Urology" of the Russian Ministry of Health has a unique experience in organizing and carrying out real educational courses for urologists using e-learning. The educational project UroEdu.ru (<http://uroedu.ru>) was opened in 2011, where every urologist can, free, without departing from the main job, go through educational cycles. This course is available online - in either direct on-line translation and or in the recording mode, which provides a certain degree of freedom for urologists to choose a time for learning [103].

Additions in the form of distance learning technologies were introduced in the 2009-2012 within teaching and thematic plan of the certification cycle on the specialty "Organization of Health and Public Health» (<http://cdo.krasgmu.ru>) in the Krasnoyarsk State Medical University: 288 hours of 504 training are in distance form of [104].

In the distance-learning department of the "Ural State Medical Academy" (UGMA) in Ekaterinburg, a program of absentee cycle of thematic advanced training for physicians, general practitioners, gastroenterologists has been developed [105]. Training course consists of three modules. The modular training system does not allow the formation of "gaps" in the assimilation of the course: for each passed section student reports to the teacher, and only then can move on further, control of acquired knowledge can be very detailed and almost constant [106].

Implementation of distance learning technologies in the Nizhny Novgorod State Medical Academy was held in two stages [107]. In a first phase (2002 -. 2008) the elements of postgraduate distance learning on basis of the regional telemedicine center have been worked out (Fig. 93). Selected lectures for doctors on a number of clinical disciplines (cardiology, endocrinology, neurology, public health and health care, etc.) were carried out by videoconferences.



Fig. 93. Distance medical training in endo-video-surgery (Nizhny Novgorod Semashko Regional Clinical Hospital, Nizhny Novgorod, 2009).

In 2011, at the Institute of Continuing Medical Education a Department of Information Technology was founded.

The further development of the system is associated with the appearance of fundamentally new technologies and services in the field of information technology. Apparently, the most promising of distance learning technologies in the future will be artificial intelligence and virtual environment. Thus, during the development of distance education system it has gone through several stages.

The content and the means of each of them are successfully implemented in various forms of modern distance education. Their approaches and components are mutually reinforcing itself.

Administrative Direction of e-Health

The universal IT opportunities enables to discuss any management issues with distant audiences (heads of health departments, leading specialists of medical services, chief physicians of medical institutions) with the presentation of high-quality visual materials [108-111]. This videoconferencing allows participants to gather large audience without significant finance costs and time. Since 2011, the Russia Ministry of Health conducts regular videoconferencing on most of the public health issues, the implementation of the strategic medical and social programs.

In the period up to 2020, a significant expansion of the administrative direction of the use of IT is planned: implementation and improvement of electronic document management system in health departments, territorial insurance funds, monitoring the programs of public health development etc.

Training in Telemedicine

When implementing telemedicine techniques in Health practice in Russia, it became clear that, along with the need to solve a number of technical, organizational and economic issues, a significant problem being the insufficient computer literacy of doctors and practically full lack of knowledge and skills in the field of telemedicine technology and services.

The development of telemedicine services, in addition to the other difficulties that accompany any innovative technologies, faced a number of serious psychological barriers at the level of potential executors and users as well as health managers.

As such, arose the issue of a swift development, testing and implementation for large contingent of doctors and students the forms of training in the basics of telemedicine, as well as effectively informing the medical society about the importance, opportunities and potential of new direction.

The first experience of a telemedicine training was the "Telemedicine" course, designed for students at the Faculty of Fundamental Medicine of Moscow State University. (MSU) in 1995, as well as a 30-hour seminar for practitioners, conducted in 1997-2004 by the Educational Research Center of Space Biomedicine.

In some regions, the telemedicine schools were conducted for doctors training, as for example at the federal (Bakulev Scientific Center of Cardiovascular Surgery, Petrovsky Russian Scientific Center of Surgery) and regional telemedicine centers (in the Republic of Bashkortostan, Udmurtia). Since 2000, the Russian Telemedicine Association annually held the International School of Telemedicine (Fig. 94).



Fig. 94. Annual International School "Modern Aspects of Telemedicine"

Currently, a number of medical universities include telemedicine courses in the training of future doctors - Moscow State Medical and Dental University, Russian University of Friendship of Peoples, at the Faculty of Fundamental Medicine Moscow of State University, North-West State Medical University, Northern State Medical University, Ulyanovsk State University, and others (Fig. 95) [112].

For example, in the Nizhny Novgorod State Medical Academy at the Chair of Social Medicine and Health Organization, a 72-hour course "Foundations of Telemedicine and e-Health" is held annually for students of the medical faculty. This course uses widely the distance education technologies. The best works are presented at the annual session of young scientists and students [113].



Fig. 95. Session of Young Scientists - Nizhgma - 2015 - IT Technology Section in the healthcare and medical education.

Currently the implementation of IT methods are maintained in accordance with the State Program "Development of Healthcare" for 2013 - 2020 [114]. It formulates the following objectives:

- Digital healthcare, including the development of telemedicine;
- Organization of personalized working in health care institutions with high-risk groups of patients, including the use of mobile communication, "internet" network;
- Increasing of the availability of medical experts and services through the use of telemedicine consultations;
- Increasing the efficiency of health care in high-risk groups of patients through the use of remote screening technologies;
- Implementation of electronic educational courses and support systems of medical decisions in the daily activities of health professionals.

In the period up to 2020, expanding of the application of modern information systems in health care organizations activity is planned. It envisages the creation of telemedicine infrastructure at the federal and regional levels and in interregional centers of specialized medical assistance, including federal and regional data processing centers.

The main directions of telemedicine development in the Russian Federation in the short run formulated by the Ministry of Health of the Russian Federation are:

- Working out the regulatory and methodological documents;
- Creation of a federal telemedicine consultative and diagnostic system;
- Distance education of doctors and health professionals by leading experts of federal institutions;
- Pilot projects on the remote monitoring of patients' health status;

- Development and implementation of new methods of diagnosis using telemedicine technologies;
- Promotion of international cooperation [115].

Therefore, it is in the nearest plans of the Ministry to introducing amendments to the Federal Law dated 21 November, 2011 N 323-FZ "About the Basis of Public Health Protection in the Russian Federation" [116]. The latter is related to telemedicine, approving the procedure of providing telemedicine consultations and development of the modern nomenclature of telemedicine services.

In 2015-2016, the preparation of a draft law, providing for the amendment of the legislation on the use of information and communication technologies in the field of public health protection, was initiated. The law aims to establish the foundations of the remote communications for decision-making in the prevention, diagnosis, treatment and rehabilitation, assessment of the validity and effectiveness of therapeutic and diagnostic measures, conducting the medical remote consultation, monitoring of the patient's health status, as well as decisions on other medical issues. The Russian Ministry of Health, the Foundation for the development of Internet initiatives, the Institute of Internet Development, and the medical community participated in its run-up. At the time of writing this chapter a public discussion of the project is being held in the mass media and Internet sites, at the Ministry of Health and in the Committee on Information Policy, Information Technology and Communications of the State Duma of the Russian Federation [117]. It allows to reveal the alternative points of view on some issues, including the identification of participants in teleconsultation, the boundaries of medical decision making, incorporating telemedicine services in the compulsory health insurance scheme.

The plans are to continue the standardization work in the field of medical informatics, including more than 40 information systems, which are the basis for the development of EGISZ - centralized system components, a unified information space in healthcare and applied components - administrative, transactional and reference.

The Federal Agency for Technical Regulation and Metrology has also prepared a package of state standards for telemedicine systems, regulating at international level the issues related to terminology of telecommunications, data protection, mobile and stationary telemedical systems, etc. [118]. Their implementation, after discussion, consideration and adoption is expected to take place in 2017

At the Russian Ministry of Health was created the position of chief specialist in digital healthcare and an Expert Board in the use of information

and communication technologies in healthcare. A portal of EGISS participants operational cooperation work have been installed [115].

One of the leading sites for discussion of the telemedicine issues is the RAMS portal [119] - an information web-resource, which allows carrying out navigation for physicians and patients on the latest biomedical technology, specialists, a leading clinical and research centers and healthcare organizations in Russia and abroad. In particular, at the meetings of the working group of IT-specialists the "Virtual Medicine and mHealth» topical issues of biomedical informatics, information and communication technologies, solutions in the field of virtual medicine and remote health monitoring are actively discussed.

Prospects for the Development of Telemedicine and e-Health

Within each period of telemedicine development are already visible the features of the next. Therefore, it is interesting to try to build a forecast of further development of information and telecommunication technologies for the nearest years.

For effective development of telemedicine, it is not enough to improve its technologies. It is vital to make a finalization of the normative base, bring it in line with the requirements of other laws, development of standards, norms, technical and organizational requirements for the functioning of telemedicine centers and offices, including staffing and personnel issues, licensing and accreditation.

Taking into account the global trends, in the nearest future we can expect the mass introduction of telemedicine technologies in different spheres of the healthcare system.

The possibility of using information and communication technologies, not only for teleconsultation, tele-diagnostics and out-of-hospital monitoring, but also for tele-education, management and administration, research, information support of anti-epidemic measures, primary disease prevention seems to be a logical application of experience in telemedicine activities.

In organizational terms, the creation of the federal telemedicine network should become a part of a unified national healthcare information goal.

Previous stages in the development of Russian telemedicine have lead to the creation of a number of federal and regional telemedicine centers that, in particular, found their practical application in providing the high-tech medical care.

The further development of clinical telemedicine can take place both on the already created technological and methodological base, and on new organizational approaches, based on an improved normative platform and sufficient funding for their maintenance and development.

We can highlight the following telemedicine tools for which a rapid development can be expected in the nearest future: **remote medical consultations, remote interactive education, creation of mobile systems and home telemedicine.**

Although the uncertain legal status of teleconsultations is still a significant problem, a system of counseling centers and remote medical monitoring centers should be developed (Fig. 96).

These centers can be created for socially important diseases (cardiology, neurology, endocrinology, oncology, traumatology, etc.). At the same time they can perform two types of activity - consultancy of difficult investigations coming from health professionals, mainly from the primary health care institutions, and counseling of patients (especially with chronic diseases), using the telemedicine systems.



Fig. 96. Teleconsultation center of Cardiology Institute (Almazov Center) and teleconsultation of patient at home (Pirogov Center)

In Russia and abroad there is a wealth of experience in creating electronic reference and expert systems, training programs, that can provide access in the form of digital libraries, forums, distance learning centers, specialized websites for professionals and the public (Fig. 97). Therefore, we can predict, with high probability, the widespread introduction of Internet medicine in a variety of forms.



Fig. 97. Web-portal with many services (library, health calculators and others) and psychological service podusham.ru

The first steps have been made in areas such as remote surgery. It seems that in the coming years this trend will remain experimental and at the level of comprehensive studies. However, it will move into the category of real designs. At the same time, the more simple technologies of remote medical devices management (microscopes, analyzers, video cameras), can significantly enhance the ability of remote morphological, laboratory and functional diagnosis and monitoring of patients during the critical manipulations, in the postoperative period, during hemodialysis sessions and so on.

Different structures are working on the design of mobile telemedicine systems, including portable ones (Fig. 98).



Fig. 98. Mobile telemedicine systems: (a) Russian railways; b) “Regioncom”; c) TrueConf + “Angel” for extreme situations

A promising area of telemedicine technology is the use of nanotechnology to enable to miniaturized diagnostic equipment so that it will be possibly to introduce diagnostic capsules, containing analyzers and video, directly into the bloodstream, the gastrointestinal tract or other system for direct study.

The development of "home" or "personal" telemedicine is the most promising field for the future.

The largest sector in design and manufacture of portable wearable devices are personal cardiographs, which can record and transmit the ECG signal and be configured to identify and signal dangerous cardiac events (Fig. 99). Most of these devices include software for the heart rate variability (HRV) analysis.



Fig. 99. ECG monitors with wireless data transmission

Here we must mention the Soviet and Russian scientists – Professor R. M. Baevsky. He worked in space medicine since the beginning of space exploration till today. R. M. Baevsky is one of the founders of the first space biotelemetry systems, the founder of the Russian scientific school of heart rate variability (HRV) analysis, one of the founders of the concept of preclinical (prenosological) diagnosis. He has written the book "Problem Health. Assessment and the Concept of the Norm in Space Medicine" in collaboration with Academician A. I. Grigoriev [120].

R. M. Baevsky (Fig. 100) continues to work actively not only for scientific research in space, but also to develop new modern telemedicine Internet-based (cloud technology) devices [121] and even mobile application.

There is a certain progress in the area of personal telemedicine systems, embedded in mobile devices. This line includes systems for monitoring of physiological parameters, the possibility of transmitting information about the health to the family doctor using specialized medical recorders and video for advices, referring to preventive health Internet resources. An

iPhone with integrate cardiograph CardioQVARK was designed in Russia. It allows the user to perform an ECG, from special sensors.



Fig. 100. Professor Baevsky R.M. and his new designs



Fig. 101. CardioQVARK cardiograph for iPhone, ECG Dongle device and CardioMood mobile application

The compact device ECG Dongle (“Nordawind” company) for express monitoring of the cardiovascular system uses the cloud service to send ECG data to cardiologist and get recommendations (Fig. 101). The new device is a complete 6-channel electrocardiograph made in the form of an usual USB-stick, weighing only 9 grams. “CardioMood” mobile application is free, compatible with a variety of ECG belts (electrode). It works with Android and iOS, Bluetooth 4.0 protocols.

Among new tools for home medicine is the "CARE-04" system (Fig. 102). It is intended for self-diagnosis in real time or remote monitoring of cardiac activity and other physiological parameters of health. Biometric data and analytical reports are available through the "cloud" for the medical centers and physicians, as well as to the user with the interpretation of the results on a smartphone. It includes "CARE-03" communicative bracelet

with two-way GSM speakerphone, alarm button, ECG one-lead registration with wireless transmission and other functions.

The Russian "Republic" company introduced a system of patients medical identification. Personal data about the patient – blood group, disease, medications, allergies, surgeries - in the form of a QR-code pre-applied to the wrist silicone bracelet with metal insert. The emergency doctor can read this code from patients wristband by smartphone. This bracelet can save a person's life if he lost consciousness or memory.

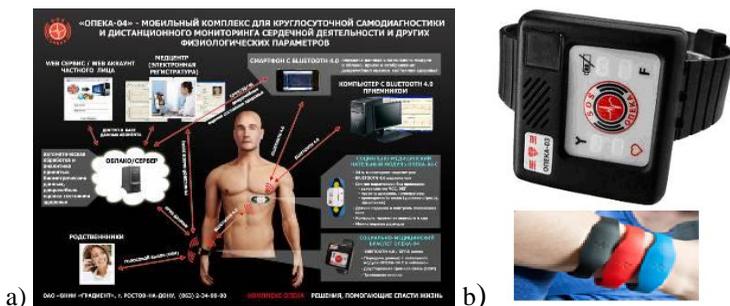


Fig. 102: a) "CARE - 04" system for self-diagnosis; b) "CARE - 03" and social care-bracelet with QR-code

In future (Table 5), we can expect full integration of telemedicine technologies in the daily work of agencies and healthcare institutions, individual physicians with the transfer of telemedicine centers activity at the workplace of specialists in various fields. This is put in evidence by the growth of publications on the use of telemedicine technologies, in medical literature and the appearance of specialized journals, such as “Modern Technologies in Medicine” [“Sovremennyye tehnologii v medicine”], “Virtual Simulators in Medicine” [“Virtualnyye simulyatori v medicine”], “Information Technologies” [“Informacionnyye tehnologii”], “Information technologies for the Physician” [“Vrach i informacionnyye tehnologii”], “Journal of telemedicine and e-Health” [“Jurnal telemeditsini i elektronno go zdравoohraneniya”].

Table 5. The main stages of telemedicine in Russia

Years	Definition	The main content
Early twentieth century – 80's	The period of primary accumulation of information about	The use of radio, telegraph, telephone, television for medical purposes in solving organizational problems, teleconsultations.

	the use of ICT in health care	Space bioradiotelemetry. The "ECG by phone" project. Creating portable medical devices. Experimental use of computer technology. Development of automated diagnostic questionnaires. Russian-US experimental projects on teleconsultation in emergencies. The "Barents-region" project. The works of the leading institutions of Moscow and St. Petersburg.
90's	The period of federal and departmental projects	Projects of "Telemedicine" Foundation, "Moscow - Russian regions" project, Research Institute of Pediatrics and Pediatric Surgery. Polar projects, projects of Foreign Ministry, the Ministry of Railways, the basin system of hospitals. Moscow TM projects. The first draft of the federal TM program.
2001–2010	Period of regional telemedicine systems creation	Approval of the Concept of TM development in the Russian Federation, the development of draft laws and federal programs projects. The adoption of the regional TM development programs. Creation of the first regional TM networks. The growing number of TM-centers of up to 200 in 50 regions of Russia.
After 2011 and near future	Period of telemedicine services diversification	The transition to the concept of "e-health", expansion of services, the creation of a unified Russian telemedicine service, the development of a unified normative framework, financing mechanisms, medical - technology and medical - economic standards of TM services, including TM training in high schools programs

Space Telemedicine

Space and "Earth" Telemedicine

The subjects of medical investigations in space are the healthy people. The remote health assessment of crewmembers and forecasting of possible

health risks on the base of prenosological diagnostics methods have been used in space medicine for a long time. Because of this reason, the “medicine of health” appeared in space.

The subjects of Earth telemedicine usually are the patients with various diseases, where the focus is on the diagnosis and detection of already existing disease. Preventive orientation, early detection of health deviations became the main trends in the development of Earth telemedicine only recently [122].

Space medicine also brought up a lot of experience in individual health assessment of cosmonauts and characteristics of their adaptation. It was originally "patient-oriented", and the "Earth" telemedicine has now also reached this point.

The "Telemedicine" foundation was organized in 1997 on the initiative of the Space Biomedicine Center. Academician O. I. Orlov headed it, until 2006. Since 2006, he was Deputy Director and in 2015, he became Director of the Institute of Biomedical Problems (Fig. 103). The Fund implemented the program of the telemedicine services at national system organization, which by its scale and complexity of tasks and technology can be called unique, not only for Russia.

In addition to the organizational work, the Foundation is involved in realization of concrete telemedicine projects and creation of new telemedicine systems for public health.

The cooperation between the "Telemedicine Foundation", Space Biomedicine Centre, IBMP and the Nizhny Novgorod State Medical Academy has led to the creation of a mobile telemedicine unit for health status assessing in inaccessible and remote areas, the centers of man-made and natural disasters and terrorist acts [123].



Fig. 103. O. I. Orlov, Academician of RAS, Director of IBMP

The mobile telemedicine unit is a minibus, equipped with a set of medical, computer and telecommunications devices with VSAT satellite communication system. Automated workstations provide the support for patients electronic records database, teleconsultation, perform functional and laboratory tests. The equipment allows connecting to the diagnostic tools available in health facilities, and transfer images in leading medical centers for teleconsultations (Fig. 104).



Fig. 104. Testing of mobile telemedicine complex

Thus, space telemedicine is and remains an outpost of telemedicine science. Its theoretical and practical approaches are constantly being introduced in the public health system, and there is the reverse flow of ideas and most advanced technologies in the space industry.

Space Telemetry

In contrast to terrestrial conditions, the features of space biotelemetry are:

- Need for data transmission over long distances,
- Discrete transmission, depending on the parameters of the orbit and the geographical location of the receiving stations,
- Limits of the bandwidth of transmission channels,
- The simultaneous transmission of a large number of parameters,
- Need to collect information during the cosmonaut activities, not only at rest.

There are also other objective limitations of medical activities in space, such as limited choice of used medical diagnostic equipment in its composition and weight and size characteristics, the need for use of equipment, which is not required for its use of special medical qualifications. There are usually no medical specialists with proper qualifications among the crews, as well as the possibility of control or medical assistance to the cosmonauts by the doctors from the mission medical team.



Fig. 105. From first steps in space – to life and work at orbit

All this determined the progress in the use and development of telemedicine tools in manned space exploration.

There are signals compression techniques used in space (for example, by highlighting only the most important parts of messages) and commutation of few slowly changing parameters on a single telemetry channel. Methods of transmission of several parameters over one channel and of "compression" of information through its pre-automatic processing on board have also been developed.

Medical telemetry sensors embedded in the cosmonaut spacesuit, are used in space medicine at all stages of a space flight: from spacecraft start to the capsule landing back on Earth, as well as during the execution of extravehicular activity (EVA).

The Scientific and Production Enterprise "Zvezda" have carried out the development and production of spacesuits in Russia. Founded in 1952, it is located in the Tomilino, near Moscow. Yuri Gagarin was wearing a spacesuit from "Zvezda" (Fig. 105). Alexei Leonov made the first in the history space "walk" in the "Zvezda" spacesuit. Today, modifications of the spacesuit for EVA - Orlan-MKS are in their final testing stage (Fig. 106).

The spacesuits provide a supply of oxygen for breathing, removal of carbon dioxide, maintaining the required temperature for a cosmonaut, radio-communications and telemetry.

When preparing for EVA, the inspection of standard telemetry resources of spacesuit is mandatory. "It is less than two days before the spacewalk on EVA program. Preparation works are conducted daily. The crew performed preparing the suit, checking its systems, testing of medical telemetry"[124].



Fig. 106. The spacesuit for EVA "Orlan-MK" (photo - Roscosmos)

The cosmonaut's medical control at the critical stages of flight (start and landing), operational control of conditions during EVA and in-depth investigations of cardiovascular system are carried out in space with equipment, designed in the Special Design and Technological Bureau "Biofizpribor", St. Petersburg. Founded in 1955 it is the leading Russian company in the development, manufacturing and delivery of medical and biological devices for space objects. "Biofizpribor" participates in the implementation of national and international space programs, "Almaz", "Soyuz-Apollo", "Intercosmos", "Bion", "Mars" and others. All manned spacecrafts, orbital stations, biological satellites are equipped with "Biofizpribor" devices, created in collaboration with leading Russian academic and medical research institutions.

Medical monitoring of astronauts during launch and landing are carried out with "Alpha" devices. The "Alpha" complex is used for registration, amplification and transmission of physiological signals (ECG in DS lead and pneumogram) in real time simultaneously on three cosmonauts at the active stages of the flight.

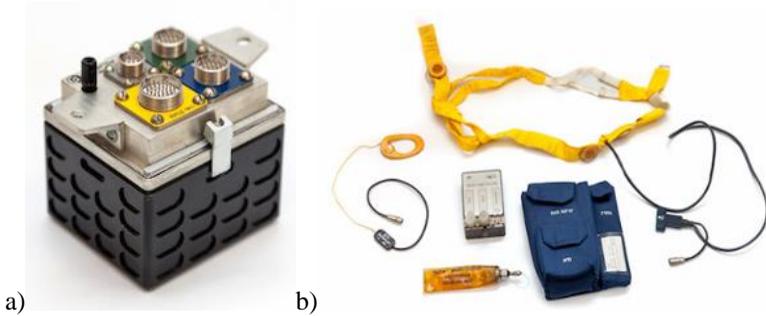


Fig. 107. "Alpha" and "Beta" complexes for medical monitoring of cosmonauts (a) "Alpha" b) "Beta") [89]

Complex "Beta" is used for the operative monitoring of the cosmonaut's conditions during EVA. It provides obtaining, amplification, conversion and transfer to the system of registration the following physiological information: ECG in DS lead, pneumogram and the body temperature (post-auricular) (Fig. 107).

The "Gamma-1M" complex (Fig. 108) enables in-depth studies of the cardiovascular system alternately in few people on board the orbital space object.



Fig. 108. "Gamma-1M" complex for medical monitoring of cosmonauts [125]

It helps to assess:

- Electrical heart activity by ECG;
- Phase relations and mechanical heart activity by kintogram;
- Elastic characteristics of vessels in the form of pulse curves;
- Vascular tone and mechanical heart activity by blood pressure;
- Pulse blood filling of brain vessels and stroke volume by rheogram;
- Circulation in limbs, lungs, liver.

Registration is carried out simultaneously on six channels. The "Gamma-1M" complex has connections to radio telemetry system, to magnetic recorder and to a computer. Time of continuous work of the complex is not less than 8 hours.

Space technologies, adapted to the needs of clinical medicine, have been greatly enriched not only by the experience of "earth" medicine, but also by modern informatics achievements. Currently, there is a repeated entry of telemedicine, yet in a new way, in the system of space flights medical care. Works to design a system of telemedicine support for manned space flights, including for the International Space Station, are underway. The projects to maintain flight to Mars and other promising areas are considered.

IBMP Participation in Medical Support of Space Flights

For over half a century, the State Scientific Center of the Russian Federation Institute of Biomedical Problems of the Russian Academy of Sciences (SRC RF - IBMP RAS, Fig. 109) is the leading institution in the Russia (from 1963 to 1991 - in the Soviet Union) in the field of space medicine. The Institute carries out not only the medical support of manned space flights and scientific researches on board the space crafts (currently – on the ISS), but also terrestrial researches, modeling the action of space flight factors.

A special group monitoring medically the ISS crews - IBMP employees - is constantly working at the Russian Mission Control Center (MCC). The same group has also worked in Houston. One representative of the Russian group operates in Houston, and a doctor from NASA - at the Russian MCC. Their task is to provide interaction between the groups of medical specialists from Russia and the United States.



Fig. 109. a) V. V. Bogomolov, Deputy Director of IBMP, MD, heads the IBMP activity on the organization of manned space objects crews safety and medical support, on the projects at the International Space Station (ISS);
 b) G. I. Samarin, MD, PhD, Head of the IBMP Laboratory for the development and implementation of Biomedical Researches;
 c) A. V. Polyakov, MD, PhD, Head of the IBMP Department, which includes a group of medical monitoring and supporting the ISS

Creation of a unified information system of space flights medical support (TSUMOKO), based on networking communications along the route "IBMP – MCC - Board of Orbital Station" has increased the communication efficiency (Fig. 110). These channels are used also for communication with the Center in Houston during operational meetings.

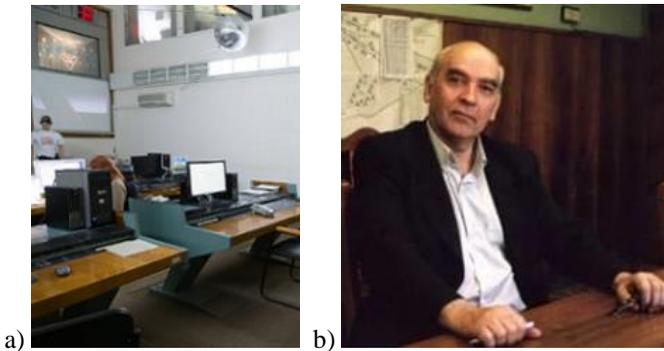


Fig. 110. a) The Medical Support of Space Objects Control Center (TSUMOKO) in IBMP, b) A. P. Shulenin, technical head of TSUMOKO (photo: IBMP)

The medical team that works at the Russian MCC includes a variety of medical specialists, most of them during shifts of 24-hours. There are also

experts who are responsible for psychological support of the crews, who control the optimal mode of work-and-rest, experts who decipher the information from the onboard medical equipment, a group of clinicians and others.

New Telemedicine Tools on-Board ISS

IBMP is working on the creation of new advanced telemedicine tools in the Russian segment (RS) of the ISS. Presently, telemedicine on board of the ISS is focused on digital and software research.

To meet this challenge, the BIMS scientific experiment is carried out on-board the ISS [126]. Its objective is the assessment of efficiency in using telemedicine technologies for getting information from ISS RS crews for medical support of human space flights and information support of life science flight studies. In the course of this experiment the methods for getting on-board telemedicine information are tested using experimental samples of TBK-1C (telemedicine board kit), and the results of telemedicine relevant research are analyzed.

Kit TBK-1 (telemedicine onboard kit) contains secondary power supply unit, image capture device, otoscope, cover and cable set. An onboard computer for medical support of Model IBM Think PAD A31p-RSE Med is being used.

Kit "TBK-1 Accessories" contains removable nozzles for otoscope, wipes and cover. Kit "TBK-1 Data" contains PCMCIA card and cover.

Project implementation enables enhancing the efficiency in medical monitoring of human space flights, adds to practice of medical support advanced methods and technologies for transmission of real-time information and standardizes information support of life science studies onboard the ISS RS.

The following examinations are carried out during the experimental session:

- Study of small skin sites;
- Otorhinolaryngology examinations (examination of external acoustic meatus, tympanic membranes, examination of nasal passages);
- Stomatology examination of gums and teeth.

Video data are recorded on hard disk of the RSE-Med computer and copied to a PCMCIA memory card, which will be returned to the ground upon completion of the Expedition.

This is how one of the cosmonauts describes the BIMS experiment in his blog on the "Roscosmos" Web-site [127].

"Let's start with the experiment BIMS. Its purpose is the evaluation of telemedicine technologies effectiveness. During this experiment, we

conduct video sessions, focusing on the skin and mucous membranes. It is expected that with the gradual introduction of network technologies based on this BIMS experiment, it will be possible to ensure interaction between cosmonauts on board and medical professionals on Earth in Real Time" (Fig. 111).



Fig. 111. Telemedicine experiment BIMS: telestomatology on-board the ISS (photo - Roscosmos)

Tele-Biological Consultative-Diagnostic System to Monitor the Cosmonauts' Status at the Landing Place

The landing of space crews on ships such as "Soyuz" after long-duration space flights is associated with high technical and medical risks. This is due not only to the action of overloads on the cosmonaut body during descent from orbit, shock loads at the time of landing, emotional stress, but also to the urgent re-adaptation reactions in the form of orthostatic instability, adverse vestibular-vegetative reactions, characteristic changes in the regulation of basic bodily functions.

At present, it is a very urgent task to ensuring the efficiency of health assistance in a space crew's landing along a ballistic trajectory and in adverse weather conditions. To solve this problem the tele-biological consultative-diagnostic system was developed at IBMP (Fig. 112) [128-129]. It allows for express diagnosis of the space ships crewmembers at the point of landing and at evacuation stages, with the possibility of remote consultative medical support.

The wearable kit includes laptop computer, display, microphone and earphones, placed on the headset, a keyboard fixed on the sleeve of the jacket, as well as the processor and battery, attached to a belt. It is equipped with a portable video camera, also located on headset. The integration of diagnostic devices into a specific module manages to reduce significantly the time for diagnosis by simultaneous recording of various physiological parameters.

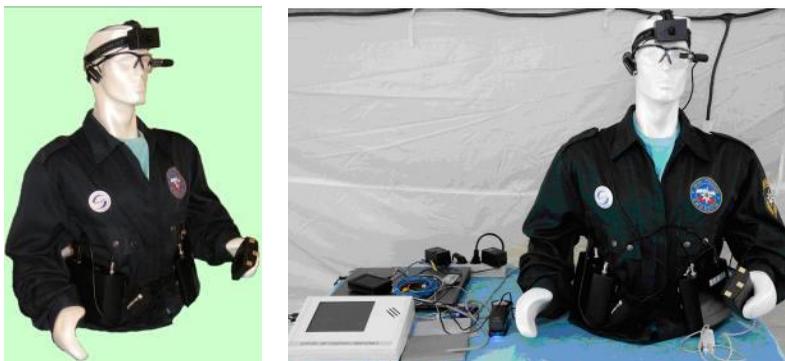


Fig. 112. The tele-biological support system for space crews at the landing places and at evacuation stages (photo: IBMP)

The express diagnosis module provides the registration of the following parameters:

- ECG in three leads,
- Respiration rate,
- Arterial blood pressure,
- Blood oxygen level,
- Body temperature.

Diagnosis of clinical and physiological parameters of the human body are carried out. Data are accumulated on a remote server with the possibility of access via various communication channels, as well as the use of video conferencing technology for the organizing the interactive remote communication of rescuers and medical consultants. Specialized software developed in the IBMP is applied.

Testing of the system components in real conditions of space crews landing was carried out in the period between 2011 and 2014. The tele-biological support system for space crews at landing places and during evacuation stages is protected by a patent.

Telemedicine in Model Terrestrial Experiments

Terrestrial experiments at IBMP are carried out not only to investigate the simulated space flight influences, but also to test new devices and software for medical monitoring, including telemedicine. An example of such research are the "Mars-500" (2010-2011) and the "Moon 2015" (2015) projects (Fig. 113).

The conducting of experiments with human isolation in hermetic conditions simulating a long space flight requires the compliance with a number of same objective limitations as during long-term space missions.



Fig. 113. "Mars-500" and "Moon-2015" projects at IBMP (photo: IBMP)

Medical support in the experiment "Mars-500" required the following [130]:

- Medical safety and full autonomy of experiments,
- Qualified medical assistance rendered by the physician-crew member and extended by consultations of medical support services,
- Confidentiality of obtained medical information.

It was impossible to implement all this without the use of telemedicine (TM) technology. TM-system on the "Mars-500" experiment has allowed simulating some contours of a Mars mission TM system:

- EVA simulation contour that simulated the work of EVA TM systems;
- Contour of remote medical support of crew by the project medical support group that simulated the interaction of the interplanetary spacecraft TM subsystem and TM subsystem in MCC;
- Contour of "external" telemedicine, which simulated the interaction of a medical support group in MCC and consultants from medical institutions.

The EVA simulation contour included a means of individual monitoring of the basic vital parameters of the crewmembers and their transmission via

the wireless channels. Another crewmember could correct the activities of those whose indicators were close to critical values.



Fig. 114. TM-contour of EVA simulation in the “Mars-500” project (photo: IBMP)

The individual monitoring unit ensured the possibility of ECG recording in DS lead, as well as heart rate, blood pressure and blood oxygen levels. These parameters were transmitted via radio channel to a receiver. The transmission and visualization of data was performed in real time with minimal delay, not exceeding 1-2 seconds.

The contour of crew TM support included two TM-stations (Fig. 114). One of these was in a simulator of an interplanetary orbiter, and the second, in the group of medical support of the experiment. The TM-station is a computer with a set of interfaces, which connects medical diagnostic equipment, as well as video capture card providing digitized video signals from cameras and devices such as otoscope.

Data are transmitted to the TM-station in the group of medical support in delayed mode. After their analysis, the experts of this group could also transfer to the crew doctor their recommendations in delayed mode. The delay between the time of sending data and their reception was about 20 minutes. All transmitted data were stored in a database for further processing.

The TM-station of this circuit has been used in the simulation of upper limb trauma in one of the crewmembers during the EVA on the Mars surface, followed by examination and treatment with supervision of the

orbital module physician and a consulting medical team from Earth (Fig. 115).



Fig. 115. The experiment with simulation of upper limb trauma in one of the crewmembers during EVA on the Mars surface (photo: IBMP)

The "external" TM contour has allowed holding TM consultations between the "Mars-500" expert group of medical support and consultants from the Central Clinical Hospital of Russian Academy of Sciences (RAS CCH).

These TM operations were held in real time using video conferencing technology. The Corporate Network of the Russian Academy of Sciences (RASNET), which has the required high bandwidth for data transfer, was used as an information channel (Fig. 116). Three sessions were held during the videoconference experiment - one organizational session and two work sessions.



Fig. 116. TM consultation between the “Mars-500” expert group of medical support and consultants from the Central Clinical Hospital of Russian Academy of Sciences (photo: IBMP).

The following studies were conducted during the experiment using the TM systems in the "Mars-500" project:

- Holter ECG monitoring,
- Arterial blood pressure monitoring,
- 12 lead ECG at rest position,
- The experimental testing of vital parameters monitoring during EVA simulation at mars surface,
- Dermatoscopy (routine examination and during treatment),
- Ophthalmoscopy (routine examination),
- Stomatoscopy (routine examination),
- Otoscopy (routine examination),
- Audiometry,
- Consultations between crew doctor and specialists of medical support group,
- Psychiatric control.

Within the framework of the Mars-500 project, the possibility of conducting multi-level testing of the TM supporting system for the crew of interplanetary travel spaceships was realized. It made it possible to evaluate and clarify the requirements for a fully functional TM system on interplanetary flights:

- The inclusion in TM-systems of expert systems elements to enhance the autonomy of actions of the crew members;

- The use of non-invasive diagnostic methods and biosensors, providing a long multi-parameter monitoring of the main human body systems;
- The integration of TM systems with other life support systems in hermetic conditions;
- The presence in the TM system of specialized database for storing multi-type medical information and data.

In 2015, the IBMP has conducted the experiment "Comprehensive Assessment of Psycho-Physiological Status of a Female Crew during a Short-Term Isolation in Hermetic Conditions Hermoobject, within the Lunar Mission Simulation" ("Moon 2015"). Scientific investigations in the project were as close as possible to the scientific experiments on the ISS and included the development and testing of medical crew control, including telemedicine.

Telemedicine monitoring of vital functions included visualization, processing and analysis of the primary operative parameters (3-leads ECG, breathing rate, SpO2), storing data in memory, creating and transmission of the report. The protocol for use of monitoring tools, designed for inclusion in a set of landing modules, was followed (Fig. 117).



Fig. 117. Telemedicine monitoring of vital functions telemedicine stomatology within frameworks of the “Moon-2015” project. Telemedicine stomatology testing of a prospective on-board telemedical diagnostic dental kit (photo: IBMP).

Video-registration - continuous video monitoring (without sound) in the living compartment, from waking-up until bedtime was also performed. On the background of video-registration, group discussions, modeling stress

and conflict situations, were conducted. A method was designed to assess mental and emotional state of the subjects by their behavior.

In order to detect transient and premonitory conditions, not manifested clinically, assess and forecast the health status and working ability of the crew members, self-monitoring (Fig. 118) of the functional state of all crew members was conducted twice daily (software "Antistress" based on the heart rate variability analysis).



Fig. 118. Self-monitoring of functional condition and video-registration of emergency within the “Moon-2015” project (photo: IBMP).

Remote monitoring and distance support of the crewmembers by the Earth-based clinical medicine specialists is becoming increasingly important. The biomedical ethics and confidentiality of the exchanged medical information has to be taken into account. It is evident that during interplanetary flights, biomedical issues will be much more difficult to deal with than during orbital flights of the same duration. Such a long-duration flights will require development of a special telemedicine support system, as well as onboard facilities, which will present many new challenges. This new system will involve the integration of information technologies with biological ones, as well as physics and chemistry, representing a new interdisciplinary technological breakthrough [131].

Telemedicine technologies are constantly improved and used in space research, in the daily practice of health and performance monitoring of space crewmembers. Our experience reveals that it not only lays the foundations for the future of telemedicine systems on interplanetary space travel, but also enriches the development of "terrestrial" telemedicine.

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Orlov Oleg, Director of SSC RF IBMP RAS. Full member of Russian Academy of Sciences and of International Academy of Astronautics (Life Sciences section), MD. He was a member of expert and coordinating councils on telemedicine at the State Duma of the Russian Federation and the Ministry of Health. He was invited to provide advice on telemedicine in the UN, the WHO, represented the RF in the "Group of Eight Countries" on telemedicine. In 2008-2013 – member of the ISfTeH (International Society for Telemedicine and eHealth) Board of Directors. Member of the editorial

boards of several scientific journals. Author of more than 150 scientific publications.



Levanov Vladimir, MD, Professor of the Department of Social Medicine and Health Organization in "Nizhny Novgorod State Medical Academy» of Russian Ministry of Health and Leading scientific researcher in SSC RF IBMP RAS. Author of 150 scientific papers, two monographs and 12 teaching courses in cardiology, functional diagnostics, public health, telemedicine, including educational complex course "Basics of telemedicine and e-health."



Perevedentsev Oleg, PhD, Head of the Laboratory "Medical Informatics and Telemedicine" in SSC RF IBMP RAS. His main research interests are telemedicine and use of information and communication technologies in health care and in medical care of spaceflights. He is the developer of original telemedicine complexes and systems, including for use in extreme conditions. Has more than 30 scientific papers.



Chernikova Anna, PhD, Senior scientific researcher in SSC RF IBMP RAS. Full member of International Academy of Astronautics (Life Sciences section). Has more than 100 scientific publications in space medicine and telemedicine. Her main interests are human adaptation in space, preventive orientation of medical care and using of space technologies for public health care.

HISTORY of the ISfTeH

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²Director, Med-e-Tel

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The seed of the International Society for Telemedicine was planted at the First International Conference on the Medical Aspects of Telemedicine, held in Tromsø, Norway in 1993. A group of experts at the meeting met to discuss the possibility of forming an international society. The field was as yet in its infancy, and, owing to the varied interests and contrasting ideas of the participants, agreement on a course of action could not be reached and the proposal was unsuccessful.

A further attempt was made at the Second Conference, held at the Mayo Clinic in 1995 in conjunction with the 2nd Mayo Telemedicine Symposium. Similar problems arose, and the proposal was again unsuccessful.

Third time lucky. The Third International Conference on the Medical Aspects of Telemedicine was held in Kobe, Japan in May 1997. In the lead up to the meeting, the Secretary, Guy Harris, embarked on an aggressive plan to found a society. Luminaries from around the world were recruited to join a Founder's Committee, many of whom were able to attend the conference. The Committee also included the members of the conference's Japanese organizing committee.

The members of the Founders' Committee were:

Drs DeBakey, Goldberg, Koop, Nicogossian and Satava, (USA), Castellano (Mexico), Medvedev (Russia), Hjelm (HK), Rossing (Denmark), Alexander and Yellowlees (Australia), Michaelis (Israel), Kvist (Finland), Lareng (France), Lun (Singapore), Meme (Kenya), Filler, Elford, Picot and Lacroix (Canada), Bracale (Italy), Padeken (Germany), Ashihara, Barron, Fujino, Fukuda, Harris, Inamoto, Inamura, Kiyotani, Koike, Maeda, Matsuoka, Mizushima, Nakajima, Ohtsuki, Shimosato, Tanaka, Tsuda, Ueda, Yamauchi (Japan) and International Advisory Board (Allen, Brugal, Ferguson, Gitlin, Lemke, McGee, Preston and Wold) of the 3rd International Conference on the Medical Aspects of Telemedicine.

The meetings were held over two days. Discussion was spirited as each of the thirty participants sought to establish their view on what all sensed was an ground breaking occasion. About halfway through the first meeting it seemed history would repeat itself, with the predominance of a particular view that sought to see the new group founded along political lines. A deadlock ensued. Finally, as the meeting approached its scheduled conclusion, relief came in the form of a particularly impassioned speech, so cleverly crafted and forcefully delivered that none dared contradict it. The meeting chairman, a canny veteran of a dozen similar battles, seized the moment and forced the vote. The motion was carried - the International Society for Telemedicine (ISfT, Fig. 119) was formed along the lines its original promoters had sought. Officers were empanelled and the future was mapped out.



Fig. 119 Logo of the International Society for Telemedicine

Subsequent activity focussed on development of the biannual conferences, The host country for the first conference of the new society was Jerusalem, Israel, as the Fourth International Conference on the Medical Aspects of Telemedicine. At that meeting the decision was made to hold the conferences on annual basis. The Fifth Conference was held in 2000 in Montreal, Canada, the Sixth in 2001 in Uppsala, Sweden, the Seventh in Regensburg, Germany. The Eighth Conference, in 2003, fittingly returned on the 10th anniversary of the First to the place of its founding, to Tromsø, Norway. The meetings were all very well attended and admirably served the purpose of the International Society for Telemedicine in furthering the knowledge about telemedicine.

In the run-up to the Regensburg meeting, the decision was made that the International Society for Telemedicine needed to be reformulated. Although the meetings had been greatly successful, the society had found it difficult to fulfil its other goals, and so a new way forward was sought. After discussion at Regensburg, it was decided to re-establish the Society more along the lines of a federation of national bodies. The decision was endorsed and in September 15th, 2003 'ISfT 2' was officially established as not-for-profit organization under the Swiss law.

The members of the first Board of the renewed ISfT were (Fig. 120):

- Prof. Dr. Michael Nerlich, Germany, President;
- Prof. Ricky Richardson, U.K., Vice-President;
- Mr. Lars Hulbaek, Denmark, Secretary;
- Mr. Frank Lievens, Belgium, Treasurer;

- Prof. James McGee, U.K.;
- Prof. Marian Noga, Poland;
- Dr. Jarmo Reponen, Finland;
- Prof. Robert Rudowski, Poland;
- Mr. Mark Vanderwerf, U.S.A.

The ISfT became ISfTeH (International Society for Telemedicine and eHealth), when the General Assembly, held on April 6th, 2005, in Luxembourg, voted in favour of a name adaptation of the Society to ISfTeH, as to position it more in line with the international “eHealth” recognition by all International Organisations such as WHO, ITU, EU, etc.

Also the logo has been adapted to reflect the new name (Fig. 121).



Fig. 120 From left to right: Frank Lievens (Belgium) – Treasurer, Jarmo Reponen (Finland), Robert Rudowski (Poland), Michael Nerlich (Germany) – President, Ricky Richardson (United Kingdom) - Vice President, James McGee (United Kingdom), Mark VanderWerf (USA), Lars Hulbæk (Denmark) – Secretary, Marian Noga (Poland)

Originally, all elected Board members would stay in office for a period of 3 years. Yet, from 2011 onward, in order to secure management continuity, only three members would be replaced annually.

Also at that time, Prof. Yunkap Kwankam (Switzerland) was appointed as Executive Director.

In 2012, after 9 years of dedicated leadership, Prof. Dr. Michael Nerlich stepped down as President of the Society and was replaced by Dr. Andy Fischer (Switzerland), who was elected by the Board as new President.



Fig. 121

The list of successive members of the so far nine Boards of Directors since 2003 can be found on the ISfTeH website under <https://www.isfteh.org/about/history>.

Since 2010, the ISfTeH obtained the status of “NGO in Official Relations with WHO”, renewed every 3 years since then.

Over the years, the ISfTeH developed a series of activities, such as:

- Working Groups : Education, Students, Nurses, Open Source, Social Media, Women (WoW), eHealth Economics, Chronic Disease Management, Tele-Dentistry, Tele-Optthalmology, Tele-Audiology, Medical & Bio-Informatics, e-Hispanic (https://www.isfteh.org/working_groups);
- A serie of regular Webinars has started in 2015 and will be further developed over the years to come;
- In 2013, the virtual JISfTeH (Journal of the International Society for Telemedicine and eHealth) was created (Fig. 122). It is an open access, peer reviewed, publication accessible via the website https://www.isfteh.org/media/category/isfteh_e-journal and presents papers in categories such as Original Research, Reviews, Special Themes, Preliminary and Short Reports, Conference Abstracts and Reports. Volume V has started in 2017.
- The ISfTeH pays major attention to Education. It lists information related to educational programs in the field of Telemedicine/eHealth <https://www.isfteh.org/education>.
- The ISfTeH edits quarterly its Newsletter, which is distributed to over 30,000 contacts worldwide <https://www.isfteh.org/media/category/newsletters>.
- On the Website of the ISfTeH <https://www.isfteh.org/media> one can find copies of
 - Reports;
 - Publications;
 - National eHealth Strategies;
 - Good Practice Models.
- The ISfTeH Lifetime Achievement Award was created back in 2012 (Fig. 123). It has recognized so far four eminent personalities who strongly contributed to the development and dissemination of Telemedicine/eHealth:



Fig. 122 Logo of the JISfTeH

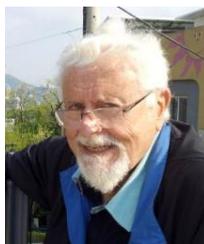
- Prof. Louis Lareng (France)
https://www.isfteh.org/about/prof_louis_lareng;
- Prof. Ronald Merrell (United States)
https://www.isfteh.org/about/prof_ronald_merrell;
- Prof. Györgi Böhm (Brazil)
https://www.isfteh.org/about/gyoergy_miklos_boehm
- Dr. Prathap C. Reddy (India).



Prof. Louis Lareng



Prof. Ronald Merrell



Prof. György Böhm



Dr. Prathap C. Reddy

Fig. 123

Besides the Events organized in various parts of the world and countries by its members, which the ISfTeH supports, there are two major events in which the ISfTeH is directly involved:

- Med-e-Tel (Fig. 124), which takes place every year in Luxembourg (G.D. of Luxembourg) either the second week before or the second week after Easter. The first edition took place back in 2002 and has gathered every year participants from over 50 countries worldwide. Program of all editions since 2004 can be found under

https://www.medetel.eu/?rub=educational_program&page=info.

And you can access abstracts and presentations in the Global Knowledge Resources Center

https://www.medetel.eu/?rub=knowledge_resources&page=info.



Fig. 124

- ISfTeH International Conferences. These are organized annually by one of the members under the umbrella of the International Society. They have taken place so far in:
 - 1997 Tromsø (Norway);
 - 1995 Rochester (United States);
 - 1997 Kobe (Japan);
 - 1999 Jerusalem (Israel);
 - 2000 Montreal (Canada);
 - 2001 Uppsala (Sweden);
 - 2002 Regensburg (Germany);
 - 2003 Tromsø (Norway);
 - 2004 Brisbane (Australia);
 - 2005 Sao Paulo (Brazil);
 - 2006 Cape Town (South Africa);
 - 2007 Chennai (India);
 - 2008 Ottawa (Canada);
 - 2009 Moscow (Russia);
 - 2010 Perth (Australia);
 - 2011 Cape Town (South Africa);
 - 2012 Abuja (Nigeria);
 - 2013 Takamatsu (Japan);
 - 2014 Paris (France);

- 2015 Rio de Janeiro (Brazil);
- 2016 Chennai (India)

More information is available at https://www.isfteh.org/events/category/isfteh_international_conferences.

the 1990s, the number of people in the UK who are employed in the public sector has increased from 10.5 million to 12.5 million, and the number of people in the public sector who are employed in health care has increased from 2.5 million to 3.5 million (Department of Health 2000). The number of people in the public sector who are employed in health care is expected to increase further in the next 10 years (Department of Health 2000).

There are a number of reasons why the number of people in the public sector who are employed in health care is expected to increase. One reason is that the population of the UK is expected to increase in the next 10 years (Department of Health 2000). Another reason is that the number of people in the public sector who are employed in health care is expected to increase as a result of the increasing number of people who are aged 65 and over (Department of Health 2000).

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