A Century of Telemedicine: Curatio Sine Distantia et Tempora
## Content

**Introduction** 1

**Chapter 1**

Telemedicine Development Based on Main Telecommunication Technologies

1.1. Telegraph Communications in Telemedicine 9
1.2. Radio Communications in Telemedicine 14
   1.2.1. The formation of Air Medical Service in Australia 14
   1.2.2. Marine telemedicine 18
   1.2.3. Radio communication in distant medical learning and management 32
   1.2.4. Emergency radio communication by amateurs 34
1.3. Telephone Communications in Telemedicine 41

References 52

**Chapter 2**

Telecardiology 57

2.1. Early Stage of Telecardiology 57
2.2. Telecardiology in the Middle of the 20th Century 64

References 133

**Chapter 3**

Videoconferencing in Medicine 145

3.1. Early Period of Development: Medical Television 146
3.2. Clinical Medical Videoconferences 164
3.3. Telemedicine Network of Massachusetts General Hospital (MGH), Boston, Massachusetts 167
3.4. Telemedicine Projects Based on Videoconferencing in 1970-1980 174

References 179

**Chapter 4**

Biotelemetry 185

4.1. Aerospace Biotelemetry 188
4.2. Biological Telemetry in Physiology and Sports Medicine 203
   4.2.1. Key Accomplishments of Dynamic Biotelemetry 203
   4.2.2. Sverdlovsk Bioradiotelemetry Group 214
4.3. Clinical Biotelemetry 222
4.4. Tele-EEG - Biotelemetry of Electroencephalogram 226

References 236

**Chapter 5**

Computational Telediagnosis and Development of Clinical 251
Telemedicine
  5.1. Main Achievements of Computational Telediagnosis in the Middle of the 20th Century 251
  5.2. Clinical Telemedicine Formation 259
  5.3. Formation of Separate Lines of Clinical Telemedicine 267
    5.3.1. Teleradiology 267
    5.3.2. Telepathology 271
  References 272

Chapter 6 276
Telemedicine Satellite Technologies
  6.1. Transatlantic Telemedicine 276
  6.2. Polar Telemedicine 289
  6.3. Mobile Telemedicine 296
  References 301

Afterword 304
Short Biographies 309
Dear Reader,

The book “A Century of Telemedicine: Curatio Sine Distantia et Tempora” is now in your hands.

“The Past supplies the key to the Present and Future”. These words belong to an ancient historian who understood the necessity of studying history. History tells us how we came to know what we know today. The importance of history was summarized by Marcus Tulius Cicero (106-43 BC), roman writer, politician and great orator almost 2000 years ago: “Not to know what has been transacted in former times is to always remain a child. If no use is made of the experiences of past times, the world will always remain in the infancy of knowledge”. These words are especially applicable to the necessity of studying history of medicine. The latter is much more than the history of doctors, nurses and medical discoveries. The patients are actually the most important part of the broad picture. No doubt, throughout human evolution, health and diseases always were matters of main concern and had a profound effect on human society, shaping it.

This book is an overview of the scientific research in one specific field of the History of Medicine, that one of telemedicine. It is an enriched and adapted version of two previous publications (Vladzymyrskyy A. V., 2011; Dumanskyy Yu. et al., 2013), that already clearly revealed the range and complexity of Telemedicine development over the past 100 years. Yet, the book is not just a duplication of the previous publications. Researchers of telemedicine history will not be disappointed. New facts, theories, and amazing stories from different parts of the world are included. Moreover, some of them were identified even after the present book was ready for print. For example, in 1858 Dr Jabez Baxter Upham, in cooperation with the engineer Moses Gerrish Farmer, doctor William Francis Channing, Mr. Steams, Mr. Kennard and Mr. Rogers, created a telemedical device called «sphygmosphone». It allowed fixing heart pulse as a curve and sending these data via a telegraph. On January 24, 1859 the device was successfully tested, and heart rate data of a Mr. Eugene A. Groux, who suffered from congenital sternal fissure, were sent via wires from Boston to Cambridge (USA). Ten years later, in 1869, Dr. Upham repeated the experiment at the American scientists’ conference. More details, pictures and references about this event we will publish in near future.

Perhaps, at the very beginning it is necessary to clarify what is telemedicine. Telemedicine encompasses diagnostic, treatment and prevention processes within the frame of modern health care services, which are carried out primarily by means of telecommunication and
For decades there was no internationally accepted definition of telemedicine. A study published in 2007 found 104 peer-reviewed definitions of the word (Sood S. et al., 2007). Recognizing this, the World Health Organization adopted the following broad description of telemedicine:

“The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities” (WHO, 2010).

In sum, WHO had underlined that telemedicine includes four germane elements:

- Its purpose is to provide clinical support;
- It intends to overcome geographical barriers, connecting users who are not in the same physical location;
- It involves the use of various types of information technology;
- Its goal is to improve health outcomes.

When presenting the history of telemedicine, some authors refer to the attempts to exchange messages related to medical topics by post, sound alarm (drums, bells) and even smoke alarms, in ancient times and in the middle ages. However, we consider such approach incorrect, as we firmly believe in the ultimate connection between telemedicine and electrical and/or electronic telecommunication tools. Thus, when conducting the research on telemedicine history, we have intentionally limited ourselves to the period 1850-1990. We consider that the initial use of modern telemedicine technologies began towards the end of the 1980’s and were further developed in the 1990’s. This complex process of new and recent history deserves a separate, thorough research, and is a topic for another publication. We have predominantly focused our attention on the events and processes that took place before 1990, but it should still be underlined that only the most significant facts were taken into consideration.

In each time period only the most advanced technologies were applied in telemedicine. The development of distant delivery of health care services is the prime result of progress in telecommunication facilities. Thus, history of telemedicine may be presented as the sequence of stages following the progress of telecommunications and of the remote information exchange. In brief, the development of clinical telemedicine could be classified as:
Telemedicine development based on telecommunication tools:
- Telegraph;
- Telephone;
- Radio;
- Television (cable television, with slow scanning, wireless, black-and-white to colour television);
- Satellite-link communication;
- Computer networks, internet;
- Wireless networks and data transfer protocols.

Telemedicine development based on clinical application forms:
- Teleconsultations with oral or short written description of clinical evidences;
- Distant learning (elearning);
- Teleconsultations with medical data remote transfer;
- Computing telediagnosis;
- Biotelemetry;
- Telemonitoring;
- Comprehensive clinical telemedical systems;
- Individual telemedicine (tele-homecare).

No doubt, both tracks are rather conventional, most stages interlace or can exist concomitantly. It is important to emphasize that "the distant delivery of medical aid and healthcare provision by means of telecommunication" itself started to being applied worldwide many years before the idea and understanding of telemedicine were formulated, and the term came into use.

Prior to describing the succession of events and processes, it is necessary to clarify the appearance of the term "telemedicine".

Nowadays the term "telemedicine" is applied for remote delivery of medical services and healthcare provision via computer and telecommunication technologies at any given location, in other words, wherever geographical distance is a critical factor. When this terminology appeared is an interesting question. It is obvious that the application of various electrical and electronic telecommunication tools for medical purposes started in the late 19th century; but the appearance of the specific term marks the semantic start of this phenomenon’s concept.

The Latin prefix "tele-", designating the remote delivery of medical service, was introduced by Willem Einthoven in 1906, when he suggested the term "telecardiogramme" (Vladzymyrskyy A., 2008; Bashshur R., Shannon G., 2009). It should be pointed out that already in the early 1950’s Jacob Gershon-Cohen suggested the term "telegnosis" and "videognosis" designating facsimile X-ray patterns that were received remotely by phone,
radio or television connection (ibid). Around the same time Albert Jutras offered the term "telefluoroscopy" (ibid). However, all these definitions covered a very narrow scope, referring only to radiology, and for this reason they did not reach a wide circulation. The above mentioned scientists will be discussed more in detail in the adequate chapters.

In the 1960s the term "telediagnosis" appeared. It meant distant diagnosis and follow-up of pathology with telecommunication technologies (Fabris U., Ravara A., 1968; McLaughlin L., 1969; Murphy R. Jr, Bird K., 1974). Yet, the obvious incomplete semantic constituent blocked its wide application.

What is to be said about the term "telemedicine"? Many authors dated its origin in 1974, referring to the article of R. G. Mark (Mark R., 1974). However, as we have mentioned in other publications (Vladzymyrskyy A., 2011; Vladzymyrskyy A. et al., 2012 a; b) the term "telemedical technique/technology" was used by R. L. Murphy et al. in 1970 (Murphy R. et al., 1970). But, further historical investigations have forced us to revise even this discovery. In 2014, while working with reference sources, we found that the term "telemedicine" had been used as far back as 1927!

A column of the retrospective articles and letters to the editors were published on page 47 in the newspaper "Greeley Daily Tribune", Greeley Town, Colorado, USA, on November 16, 1970. They cited the story of Geo W. Gale “Wants Plane to Change Weather Here”. This information represented a rather doubtful discourse concerning meteorological changes that could be caused by planes. However, the last paragraph was of special interest as the author unexpectedly quotes the following: "If we have telephotography, why can't we have telemedicine, so that you could walk up to the radio machine, drop your dollar in the slot, take down the particular receiver required and apply it to that part of your anatomy where the pain is? (doctors, please snicker)” (Gale G., 1970) (Fig. 1). The cited article was dated December 29, 1927.

It is obvious that this material is not a scientific article. Nevertheless, we record that the term “telemedicine” was used for the first time in a publication in December 1927.
In the scientific literature we have recorded the first use of the term "telemedicine" (to be more precise "telemedical technique/technology") in the article by R. L. Murphy, D. Barber, A. Broadhurst and K. T. Bird, published in the journal "American Review Respiratory Diseases" in November 1970 (Murphy R. et al., 1970) (Fig. 2).

In December 1972 the term "telemedicine" appeared in the description of the telemedical project of the Arizona Medical University (Arizona TeleMedicine Network: Engineering Master Plan, 1972). It was also mentioned in the works of R. G. Mark (1974) and J. S. Gravenstein et al. (1974), in February and July 1974, respectively. Later it was used in numerous publications on space medicine, telemedical system in Puerto-Rico in 1975, NASA reports since 1977, etc.
Utilizing a telemedical technique which consisted of a 2-way closed circuit television with transmission of the signal by a microwave, comparisons were made of the interpretations of roentgenograms viewed directly and after transmission by the closed circuit system. A remotely controlled plubicon camera with zoom lens focus control was used to obtain panoramic and detailed views of each roentgenogram.

Fig. 2. Fragment of the article, where probably for the first time ever in scientific literature the term "telemedicine" - "telemedical technique" was used.

The term "teleconsultation", more specifically "teleconsultation center" was for the first time met in Russian-language literature in the publication of Zigmas I. Yanushkevichus "Teletransmission of phonocardiograms" in 1966 (Yanushkevichus Z., 1966). In 1974 this word was used the publication by E. Quinn (Quinn E., 1974). Later, "teleconsultation" appeared also in NASA reports (since 1977) and several other publications.

Thus, in following years, the remote application of medical care or services was defined by adding the Latin prefix "tele-" ("teleradiology", "telecardiology", "telesurgery", etc.) to common terminology ("radiology", "cardiology", "surgery", etc.). Yet, let’s not forget that this construction was introduced by Willem Einthoven in 1906 ("telecardiogram"). The word "telemedicine" appeared in a publication in 1927 by Geo W. Gale, and it was introduced into the scientific literature by R. Murphy, D. Barber, A. Broadhurst and K. T. Bird in 1970 (Murphy R. et al, 1970; Murphy R., Bird K., 1974).

In sum, telemedicine was brought to life by changes of technology and offered enormous possibilities to improve both access to and the standard of healthcare, and thus to close the gap between the demand for affordable, high quality healthcare to everyone, at any time, everywhere, and the lack of medical personal. Chapters in this book reveal various national and cultural points of view on how telemedicine solutions were developed and implemented in earlier decades.

Finally, the authors would like to underline that:

- The content of the book is divided in chapters covering various areas of telemedicine.
- In the text, after the title of cited papers, a maximum of 3 co-authors are listed, while the rest are marked as “et al.”
- References lists are added at the end of each chapter. They contain only the details of the sources cited in the body of the chapter.
- The cited sources are listed in an alphabetical order. Part of referring sources is in Cyrillic. In these cases the names of the authors are translated in English. The titles of the references are also translated in English and included in square brackets with a language descriptor at the end. In addition, the source titles and authors’ names are also given exactly as they appear in the original language.
- In order to shorten repeated references in the text 2 abbreviations are used. One is “ibid” originating from Latin ibidem, i.e. "in the same place". This repeats the previous author/s and title/s and whatever else is identical. The other one is “idem” from Latin idem "the same". It also indicates the repetition of the previous author/s.
- At the end of the book a separate chapter provides a comprehensive directory of people – doctors, engineers, technicians, scientists, etc., that contributed a lot to the development of telemedicine. In several lines their works and achievements are highlighted, while their photos are usually included as illustrations in the chapters.
- Despite the amount of information included in this book, no doubt that many events and facts are still out-of-sight. We hope to be able to fill in this gap in the near future.

We hope that everyone involved in telemedicine and eHealth will find this book not only interesting, but most valuable as well. We are open for collaboration, comments and joint researches. Let’s make the origin of telemedicine better known.

Enjoy your reading!
Anton Vladzymyrskyy, Malina Jordanova and Frank Lievens

References


CHAPTER 1
TELEMEDICINE DEVELOPMENT BASED ON MAIN TELECOMMUNICATION TECHNOLOGIES

In the early period of telemedicine applications, telegraph, telephone and radio connection were the main available telecommunication technologies for its implementation. Taking into account that precisely these facilities in one or another form were the main tools for information exchange during several decades, we recognize them as the basic tools during the start-up of telemedicine. It is necessary to underline that telephone has remained one of the most consistent equipment for medical information exchange, whereas radio is still being used today in transport telemedicine.

1.1. Telegraph Communications in Telemedicine

Telegraph was the first electrical telecommunication tool in the history of humanity, which provided "globalization", i.e. free communication and information exchange between any points on Earth. This type of communication is now called the "Victorian Internet" (Standage, 1999), because, for the first time, thanks to telecommunication people stopped living isolated and could "reach" any part of the globe.

In the 1860s, in the USA (the southern states, the Confederation), William S. Morris and Albert James Myer (Fig. 1.1) worked on the development of a national system of telegraph communications in war conditions. Both were medical doctors. At that time W. S. Morris was the head of the military telegraph service, while A. J. Myer invented his own system (wigwag) and special cart for providing and conducting telecommunication between the troops (http://www.mercurians.org/1999_Spring/flashback.htm). It was Myer who proposed using the telegraph for military and medical purposes such as asking for medical supplies on the front line, ordering the required quantity of bandaging materials and medicines, specifying the delivery points, coordinating the transport of patients, etc.

Fig. 1.1. Albert James Myer (20.09.1828-25.08.1880)
The first documented case of the use of telegraph for medical purposes (carrying out teleconsultation) was recorded in Australia in 1874. On Sunday 22nd February 1874, the Barrow telegraph station Creek (280 km north of Alice Springs) was attacked by aborigines from the Kaytetye tribe, provoked by what some said was poor treatment of their women by white men on the fence of a water hole (Eikelboom, 2012). As a result of the attack, one employee of the station was killed, three more were wounded, and James L. Stapleton was deadly injured. A surviving policeman, Samuel Gason, sent a message about the incident via telegraph to Adelaide: “This Station has been attacked by natives at 8:00 o’clock. Stapleton has been mortally wounded, one of the men, named John Franks, just died from his wounds. Civilized native boy has 3 spear wounds. Mr. Flint, assistant operator, one spear wound in the leg, not serious. Full particulars in the morning” (Eikelboom, 2012). Doctor Charles Gosse came at night at the Adelaide telegraph station to make a distant consultation for the seriously injured J. L. Stapleton. The newspaper “South Australian Advertiser” wrote on 24 February, 1874: “We are informed by Mr. Todd that on Sunday night Dr Charles Gosse (Fig. 1.2), at his request, went to the Telegraph Office and gave instructions as to the proper treatment of the wounded, and up to about 11 o'clock all were progressing favourably. Later in the day, however, a change for the worse took place in Mr. Stapleton's condition, and notwithstanding all the assistance that was possible to render him, he sank under the effect of his injuries, and died, very quietly, at a quarter to six in the evening”. The spouse and children of the dying man were also in Adelaide during the incident, and according to newspaper publications, they kept in contact with their unfortunate relative by telegraph till the last moment (Fig. 1.3).

Another important participant in this story is the founder of the national system of cable communication in Australia (so-called Overland Telegraph), Charles Todd. After receiving the telegram about the tragedy, he personally invited Stapleton’s family in the telegraph office, and also organized the participation of Dr. Charles Gosse for distant consulting.
According to publications, Charles Todd was working closely with state worker and surgeon William Christie Gosse who was the doctor’s brother (Eikelboom, 2012). So, according to R. H. Eikelboom’s paper, the first documented case of telegraph use for teleconsultation is recorded on February 22nd-23rd, 1874 as distant consultation between Barrow Creek and Adelaide (Australia) led by Doctor Charles Gosse and probably his brother – surgeon William Gosse (ibid).

Back to the military medicine - the idea of Dr Myer gained motion in the first half of the twentieth century. Telegraph communications were widely used during war conflicts both for organizational issues of medical help and for teleconsultations. Here are some examples from army medical officers' memoirs.

The Russian-Japanese War (1905, Vikenty V. Veresaev, Fig. 1.4) (Veresaev, 1986):

"The telegrams from army medical head officers were reaching the barracks over and over again: to evacuate four hundred people immediately, another one for evacuating seven hundred people immediately. The command, subject to insane delirium, could think only about one thing: to send the wounded as far away from the front as possible and in the shortest period of time..."
"...Soldiers started catching ... Siberian plague. These cases happened in our crew, too. The paper machine started to work, the telegrams were sent off from us to all directions and in reply the telegrams with strict orders came back to us: "to isolate", "to apply thoroughly disinfection", "to report about the measures taken"... We did everything and reported..." "Suddenly, at nine in the evening we received the telegram from our corps doctor, on the corps commander's order to evacuate all the wounded from the hospital, to pack spare government property and take away to the North..." (Veresaev, 1986).

The First World War (The German War, 1914-1918):

"A telegram addressed to my name has been received from the division headquarters: "To conduct medical examination of the 70th and other divisions located in Kzhishov".

"...Have you got little work to do? Help me, for Christ sake! A telegram was received. I am sending the wounded in seven trains. Though I have got just one medical attendant ... Take upon you arrangements for hospital admissions..." (Voytilovskiy, 1998).

The Second World War (The Great Patriotic War) (1941-1945)

Numerous descriptions of teleconsultations, including the help of telegraph and teletype connection ("Baudot machine", Fig. 1.5), were given in the army diary of the great surgeon, academician Aleksander A. Vishnevsky (Fig. 1.6) (Vishnevskiy, 1970).
"...I went to Bryansk to connect with Moscow by telegraph. I was very successfully connected and was directed to Smirnov at once. He gave the exact instructions concerning what to do in priority and promised to comply with all our requests, putting us in charge of the hospitals of the Orlov Military District. Then, he informed where the frontline medical supplies storage was located and the numbers of the hospital trains transferred to us ... I always have some strange feeling, when "talking" using "Baudot". It is a wonderful device... I have just remembered Ukhta and the way I myself and Gurvich, Director of Health Services of the 9th Army, called up Smirnov and asked him the permission to plaster the wounded with extremity bone injury..."

"In the morning I performed an operation... Came back to Olonets, where I was immediately handed over a telegram: "Ushakov feels bad, consecutive hemorrhage from the residual limb, there is no granulation tissue in the wound". I told by phone what to do."

"Then a telephone call from Vidlitsa was waiting for me about the wounded with purulent pericarditis".

"I have received the telegram that Koryagina is bad. I am sure that it is nothing serious, and posted that leakages were impossible. They undid her entire wound but found nothing..." After the operation debriding the heart, during a week A. A. Vishnevskiy regularly received messages by telegraph about the health status of the patient (Vishnevskiy, 1970).

An interesting fact about the use of telecommunication for examining the wounded is mentioned by A. N. Babiychuk (Babiychuk, 1979): "...It has become more complicated to administer medical aid to the wounded pilots, who landed outside their airfields. The senior physicians from the air regiments dealt with their searching... For this purpose they used primarily communication facilities, which were available in the air regiments and divisions (telephone, radio, telegraph). The constant air surveillance was carried out by duty medical officers and by military officers of airborne surveillance and warning posts. Besides, we also received information from the flying crews, who were coming back from their combat missions..."

In the 1940s, in Germany, telegrams and telegraph communications were used to inform about epidemic and dangerous contagious diseases (http://www.holocaustforgotten.com/eugene.htm). The above described telecommunication facilities were also used in civil medicine.

There are reports of the use of telegraph communications for doctor home visits in the 1900 - 1920s (Doctor - Homeopath, 1914).

In 1929 photographic prints of two dental radiographic images were published, which had been transmitted by telegraph (involving Western Union Telegraph). The high quality of the images was pointed out ("Even
the filled root canals are seen clearly...”). This service was offered as commercial distant consultations for dentists (Kantor, 2005; Sending Dental X-rays by Telegraph, 1929), however, there is no available information about the further development of this technology.

A funny fact can be cited, too. Telegraph devices of Baudot system present some analogy with the modern social media – an hours-long “talkie-talkie” (in modern terms - chatting) feuilleton about of two telegraph operators (to be more precise "Baudot operators") from Kiev and Moscow was published by M. A. Bulgakov in 1925 (Bulgakov, 1992).

Telegraph communication played an important role in the understanding of the significant role of global telecommunications in the development of society in general and in healthcare service in particular. It was a basic telemedicine tool in the late nineteenth century and in the first third of the twentieth century, especially during war conflicts.

1.2. Radio Communications in Telemedicine

1.2.1. The formation of Air Medical Service in Australia

A sad story happened in August 1917 in the town Halls Creek, Western Australia. A twenty-nine-year-old farmer Jimmy Darcy was seriously injured, having tumbled off a horse during cattle grazing. His mate was taking the injured to the nearest town Halls Creek for 12 hours, having covered over 75 km. There was neither a hospital nor doctors in the town at all. Then a post clerk F. W. Tuckett connected with Doctor John Joseph Holland by telegraph (Fig. 1.7), who was in Perth at that time. Having heard the description of the patient's state, the doctor diagnosed the case as urinary bladder rhexis. Jimmy Darcy needed an urgent operation. A short and dramatic dialogue between the clerk and the doctor followed. Within a few minutes Tuckett operated the injured, using a penknife, a razor and potassium permanganate. In the course of the surgical intervention he called the doctor from time to time and was instructed how to do the next step in the operation. Following the telegraph consultation John Joseph Holland traveled the long road to his patient. He covered more than 5 000 kilometers in 11 days, getting to his destination by boat, car, on horseback and even on foot. Arriving in Halls Creek, the doctor found out that poor fellow Darcy died the day before due to malaria, but not as a consequence of surgical complications. The doctor conducted autopsy and

Fig. 1.7. John Joseph Holland (11.02.1876-04.01.1959)
stated that the operation had been performed correctly. In his diary doctor J. J. Holland wrote: "The news disappointed me more than I could expect. I felt that I had lost somebody very close and dear to me" (Classic episodes in telemedicine, 1997; Evans, Roges, 1999; John J. Holland 2015) (Fig. 1.8).

This sad story was on the front pages of the world newspapers. For the first time the problem of medical assistance in remote and isolated residential areas came to the forefront. The tragedy inspired the reverend John Flynn (Fig. 1.9.) to create the world's first Medical Aviation Service in Australia. Ten years later, in 1928, upon his initiative, Aerial Medical Service (AMS) was organized. It is remarkable that J. Flynn combined distant consultations (by means of radio and telegraph) and doctors' air travel to patients. It took several years to organize this regular service. Now a physician can reach out to seriously ill patients quickly at any point on the Australian continent. J. Flynn supposed that the availability of "radio communication in every inhabited locality” could make AMS 75% useless" (National Archives of Australia, 2015; Royal Flying Doctor Service 2015; The John Flynn Story 2015; Turner 1935; Western Australia 2015).

Fig. 1.8. The grave of Jimmy Darcy, the ruins of the post-office, where the famous telegraph consultation and operation took place (Halls Creek, Australia)

Fig. 1.9. John Flynn (25.10.1880-05.05.195)
However, the problem of electricity supply under wildlife conditions was crucial. It was solved by Alfred Hermann Traeger (McKay 1995) (Fig. 1.10), who worked out the so-called "pedal radio" (a dynamo generator with pedal drive that was used for electricity supply, Fig. 1.11-1.13). At first this ingenuity allowed exchanging messages by means of the Morse code and later, after 1930, also by means of voice messages. In the 1940s the distant
medicine was really implemented in AMS. All inhabited localities were equipped with standard sets which contained large supplies of medicines and medical tools.

Now a physician, having received an illness description over the radio, would just have to indicate the required medicines or tools and administer the therapy. The combination of medicine, aviation and radio is called
"social revolution", which enabled to change fundamentally the healthcare system in Australia. Today this organization, which is using telemedicine very actively, is called Royal Flying Doctor Service (McKay 1995; Royal Flying Doctor Service 2015) (Fig. 1.14-1.15).

So, in the 1920s in Australia, the Aerial Medical Service was established, equipped with standard widely available telecommunication facilities. The given model of the healthcare service organization became so efficient that it is still used up till now in many countries of the world (naturally, in relation to the level of communication facilities and medicine progress).

1.2.2. Marine telemedicine

No wonder that radio communication gained a widespread circulation in marine telemedicine. An episode of radio teleconsultation, which was held on January 2, 1911, was described as follows: Captain McGray of the steamer *Herman Frasch* was stricken with serious ptomaine poisoning. A member of the crew asked the USA naval base in Dry Tortugas for help over the radio (the distance between two points was about 100 miles). His message was received on board the *Merida*, which was 800 miles away close to Yucatan. The surgeon of this ship gave his recommendations, thanks to which the captain was given the correct medicine and recovered quickly. The improvised teleconsultation occurred between the two vessels, earlier than the naval base replied (Important Events in Radiotelegraphy, 1916).

In 1920 in the hospital of Haukeland (Bergen, Norway) for the first time radio teleconsultations were held for seamen. Physicians not only made remote diagnoses and recommendations for treatment but also guided complicated surgical operations via Bergen Radio (Rafto T., 1955).

In 1949 two doctors of this hospital - Jon Reinert Myhre and Johannes Boe - established a special service for marine radio consultations (Fig. 1.16-1.17).

J. Boe left the hospital and the country after a while, and Dr. Jon Myhre continued rendering the service single-handed during 35 years. Primarily, the enthusiastic doctors worked for free, but after some years they started to get sponsorship from the Naval Department of the Royal Norwegian Ministry of Trade, and then from the National Social Security.

In 1984 Dr. J. Myhre retired, and the service, now called “Radio Medico Norway”, was headed by Prof. Aksel Schreiner together with Prof. Alfred Halsteinsen, Erik Florvåg and Dr. Kjell Gisholt (Norwegian Center for maritime Medicine, 2016).
In 1920 in New York (USA), upon the initiative of Captain Robert Huntington, the world's first service of marine radio consultations was arranged on the premises of the Seamen’s Church Institute. At the beginning of his marine career Robert Huntington gained hard experience. As second officer on a small trading vessel, he had to manage and steer the ship by himself for several days, because the whole crew, including the captain, were infected with yellow fever. People were suffering and dying, without any chance to get at least some medical aid. Huntington had not only to steer the ship, but also to look after the seriously ill mates (Coulter, Stone, 1937; Medical Advice by Radio at Sea 1925).

During almost thirty years the question “how to help seamen?” remained open. And the answer came only after the invention of the radio and when on November 3, 1920 at the Seaman's Church Institute, Robert Huntington (a principal of the Merchant Navy School, Head of the courses of medical and first aid help for seamen and a Navigation teacher) organized the service for radio consultations at sea for crews of merchant vessels. (Fig. 1.18-1.19) (Captain Hintington Retires, 1942).
The initial idea was heartedly supported by the superintendent of the Institute Dr. Archibald R. Mansfield, and the financial grant for its realization was donated by a businessman, Henry A. Laughlin. The radio station with the call signal KDKF was located in the Institute building. At the beginning it provided consultations every day from 9.00 to 17.00, and starting April 20, 1921, it went on around-the-clock. After one year, the Radio Corporation of America and the Health Service joined the project. Radio medical consultation service had improved its own infrastructure by involving all coastal radio stations and a telephone connection with the New York Naval Hospital. All radio teleconsultations were provided to seamen free of charge. Initially, only the staff of the Institute provided all radio consultations, however, during the next 5 years, naval hospitals, organized by the public health service system, joined the network, as well as medical centres in Columbia, Panama, Costa Rica, Norway and Sweden. Consulting physicians had to deal with contagious diseases, traumas, acute surgical pathologies and even with childbearing. In the course of time a special doctor's bag was developed, which allowed to improve partly.
teleconsultations: seamen could follow the instructions carefully, using the standard doctor's bag with medications and instruments (Covers Seas with Medical Aid by Mary Phillips, 1926; Medical Advice by Radio at Sea, 1925). Also, a special manual on emergency aid under the conditions at sea was written up (Fig. 1.20 - 1.23).

Fig. 1.21. Dr. Ezra K. Sprague (New York Naval Hospital) is conducting radio teleconsultation for an ill seaman. A liaison officer is providing medical wireless consultation services; coastal radio service, where medical messages came in (Seamen’s Church Institute, 2016; The Original Radio Outfit, 1923; When Radio Turns Doctor, 1925)
Captain Robert Huntington used to say: "It does not matter, where a vessel can be, after a captain asks for help over the radio, an ill seaman can get the most qualified medical consultation within 13 minutes".

On February 16, 1935, in Italy, the International Medical Radio Centre (Centro Internazionale di Radiocomunicazione Mediche - CIRM) for providing distant medical assistance to seaship crews and island inhabitants (Fig. 1.24) was founded upon the initiative of Prof. Guido Guida (Fig. 1.25).
The famous scientist Guglielmo Marconi became the first President of the Centre (Fig. 1.26) (Guida 1968).

According to recollections of his contemporaries, Guida's idea of the centre foundation was connected with his childhood impressions - his father was a seaman and he told many horrible and tragic stories about ship crews dying of different injuries and diseases at sea. In some sources it is said that Guido Guida's father died of bleeding at sea. In 1935 Guido Guida (an otolaryngologist by occupation) put together a squad of like-minded people, who agreed to provide seamen with consultations free of charge. Doctors M. Acqua, A. Bensoir, G. Bernieri, F. DeGennaro, G. DiBlasi, M. DiRorai, A. Dubinsky, G. Goretti, F. Gruccione, V. Lanza, E. Lipani, G. Mavagna, P. Monchi, G. Musti, L. Priore, A. Razza, A. Rizutti, Sallustri, Sciafra, A. Scontrino, B. Sparacio were among the volunteers (Amenta et al. 1996; Centro Internazionale Radio Medico 2016; Library of Congress 2016; Modern Mechanics 1953; Rizzo et al. 1985).

On April 7, 1935 CIRM received its first message in Morse code from the Italian steamship, the Perla, which made possible distant consultation between the ship captain and the CIRM medical team. Later on, CIRM received the call signal "Medrad". During World War II the activity of the centre was interrupted. It was reopened in 1946 (Fig. 1.27). For exactly twenty years the unique and
extremely important centre existed only thanks to its founder - Professor Guida paid all expenses himself.

And only in 1955 the Italian government started providing financial support for CIRM. Thanks to the new budget the centre developed and in 1957-1958 a scientific department was established there, which enabled to move on from simple teleconsultations to the study of seamen's occupational pathology. A scientifically based conception of medical assistance at sea was developed (Blisters are laid to butterfly dust 1948). The staff of consulting doctors was enlarged to 50 physicians, who had to deal with the widest range of diseases and injuries. Once, experts had to guide the actions of a captain's mate of one of the merchant vessels over the radio, which had to perform appendectomy on a sailor. In 1948 Prof. Guida consulted over the radio a seaman with the symptoms of acute allergic response to butterflies: a tanker was sailing from Venezuela to Sweden, when, in the Caribbean Sea a big swarm of insects "attacked" the ship, as a result one of the crew got high fever, blisters and ulcers on his skin. After the administered treatment according to the radio consultation, the seaman recovered (Blisters are laid to butterfly dust 1948). It is known that in 1959 the doctors of CIRM conducted 7 055 radio teleconsultations and more than 9 000 in 1978. The unique work of Prof. Guida was recognized by the WHO in 1965. It was not until the end of the 1960s that Guido Guida published CIRM working experience (Guida 1968) (Fig. 1.28).

CIRM continues its activity nowadays as well. Dozens of thousands of radio teleconsultations have been conducted since that time (Guida 1968; Amenta et al. 1996; Centro Internazionale Radio Medico 2016; Library of Congress 2016; Modern Mechanics 1953; Rizzo et al. 1985)
The results achieved by the CIRM over 61 years include medical assistance to 42,935 patients on board ships (as well as on small islands and...
aircraft) with 37,526 medical messages received and transmitted. In terms of the number of patients assisted by radio, the Center is the foremost organization in the world. During the years before World War II, there was an average workload of about 60 cases and 250 medical messages per year. This rose steadily, to peak during the early 1970s at an average of about 1,400 cases and 11,000 medical messages per year. Since then it has declined slightly to its present volume of about 700 cases and 7,000 messages per year. The reduction in the number of cases can be attributed to the growing number of national radio medical centres around the world, and to the decrease in the number of sailors at sea due to the high degree of automation on modern vessels, a factor which also helps the shipping companies to select personnel in good psychological and physical health” (Amenta et al., 1996).

Centers of marine telemedicine have been established and operating efficiently following the CIRM example all over the world. It is almost unknown that since February 2, 1931 the Cuxhaven Medical Center (Lower Saxony, Germany) operates as a hospital-based radio medical advice center for ships worldwide. This center is known as Medico Cuxhaven.

Fig. 1.29. Meinhard Kohfahl (13.03.1926-01.08.2013, Germany; “Father of the Naval Medicine in Germany”, (Flesche et al., 2004; Meinhard Kohfahl, 2016; Kohfahl, 2016)

Fig. 1.30. Biotelemetry from the rescue boat “Hermann Ritter” to Medico Cuxhaven, 1978. Medical kit on the rescue boat: box with medications and tools, respiratory machine, and tele-ECG device, 1990 (Germany) (Flesche et al., 2004; Meinhard Kohfahl, 2016; Kohfahl, 2016)
For a long time this task was performed on an honorary basis by the hospital's physicians. Only in 1994 Germany accepted the International Maritime Organisation and International Labour Organisation resolution 164. Therefore, in 1998 a formal contract of the German Ministry of Transport officially installed Medico Cuxhaven. In the 1950s, Dr. Meinhard Kohfahl (Fig. 1.29) developed a special check-list (algorithm) for radio medical advising which made teleconsultations much more efficient (Fig. 1.30). In 1976 he and Dr. Peter Koch developed a special medical kit (box) for sea vessels. This kit allows procuring aid at sea more easily and safely, especially during radio consultations when there is no doctor on board. In the 1970s Medico Cuxhaven team (under supervision of Dr. Koch and Dr. Kohfahl) started to develop a biotelemetry system of twelve-lead ECG, blood pressure, CO₂, SaO₂, pulse and respiration rates. In general, more than 42 000 radio teleconsultations were lead by Medico Cuxhaven between 1960 and 2005 years (ibid).

In the context of the marine telemedicine one must also mention a telemedicine system, which was developed in Greece approximately in 1946 by Skevos Georges Zervos, Prof. of History of Medicine at the School of Medicine at the University of Athens (Fig. 1.31).

Using radio station with microphones, dynamic speaker, headphones and special recording device, Professor Zervos performed broadcasting of auscultation of lungs and pulse. In 1946–1956 a new technology was demonstrated repeatedly at the meetings of the Athens Medical Society and other scientific and practical events, when telemedicine sessions were conducted between different cities.

Fig. 1.31. Skevos Georges Zervos (1875-1958 or 1966)

Fig. 1.32. Professor Skevos Zervos is performing "tele-examination" by means of radio connection (Athens, Greece, 1936)
Professor Zervos affirmed that he could “broadcast auscultation of lungs and heart rate to any point of land and sea, without any doubt, absolutely distinctly. This special tele-examination is of utmost importance for humanity” (Fig. 1.32) (Autobiography of Skevos Zervos, 2003). It was proposed to use the system of "tele-examination" on marine vessels, cruising across the Atlantic Ocean from Piraeus to New York, and also to hold teleconsultations between Athens and Paris. However, according to Professor Zervos himself, because of "heartlessness and criminality... of the state science" at that time, the project was not put into action.

In the middle of the XX<sup>th</sup> century, the services of marine teleconsultations operated in all countries of the world. For instance, in Great Britain free service of radio marine teleconsultations was founded in 1964. In the first year it conducted 365 teleconsultations. In addition to KDFK, in the USA, marine consultations were conducted by coast guard (AMVER service from Atlantic Merchant Vessel Report). In 1963 they conducted 240 sessions.

The experiments with biomedical information transmission from the sea to coastal medical centre can be considered as a separate chapter in marine telemedicine. There is a report about radio transmission of auscultation of heart beating in 1921 by S. R. Winters from the United States Navy board to the coastal medical centre.

In 1964 a team consisting of Dr. Albert-Jean Monnier (SS France liner), Prof. Irving S. Wright, Dr. Donald J. Cameron (both from medical college of Cornell University, New York, USA), Prof. Jean Lenegre, Dr. Bertrand Coblentz (both from Paris University, France) made it their mission to carry out transmission of ECG and X-ray images from sea to shore (Monnier et al., 1965) (Fig. 1.33-1.34). The transmissions were carried out from the SS France liner in New York and Paris by means of national telecommunication companies. Technically the process of image transmission (in fact, scanned X-ray patterns and ECG curve tapes) represented facsimile transmission (Fig. 1.35). The pilot testing was performed in July and August 1964, ECGs were transmitted on November 13 and 27 in the same year. After first successful sessions the liner changed its location in the ocean several times, but the transmission was properly repeated. In all cases the quality of the medical information received on the continents was similar (Fig. 1.36). The overall time of the marine teleconsultation using facsimile transmission was about 1.5 hours (from the start of the image delivery to the moment of its receiving by an expert), the further case discussion was held over wireless telephone.
On June 14, 1965 ECG was transmitted from the SS France to New York. It was retransmitted to Doctor Jean Lenegre in Paris via the "Early Bird" satellite.

The data quality was good enough for interpretation, and the consultant informed over the phone the analysis results to Doctor Albert Jean Monnier, the head of Maritime Medical Service. As such, the researchers proved the possibility of qualitative telediagnostics by means of facsimile and radio transmissions. This case focused on X-ray patterns and ECG, because cardiologic pathology and bone fractures were considered the most widespread problems in marine medicine.

![Fig. 1.33. Jean Lenegre (25.03.1904-09.02.1972, a pioneer in cardiac catheterization, an author of the famous text-book on clinical echo-cardiography)](image)

![Fig. 1.34. Irving S.Wright (27.10.1901-08.12.1997, a pioneer in anticoagulant treatment application)](image)

![Fig. 1.35. The SS France liner (1962), Getty Images photo](image)

Similar experiments were held by the team under supervision of Doctor Winsor on September 17, 10 and 25 and also on December 1, 1964, performing facsimile transmission of medical data at different distances between sea vessels and the shore.
Albert-Jean Monnier himself informed about this fact, with reference to the oral conversation with T. Winsor on February 8, 1965 (Monnier et al., 1965).

Fig. 1.36. Facsimile of X-ray pattern and ECG, transmitted from the SS France liner to New York and Paris on 27.11.1964 (Monnier et al., 1965)

Fig. 1.37. Examples of medical transmitted for teleconsultations in RMDS system (USA, 1982)

Between 1972 and 1982 (or possibly longer) in San Diego (California, USA) the "Navy Remote Medical Diagnoses System" (RMDS) was established for teleconsultations between coastal points and marine vessels. Will T. Rasmussen, Ilya Stevens, F. H. Gerber, Jayne A. Kuhlman, J. Silva were the authors of this telemedicine system. Black-and-white slow-scan television communication and biotelemetry were applied for the exchange of X-ray patterns, ECG, auscultation (electronic stethoscope) and other physiological data. Satellite technologies and radio served as communication means. The marine vessels Juneau (LPD-10), Fort Fisher (LSD-40) and Alamo (LSD-33), located on the southern coast of California
and on the western part of the Pacific, participated in the first system testing. The exchange of audio- and video-information between the vessels and the coast (Regional Maritime Medical Centre in San-Diego) was performed successfully with the help of the above mentioned technologies and involving telecommunication stations in the Philippines (Bennett, 1978; Stevens and Rasmussen, 1962) (Fig. 1.37).

Based on the results of the testings, the system was improved, special terminals for radiological image exchanges were developed; a retesting was involving the Enterprise (CVN-65). The authors undertook a thorough study of diagnostic value, specified scientifically based technical requirements, as a result of which the system was widely introduced in the form of telemedicine network between the naval medical centres in California, San Nicolas and San Clemente Islands. The network worked irregularly; for instance, 37 ECG of 18 patients were transmitted for teleconsultations from March 1977 to November 1979 from San Nicolas Island, whereas in San Clemente Island the terminal was almost not used and soon it was dismantled. In general, the system was acknowledged as the most efficient for preventative medicine in the isolated and remote localities with the focus on teleradiology.

In the 1980s in the USSR, at the Main Military Clinical Hospital named after N. N. Burdenko, the establishment of the common Naval Consultative Medical Centre, automated management systems were introduced to support the medical service. In average, more than 50 consultations to the stuffs of marine vessels and submarines were conducted annually. Regular day-and-night duty was provided (Main Military Clinical Hospital. NN Burdenko, 2016).

So, radio communication remains one of the basic telemedicine facilities. Medical Aviation Service combined with radio communications represents an efficient model of medical aid arrangement under certain geographical conditions. This mode of communications was used actively in hard-to-reach areas and isolated districts till the 1960-1970s, i.e. until alternative satellite transmission facilities appeared. Naval medicine services have been operating on the basis of the radio (since the 1920s up to now).
1.2.3. Radio communication in distant medical learning and management

In the 1930-1940s radio broadcasting, dedicated to different issues of the healthcare system, became popular. Radio was used in training of physicians and in holding distant round tables on different clinical questions, popular radio shows for the public were organized (Anterior poliomyelitis, 1939; Bauer, 1935; Blanchard, 1937; Turner et al., 1935). It is worth mentioning that as early as 1939 the statement concerning inadmissibility of advertising for medicines and self-medication propaganda by mass media (radio) was discussed by medical communities (Joint Committee on Professional Relations, 1935). Later, in the USA, academic teaching hospitals began creating their own wireless networks, which were used mainly for educational purposes (Fig. 1.38).

For instance, they were operating in Philadelphia under the supervision of Doctor Fred Richardson, in North Carolina (Dr. William P. Richardson), in Ohio (Drs. John A. Prior and William Pace), Utah (Dr. C. Hilmon Castle), California (Dr. Seymour M. Farber), in Maryland (Dr. Fred J. Heldrich), in Wisconsin (Dr. Thomas S. Meyer) (Woolsey, 1960).

Starting from 1955, radio connection was used in Albany (NY, USA) to implement distant learning (Fig. 1.39). The equipment was placed in the local medical college and in 24 hospitals, the total audience of the daily 20-minutes' lectures with the subsequent interactive discussion counted 200 physicians (not including the interns and residents) (Hospital hookup saves much travel, 1957). This work was carried out under direction of Dr. Frank M. Woolsey Jr. (Associate Dean, Professor and Chairman, Department of Postgraduate Medicine). Initially, an amateur equipment set was used, but in 1957 a professional radio center was created at the college (Nelson, 1958; Woolsey, Strauss, 1964; Woolsey, 1958; 1960; 1967; Woolsey, Ruhe, 1956).
Later 5-7 medical universities joined the program. The hospital network was constantly enlarging, up to 800 physicians could take part in the interactive teaching radio conferences simultaneously. The evident disadvantage of such type of teaching was the absence of visual aids. This problem was solved by sending out beforehand copies of tables and illustrations, which were carefully listed. The audience could watch such "charts", following the instructions of the reader (ibid).

In 1973, in Ohio, a microwave radio network was applied for medical data exchange between five hospitals. Several years later closed-circuit television network replaced it, which allowed making color video conferences (Stamford radio unit to aid 5 hospitals, 1973).

Between 1975 and 1989 the Mexican government established the radio network «IMSS-Coplamar» for health care coordination and epidemiological control in isolated areas (Decree decentralizing to the state governments … 1984; DeEsparza, 1985).

1.2.4. Emergency radio communication by amateurs

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 (non documented) of amateur radio use in an emergency situation happened in 1906. Barney Osborne set up and operating amateur wireless station which he used to pass on emergency traffic after the huge earthquake and fire in San-Francisco (April 18, 1906). The information is from the family archives (Fig. 1.40) (Lee 2016).

The first real documented case dates from 1913. Herbert V. Akerberg was the first person reported to use amateur radio in disaster relief (this fact was recorded). As a 15 year old, Herbert used his modest radio to transmit information to the Overland radio station in the Huntington Bank Building near the Columbus, Ohio, City Hall in March 1913 during a terrible flood. During three days the young man was on duty at his radio set, in communication with the “outside” radio station, sending messages to the mayor and keeping the public advised as to the conditions in the devastated areas (Fig. 1.41-1.42) (Tebben, 2013).
On May 27 1925, Santa Barbara (California, USA) was completely destroyed by an earthquake which cut off the city from the rest of world. Just in a couple of hours after the hit, a few radio enthusiasts led by 19 years old Graham D. George (Fig. 1.43) built up a working radio station (from various stations in the city), and did what was necessary to communicate with the outside to inform them about the disastrous situation in Santa Barbara.

A citation describes this fact in an original way. Quote from Radio News Bulletin published by M. Jogoleff in 2008 (Jogoleff, 2008): “The first news telling the outside world about the city’s ordeal … Within an hour after the first shock they [B. Wentworth Jr. and G. George] had assembled a three inch spark coil … twelve volt battery and a key for transmission of an SOS. An undamaged super heterodyne receiver from the store stock took care of the reception, and the busy pair of radio men immediately started sending out their SOS. The tanker H. M. Story, station KDVV, and the tug Pencock, station KDKY, were the first two to pick up the calls. The tug acted as a relay station in the call for naval aid and in sending out the news of the disaster. The emergency station continued its work until other communication was restored” (Fig. 1.44-1.45).

The radio-enthusiast Clinton B. De Soto has to be mentioned, too. He (Fig. 1.46) was the assistant to the secretary of The American Radio Relay League, editor of the QST magazine, and author of a large number of papers and books. In a few excellent articles he gave us an opportunity to read about amateur radio operators’ participation in emergency situations in the first half of the 20th century (DeSoto, 1933; 1935, 1936).
The Long Beach earthquake (California, USA) took place on March 10, 1933, and a huge number of radio amateurs came to help establishing the emergency communications: Francis M. Sarver, Don Wallace, Al Martin Jr., W. A. Adams, Vernon Keays, Ludwig A. Hedstorm, A. W. Fuller, George F. Moynahan Jr., C. N. Fisher, Covina, Vernal Routh, Martin Corcoran, Artesia, Edward Seeley, M. J. Campbell, Ed Stevens, Dwight B. Williams, George W. Bailey, and a few hundreds (!) others (Fig. 1.47.-1.49) (DeSoto, 1933; 1935, 1936; Lee, 2010). NB: The reader interested of the signcall of all people cited in this article, please contact the authors. The signcalls will be provided.

Within a couple of days the amateur radio networks were built for official and private communications between damaged territories, authorities, medical and military services, as also with relatives and friends. Thousands of messages were sent via radio during just a few days after the disaster (ibid).

Two years later (September 1935) the so-called Labor Day hurricane hit Florida (USA). There is a description how radio amateurs were dealing with the disaster (ibid): “For twenty-three hours, while buildings crashed around him, Fred E. Bassett, Jr., of Eustice, Fla., described scenes of horror and gave directions for relief over his 50-watt portable transmitter, W4AKI. In Miami, Alonzo O. Bliss, Jr., operator of W4COT picked up the messages and relayed them to the Red Cross and army relief workers. Other amateurs in the hurricane area also carried out heroic work wherever it was possible to erect emergency transmitting equipment... Death by storm, flood, earthquake, and disease is followed by the ever-watchful radio amateurs. When other means of communications fail, they fill the gap. Their emergency call, QRR, often restores the link to information over which the relief and reconstruction work is carried on...“ (ibid).
Fig. 1.46. Clinton B. De Soto (W1CBD) (1912-1949, USA),
http://www.arrl.org/desoto

Fig. 1.47. Emergency radio and telephone communication point during The Long Beach earthquake (1933), left to right: Edward Seeley, M. J. Campbell ((DeSoto, 1933; 1935, 1936)

Fig. 1.48. W6GJO handling emergency radio communication during The Long Beach earthquake (1933, USA

Fig. 1.49. Don Wallace’s (W6AM) radio station in a field (his family and “house” in the background) during The Long Beach earthquake (1933) (Lee, 2010)
Table 1.1 shows more or less documented episodes of amateur radio stations participation in emergency communications during disasters in the 20th century.

Table 1.1. Amateur radio for an emergency communications during natural disasters in 1913-1989 years (Bajenov, 2010; History of RAS, 2015; Amateur Radio Emergency Service of Russia (ARES Russia), 2015; DeSoto, 1933, 1935, 1936, Lee, 2010; Local radio hams assist with traffic relays in earthquake, 1959; Pasternak, 1976; VK4JK, 2014)

<table>
<thead>
<tr>
<th>Date</th>
<th>Place</th>
<th>Disaster</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.04.1906</td>
<td>San-Francisco, USA</td>
<td>Earthquake and fire</td>
<td>Barney Osborne</td>
</tr>
<tr>
<td>23-26.03.1913</td>
<td>USA</td>
<td>«The Great Flood»</td>
<td>Herbert V. Akerberg</td>
</tr>
<tr>
<td>27.05.1925</td>
<td>Santa Barbara, USA</td>
<td>Earthquake</td>
<td>Graham George, Brandon Wentworth Jr., A.B. (Bennie) Lopez, Archie Banks, Jim</td>
</tr>
<tr>
<td>Date</td>
<td>Location</td>
<td>Event</td>
<td>Authors</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------</td>
<td>------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>February-March 1929</td>
<td>Lwow, Poland/ Ukraine</td>
<td>Floods in highland regions</td>
<td>Vlodzimej Levitskiy, Jacub Khenner, Alfred Kranzler, Julius Kolachek, Adam Ligeza</td>
</tr>
<tr>
<td>Winter 1929</td>
<td>Tula, Russia/USSR</td>
<td>Floods</td>
<td>-</td>
</tr>
<tr>
<td>July 1929</td>
<td>Leningrad, Russia/USSR</td>
<td>Floods</td>
<td>-</td>
</tr>
<tr>
<td>1931</td>
<td>New Zealand</td>
<td>Earthquake</td>
<td>-</td>
</tr>
<tr>
<td>10.05.1933</td>
<td>Long Beach, USA</td>
<td>Earthquake</td>
<td>A few hundreds radio amateurs</td>
</tr>
<tr>
<td>Spring 1934</td>
<td>Duluth (Minnesota)</td>
<td>Sleet storm</td>
<td>James H. Leach (Fig. 1.52), T. O. Jorgenson</td>
</tr>
<tr>
<td>September 1935</td>
<td>Florida, USA</td>
<td>Labor Day hurricane</td>
<td>Fred E. Bassett, Alonzo O. Bliss, Jr.</td>
</tr>
<tr>
<td>1936</td>
<td>USA</td>
<td>“North-West Flood”</td>
<td>400 radio stations (Fig. 1.51)</td>
</tr>
<tr>
<td>1939 (Black Friday)</td>
<td>Australia</td>
<td>Bush fires</td>
<td>-</td>
</tr>
<tr>
<td>1948</td>
<td>Washington, USA</td>
<td>Flood</td>
<td>ARES USA**</td>
</tr>
<tr>
<td>1957</td>
<td>USA</td>
<td>Malibu fires, Hurricane Audrey</td>
<td>ARES USA**</td>
</tr>
<tr>
<td>17.08.1959</td>
<td>Montana, USA</td>
<td>Hebgen Lake earthquake (or Yellowstone earthquake)</td>
<td>E. Carl Lanzendorfer, Bill Hammond, John Bielenberg, Florence Majerus</td>
</tr>
<tr>
<td>27.03.1964</td>
<td>Alaska, USA</td>
<td>The Great Alaska Earthquake and Tsunami</td>
<td>Lenore Jensen, Steve Jensen, Bob Ringwald, Al Hershberger, Ed Back, Zilla Maile (Fig. 1.59)</td>
</tr>
<tr>
<td>1967</td>
<td>Central Americas</td>
<td>Earthquake</td>
<td>College Station W5AC, Texas, USA</td>
</tr>
<tr>
<td>1972</td>
<td>USA</td>
<td>Hurricane Agnes</td>
<td>David Otey, ARES USA** (Fig. 1.55)</td>
</tr>
<tr>
<td>23.12.1972</td>
<td>Managua, Nicaragua</td>
<td>Earthquake</td>
<td>Nate Brightman (K6OSC) (Fig. 1.58)</td>
</tr>
<tr>
<td>1974</td>
<td>Darwin,</td>
<td>Cyclone</td>
<td>-</td>
</tr>
<tr>
<td>Date</td>
<td>Location</td>
<td>Event</td>
<td>Authors</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------</td>
<td>----------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4.02.1976</td>
<td>Guatemala</td>
<td>Earthquake</td>
<td>Bella Russ, Texas College Station, Radio Amateurs of Southern California, Doug McDowell</td>
</tr>
<tr>
<td>1978</td>
<td>Los Angeles area</td>
<td>Torrential rains and flooding</td>
<td>Len Drayton</td>
</tr>
<tr>
<td>15.04.1979</td>
<td>Montenegro</td>
<td>Earthquake</td>
<td>Amateur Radio Club in Žabljak</td>
</tr>
<tr>
<td>1983</td>
<td>Australia</td>
<td>Bush fires</td>
<td>-</td>
</tr>
<tr>
<td>20.09.1985</td>
<td>Mexico-city (Mexico)</td>
<td>Earthquake</td>
<td>Lenore Jensen (Fig. 1.54), San Fernando Valley Amateur Radio Club (Len Drayton, Bill Bell, Esther Wolf, Texas College Station, William Dave Paperman (Fig. 1.57); and more than 10 thousands radio amateurs</td>
</tr>
<tr>
<td>07.12.1988</td>
<td>Spitak, Leninakan, Armenia/ USSR</td>
<td>Earthquake</td>
<td>ARES/RARES*, Karen A. Karapetian, Gennadiy Grigorievich Shul’gin, Constantine Kh. Khachaturov, radio station RK4CXH, Viktor Petrovich Jirnov, Valeriy Bazhenov, Anatoliy (Toly) Nikolaevich Bayakin (Fig. 1.53) etc</td>
</tr>
<tr>
<td>1989</td>
<td>Loma Prieta, USA</td>
<td>Earthquake</td>
<td>ARES USA** (Fig. 1.56)</td>
</tr>
<tr>
<td>1989</td>
<td>Tatarstan, Russia</td>
<td>Floods</td>
<td>ARESR/RARES*</td>
</tr>
<tr>
<td>1989</td>
<td>Newcastle, Australia</td>
<td>Earthquake</td>
<td>ARESR/RARES*</td>
</tr>
<tr>
<td>1989</td>
<td>Iran</td>
<td>Earthquake</td>
<td>ARESR/RARES*</td>
</tr>
</tbody>
</table>

* - ARES: Amateur Radio Emergency Service of Russia, RARES: Russian Amateur Radio Emergency Service
** - ARES USA: Amateur Radio Emergency Service of USA

In the second half of the 20th century, a lot of associations and societies for emergency communications were founded by radio amateurs worldwide (such as MARA: Medical Amateur Radio Association in 1990 in USSR by...
Anatoly Ivanovich Podolyan and 80 other radio-enthusiasts from different health care institutions (Fig. 1.60).

1.3. Telephone Communications in Telemedicine

At the end of the 19th century the Italian Antonio Meucci and the American Alexander Graham Bell almost simultaneously presented a new technology of sound communication to the world - the telephone. This term was introduced by the German Johann Philipp Reis.

It is oftren cited that Bell made the first telephone call to his friend and assistant Doctor Watson, asking him to provide aid (probably in a case of chemical burn). The famous scientist and telemedicine historian, Professor Rashid Bashshur supposes this story to be an apocryphal one. In 2006 professor Magnus Hjelm dispelled this myth. In the original paper he had cited the working diary of Alexander Bell, with the description of procedure and stages of the first call. The medical component in these authentic records is completely absent. Moreover, M. Hjelm found out that the «legendary» episode was actually taken from the movie «The Story of Alexander Graham Bell» made in 1939 in the USA (http://www.youtube.com/watch?v=9WDyKO7GQ70). Thus, it is the unfair relation of the Hollywood’s screenwriter of historic facts that led to emergence of this myth (Hjelm, 2005).
Fig. 1.51. Original pictures from papers by Clinton B. DeSoto: radio amateurs fights with floods in 1936 (DeSoto, 1933; 1935, 1936)
There is a documented proof of the first use of telephone communication for medical purpose in the USA in 1879: a short note was published in “The Lancet” with the description of the situation, when relatives of a little child called their family doctor at night with a complaint about severe cough. The doctor told to hold a receiver close to the child's head for him to hear the coughing, which was done. In a few minutes the doctor announced, that the
child did not have croupous cough and that the matter could be postponed till the morning (Practice by telephone, 1879) (Fig. 1.61).

Fig. 1.55. Emergency amateur radio communications during natural disasters in USA; up, from left to right: flood in 1948, fires in 1957, hurricane in 1957; bottom: hurricane in 1972 (Lee, 2010)
In 1887, a telephone communication, probably for the first time ever, was used for communication of patients from a contagious isolation ward (especially, those with scarlet fever) with their relatives (Aronson, 1977).

In fact, in the 1880s, the possibility and even the necessity to use telephone for communication between doctors and patients were discussed actively. One of the zealous supporters of the installation of a telephone system in medicine was the British Doctor Alfred H. Twining, who recommended in 1888 to use widely the new mode of communication, especially in the rural areas, for “long lasting social or professional conferences around-the-clock“ (ibid). The remarkable thing is that a few years before its appearance the telephone became an integral part of a doctor's office; in particular, there is a fact of total installation of telephone system in Birmingham Women's Hospital in 1880 - "all internal and external departments, and also doctors' residences" were connected online (Aronson, 1977; Swoyer, 1949).

In 1891 the famous English orthopaedic surgeon Richard Davy insisted on the development of telephone communications between hospitals for the purpose of logistics optimization, and to prevent refusals in hospital admission and patient transportation between health care institutions. As an argument the doctor suggested the description of a clinical case: a boy with lower limb fracture, who was transported several times from one hospital to another for the
reason "no beds available". Doctor Richard Davy (1839-1920), by the way, invented a special medical vehicle for transportation of the injured, and a range of methods for surgical treatment of osseous-articular tuberculosis, and on the other hand, he was a vigorous critic of the antiseptics theory. In one form or another, the discussion regarding the appropriate installation of telephone system in healthcare service continued up to the 1950s. Yet, emergency medical service, fire emergency and police started to be equipped with telephone communications during the 1920-1930s.

![Fig. 1.59. Al Hershberger, Ed Back, 2000s (photo by M. Scott Moon), Zilla Maile, 1954 (photo courtesy of Donna Van Lone) – they used amateur radio to communicate with the outside world following the 1964 Alaska earthquake (Hermanek, 2006)](image1)

![Fig. 1.60. Medical Amateur Radio Association (MARA) official badge, 1990, USSR](image2)
At the end of the 19th century an interesting deontological dilemma was recorded. In the described period, doctors were not allowed to use public advertising for their activity in the newspapers or by other means, for ethical reasons. But in order to connect to a telephone company it was required to give full information about oneself (including address and occupation) in the telephone directory, which could be regarded as advertising. However, within time, the dilemma was solved in favor of the installation of a telephone system and availability of doctors' contact information. There was another ethic problem - in 1911 "The Lancet"
highly recommended doctors not to interrupt examination of a patient by answering the telephone calls (Aronson, 1977).

As far back as in 1878 the ideas about combining the stethoscope and the telephone for distant auscultation were expressed (ibid), though they were implemented only in the beginning of the 20th century when in Europe and America several similar stethoscopes and devices were patented. This allowed the transmission of heart and lungs auscultation over the telephone. Among these devices was the "electrical relay" of S. G. Brown, recognized as the first device to enable auscultation transmission over telephone. (Fig. 1.62-1.63) (Brown, 1915).

In 1910 in Great Britain an engineer Sydney-George Brown conducted the first world's teleconsultation with the help of his own inventions (an electrical relay and an electrical stethoscope): auscultation of heart tones was transmitted over the telephone between London Hospital and the Isle of Wight for a distance over 50 miles. After that S. G. Brown concluded: “This trial proved that it is now possible for a specialist, say, in London, to examine a patient, say, in the country, stethoscopically, and to arrive at a correct diagnosis” (Bashshur and Shannon, 2009). Five doctors participated in the session, who appreciated favorably the quality of this device (Brown, 1912; Gregory, 1951; National Portrait Gallery, 2014). Also, similar experiments were conducted between several points within London (Brown, 1912).

In 1928, (patent priority of 1924) Harold F. Dodge and Halsey A. Frederick in the USA patented “Stethoscopic apparatus”, which “...may be connected to the telephone lines for consulting with remote physicians and for the transmission of heart and chest vibrations to a central laboratory equipped to make permanent records” (Dodge, Frederick, 1924). Later a range of similar inventions were made by C. A. Mason, H. von Baussen and others appeared (Mason, 1935, Von Baussen, 1938) (Fig. 1.64-1.65).

In the 1930-1940s cable communications were used to solve practical arrangements in Healthcare Service, to conduct research and to collect epidemiology data (Coulter, Stone, 1937; Health Organizations and the Telephone, 1941).

In the 1950-1970s there were programs for distant medical learning entirely on the basis of voice communication.
Fig. 1.63. An electrical relay of Sydney-George Brown

For instance, around 1958, the medical centre of Nebraska University (Omaha, USA) performed distant learning. Lectures were presented by phone for doctors from four local hospitals and three hospitals from the neighbouring states (Hospital hookup saves much travel, 1957). In 1972 in Oklahoma (USA) the distant learning network for doctors was developed in 10 regional hospitals. Technically the process was implemented based on a telephone conference line, which allowed carrying out “collaborative conversation” of all the participants of a lecture (Education via teleconference, 1972).
Starting in the 1960s telephone communication and the information transmission services on this basis (telemetry, dataphones, fax machines, teletype machines, etc.) have been used in full scale all over the world for various health information exchanges (Bachmann, Thebis, 1968; Hoffman, Cosby, 1964; Levine, 1964; Maier, 1976; Melvin, 1964) (Fig. 1.66).
Telephone is the most widespread and the oldest telemedicine device providing voice communication. It serves as a data transmission feature (distant-reading instruments, dataphones, slow-scan television systems, facsimile machines, teletype machines, IP-Protocol, etc.). In the beginning of the 21st century the mobile phone became the technical ground for a radically new technology in healthcare service - mHealth (mobile health).

In conclusion: Between 1880 and 1945 the main telecommunication facilities in telemedicine were the telegraph, the telephone and radio communications.

Telegraph was used for medical purposes from time to time, primarily during war conflicts.

In the 1920s models for healthcare service were developed, which used radio for care delivery wherever and whenever necessary, such as the system of emergency medical consultations in the transport field (marine medicine) and medical aviation service in combination with teleconsultations and instructions. The above models are still fully performing even now.
Telephone communication was initially used as a mean for simple consultations and coordination of healthcare practitioners’ actions; however, it has become a multi-purpose telecommunication tool for various health information exchanges (primarily in biotelemetry systems and telecardiology).

References


Blisters are laid to butterfly dust. Clovis News Journal, Clovis, New Mexico, 1948, Thu, Nov 11, pp. 9.


Decree decentralizing to the state governments the health services lent by the Secretariat of Health and Welfare to the states and those within the program for social solidarity through community participation, called "IMSS-Coplamar" which are provided by the Mexican Institute of Social Security]. Salud Publica Mex. 1984, Mar-Apr; 26, 2, pp. 213-216.


[47] Hjelm M. Bell's first telephone call - not the first telemedicine consultation, J Telemed Telecare, 2005, 11, pp. 216
[49] Hospital hookup saves much travel, The Amarillo Globe -Times (Amarillo, Texas), Fri, Mar 22, 1957, p. 4
[57] Levine I. M., Jossmann P. B., Tursky B. et al. Telephone telemetry of bioelectric information, JAMA, 1964 Jun; 1; 188, pp. 794-798
[62] McKay F. Traeger, the pedal radio man: He gave a voice to the bush and to flying doctors, Boolarong Press, 1995, p. 108
[65] Melvin J. P. Telephone telemetry, J Miss State Med Assoc, 1964, Mar; 5, 3, pp. 84-86
[73] Pasternak B. Looking West, Amateur Radio, Aug 1976, pp. 18-22
[81] Seamen’s Church Institute, 2015, http://www.seamenschurch.org/archives
[82] Sending Dental X-rays by Telegraph, Dental Radiography and Photography, 1929, 2, p. 16
[83] Ships receive medical advice from physician by the radio, The Charleston Daily Mail, Charleston, West Virginia, Sun, Jun 18, 1922, p. 17
[85] Standage T. The Victorian Internet, Phoenix, New Ed edition, 1999
[87] Swoyer C. A. The first physician's telephones and the first telephone secretary in Columbus, 1879, Ohio, Med. 1949 Jun; 45, 1, pp. 50-52
[88] Tebben G. Hilltop teen was first to transmit from home radio during disaster, The Columbus Dispatch, Nov 6, 2012, http://www.dispatch.com/content/stories/local/2012/11/06/hilltop-teen-was-first-to-transmit-from-home-radio-during-disaster.html


