Digital healthcare

Societal and technology trend report
Executive summary

In an era in which it is no longer uncommon for people to live more than 100 years, we stand at the threshold of a digital revolution in healthcare. It is an exciting time, offering the potential for innovative and advanced technologies to focus on promoting lifelong wellness and illness prevention throughout a person’s lifespan. The ideal vision for digital healthcare in 2030 is a society in which people will be able to live longer and in better health thanks to a lifetime of technological and social healthcare support.

Involving an emphasis on the cycle of prevention, diagnosis, early treatment and recovery, current and projected developments in technology and digitization of data are making ongoing preventive care available to individuals throughout the world, with personal multimodal data, including prenatal information, being collected throughout a person’s lifetime. Digital healthcare carries great promise for helping people skillfully manage their conditions, coordinate their care, and partner with their clinicians for a lifetime of better physical and mental health.

With healthcare costs continuously increasing and people living longer in their own homes, the concept of digital healthcare must be analyzed across the entire healthcare system with a view to decreasing costs while increasing delivery of services. Examples of efficient services and systems include implementation of artificial intelligence to identify better and more efficient healthcare delivery services, increased use of robotic systems both in the service area and in medical applications, expanded use of sensor technologies including wearables, and extensive implementation of 5G technology.

To provide support for innovations in “personalized” care as part of a future model of digital healthcare, an approach to dealing with the pace and complexity of the changes involved must be identified. One method to achieve this is by retrofitting the aggregated information captured through digital healthcare applications into new standards governing healthcare and well-being. Accordingly, this paper also provides relevant use cases, with each referencing key technologies, related standardization fields and industry segments.

Section 1 of this report provides an introduction to the subject matter and states the objective of the paper. Section 2 presents a vision of digital healthcare in the future, with Section 3 focusing more specifically on approaches foreseen for 2030. Use cases are presented in Section 4. Section 5 offers an analysis of perceived gaps in related standardization fields as well as gaps between the projected future society and current standardization activities. This includes suggestions to IEC on potential opportunities for future standardization. Section 6 contains the conclusions of the report.
Executive summary

Acknowledgments

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<th>Technical and scientific terms</th>
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<tr>
<td>Active assisted living</td>
<td>AAL</td>
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<tr>
<td>Artificial intelligence</td>
<td>AI</td>
<td>artificial intelligence</td>
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<tr>
<td>Augmented reality</td>
<td>AR</td>
<td>augmented reality</td>
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<td>Electronic health record</td>
<td>EHR</td>
<td>electronic health record</td>
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<tr>
<td>Frailty index of working</td>
<td>FIW</td>
<td>frailty index of working</td>
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<tr>
<td>Information and communication technology</td>
<td>ICT</td>
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<td>Internet of Things</td>
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<td>Internet of Things</td>
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<td>Information technology</td>
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<td>information technology</td>
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<td>Machine learning</td>
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<td>Magnetic resonance imaging</td>
<td>MRI</td>
<td>magnetic resonance imaging</td>
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<tr>
<td>Natural language processing</td>
<td>NLP</td>
<td>natural language processing</td>
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<tr>
<td>Operating room</td>
<td>OR</td>
<td>operating room</td>
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<tr>
<td>Open source software</td>
<td>OSS</td>
<td>open source software</td>
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<tr>
<td>Quality of work</td>
<td>QoW</td>
<td>quality of work</td>
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<tr>
<td>Rehabilitation, assessment, compensation and alleviation robot</td>
<td>RACA robot</td>
<td>rehabilitation, assessment, compensation and alleviation robot</td>
</tr>
<tr>
<td>Software / hardware</td>
<td>SW/HW</td>
<td>software / hardware</td>
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<tr>
<td>Virtual reality</td>
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Humans are entering the age of the 100-year lifespan thanks to advances in technology and increased awareness about health [1], [2], [3]. On the other hand, the lives of young children continue to be lost due to a lack of appropriate medical care when needed. The goal of building a society in which everyone is able to receive adequate medical care whenever required is taking on increasing importance. While for the most part people in developed countries are enjoying increased longevity, social problems are emerging that affect access to this advance, such as demographic changes and rising medical costs [4]. Consequently, more attention needs to be paid to the expectancy of a healthy life unburdened by excessive expense.

Today, it has become more important to assure both the physical and mental well-being of people in countries where life expectancy is already elevated. The effect of such an approach is to keep productivity high and social costs low, thereby protecting the overall welfare system. In developing countries, this shift will lead to increased social and economic stability.

In order to maintain physical and mental health, it is important to detect medical disorders or health changes precisely at an early stage [5]. Since the condition of each individual may differ depending on environment or life habits, such services should address specific personal requirements. People need to be able to store and utilize the various kinds of medical data generated throughout the course of their life. The data can also help optimize the processes and technologies used in later phases by tailoring them to meet individual needs in all scenarios and environments relevant to a person’s health and well-being.

A system to collect such life course data from the moment of birth to the end of life is essential. Digital technologies including artificial intelligence (AI) are in practical use, and broader application of them in the healthcare area is anticipated to assist with this collection of data. In light of such digitalization trends in the healthcare field, it has become more important that IEC take the matter of digital healthcare into consideration for future standardization activities.

The objective of this report is to provide a high-level view on how IEC could contribute to enabling the healthcare field of the future and to analyze potential technology gaps in this regard, especially relating to the following items:

- smart technologies such as AI and robots to support eHealth
- smart homes and smart facilities to support active assisted living (AAL)
- efficient systems for decreasing healthcare costs while increasing delivery
- privacy and security issues

This report does not address details of privacy and security, since neither area is healthcare-specific but rather involve general issues relating to wider systems and applications in the society.
Section 2
Vision and image of the future society

Today, as shown on the left side of Figure 1, a person can expect to live a physically healthy life from birth until possibly the age of 70 or 80, and then become ill or unable to live without medical assistance. The medical care involved can be very costly, both for the individual and the society, with the price of such care expected to rise significantly by 2030.

The ideal vision for digital healthcare in 2030 is shown on the right side of Figure 1. By investing more on healthcare from birth through the me-byo state [6] (i.e. the state existing between full health and illness) toward the end of life, the cost of medical care for the elderly is expected to be significantly reduced, leading to an overall reduction of society’s total healthcare costs. Extending medical care to cover lifetime social healthcare will make it possible for individuals to lead a longer healthy life.

Figure 1 | Vision for digital healthcare in 2030
A healthcare cycle can be defined as consisting of four states: prevention, diagnosis, treatment, and recovery. The present report focuses on these four states in terms of mental and physical well-being and its management, as shown in Figure 2.

3.1 Primary focus on the “prevention” phase

Lifetime well-being is realized through the application of healthcare that focuses on prevention, which increases the chances of avoiding serious illnesses and recovering more quickly.

For mental and physical well-being, a cycle encompassing preventive measures, early treatment by diagnosis and subsequent recovery is repeated throughout a person’s lifetime from the pre-natal state to the end of life, as shown in Figure 2. By paying more attention to prevention throughout the individual’s life, the costs of recovery and nursing care will be decreased accordingly, which will eventually lead to reduction of the social cost.

This cycle is supported by personal multimodal data collected throughout a person’s lifetime, “life course data”, and the social big data generated from this information. The big data can be analyzed and used to identify an individual’s health status, which will enable appropriate actions at the appropriate time throughout that person’s life cycle.

3.2 “Diagnosis”, “treatment”, and “recovery” phases

The personal multimodal data collected throughout a person’s lifetime can also be used to improve the outcome of diagnosis, treatment and recovery from illnesses. A focus on prevention will likely reduce the probability of serious illnesses...
developing during an individual's lifetime. However, the probability of illnesses, including serious ones, still exists. The same data used to prevent illnesses, can also help optimize the processes and technologies used to diagnose, treat and recover from them. This can be done by tailoring these processes and technologies to the needs of each individual.

In order to be effective, this technology optimization at the individual level has to be implemented in all scenarios and spaces relevant to a person’s health and well-being. The framework illustrated in Figure 3 provides a better visualization of what those scenarios and spaces include,
The three spheres shown in the framework are defined as:

- **Self wellness**: this sphere refers to an individual's will, mind and body.
- **Home**: this sphere covers the space an individual considers his/her home, and
- **Community**: this involves the social network, as well as spaces and resources available to an individual, that can impact his/her health and well-being.

Any process optimization or technology developed for healthcare or well-being will address needs specified in those three spheres. Figure 3 provides several examples of the needs in each sphere.

Technologies such as machine learning (ML) and AI can leverage the data collected throughout a person's lifetime to improve the outcome of diagnosis and treatment. These technologies, which are already being used at healthcare facilities (community sphere), will eventually be adapted to the self wellness sphere, as the accuracy and reliability of wearable devices and wellness applications improve to a level that can be exploited as a serious source of health data.

Robotics is another example of a technology that is already addressing needs in the community sphere and will likely find its way to the home sphere in an individualized form, as rehabilitation and service robots become more user friendly and safer for use by untrained personnel.
Section 4
Use cases and possible solutions

4.1 Mapping of the use cases

The cycle of prevention, diagnosis, treatment, and recovery phases repeated throughout a person’s life is essential for realizing lifetime social healthcare. Some typical use cases are mapped on the cycle of life phases as shown in Figure 4. Each use case corresponds to the phase below.

The following subsection introduces the use cases to further analyze the key technologies involved in enabling these cases toward 2030.

4.2 Major use cases

4.2.1 Mental healthcare

Over 80% of people suffering a mental health condition do not receive any high-quality, affordable mental healthcare [7]. By continuously monitoring items such as sleeping status, facial expressions, breathing, pulse, blood pressure, and body temperature with monitoring devices (i.e. electroencephalographs, cameras, microphones, wearable sensors), data can be collected on a person’s mental status, as shown in Figure 5. The
Use cases and possible solutions

collected data is then analyzed by AI. If the AI function finds that the person monitored has not slept well or is feeling depressed compared to his/her ordinary state, then the AI may automatically reschedule his/her appointment with a therapist.

**Key technologies:** biometric sensors, contactless sensors, secure communication, biometric analysis, AI

**Related standardization fields:** data format, medical record format, mental health management

**Industry segments:** health / medical equipment, health management, hospitals, house maker

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**Figure 5 | Mental healthcare**

### 4.2.2 Smart asthma inhalers

Connected and smart medical devices are becoming increasingly available on the market. In addition, drugs and devices are being combined into products to provide therapeutic or diagnostic healthcare solutions. The convergence of data, drugs and devices constitutes an area promising numerous benefits to patient care in the future.

An example of such products is the smart asthma inhaler, which can be used to monitor and remind users about the correct use of their medication. The device offers opportunities to improve the way asthma is self-managed by people suffering from the condition, and by the healthcare professionals who support them. While the benefits from smart asthma inhalers could be significant for the general population, the wide deployment of this technology will need to be managed carefully in order to protect patients from any risks relating to the medicine, the delivery device and the utilisation of personal data in the wider environment.

**Key technologies:** data, medical devices, medicines

**Related standardization fields:** cyber security

**Industry segments:** health informatics, health prevention, data management, medical electrical equipment
4.2.3 Workplace environment management

The physical workplace environment of the individual is controlled adaptively to enable the person to feel more comfortable at work, thus increasing alertness and productivity (see Figure 6). Various sensors, cameras and microphones are used to monitor the environment in workplaces such as offices and classrooms, with sensors collecting such data as room temperature and humidity. Cameras and microphones are used to collect biometric information, e.g. facial images and voices of people in the room. AI analyzes this information, and if it finds that workers are lacking concentration or feeling tired or sleepy, it may control the air conditioner or window shades to increase the comfort of the people in the room, thus contributing to increased productivity.

**Key technologies:** environmental sensors, coordinated control, AI

**Related standardization fields:** safety, data format, indoor environmental quality, office environment

**Industry segments:** building, hospitals

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**Figure 6 | Workplace environment management**

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4.2.4 Personal health management

The prevalence of diabetes has increased steadily over the last three decades, reflecting the increasing numbers of obese and overweight people [8]. In efforts to reverse such trends, however, it is possible for individuals to be directly involved in their own personal health management. By monitoring various data points collected through smart monitoring devices and then analyzing the data using AI, suggestions for a healthy lifestyle can be generated, for example, recommendations concerning a healthy diet, reminders to engage in regular exercise and suggestions regarding personalized supplement prescriptions. In the example shown in Figure 7, a person is standing in front of a mirror. The mirror automatically monitors the complexion of the person and senses his/her body temperature without the person knowing...
Use cases and possible solutions

(although they have given consent at some stage). The data is then analyzed by AI. If the AI judges that the condition of the person reflects latent infirmity or can lead to future difficulties, it can suggest increasing the dose of supplements or taking medications as a preventive measure. AI may also create more effective medicine to improve people’s personal condition.

Key technologies: biometric sensors, biometric analysis, AI

Related standardization fields: data format, health record format, contactless sensors

Industry segments: health management

Figure 7 | Health self-management

4.2.5 Frailty management

The concept of frailty relates to physical and mental infirmity, a condition which has been increasingly acknowledged and studied in recent years, particularly in the fields of medicine and aging. Such infirmity is defined as a condition in which the elderly are in a state of weakness not yet requiring nursing care due to a loss of muscle strength or activity, but from which they can return to a healthy state with appropriate intervention. Research leading to improvements in corporate performance and feedback for social development, which examines the possibility of using electromechanical measurements to understand the elderly worker’s condition with respect to safety, efficiency, motivation, job satisfaction, and well-being, and also evaluates the relationship of such factors to organizational and corporate performance, is an important element for the realization of quality of work (QoW) management.

Key technologies: AI, data analysis

Related standardization fields: safety, data format, office environment, AAL

Industry segments: workplaces in all industries, medical and health insurance
Use cases and possible solutions

**Use cases and possible solutions**

**Figure 8 | Frailty management in the era of 100-year lifespans**

- **<Labour participation>** Expanding the number of people who can work
  - Control healthcare costs
  - Healthcare advice
  - FIW
  - STEP1 Participation

- **<Continuation of employment>** Maintaining and expanding employment by the working environment
  - Work through lifetime
  - Pension restraint
  - Working-time management
  - Scheduling
  - Looking after
  - STEP2 Continuation

- **<Economic & social growth>** Drawing out the ability to work by improving job satisfaction
  - STEP3 Growth
  - Job satisfaction
  - Economic & social growth

- Field survey of physical fitness
- Want to keep working over 60s

- Establish FIW (frailty index of working)
- Evaluating by FIW
- Evaluating by FIW
- Building data sets for measurement items and analysis in IoT systems that look after workers’ health

- Existing medical health information infrastructure
  - Potential workforce of the elderly
  - Improvement of performance
  - Still active!
4.2.6 Safety and health in workplaces

As more and more machines are integrated into the mobility, healthcare and factory and logistic automation processes, a holistic approach to ensuring safe procedures for people working with machines is required. Such an approach involves considering the safety of workplaces and environments. Safety and health at work can be of crucial importance to the achievement of key elements of United Nations Sustainable Development Goal 3 (UN SDG 3): Good health and well-being. Technology is advancing at an ever-increasing rate across the world. Innovations in computing, communications, materials science and engineering are contributing to individual and collective progress. Digital technologies and their resulting applications are not limited to selected industries or sectors of the economy, but rather are far-reaching and impact all levels of society, including healthcare and general well-being. These transformations imply a needed redefinition of social, political, cultural, and economic developments, including safety, in the 21st century.

**Key technologies:** AI, data analysis, Internet of Things (IoT), information and communication technology (ICT)

**Related standardization fields:** safety, AAL, robotics

**Industry segments:** workplaces in all industries including civil engineering, farming, etc.

**References:** See [9] and [10]

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**Figure 9** | Tripartite system for safety in the future

4.2.7 Home healthcare assistance robots

An ageing population will likely increase the demand for medical and nursing staff in many countries. This demand will encounter the reality of already overloaded healthcare systems. In the case of Europe, for example, some models anticipate that by 2030 there will be a shortage of 4.1 million healthcare workers (0.6 million physicians, 2.3 million nurses and 1.3 million other healthcare professionals) [6].

One way to address this issue is through the use of robotics and automation. Service
robots are already being developed to support healthcare facilities [7]. However, the saturation of these facilities during the COVID-19 pandemic highlighted the importance of home care in the overall healthcare system. Robots for home care will constitute the next frontier in the development of this technology. Introducing robotics into the home sphere is still 10 years away, as this requires overcoming challenges such as navigating changing spaces or dealing with unskilled users [8]. However, research is already being conducted to address these challenges [9], and the use of service robots for home care assistance is expected to be a reality in the future.

**Key technologies:** robotics, cybersecurity, telecommunication, navigation systems, AI

**Related standardization fields:** usability / interfaces, data ownership, privacy

**Industry segments:** health equipment, wellness

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**Figure 10 | Patients and staff interacting with a service robot in a rehabilitation clinic in Switzerland [16]**

### 4.2.8 Telemedicine

Telemedicine can be defined as the use of ICT to provide patient access to care and medical information [11]. The COVID-19 pandemic has driven an exponential growth of telemedicine. Prior to the pandemic, the adoption rates for this service in the US were 0.15% for family medicine and 0.1% of Medicare primary care visits, even though telemedicine services have been in place since 1964. However, since the onset of the COVID-19 pandemic, the adoption barriers for telemedicine seem to have become irrelevant. For example, between 2 March and 14 April 2020, virtual urgent care visits at NYU Langone Health grew by 683%, and non-urgent virtual care visits grew by an unprecedented 4345% [12].

Telemedicine is expected to form a key component in the future of healthcare. 76% of consumers in a survey related to this topic indicated they are
highly or moderately likely to use telehealth going forward, compared to 11% before COVID-19 [12]. This trend positions telemedicine as a prominent technology for the future of healthcare in all spheres.

Technologies that enhance the telemedicine experience for patients and practitioners will likely thrive in the next 10 years. Immersive technologies for care delivery, such as virtual reality (VR) and augmented reality (AR), which are already being used in hospitals to help patients deal with pre-procedural anxiety [13] or for rehabilitation treatment [14], will probably be adopted in the home sphere.

Automated digital scribes, which are intelligent documentation support systems that leverage speech recognition, natural language processing (NLP), AI and ML to automate documentation of the spoken aspects of a clinical encounter, will likely be incorporated into telemedicine sessions. This technology will reduce the burden of clinical documentation for health practitioners and by 2030 will probably include AI-enabled clinical decision support capabilities (e.g. prompting clinicians to seek further information, suggesting potential provisional diagnoses, recommending the ordering of a specific test) [15].

**Key technologies:** cyber security, computer systems, telecommunication

**Related standardization fields:** data format, medical record format, usability/interfaces, data ownership, privacy

**Industry segments:** health management

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Figure 11 | Telemedicine is providing patients access to care and medical information

4.2.9 Digital imaging AI / AI doctors

By using data and AI to transform pathology, radiology and imaging services, hospitals can deliver the earliest possible diagnosis to patients along with precisely targeted new treatments. This provides the best opportunities for curing medical conditions at the earliest stage possible, using the most appropriate available treatment for each individual circumstance, leading to better outcomes, improved patient experiences and a more efficient and effective healthcare system.
An example of such technology is the use of a ML algorithm to analyze clinical images in relation to the presence of cancer in a patient. In some specific investigations, around half of the images show no sign of any problems and the remainder need to be investigated further. Manual analysis of these images takes up a significant amount of a doctor’s time that could be spent providing more effective care elsewhere. As a result, some hospital services are starting to use AI as a way to identify which patients may need the most urgent attention, thereby allowing clinical resources to be focussed towards the most critical cases.

**Key technologies:** AI, ML, data, imaging, magnetic resonance imaging (MRI)

**Related standardization fields:** data format, image format

**Industry segments:** health informatics, health organization management, hospitals, data management, medical electrical equipment

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4.2.10 Microrobots / nanorobot swarms

The miniaturization of robots can allow intervention and treatment at a local anatomic level. Nanorobots will enable surgery from within the body and tissue repair at the cell level. Diseases can be treated at the earliest possible opportunity in a minimally invasive way and without the need for dedicated facilities. Micro- and nanorobots can enable health monitoring, diagnostics, biopsies, delivery of medicines, tissue restoration and many other therapies.

**Key technologies:** robotics, navigation systems, micromechanics, AI, ML, power harvesting, nanotechnologies

**Related standardization fields:** interface with diagnostics, modularity, collaboration, hardware interoperability

**Industry segments:** health / medical equipment, health prevention, health management
4.2.11 Rehabilitation robots

The use of robots for applications in healthcare has been growing at a rate of 17.5% annually for the past four years. It is expected that by 2022, healthcare will constitute the second largest sector in the use of commercial robots.

One class of robots gaining considerable attention lately are the so-called rehabilitation robots. These devices perform “actively controlled physical interactions” with patients. Such interactions are not limited to training a patient, which is considered rehabilitation, but can also apply to assessing a patient’s condition, supporting a patient or providing compensation, or addressing other types of complaints such as pain or circulation problems, which is termed alleviation. As a result, this type of robot is called a rehabilitation, assessment, compensation and alleviation robot, or RACA robot.

As rehabilitation treatments increasingly take place at patients’ residences, RACA robots will likely enter the home sphere. However, as in the case of service robots, for this technology to be integrated in domestic environments, the challenge of dealing with unskilled users will need to be addressed.

Key technologies: robotics, cybersecurity, telecommunication, AI

Related standardization fields: usability / interfaces, data ownership, privacy

Industry segments: health equipment, wellness

References: See [17] to [20]
4.3 Summary of use cases and enabling key technologies

Based on the use cases outlined above, key technologies, related standardization fields and possible markets are identified and summarized in Table 1.

Five common key technologies are identified from the use cases, including sensing, secure communications, health informatics, AI, and robotics. For the related standardization fields, smart technologies (AI, robot), smart facilities (hospitals, workplaces, home), format (data, record), interface, and security and privacy are extracted. It is suggested that these areas should be examined closely to analyze the gaps between the current healthcare framework and expected future digital healthcare in which people will be able to live a longer healthy life through lifetime social healthcare support.

Figure 14 | RACA robots will play a key role in the future of healthcare
## Table 1 | Summary of the use cases

<table>
<thead>
<tr>
<th>Use case</th>
<th>Key technologies</th>
<th>Health informatics</th>
<th>Sensing</th>
<th>Secure communication</th>
<th>Smart medical devices (AI, robot)</th>
<th>Format interface</th>
<th>Security privacy</th>
<th>Medical equipment</th>
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Section 5

Analyses

5.1 Perceived gaps in related standardization fields and potential opportunities for IEC

For each of the related standardization fields specified in Table 1, perceived gaps are identified and listed in Table 2.

<table>
<thead>
<tr>
<th>Area / Related standardization fields</th>
<th>Related and existing standardization activities</th>
<th>Perceived gaps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensing for continuous data collection</td>
<td>IEC TC 47&lt;br&gt;ETSI TC SmartBAN&lt;br&gt;IEEE Wearables and medical IoT interoperability &amp; intelligence (WAMIII)</td>
<td>Mental sensing</td>
</tr>
<tr>
<td>Format (data, archive, record, storage)</td>
<td>ISO TC 215&lt;br&gt;ITU-T SG 16/Q28 (Multimedia framework for e-health applications)&lt;br&gt;ITU-T SG 17/Q9 (Telebiometrics)</td>
<td>Long-time reliable storage for life course data&lt;br&gt;Efficient system for decreasing healthcare costs while increasing delivery&lt;br&gt;EHRs for reporting outcomes&lt;br&gt;Open-source SW/HW for diagnostics with standards-based interoperability</td>
</tr>
<tr>
<td>Secure and high-speed data exchange with privacy protection</td>
<td>ISO TC 215/JWG 7 (application of risk management to information technology (IT) networks incorporating medical devices)&lt;br&gt;ISO 27799 (information security in health management)&lt;br&gt;ISO/IEC 20547 series (security and privacy)</td>
<td>Security of digital health technologies in the operating environment / supply chain&lt;br&gt;Managing rapid cycle of post-market iterations in digital health software</td>
</tr>
</tbody>
</table>
In response to these perceived gaps, a number of potential opportunities for IEC standardization activities may be suggested as follows.

Concerning the area of sensing for continuous data collection, it is suggested that a standardized data format may be necessary to analyze the mental status of a person. Mental health status is determined by combining several factors collected by various types of sensors, including wearable devices. It will be important for the sensors to provide data in a standard format enabling AI to analyze the data.

One of the technologies expected regarding data format is long-time reliable storage. If life course data is to be collected and retained for 100 years for every person, the storage capacity should be sufficiently large and should insure persistence and security of the data. In addition, to deliver...
a personalized healthcare service efficiently, a standardized electronic health record (EHR) and a framework for such a service system would be required. Open source software (OSS) and OSS-implemented hardware may become an option for low-cost systems.

For secure and high-speed data exchange with privacy protection, a secure means of exchanging information is indispensable, especially when such exchanges concern personal health records. Protection of privacy is another important technology that needs to be standardized, along with authentication for accessing data. A management standard for the rapid cycle of digital health software will also be important.

Since utilizing AI is required in most use cases, performance metrics for AI will be necessary to provide consistent services. To assure the quality of AI, periodical maintenance and update is essential, as are transparency and interoperability. Trust and liability issues will also need to be considered from a different perspective, since the boundaries between products and services are increasingly blurred, e.g. between overall product safety and AI-implemented product safety.

Incorporating robots into eHealth approaches would require the elaboration of safety standards for robots at home and standards to protect such devices from cyber attacks. Bringing robots into the home requires interoperability of multiple technologies and platforms for operation in an environment where other devices are already present. Human-friendly interfaces are also important in this regard.

Cooperation with other standards developing organizations may be necessary for the elaboration of these standardization activities.

5.2  Gap between the expected future society and current standardization activities, and suggestions to IEC

One of the aims of digital healthcare is to support a long, healthy and productive life for all. This implies provision of new solutions that will help people to live longer and increase their quality of life, fitness and well-being. In order to successfully deploy these solutions at scale, new markets, products and services that meet the care needs of society, throughout all life stages, will need to be created. The current barriers and challenges surrounding adoption of such solutions will also need to be addressed. Some of the required technologies already exist, some are already mature and equipped to be scaled. However, integration of these technologies is not yet mature, and further work needs to be undertaken to ensure that they are safe and secure, provide beneficial patient outcomes and furnish effective solutions that offer value for money across the healthcare system.

5.2.1 Requirements of standards

Standards have an important role to play in providing the necessary infrastructure for establishing new and innovative markets. Standards are documented ways of doing things and are agreed by groups of experts. They are written in the form of precise criteria that can be used as rules, guidelines or definitions in order to:

- underpin relationships across industry, healthcare services and consumers
- enhance efficiency, drive quality patient experiences and health outcomes, reduce risks and provide value for money in the healthcare system, and
- commercialize innovation by supporting emerging markets and the potential to do things differently
Digital healthcare is broad in scope, and several key areas exist where standardization can support its development and adoption. Several existing standardization committees already operate, covering relevant digital healthcare topics. Key standardization areas in this connection include:

- engineering, design and technical best practices to define what constitutes good digital healthcare
- technical and organizational management aspects that support the deployment of digital health in clinical services
- alternative care pathways, emerging supply chains and processes that will create economic value for new digital healthcare solutions
- data infrastructure and governance (security, sharing agreements, interoperability, ethics, and integration of platforms) so that personal data can be used for monetization and deployment of digital solutions
- adaptation of regulatory infrastructures to meet the challenges involved in applying novel technology in healthcare, together with the role of standards in supporting compliance to existing regulations in order to ensure safety, security and performance
- social aspects, including trust, acceptance, quality, competence and human factors in digitally enabled service provision

A successful standardization framework will recognize the transformation involved in the way healthcare is accessed, not only in hospitals and healthcare environments but also in homes, workplaces, leisure spaces and mobile phones.

The development of new and revised standards needs to be accompanied by approaches aimed at helping organizations access, navigate and make the best use of those standards, as well as ways to define and measure the benefits of standardization activities to ensure those benefits are realized and opportunities capitalized.

### 5.2.2 Leveraging data for standardization

Future standards must also address the complex interaction of three key factors in the evolution of healthcare:

- society, which involves the human factor, social interactions, social institutions, etc.
- technology, which involves the equipment, processes and methodologies related to healthcare and well-being, as well as the skills required to use them, and
- infrastructure, which includes the physical or cyber infrastructure used for healthcare and well-being and required for application of the technology
None of these key factors are independent of one another, but rather involve clear interfaces. Figure 15 cites several examples of these interfaces.

- In the interaction between society and infrastructure, issues such as usability, accessibility and the environment need to be addressed.
- In the interface between technology and society, issues such as usability, performance of the technology and the skills required to use it demand attention.
- In the relation between technology and infrastructure, the resources required to support the technology and the capacity of the infrastructure to provide those resources are determining elements.

These three factors are tending to converge and together will enable a comprehensive approach to healthcare and well-being. Any future healthcare framework envisaged will necessarily involve an active relationship between these three key factors. The convergence of these factors implies that even small changes in any one of the three, will be met with rapid adjustments in the other two areas. The role of standards is to keep the interactions between these factors safe and secure as these elements transform.

As digital technology evolves, these adjustments will increase in both speed and frequency. They will also become more complex, as issues affecting society, infrastructure and technology grow more interwined.
In order to provide support for the future of healthcare, it is crucial to find a way of dealing with the pace and complexity of these changes.

One way to achieve this is by retrofitting the aggregated information captured through digital healthcare into the new standards for healthcare and well-being. The use of aggregated information provides statistical accuracy and additionally will help address privacy concerns.

Support provided by AI will be required to detect and understand the changing patterns in any of the three factors and use them to shape standards.

The concept can be illustrated by reference to two use cases: the employment of robots for healthcare and wellness, and the popularization of home healthcare measures.

In the example of robots for surgery and rehabilitation, existing safety standards focus primarily on the technical aspects of robots, but as this technology increases in popularity, and the use of robots expands beyond supervised environments, standards will have to address the other two factors: infrastructure and society.

In the case of home healthcare, standards focusing solely on technologies will not be sufficient to ensure a proper implementation of those technologies, as the latter will be increasingly intertwined with humans and the infrastructure. Biometric monitoring systems, for example, will require designs that are not only safe but also easy to use by the target population. The infrastructure required to support such systems must also be addressed.

Changes in the three factors affecting the spheres of the suggested framework (see Figure 3) will occur at a faster pace and become more frequent with time. The development of new standards should effectively use the aggregated information captured through digital healthcare to keep pace with these changes.
This trend report has focused on new standardization topics identified as pivotal to the realization of digital healthcare in 2030, a society in which people will be able to live a longer healthy life enabled by lifetime social healthcare support.

Two approaches were used in the drafting of this trend report. The first is based on a time axis involving life stages and the phases associated with each stage, i.e. prevention, diagnostics, treatment, and recovery. The second approach is formulated along a spatial axis, a perspective derived from the social environment, defined by the three spheres framework of community, home, and self wellness.

Drawn from the use cases collected for each phase referenced in this trend report, perceived gaps vis-à-vis the content of current standards were identified and new items to be standardized were brought to light. In addition, it was seen that new areas of standards for digital healthcare should be developed using the aggregated information captured through “digital healthcare” to respond to frequent and rapid changes in the external environment surrounding the three spheres framework.

For the realization of digital healthcare in the future, new standardization opportunities are suggested for IEC to consider. Cooperation with other standards bodies may also be necessary, as digital healthcare spans all areas of society, with many disciplines outside the remit of IEC.

Although not addressed in this report, attention should also be paid to universal physical exercise, accessibility and ethics, as these are also considered to be important factors in digital healthcare.
Bibliography


About the IEC

The IEC, headquartered in Geneva, Switzerland, is the world’s leading publisher of international standards for electrical and electronic technologies. It is a global, independent, not-for-profit, membership organization (funded by membership fees and sales). The IEC includes 173 countries that represent 99% of world population and energy generation.

The IEC provides a worldwide, neutral and independent platform where 20 000 experts from the private and public sectors cooperate to develop state-of-the-art, globally relevant IEC International Standards. These form the basis for testing and certification, and support economic development, protecting people and the environment.

IEC work impacts around 20% of global trade (in value) and looks at aspects such as safety, interoperability, performance and other essential requirements for a vast range of technology areas, including energy, manufacturing, transportation, healthcare, homes, buildings or cities.

The IEC administers four conformity assessment systems and provides a standardized approach to the testing and certification of components, products, systems, as well as the competence of persons.

IEC work is essential for safety, quality and risk management. It helps make cities smarter, supports universal energy access and improves energy efficiency of devices and systems. It allows industry to consistently build better products, helps governments ensure long-term viability of infrastructure investments and reassures investors and insurers.

Key figures

- 172 members and affiliates
- >200 technical committees
- 20 000 experts from industry, test and research labs, government, academia and consumer groups
- 10 000 international standards published
- 4 global conformity assessment systems
- >1 million conformity assessment certificates issued
- >100 years of expertise

A global network of 173 countries that covers 99% of world population and electricity generation

Offers an affiliate country programme to encourage developing countries to get involved in the IEC free of charge

Develops international standards and runs four conformity assessment systems to verify that electronic and electrical products work safely and as they are intended to

IEC International Standards represent a global consensus of state-of-the-art know-how and expertise

A not-for-profit organization enabling global trade and universal electricity access