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Medicine of the future: How and who is going to treat us?

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ABSTRACT

Medicine's ability to quickly respond to challenges raises questions from researchers, practitioners, and society as a whole. Our task in this study was to identify key and atypical current factors influencing the development of medicine and to predict the development of medicine in the short, medium, and long term. To implement our study, we selected 22 medical experts and applied the three-level Delphi method. The current trends caused by COVID-19 have a short-term impact, but they will launch other drivers that will transform the healthcare industry. Well-being technologies, data-informed personalization, and climate change will become key drivers for the development of medicine over the period of 1–50 years. Expert opinion is divided about the future of mass availability of advanced medical treatment and sustainable development of healthcare.

1. Introduction

With increasing well-being and longer life spans in developed countries, the demand for preventive medicine that can preserve and improve health through modern technologies has become a game changer. Helping enhance individuals' experience of later life and allowing people to live independently for longer becomes more and more important as a population ages. Unlike political and sociological forecasts, which often foresee global processes of a negative and even catastrophic nature in the future, forecasts regarding science are usually replete with bright prospects. Throughout human history, medicine has been predicted to cure mankind of all diseases, leading to immortality and the appearance of new physical and psychophysiological properties in humans. These predictions have never fully come true. People continued to get sick and die, and medical science continued to develop systematically.

Our motivation for the study was twofold. Firstly, even a few years ago, researchers based their forecasts on gradual progress against cancer, cardiovascular disease, etc. (for example, Page et al., 2011; Nussinov et al., 2014) and the introduction of technologies

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in healthcare (for example, Kostkova, 2015). However, with the onset of the COVID-19 pandemic, most researchers have shifted their forecasts for the industry's development and point now to changes associated with this phenomenon. Nevertheless, already in 2022, we see that the significance of the COVID-19 pandemic is reduced for the global community, and people are returning to pre-pandemic life. We believe that such turns cannot be the basis for long-term forecasts, and consequently we decided to discover the experts' forecast in the short, medium, and long term in healthcare. Secondly, our motivation for the study was the publication of the special issue "The FutureS of Healthcare" in *Futures* (Schiavone & Ferretti, 2021). The guest editors were able to assemble ten promising articles examining the perspectives of the healthcare industry from different angles, as well as offer their fruitful conclusions. However, in the issue, several requests for further research were formed, and we would also like to cover a number of limitations.

First, the authors of the issue focus on the challenges (and possible responses) that the focal industry faces in the next decade (Boutillier et al., 2020; Ciasullo et al., 2020). The proposed solutions are made on the basis of case studies, which can suggest trends and direction of development. Authors and editors limit themselves, mentioning that the probability of realizing the forecasts is low.

Second, many authors in *Futures* refer to the COVID-19 pandemic in describing current trends, suggesting that the development of the pandemic could represent a paradigm shift in the healthcare industry (Ćwiklicki et al., 2020; Wosik et al., 2020). We do not argue for the impact of the pandemic on the transformation of society. We believe that the COVID-19 virus triggered important changes in healthcare; however, other factors may be more important and are underestimated in the current studies. The authors of the special issue talk about several specific industrial factors, but how they are formed remains unstudied.

Third, researchers study the role of technology and big companies in the healthcare market, mentioning that "health tech" is actively penetrating our lives (Aldieri et al., 2020; Schiavone & Ferretti, 2021). However, questions about the long-term impact of technology on society within the framework of healthcare and how society will adapt to new realities remain open.

We believe each of these forecasts could be a piece of a puzzle, creating a colorful picture. Every research group has its view, which sometimes crosslinks with others by bringing more evidence on some trends or going against these trends by presenting its innovative perspective on the subject. We consider it vital for the healthcare industry and society to understand where medical care is heading and its trends and development prospects. In these uncertain times, society should acknowledge and more accurately predict the capabilities and resources required for implementing new approaches to providing medical care. We believe the industry's main stakeholders, such as doctors, patients, hospitals, and policymakers, as well as additional stakeholders, such as supplier companies, insurance companies, universities, and others, will create a demand for these results.

Based on the following limitations and research gaps, we pose the following research question for our study: *What are the short-, medium-, and long-term healthcare development trends over the next 50 years?* Therefore, we set ourselves the task of analyzing existing trends in the healthcare industry, as well as predicting the development of healthcare over the period of 1–50 years. The implementation of this study was based on the involvement of 22 experts with extensive experience in the healthcare market and the use of three rounds of the Delphi method as a research method of our study.

Our article consists of the following: After the Introduction, we discuss the current state of the academic literature, followed by the key research terms. Next, in the Method section, we describe the Delphi method and our application of it. In the Results section, we analyze three key drivers (well-being, data-informed personalization, and climate change) and signals as components of these drivers. The Discussion and Contributions sections summarize our research. Several future research areas are offered after the Discussion section. The Conclusion ends the paper.

2. Literature review

At the beginning of the 19th century, the average life expectancy was as low as 40 years (Greene, 2001). In the 1950 s, this indicator was already above 60 in Europe, North America, and some other parts of the world (Brunborg, 2012). On the other hand, new health risks have emerged worldwide associated with "sedentary lifestyles" in developed countries and the fast-food industry (Lurati, 2018). One out of three American adults is obese, and 60% of Americans live with at least one chronic disease (Raghupathi & Raghupathi, 2018; Wu et al., 2018). Approximately 85% of the nation's annual healthcare costs are spent on treating chronic and mental health conditions. Moreover, in the 1960 s in the US, 50% of all work involved physical activity (Church et al., 2011). In contrast today, because of technological progress, 80% of people are engaged in "sedentary" work, as they work in offices. Nevertheless, by 2020, the life expectancy for the world had reached already 72.6 years. Mental health claims have increased globally over 100 % over the past 10 years (Gunawan et al., 2020). Nowadays, people have an opportunity to be actively interested in their health and follow up on a wide range of factors, including biological indicators and lifestyle. Scientific research and discoveries in recent decades have uncovered a link between lifestyles and the development of disease in the future. This is how the trend for healthy lifestyles and preventive medicine was born: by putting the focus maintaining health rather than curing disease (Razzak et al., 2020). Due to increased economic well-being, residents of developed countries could pay more attention to personal well-being by the late 20th century. Patients are taking the lead in managing their own health and transforming from care recipients to participants in the treatment process. People are now accustomed to medical research and technological devices such as weights and watches or even miniature electroencephalographs that help in meditation (Carissoli et al., 2015). There are over 300,000 health apps available, almost double the number in 2015 (Ming et al., 2020). This led to lower barriers of entry to the market for start-ups as well as big techs. Consumerization is opening the healthcare industry to new entrants and disruptors (Kulkov & Tsvetkova, 2021).

Moreover, medicine is moving to value-based care to control escalating costs and improve efficiency (Gray, 2017; Putera, 2017). Cardiovascular diseases, stroke, and cancer are still the most common reasons for death nowadays (Baek et al., 2021; Poulalhon et al., 2018). However, in the last decade, for example, the overall cancer death rate has continued to decline (Ozen et al., 2020). With today's breakthroughs in genetics and bioinformatics and the arrival of high-tech startups, medicine is rapidly moving from healthy

lifestyle recommendations for everyone to personalized programs based on modern and highly accurate diagnostic tests such as DNA tests, which now sell for a couple of hundred dollars (Denicolai & Previtali, 2020).

In addition, the pandemic has accelerated the development of technology in the field of medicine and brought attention to trends that were not so noticeable before (Jung et al., 2021; Kulkov et al., 2021). Robots learn to disinfect spaces, take care of patients, and deliver packages; algorithms can now track breathing and the severity of a cough; and artificial intelligence (AI) can predict the spread of a virus to manage the flow of people in public places (Kalisz et al., 2021).

Based on this literature review, we would like to take a closer look and present in a nutshell a few obvious trends, such as personalized medicine, fighting with stress, biohacking, medical tourism, and collaboration between man and machine. In our opinion, this trends overview will provide a reader with deeper understanding of today's healthcare customer portrait and shed the light on technological progress. The description of current healthcare trends does not include identifying all the key factors. However, we present new and atypical trends that quickly become fashionable and are put into practice. Based on the collected information, we form a hypothesis that the personalization and technologization of healthcare will become key trends in the development of healthcare in the short, medium, and long term.

2.1. Personalized medicine

For people who closely monitor their health, general recommendations from a trainer, therapist and nutritionist are no longer enough. Modern diets are developed for the individual customer and take into account dozens of body parameters, including genetic predisposition to certain diseases, body mass index, and food and drug intolerance. Having handed over the gene material for decoding once, a person continues to receive news about health and recommendations in accordance with scientific discoveries in applied genetics.

Similarly, in sports medicine, the genome contains information about one's predisposition to different types of physical activity (Bragazzi & Khoramipour, 2020, pp. 2020). Thus, the most suitable sport and effective types of exercise can be selected. DNA analyses identify a person's predisposition to diseases and drug tolerance and therefore can enable individual recommendations for treatment and prevention to each patient (Denicolai & Previtali, 2020).

2.2. Fighting with stress

Urbanization, working in huge open offices, and digital information noise are sources of chronic stress that can be dangerous for both mental and physiological long-term health, e.g., associated with cardio complications and migraines (Murray et al., 2019). To cope with stress, people are more likely to resort to traditional relaxation practices such as yoga and meditation. In the wake of mobile meditation apps and yoga rooms in offices, new technology solutions are emerging. For example, an app that measures stress based on heart rate variability can help to identify stressful situations and activities and draw appropriate conclusions for example, by passing the necessary data to the attending physician or offering to make an appointment with a specialist. Likewise, the electroencephalographic hoop—which assists in meditation—records brain activity and helps the user learn how to calm down (Li et al., 2019; Vasiljevic & de Miranda, 2020).

Sudden changes in habitual lifestyle, self-isolation, and fear for the health of loved ones and their future have emerged as additional reasons for stress in recent times. About 80% of workers say that their level of stress and uncertainty is now higher than ever (Verma & Mishra, 2020). Even more report that stress is one of the key reasons for the deterioration of sleep, interactions with relatives, and relationships with other people (Gobbi et al., 2020).

2.3. Biohacking

This extreme form of health concern has gained popularity among tech company employees trying to "hack" the limitations of the human body in the same way that computer programs are hacked (Meyer & Vergnaud, 2020; Yetisen, 2018). The followers of this subculture implant miniature devices under the skin in order to measure the body's indicators more accurately or even to get "superhuman" abilities such as night vision or synesthesia. They starve or eat special food and take medications and supplements, which, according to the biohackers themselves, will help to improve memory, concentration, libido, and fitness, as well as delay aging.

2.4. Medical tourism

The value of the global medical tourism market is expected to reach USD 207.9 billion by 2027, expanding at a compound annual growth rate of 21.1% (Chhabra et al., 2021). Some go abroad for a second opinion and high-tech medical care, which is not available in all countries. Others travel for experimental technologies that are not recognized or allowed everywhere (Manna et al., 2020).

Vaccine tourism appeared in December 2020 when reports emerged of Indian tour operators who signed deals to transport travelers to countries where they could secure a COVID-19 vaccination (Kaewkitipong et al., 2021). Customers would pay as much as USD 1777 per person to visit a health center abroad for a Pfizer-BioNTech vaccination (Su et al., 2021). The fee also covered mandatory isolation for a specific period and a tour around the city before the guest returned home.

2.5. Collaboration between man and machine

AI is another trend that is fundamentally changing modern healthcare. According to recent research, 70% of healthcare organizations in Europe and the US are adopting or already deployed AI to automate their work (He et al., 2019; Wahl et al., 2018).

The importance of human-machine collaboration has been debated for a long time, but its absolute requirement for the successful development of humanity has been best demonstrated by the pandemic (Bragazzi et al., 2020; Dananjayan & Raj, 2020). During outbreaks of the coronavirus, AI helped to find the primary signs of the disease, kept electronic medical records, answered questions from patients, and thereby accelerated, improved, and reduced the cost of clinic services. A typical example of such technology is a service from Partners HealthCare, which helps physicians in the initial triage of patients. It is not the physician who communicates with the patient, but AI (Lai et al., 2020). It is AI who determines whether there is a risk of infection and, due to the speed of data processing, greatly relieves the clinic's hotline.

In this section we also provide key definitions used in our research. The concept of *medicine* includes actions taken by physicians, nurses, and other medical personnel directly in hospitals, laboratories, medical centers, and so on. In turn, *healthcare* is a comprehensive concept that includes genetics, nutrition, and circumstances of birth and life. It also includes additional stakeholders, such as insurance companies, businesses, and others (Abbod et al., 2001; Ristevski & Chen, 2018). Medical actions make up about 10–20% of the entire healthcare industry. In addition, we want to provide clarification regarding drivers and signals, concepts that we will use later in this study. There is the concept of "megatrends''—these are large social, economic, and technological forces that will shape the direction of development of society as a whole in the next 10–15 years: for example, global economic power, demographic change, rapid urbanization, and the rise of technology (King et al., 2017; PricewaterhouseCoopers, 2016). Megatrends, for example, include urbanization, demographic change, and shifting economic power. In our work, we do not set ourselves the task of identifying and predicting megatrends; we concentrate more on those trends (drivers and signals) that will be characteristic of healthcare in the future. However, megatrends are the basis for our study. Thus, "drivers" are events that shape change and influence or shape the future in a particular area—in our case, healthcare. In turn, "signals" are the key forces that form drivers and are more applied in nature (Saritas & Smith, 2011).

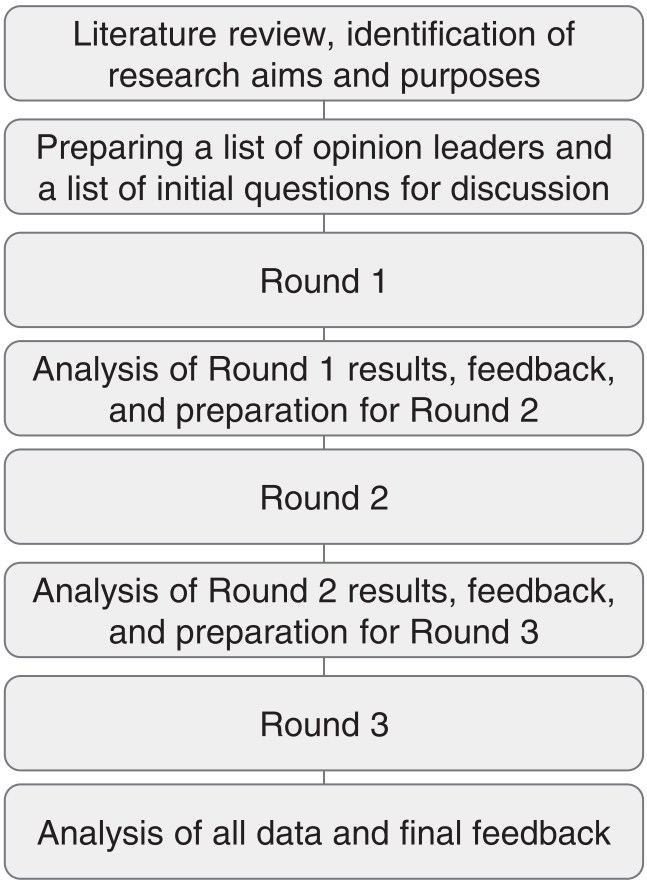

Fig. 1. The main stages of data collection and analysis for the study.

3. Method

As the main research approach for our study, we chose the well-established and proven Delphi method. Despite the fact that the Delphi method is often criticized by researchers, this approach is an effective way to collect data from experts in a particular field (Ribeiro & Quintanilla, 2015; Toppinen et al., 2017). The Delphi method is best suited for research if the issue under study is multifaceted and future understanding depends on the actions taken by the interviewed research participants, their level of training, and the ethical component (Nygren et al., 2017). The Delphi Method is based on the assumption that a group of experts in the field are able to form a forecast for the development of the field through discussion and exchange of opinions. The consensus approach in forecasting has more basis and credibility than individual opinions (Varho & Huutoniemi, 2014). Typically, the Delphi method is carried out in two or more rounds and feedback is provided to the experts after each round. The number of experts may vary from a few to several dozen; however, the most significant parameters of representatives are expertise and the ability to contribute to the studied area (Blind et al., 2001). The key parameters for the success of the Delphi method are iteration, anonymity in providing answers to surveys, and feedback provided under the control of the organizers. It is also worth noting that despite the many variants of the Delphi method, it is always important in the process of collecting information to identify different opinions and supporting arguments (Toppinen et al., 2017).

Selecting and engaging panelists is one of the most difficult parts of the method. In a small sample, it is especially important to prepare for the participation of key experts in the field in order to obtain conclusions that are not subject to doubt and challenge (Nygren et al., 2017). However, most often, the issue remains with the identification and involvement of experts who may be busy and not interested in principle in cooperation. One solution could be the Snowball sampling technique, which allows a sample to be formed based on a core group of experts who participate in recommendations and recruitment of new participants based on recognition of their achievements (Toppinen et al., 2017). A limitation of this technique is that the experts involved may agree with the main group, which will affect the results. It is necessary not to be limited to a specific area of expertise among experts, gender, region, and so on. A good way to select candidates for the role of experts can be participation in a conference, membership in a professional association.

3.1. Data collection

The key objectives of our study were: (a) to confirm and update main current trends in medicine; (b) to identify the main drivers for the future development of medicine; and (c) to predict the development of medicine in the short, medium, and long term. In general, the study based on the Delphi method took place from December 2021 to April 2022, and the key stages are displayed in Fig. 1.

The use of multiple rounds in our study aimed to raise and discuss all possible topics related to the research area. To do so, we targeted respondents with open-ended questions in order to motivate them to discuss the proposed topics. The Delphi rounds proceeded as follows:

1. Experts received a list of topics and questions to answer.
2. Experts prepared audio or video responses to the questions and sent them to the research group.
3. The research group used the resulting material for direct analysis using the NVivo 12 software or pre-transcribed it verbatim.
4. Anonymized and grouped analysis results were sent as feedback to the experts.

The 22 experts collected for the Round 1 study represented a total of seven European countries and conditionally can be divided into the following groups: (a) physicians, members of the largest European medical associations in their field (nine experts); (b) representatives of academia (seven experts); and (c) other industry representatives, such as policymakers and business (six experts). The background of the participants in the first and second groups partially overlapped, and the respondents independently determined their status. Most of the experts had previously taken part in the research projects of the group, while some experts agreed to participate based on referrals. The versatility among the experts was based on the desire for a comprehensive approach to the research topic. Rounds 1, 2, and 3 involved 22, 20, and 19 experts, respectively. In the first round of our Delphi method, we collected 22 experts. However, during the next rounds, some participants could not continue for reasons beyond the authors' control. Waiting for responses from all 22 experts (rather than 20 in the second and 19 in the third) would have led to a significant delay in the study and difficulty analyzing the obtained data. We decided to continue the study with a slight reduction in the number of participants. We argue that the dropout of some experts from our sample did not affect the results. The gender balance was maintained in the proportion of ten women and twelve men. All participants in the study have at least nine years of industry experience, and 14 of them have a PhD (13 in medicine).

3.2. Data analysis

Video, audio, and text responses were coded by the group's researchers independently and in parallel to reduce the likelihood of bias. The structuring of the received data, the preparation of feedback, and the formation of questions for the next round were carried out by all members of the research group during weekly meetings. The experts' answers formed the basis for subsequent rounds of questions. During Round 1, the main task was to identify opinions on current situations in the industry and outline the main signals and drivers that will shape the healthcare of the future. Rounds 2 and 3 are devoted to an in-depth study of the signals and drivers of the focal industry, which aroused the greatest interest from the respondents and required additional study. Anonymous and grouped feedback was provided after each round.

Topics for Round 1 were based on a secondary data analysis. Moreover, experts were asked to outline the main signals and drivers of the focal industry. Rounds 2 and 3 were based on previous expert responses and aimed at summarizing the opinions they received. The main outcomes of Rounds 2 and 3 were the formation of the industry development scenario in the short, mid, and long-term.

4. Results

Over the course of the study, we have identified three key global drivers, each consisting of several signals that affect the healthcare industry now and that will continue into the future (see Fig. 2). Additional drivers, according to experts, either were not global or were expected to make a smaller contribution in the future. Next, we describe the key drivers and signals. Each signal subsection consists of brief information about it, key quotes from our experts that support results, and practical examples specific to the healthcare industry.

4.1. Driver 1. Well-being

In modern society, well-being is defined as a combination of prosperity and activity, satisfaction with life, happiness, and the opportunity to develop one's potential (Huppert, 2009). People with a high level of well-being increase their efficiency and creativity, their social interactions improve, and their longevity and health benefit (Ruggeri et al., 2020). From a medical point of view, a high level of well-being is characterized by care about yourself when and where you need it; the right care for the right person; and access to emphatic and respectful care (Adler & Rehkopf, 2008). In fact, according to recent studies, mental well-being was the most important indicator of health and well-being for most of the respondents and ranked as even more important than absence of disease (Huppert, 2009).

4.1.1. Signal 1. Value-based healthcare

Value-based healthcare is based on a model in which hospitals receive funding based on patient health outcomes (Gray, 2017). Such relationships involve helping to improve health, reduce chronic disease outcomes, and increase satisfaction with a healthy life. The key difference between this approach and the existing one is the value that patients receive rather than the costs incurred by medical institutions (Putera, 2017). See some comments from our experts:

> *Value-based healthcare focuses not on the [treatment] process, but on patient outcomes, while using resources more efficiently. Just spending money on treatment is no longer interesting.*
>
> *Digitalization organically fits into [value-based healthcare], increases the demand for an individual approach, allows close interaction with caregivers, [and supports] decision-making. Digitalization of everything in medicine is an [industry] trend.*
>
> *Advanced vendors will be interested in the new way of working. New companies could appear. They will receive bonuses for achieving the required results.*

Recently, Apple launched a new healthcare service called AC Wellness, which is intended for employees and family members. Interestingly, AC Wellness created a position for a "physician designer" of health programs whose main task, apart from tracking chronic diseases, will be improving patients' long-term health by prevention and early detection of ailments. It seems that Apple is trying to provide its employees with first-class medical care that is predictive rather than spending money on treating already-sick employees. Speaking earlier at the annual meeting of shareholders, Apple CEO Tim Cook said that the company has the potential to make a significant contribution to healthcare. It would seem the line is blurred between medicine and manufacturing tech products. However, it is a definite signal of change.

Recently, Amazon, J.P. Morgan, and Berkshire Hathaway joined forces towards developing novel medical technologies and an independent nonprofit organization that will focus on innovation and improvement in the US healthcare system. It is expected that this nonprofit will serve more than 1 million employees but might also serve as a model for future healthcare.

4.1.2. Signal 2. Smart delivery of biologically active substances

Smart delivery of drugs and active substances is a therapeutic approach that is evolving into a full-fledged model of drug delivery directly to specific organs at specific times and doses. Specialized and targeted drug delivery systems keep steady concentrations of

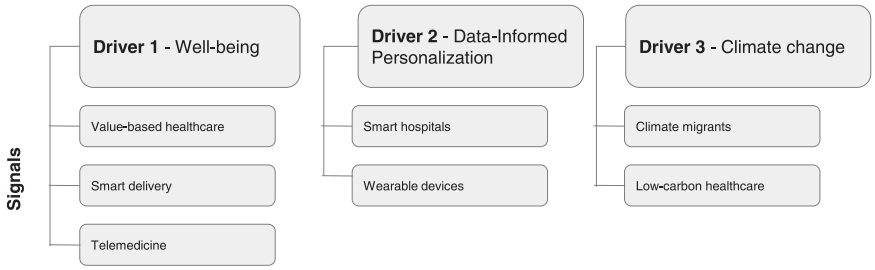

Fig. 2. Key drivers and signals that have and will have an impact on the healthcare industry.

drugs in the body to avoid the need for recurrent doses. Furthermore, this system helps to reduce the likelihood of side effects from the medication. The following citations from our experts highlight the prospects of smart delivery for the future of healthcare:

> *Frequently, existing treatment modalities have systemic effects and robust side effects. … The focus of new solutions and personalization can save many lives. … There is a need for more targeted treatment.*

> *[Smart delivery of biologically active substances] has a potential to be widely used in clinical medicine, for example, targeted cancer treatment.*

A transdermal patch introduced by American start-up Right Sciences delivers herbal-based medications through the skin. This technology allows a patient-specific solution based on individual needs. It is intended for various clinical indications including insomnia, migraine, post-traumatic stress disorder, and depression.

4.1.3. Signal 3. Telemedicine

Telemedicine comprises remote technologies for helping patients in real time. It includes such elements as virtual consultations with physicians, remote diagnostics, distant access to patient records, and more. Telemedicine ties the patient experience together, spanning the whole chain from primary diagnosis to treatment and follow-up care. Remote treatment provides the same level of personalization as conventional treatment and can even enable more effective treatments and follow-up for complex and chronic diseases such as cancer. The majority of experts mentioned telemedicine in their answers. Here are several citations related to it:

> *Telemedicine has taken a giant leap during the COVID-19 pandemic.*

> *In most of the cases, telemedicine allows solving medical problems without many associated costs, [on the] patient, doctor, and clinic side.*

> *In the era of the post-industrial world, telemedicine will move the delivery of medical care from the clinic to the patient's home.*

American healthcare companies Teladoc Health and Livongo merged in October 2020. The new company focused on developing a telemedicine platform for managing chronic disease. The platform, which processes a large amount of data and uses AI algorithms, will include a patient's complete virtual medical path. In August 2020, Google Cloud and Amwell joined forces, sharing data analysis and expertise in telemedicine, with the goal to launch a convenient, remote patient-oriented healthcare platform.

4.2. Driver 2. Data-informed personalization

Data-informed personalization refers to the concept of delivering the right product to the right place at the right time (Waller et al., 2018). This type of medicine utilizes a patient's personal data to prevent, diagnose, or treat disease.

4.2.1. Signal 1. Smart hospitals

Smartphones and tablets are already widely used in American hospitals to allow patients to easily access their own medical history and prescriptions and even chat with specialists. Using Big Data, integrating IT systems within the clinic, analyzing information about patients for more accurate diagnosis and treatment using cloud storage and machine-learning algorithms—all this is becoming a reality. Smart hospitals prompted in-depth discussion from our panelists, and we provide several quotes related to this topic:

> *The key factors in the development of smart hospitals are: (1) an urgent need to improve the quality of medical services; (2) outsourcing of many medical services, for example, vaccination, laboratory services,* etc.*; (3) greater involvement of the patient in treatment, more patient-centric care; (4) creating more value at a reasonable cost.*

> *A smart hospital is a kind of digital ecosystem, which includes all stakeholders and is based on IT infrastructure. The roles of well-known stakeholders may change and atypical stakeholders may appear. A trend based on new technologies has begun, it cannot be stopped, it must be led.*

> *A smart hospital is not just the digitalization of medical procedures, it is the reform of traditional and the construction of new business processes, healthcare management systems, for the formation of the value of which, perhaps, did not even exist before.*

The Mayo Clinic is a nonprofit American academic medical center focused on integrated healthcare, education, and research. It employs over 4500 physicians and scientists, along with another 58,400 administrative and allied health staff. Revenue of the organization was 12.6 billion USD in 2018. Mayo Clinic uses Big Data and provides bedside analytics in real time for each patient. This allows saving up to five minutes on information analysis, effectively uses the competencies of physicians, increases the validity of decisions, and also reduces costs. The system aggregates a huge amount of data, then processes it and provides physicians with the most relevant information.

4.2.2. Signal 2. Wearable devices

Wearable devices represent a noninvasive way of aggregating and analyzing personal physiological patient data. Wearable devices are typically used to improve patients' well-being in cardiology, neurology, and diabetes. However, the potential for their application is much broader and extends to other systems and diseases; see opinions from the experts:

Watches and bracelets will soon be forgotten. For permanent use, you can apply a sensor or a film on things that are familiar to you, for example, contact lenses. Personalization of devices is the next factor. Transmitter customized earrings would be a natural choice.

I think that devices will become less and less visible, but will grow in number. Next comes the process of combining all possible sensors and transmitters into a single wearable device. Of course, all existing technologies such as AI, high-speed data transfer, and so on will be connected. A logical assumption would be the implantation of such a device under the skin. The speed of this process is difficult to predict.

As an example, TracPatch is the innovative solution for health monitoring during the rehabilitation period after orthopedic surgery. TracPatch collects and analyzes data related to general physiology of motion and also to local indicators such as temperature at the operated site. Data are continuously recorded to a cloud platform that allows physicians to track progress and intervene as needed but also accessible for patient attention via app.

The Biobeat sensor uses machine learning to analyze thirteen key health indicators, including respiratory rate and heart rate, which are specifically important for cardiac patients. The Biobeat is available for both professional and home use.

4.3. Driver 3. Climate change

In many cases, the effects that climate change and associated extreme weather events are having on patients are severe. These effects will be even more prominent in the future as global warming progresses. In our experts' view, it is already a strong driver of future change in healthcare. It concerns more than natural disasters. For example, in urban areas, extreme heat accompanied by dense and busy living surroundings and infrastructure combine to impact on stagnant air and ineffective cooling. People with limited mobility, chronic respiratory diseases, and cardiovascular disease are at increased risk.

4.3.1. Signal 1. Climate migrants

Climate migrants are people who are forced to leave their regions due to long-term climate change. Such changes may include drought, rising water levels, significant changes in seasonal natural phenomena, and others. Climate migrants may change their place of residence either within the country or abroad. According to current estimates, the number of climate migrants is estimated at 1% of the world's population, while by 2070 the proportion will increase to 19% (Xu et al., 2020). It may assume that the term refers more to dry regions or countries that are heavily dependent on even a slight rise in sea level; see the opinions of our experts:

Few associate climate change with a change in approach to health care. However, it could, for example, be millions of migrants in one year. The consequences of human activity on the planet are affecting [it] now and will intensify in the future. This will be a global challenge for humanity.

An increase in temperature is not only the displacement of tens and hundreds of thousands of people to new countries. The result of this will be an increase in respiratory and cardiovascular diseases, the spread of diseases atypical for these places, psychological problems, etc. *This is a very long-term trend with hard-to-predict consequences.*

Climate change has also become noticeable in the US in 2020. Serious forest fires in the West caused significant material damage and the death of several thousand people. Wildfires were caused by a decrease in rainfall and an increase in heat and dryness in forests, partly due to human activities. Hospitals in California have seen a wave of calls from patients complaining of respiratory problems, nausea, headaches, and fire anxiety. The medical staff received additional training in helping victims of burns and heat injuries. Thousands of people were forced to temporarily relocate, and tens of thousands remained isolated at home to reduce the negative impacts of smoke and harmful particles from fires.

4.3.2. Signal 2. Low-carbon healthcare

Sustainable approaches in healthcare and alignment with global climate goals present a challenge but at the same time provide an opportunity for innovations in design and operations. They will improve the quality of healthcare in a diversity of settings, as was noted in the answers of experts:

Usually, a lifestyle with a high CO2 emission is detrimental to health. [However,] in modern society there is a steady trend towards a decrease in "diseases of affluence."

On the one hand, it is possible to reduce emissions through vegetarianism, joint consumption, and other things. All of these actions affect, in one way or another, the consumption of society and, as a result, emissions and investments in health care. On the other hand, innovation and business have an important role to play. Faster time to market for new products, testing them online instead of in humans, self-diagnosis, [and] AI-assisted disease prediction will change our lives, our habits, and routines that form the emission footprint.

Healthcare is not the top-priority industry that comes to mind when we talk about emissions. However, according to the NHS Sustainable Development Unit Report, the NHS in England alone produces about 20 million tons of carbon dioxide annually. For example, just one year of kidney dialysis is equivalent to several transatlantic flights in terms of carbon emissions (Yu et al., 2021). Despite the constant pressure on the industry to reduce emissions, this process is not going as fast as we would like; however, it can be a promising area for business.

4.4. Forecast

We challenged our experts to propose time frames for forecasts and form their opinions by category (e.g., regions, developing/developed countries, population, etc.). However, after all the rounds, the experts came to an almost unanimous decision: The forecast is global and does not single out any categories. The main prerequisites were the following factors. First, despite the dynamism of medicine and numerous innovations, regulatory features equalize all suppliers' requirements and equally distance them from the market. Currently, all new products in US and EU go through only two channels—FDA approval and CE mark registration—taking tremendous time and resources. Technological progress is occurring in all countries and industries, and new materials and technologies are emerging. In medicine, however, all this happens with a delay associated with certification, production, and so on. Second, developing countries have brought their national standards and regulatory requirements to European and American patterns over the past five to ten years. Like most other analytics, our forecasts are just assumptions based on today's innovations that have entered or are entering the market and on regulations, technology development, and customer needs. However, the experts proposed and agreed on a gradation: short-term trends (1–2 years [immediate changes] and 2–5), short-term forecasts (5−10), and long-term forecasts (10–30 and 30–50).

4.4.1. 1–2 years

COVID-19 being a wild card triggered the rapid deployment of new well-being technologies and showed that products and services can no longer be static. In real time, the world tested products that were developed in parallel with the way they were used. Experts have already called this state "eternal beta" and noted how easily people were willing to trust unfinished services and technologies. For example, the Australian government launched a newly developed application to track the spread of the COVID-19 virus. It was installed by two million citizens per day. They were ready to trust a product that no one had ever used and believed that Big Data would help physicians stop the virus. This is an instance of a new trend emerging and a habit that will spread to the post-COVID world; as well, consumers will learn that their experience influences product development. Healthcare organizations will develop technology-based products and services to continuously expand their functionality. Virtual testing of products and services will provide insight into adding value to technology and reducing the risk of product deployments in critical healthcare areas. The pandemic has motivated people to collect even more data about their health conditions.

Sales of wearable smart electronics will continue to show incredible growth. Professional wearable smart devices will be accepted and adopted to routine clinical practice in the majority of hospitals. One obstacle will be making effective data transfer seamless. Inaccuracy or inaccessibility in signal transmission can cause confusion in the collection and processing of data. Global sales of wearable smart electronics in 2020 reached $61.4 billion, representing an increase of 13.4% over 2019 (Allam, 2020). Global sales of wearable smart electronics are projected to reach $186.9 billion in 2030, representing a compound annual growth rate of 11.3% over the 2020–2030 period (Allam, 2020). This growth can be attributed to the increasing popularity of wearable devices, advancements in artificial intelligence, and the proliferation of 5 G technology.

4.4.2. 2–5 years

The COVID-19 pandemic could not slow down the technological revolution but, on the contrary, stimulated it, showing that innovation is necessary for any industry. Privatized healthcare systems will gradually take a lead. Therefore, the innovative and unique DNA of each healthcare company will directly influence the development of healthcare as a whole. A provider's DNA will definitely include digital technologies, quantum computing and disruptive scientific advances, blockchain technologies, and distributed ledgers. We foresee that healthcare companies will unite their unique DNA with their core competencies. To develop and implement innovations, healthcare organizations need an infrastructure. To become a leader by 2027, healthcare organizations will need to organize a comfortable and transparent ecosystem for working in the digital world. Robots will be used more and more frequently, which will dramatically change the way patient care works. Healthcare organizations of the future will face new challenges in investing in talent and programming and integrating robots.

Moreover, consequences of climate change may affect various areas differently depending on geographical zone. Some zones will be more inhabited than others. Therefore, there will be a need for constant local monitoring of potential impacts of climate change and regular updates on measures to prevent disruption of supply chains and infrastructure and socioeconomic disasters. All these factors directly influence healthcare providers.

4.4.3. 5–10 years

So far, healthcare is missing the opportunity to combine and analyze all patients' personal data in order to develop predictive medicine. However, continuously increasing knowledge about the human genome should lead, most probably within the decade, to the creation of personalized medicine based on an individual's unique features and tendencies to one pathology or another. In this scenario, a physician will be a predictor of each patient's future fate, based on the expression of certain genes responsible, for example, for cardiovascular or oncological pathology. Experts predict that in 5–10 years, the attention of millions of users will be focused on services that may predict when, where, and which healthcare services a patient will need. Further personalization of drugs will allow targeting very specific areas of the human body, which will drastically reduce side effects and complications. Currently, first attempts in personalized drug delivery using nanoparticles for micro-dosed treatment have commenced.

The growing share of expensive and highly effective methods of personalized treatment and prevention of serious illnesses will contribute to social stratification of society. High-tech healthcare will be medicine for wealthy people, while the quality of care for other socioeconomic groups will in contrast decline. This may also lead to protests and political events.

4.4.4. 10–30 years

It has been scientifically proven that the health of Black people is influenced by persistent racism among healthcare personnel (Krieger et al., 2005; Silva et al., 2020). Research also shows that neighborhoods with 60 or more Black residents have less access to socially significant infrastructural objects such as, for example, supermarkets and healthcare centers (Bower et al., 2014). All this creates racial segregation and inequality. It has been shown that during the COVID-19 pandemic, Black people and other ethnic minorities suffered from inappropriate and delayed healthcare as well as from discrimination (Millett et al., 2020). Moreover, racial and ethnic minorities are seldom involved in translational research efforts in personalized medicine. Based on these facts, experts foresee that within 10–15 years technological advances may be less effective in meeting the needs of these groups of patients. Moreover, the World Health Organization estimates that global climate change may kill around 250,000 people annually by 2030 (Rom & Pinkerton, 2021). Climate change will lead to increased risk of disease, hunger, and violence. Obviously, the poorest members of society will be more prone to bearing the impact of climate change.

However, we think this trend will gradually be dismissed within the upcoming 20–30 years. We believe that healthcare companies developing IT based solutions jointly with governmental support will include more participants of low socioeconomic status and from racial and ethnic minority groups. More effective wearable monitoring technologies for these categories of patients will enter the market, allowing a predictive type of healthcare. Moreover, it is also due to the fact that "an ounce of prevention is worth a pound of cure".

4.4.5. 30–50 years

Novel, innovative, and highly effective treatment modalities for socially dangerous infections such as HIV and hepatitis C will undoubtedly be found, see signals from Well-being and Data-informed personalization drivers. Nevertheless, antibiotic resistance will evolve at the same time with improvement of antibiotic therapy. The problem of cancer will remain relevant for at least 50–80 years until the underlying mechanisms of carcinogenesis will not be completely discovered. Early diagnostics, using updated lines of tumor markers and IT monitoring technologies, and mass prevention will form a strategic basis for mastering oncological diseases. Nevertheless, the research on cancer vaccines seems fascinating. Technological progress and the increased pace of life will inevitably lead to increases in depression, obsessive-compulsive disorder, and schizophrenia-like psychoses and will require the introduction of new psychotherapeutic modalities. The person of the future will be prescribed drugs to correct mood in the same way as modern vitamin supplements. Along with the development of preventive medicine, scientists will continue to look for a "magic pill," such as CRISPR/Cas technology to keep us forever young.

We also hope that a paradigm shift will happen and that high-quality healthcare services will no longer be available only to those who are able to pay for them but to all who are in need.

4.5. Discussion and theoretical contribution

We assess the healthcare industry from a strategic perspective and predict the short-, medium, and long-term development scenarios. Previous research in this area has offered blurry forecasts (Schiavone & Ferretti, 2021), focused on short-term forecasting (Boutillier et al., 2020; Ciasullo et al., 2020) or considered IT as transformation's main driver (Aldieri et al., 2020; Wosik et al., 2020).

We examined the current state of medicine from an integrated industrial approach and identified value creation through 2070 using the three-round Delphi method (Toppinen et al., 2017). According to our experts, the current factors that significantly affect health care, such as the COVID-19 pandemic and the stress associated with it, may cease to impact the industry and society in the near future (Gunawan et al., 2020; Wosik et al., 2020). Conversely, these factors have already become a trigger mechanism that has launched new long-term trends. According to experts, other current trends, such as medical tourism, may cease their mass existence and move into the category of niche services (Kaewkitipong et al., 2021). Massive short-term bursts of interest in such services can be initiated by sudden incidents that are difficult to predict.

Most of the panelists agreed with the patient-oriented approach as the healthcare industry's main trend going forward (Ciasullo, Lim et al., 2022; Epstein & Street, 2011; Håkansson Eklund et al., 2019). This approach not only implies a change in providing medical services but affects the business logic inherent in the industry. Change involves moving away from accepted norms and procedures in favor of innovating and processing previously unused resources to create and deliver value. The challenge for the industry is to adapt the infrastructure and legislation to accelerate adopting innovative practices other industries already use. One trigger was the COVID-19 pandemic, which accelerated the introduction of, for example, telemedicine or clinical trials based on IT solutions (Wosik et al., 2020). A new approach to creating value through new healthcare products and services involves rethinking the stakeholders' interactions; change management, including among conservative stakeholders; deep technical expertise; and trust. However, almost all experts argue that such changes and a patient-oriented approach will be applied, and the rate of transition to new healthcare practices will accelerate.

Growth in diagnosing disease early caused almost no controversy among experts. Using new methods based primarily on AI for diagnosing, assessing the condition, and prioritizing a meeting with a physician or hospitalization is already gaining momentum (Dananjayan & Raj, 2020; He et al., 2019; Kulkov, 2021). Advanced countries can reduce the need for narrow specialists through decision support systems based on transitioning to the even more technological industry (Ciasullo & Orciuoli, 2022). Developing countries can skip some of the massive investments in healthcare infrastructure and training. Investments in constructing hospitals and training centers may be reconsidered due to the ample supply of telemedicine services and home treatment.

Experts agree with the number of personalized medicine studies and appreciate its popularization chances (Bragazzi & Khoramipour, 2020; pp, 2020; Denicolai & Previtali, 2020; pp, 2020). Deep methods of data collection and analysis will provide the mass

character of personalized medicine; introducing intelligent methods for processing Big Data will accelerate this process. Mass personalization of medicine will contribute to new niche markets opening, and a big bet will be made on innovation and business.

Experts also unanimously recognized unplanned factors as one of the global threats to public health and all humanity. By far, the most well-known threat of recent years is the COVID-19 pandemic and its aftermath. Countries were forced to significantly increase their spending on medical treatment and mitigate the effects of lockdowns. People changed their habitual way of life; society applied new rules of interaction. However, new hostilities in Ukraine in 2022 also caused significant changes. Millions were forced to change their place of residence, and the health infrastructure in the country was reduced or destroyed. Our experts compared the military action to climate change that occurred not over decades but within weeks. A vast number of refugees impacted the medical infrastructure of other countries. Many migrants needed and still need medical assistance. Such sudden wild cards are factors that change the current development and force the adjustment of forecasts. Unfortunately, they require significant resources and can hardly be predicted.

However, experts are divided on the mass availability of advanced medical treatment. The market expects more innovations, new medicines, and more. Policymakers and businesses invest significant resources in developing and bringing products to market. Conversely, the conservatism of health care reduces its success and attractiveness for new entrants. Using already available and collected medical data usually does not exceed 5–10%. The regulatory framework and infrastructure lag far behind the participants' capabilities and desires. A notable difference in the opinions of the study's participants indicates a large share of uncertainty regarding this and the difficulty of accurate forecasting.

As a limitation of our study, we can consider the number of panelists and lack of global coverage. However, to reduce this factor, we used the Delphi method to form forecasts within the framework of a lack of information. There may also be questions about who can be considered an expert in the field of study or not. Panelists have sufficient experience and knowledge of the industry on an international scale; thus, we can assume the results obtained reflect the current state of the healthcare industry and the future direction of medical development.

5. Practical implication

We identify the following key categories of practitioners who may benefit from our research. Firstly, start-up companies can recognize the trends in developing medicine and promising areas for commercialization. We offer several important markets for developing innovative solutions or improving products for the industry's needs. We believe more in small- and medium-sized companies, as large businesses are less flexible in developing and adapting to the needs and tend to buy innovations from small businesses. Secondly, doctors and, in some cases, patients will be able to learn about possible progress in medicine, discovering the technologies of the future for themselves. Medical students will also benefit from greater understanding when choosing their specialization and identifying areas of medicine where their knowledge and skills will be more in demand. Some medical manipulations are gradually being replaced by technologies, such as in diagnostics, surgery, and patient recovery. Thirdly, we single out local and international organizations that plan to provide medical care at the state level as we raise the topic of population migration, leading to the problems of today's medicine. Our research will help them improve their standards of care and prepare for the coming global changes.

5.1. Future research areas

The need for the industry's sustainable development is not yet obvious to most market participants (Lennox et al., 2018; Sherman et al., 2020). However, this parameter will become increasingly important. Currently, forming a sustainable service may affect price competitiveness. In this case, those markets considering longer-term investments and service delivery opportunities will win. However, focusing on short-term cost reduction targets will lead to falling behind. Nevertheless, sustainable health care is a potential transformer of the current state of the focal industry.

The role of technology and its value to health care is a growing trend. However, less research is devoted to the non-technological factors shaping the medicine of the future. We continue studies conducted by Sedova and Kalkuhl (2020) and Bosetti et al. (2021), which are devoted to such parameters as climate migrants and low-carbon healthcare. For example, low-carbon health care is an emergent phenomenon in the academic literature. Recent studies show great potential for reducing CO2 emissions, non-recyclable waste, and plastic (Bhopal & Norheim, 2022; Rizan et al., 2021). However, in most cases, these studies are limited to describing and analyzing successful projects for integrating business cases or promising developments.

6. Conclusion

Our study identifies and analyzes the key factors influencing the healthcare industry's development for the next 50 years. Our experts have allowed us to make assumptions regarding the short-, medium, and long-term forecasts that will affect not only key industrial stakeholders but society. Our results provide an understanding of the processes that will influence the industry's transformation and suggest that stakeholders take appropriate measures to respond organically to events. Some of the trends are only gaining speed and are not yet the locomotive of movement, which they can become after some time, and vice versa: The key trends now can reduce their importance, forming further prerequisites for transformation.

Due to conservatism, modern technologies appear last in the healthcare industry. Nevertheless, we live in an exciting and inspiring time for medicine. Invariably, progress in health care is directly linked to politics, demographics, economics, and climate change. Governments and multilateral organizations should partner across the public and private sectors with social responsibility in mind to

allow innovation and scientific progress in health care. In this case, 100–120-year-olds who feel 60 will become the new norm—at least, this is promised by healthcare tech start-ups funded by the world's richest people.

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References

Abbod, M., von Keyserlingk, D., Linkens, D., & Mahfouf, M. (2001). Survey of utilisation of fuzzy technology in medicine and healthcare. *Fuzzy Sets and Systems, 120* (2), 331–349. https://doi.org/10.1016/S0165-0114(99)00148-7

Adler, N., & Rehkopf, D. (2008). U.S. disparities in health: Descriptions, causes, and mechanisms. *Annual Review of Public Health, 29*(1), 235–252. https://doi.org/10.1146/annurev.publhealth.29.020907.090852

Aldieri, L., Bruno, B., Senatore, L., & Vinci, C. (2020). The future of pharmaceuticals industry within the triad: The role of knowledge spillovers in innovation process. *Futures, 122*, Article 102600. https://doi.org/10.1016/j.futures.2020.102600

Allam, Z. (2020). *Biotechnology and future cities: Towards sustainability, resilience and living urban organisms*. Springer Nature.

Baek, J., Lee, H., Heo, J., Cho, S., & Kim, H. (2021). Thirty-six year trends in mortality from diseases of circulatory system in Korea. *Korean Circulation Journal, 51*(4), 320. https://doi.org/10.4070/kcj.2020.0424

Bhopal, A., & Norheim, O. F. (2022). 93: Oral Priority setting and net zero healthcare: how much health can a tonne of carbon buy?. A1-A1 *BMJ Global Health, 7*(2). https://doi.org/10.1136/bmjgh-2022-ISPH.4.

Blind, K., Cuhls, K., & Grupp, H. (2001). Personal attitudes in the assessment of the future of science and technology: A factor analysis approach. *Technological Forecasting and Social Change, 68*(2), 131–149. https://doi.org/10.1016/S0040-1625(00)00083-4

Bosetti, V., Cattaneo, C., & Peri, G. (2021). Should they stay or should they go? Climate migrants and local conflicts. *Journal of Economic Geography, 21*(4), 619–651.

Boutillier, S., Fourmentin, S., & Laperche, B. (2020). Food additives and the future of health: An analysis of the ongoing controversy on titanium dioxide. *Futures, 122*, Article 102598. https://doi.org/10.1016/j.futures.2020.102598

Bower, K., Thorpe Jr, Rohde, C., & Gaskin, D. (2014). The intersection of neighborhood racial segregation, poverty, and urbanicity and its impact on food store availability in the United States. *Preventive Medicine, 58*, 33–39. https://doi.org/10.1016/j.ypmed.2013.10.010

Bragazzi, N., Damiani, G., Behzadifar, M., Martini, M., & Wu, J. (2020). How big data and artificial intelligence can help better manage the COVID-19 pandemic. *International Journal of Environmental Research and Public Health, 17*(9), 3176. https://doi.org/10.3390/ijerph17093176

Bragazzi, N., Khoramipour, K., Chaouachi, A., & Chamari, K. (2020). Toward sportomics: Shifting from sport genomics to sport postgenomics and metabolomics specialties. Promises, challenges, and future perspectives. *International Journal of Sports Physiology and Performance, 15*(9), 1201–1202. https://doi.org/10.1123/ijs

Brunborg, H. (2012). Increasing life expectancy and the growing elderly population. *Norsk Epidemiologi, 22*(2). https://doi.org/10.5324/nje.v22i2.1552

Carissoli, C., Villani, D., & Riva, G. (2015). Does a meditation protocol supported by a mobile application help people reduce stress? Suggestions from a controlled pragmatic trial. *Cyberpsychology Behavior and Social Networking, 18*(1), 46–53. https://doi.org/10.1089/cyber.2014.0062

Chhabra, A., Munjal, M., Kuhar, N., & Vats, M. (2021). Medical tourism in the COVID-19 era: opportunities, challenges and the way ahead. *Worldwide Hospitality and Tourism Themes, 13*(5), 660–665. https://doi.org/10.1108/WHATT-05-2021-0078

Church, T., Thomas, D., Tudor-Locke, C., Katzmarzyk, P., Earnest, C., Rodarte, R., … Bouchard, C. (2011). Trends over 5 decades in U.S. occupation-related physical activity and their associations with obesity. *PLoS One, 6*(5), Article e19657. https://doi.org/10.1371/journal.pone.0019657

Ciasullo, M., Manna, R., Cavallone, M., & Palumbo, R. (2020). Envisioning the future of health systems: Exploratory insights from European countries. *Futures, 121*, Article 102585. https://doi.org/10.1016/j.futures.2020.102585

Ciasullo, M. V., Lim, W. M., Manesh, M. F., & Palumbo, R. (2022a). The patient as a prosumer of healthcare: insights from a bibliometric-interpretive review. *Journal of Health Organization and Management*. https://doi.org/10.1108/JHOM-11-2021-0401

Ciasullo, M. V., Orciuoli, F., Douglas, A., & Palumbo, R. (2022b). Putting Health 4.0 at the service of Society 5.0: Exploratory insights from a pilot study. *Socio-Economic Planning Sciences, 80*, Article 101163. https://doi.org/10.1016/j.seps.2021.101163

Ćwiklicki, M., Klich, J., & Chen, J. (2020). The adaptiveness of the healthcare system to the fourth industrial revolution: A preliminary analysis. *Futures, 122*, Article 102602. https://doi.org/10.1016/j.futures.2020.102602

Dananjayan, S., & Raj, G. (2020). Artificial Intelligence during a pandemic: The COVID-19 example. *The International Journal of Health Planning and Management, 35* (5), 1260–1262. https://doi.org/10.1002/hpm.2987

Denicolai, S., & Previtali, P. (2020). Precision medicine: Implications for value chains and business models in life sciences. *Technological Forecasting and Social Change, 151*, Article 119767. https://doi.org/10.1016/j.techfore.2019.119767

Epstein, R., & Street, R. (2011). The values and value of patient-centered care. *The Annals of Family Medicine, 9*(2), 100–103. https://doi.org/10.1370/afm.1239

Gobbi, S., Płomecka, M. B., Ashraf, Z., Radziński, P., Neckels, R., Lazzeri, S., … Jawaid, A. (2020). Worsening of preexisting psychiatric conditions during the COVID-19 pandemic. *Frontiers in Psychiatry, 11*. https://doi.org/10.3389/fpsyt.2020.581426

Gray, M. (2017). Value based healthcare. *BMJ*, j437. https://doi.org/10.1136/bmj.j437

Greene, V. (2001). Personal hygiene and life expectancy improvements since 1850: Historic and epidemiologic associations. *American Journal of Infection Control, 29* (4), 203–206. https://doi.org/10.1067/mic.2001.115686

Gunawan, J., Juthamanee, S., & Aungsuroch, Y. (2020). Current mental health issues in the era of Covid-19. *Asian Journal of Psychiatry, 51*, Article 102103. https://doi.org/10.1016/j.ajp.2020.102103

Håkansson Eklund, J., Holmström, I. K., Kumlin, T., Kaminsky, E., Skoglund, K., Höglander, J., & Summer Meranius, M. (2019). "Same or different?" A review of reviews of person-centered and patient-centered care. *Patient Education and Counseling, 102*(1), 3–11. https://doi.org/10.1016/j.pec.2018.08.029

He, J., Baxter, S., Xu, J., Xu, J., Zhou, X., & Zhang, K. (2019). The practical implementation of artificial intelligence technologies in medicine. *Nature Medicine, 25*(1), 30–36. https://doi.org/10.1038/s41591-018-0307-0

Huppert, F. (2009). Psychological well-being: Evidence regarding its causes and consequences. *Applied Psychology: Health and Well-Being, 1*(2), 137–164. https://doi.org/10.1111/j.1758-0854.2009.01008.x

Jung, S., Lee, K., & Hwang, H. (2021). Recent trends of healthcare information and communication technologies in pediatrics: A systematic review. *Clinical and Experimental Pediatrics*. https://doi.org/10.3345/cep.2020.01333

Kaewkitipong, L., Chen, C., & Ractham, P. (2021). Examining factors influencing COVID-19 vaccine tourism for international tourists. *Sustainability, 13*(22), 12867. https://doi.org/10.3390/su132212867

Kalisz, D., Khelladi, I., Castellano, S., & Sorio, R. (2021). The adoption, diffusion; categorical ambiguity trifecta of social robots in e-health – Insights from healthcare professionals. *Futures, 129*, Article 102743. https://doi.org/10.1016/j.futures.2021.102743

King, T., Cole, M., Farber, J. M., Eisenbrand, G., & Hill, J. P. (2017). Food safety for food security: Relationship between global megatrends and developments in food safety. *Trends in Food Science & Technology, 68*, 160–175. https://doi.org/10.1016/j.tifs.2017.08.014

Kostkova, P. (2015). Grand challenges in digital health. *Frontiers in Public Health, 3*, 134. https://doi.org/10.3389/fpubh.2015.00134

Krieger, N., Smith, K., Naishadham, D., Hartman, C., & Barbeau, E. (2005). Experiences of discrimination: Validity and reliability of a self-report measure for population health research on racism and health. *Social Science & Medicine, 61*(7), 1576–1596. https://doi.org/10.1016/j.socscimed.2005.03.006

Kulkov, I. (2021). Next-generation business models for artificial intelligence start-ups in the healthcare industry. *International Journal of Entrepreneurial Behavior & Research*. https://doi.org/10.1108/IJEBR-04-2021-0304

Kulkov, I., Berggren, B., Hellström, M., & Wikström, K. (2021). Navigating uncharted waters: Designing business models for virtual and augmented reality companies in the medical industry. *Journal of Engineering and Technology Management, 59*, Article 101614. https://doi.org/10.1016/j.jengtecman.2021.101614

Kulkov, I., Tsvetkova, A., & Ivanova-Gongne, M. (2021). Identifying institutional barriers when implementing new technologies in the healthcare industry (Vol. ahead-of-print No. ahead-of-print) *European Journal of Innovation Management,*. https://doi.org/10.1108/EJIM-02-2021-0093.

Lai, L., Wittbold, K., Dadabhoy, F., Sato, R., Landman, A., Schwamm, L., … Zhang, H.(M. (2020). Digital triage: Novel strategies for population health management in response to the COVID-19 pandemic. *Healthcare, 8*(4), Article 100493. https://doi.org/10.1016/j.hjdsi.2020.100493

Lennox, L., Maher, L., & Reed, J. (2018). Navigating the sustainability landscape: a systematic review of sustainability approaches in healthcare. *Implementation Science, 13*(1), 27. https://doi.org/10.1186/s13012-017-0707-4

Li, K., White, F. A., Tipoe, T., Liu, T., Wong, M., Jesuthasan, A., … Yan, B. P. (2019). The current state of mobile phone apps for monitoring heart rate, heart rate variability, and atrial fibrillation: Narrative review. *JMIR MHealth and UHealth, 7*(2), Article e11606. https://doi.org/10.2196/11606

Lurati, A. (2018). Health issues and injury risks associated with prolonged sitting and sedentary lifestyles. *Workplace Health & Safety, 66*(6), 285–290. https://doi.org/10.1177/2165079917737558

Manna, R., Cavallone, M., Ciasullo, M. V., & Palumbo, R. (2020). Beyond the rhetoric of health tourism: Shedding light on the reality of health tourism in Italy. *Current Issues in Tourism, 23*(14), 1805–1819. https://doi.org/10.1080/13683500.2019.1650726

Meyer, M., & Vergnaud, F. (2020). The rise of biohacking: Tracing the emergence and evolution of DIY biology through online discussions. *Technological Forecasting and Social Change, 160*, Article 120206. https://doi.org/10.1016/j.techfore.2020.120206

Millett, G., Jones, A., Benkeser, D., Baral, S., Mercer, L., Beyrer, C., & Sullivan, P. (2020). Assessing differential impacts of COVID-19 on black communities. *Annals of Epidemiology, 47*, 37–44. https://doi.org/10.1016/j.annepidem.2020.05.003

Ming, L., Untong, N., Aliudin, N., Osili, N., Kifli, N., Al-Worafi, Y., … Goh, H. (2020). Mobile health apps on COVID-19 launched in the early days of the pandemic: Content analysis and review. *JMIR MHealth and UHealth, 8*(9), Article e19796. https://doi.org/10.2196/19796

Murray, M., Sánchez, C., Worsley-Tonks, K. E., & Craft, M. E. (2019). City sicker? A meta-analysis of wildlife health and urbanization. *Frontiers in Ecology and the Environment, 17*(10), 575–583. https://doi.org/10.1002/fee.2126

Nussinov, R., Jang, H., & Tsai, C. (2014). The structural basis for cancer treatment decisions. *Oncotarget, 5*(17), 7285. https://doi.org/10.18632/oncotarget.2439

Nygren, N. A., Tapio, P., & Qi, Y. (2017). Lake management in 2030—Five future images based on an international Delphi study. *Futures, 93*, 1–13. https://doi.org/10.1016/j.futures.2017.08.004

Ozen, B., Ceyhan, O., & Büyükcelik, A. (2020). Hope and perspective on death in patients with cancer. *Death Studies, 44*(7), 412–418. https://doi.org/10.1080/07481187.2019.1626942

Page, R., Ghushchyan, V., & Nair, K. (2011). A call to action: Responding to the future forecasting of cardiovascular disease in America. *American Health & Drug Benefits, 4*(5), 280.

Poulalhon, C., Rotelli-Bihet, L., Fagot-Campagna, A., & Tuppin, P. (2018). Deaths in France: Characteristics, place of death, hospitalisations and use of palliative care during the year before death. *Revue d'Épidémiologie et Délelőtt Santé Publique, 66*(1), 33–42. https://doi.org/10.1016/j.respe.2017.06.008

PricewaterhouseCoopers (2016). Five Megatrends and Their Implications for Global Defense & Security.

Putera, I. (2017). Redefining health: Implication for value-based healthcare reform. *Cureus*. https://doi.org/10.7759/cureus.1067

Raghupathi, W., & Raghupathi, V. (2018). An empirical study of chronic diseases in the United States: A visual analytics approach to public health. *International Journal of Environmental Research and Public Health, 15*(3), 431. https://doi.org/10.3390/ijerph15030431

Razzak, M., Imran, M., & Xu, G. (2020). Big data analytics for preventive medicine. *Neural Computing and Applications, 32*(9), 4417–4451. https://doi.org/10.1007/s00521-019-04095-y

Ribeiro, B., & Quintanilla, M. (2015). Transitions in biofuel technologies: An appraisal of the social impacts of cellulosic ethanol using the Delphi method. *Technological Forecasting and Social Change, 92*, 53–68. https://doi.org/10.1016/j.techfore.2014.11.006

Ristevski, B., & Chen, M. (2018). Big data analytics in medicine and healthcare. *Journal of Integrative Bioinformatics, 15*(3). https://doi.org/10.1515/jib-2017-0030

Rizan, C., Bhutta, M. F., Reed, M., & Lillywhite, R. (2021). The carbon footprint of waste streams in a UK hospital. *Journal of Cleaner Production, 286*, Article 125446.

Rom, W., & Pinkerton, K. (2021). Introduction: Consequences of Global Warming to Planetary and Human Health (pp. 1–33). ⟨https://doi.org/10.1007/978–3-030–54746-2_1⟩.

Ruggeri, K., Garcia-Garzon, E., Maguire, Á., Matz, S., & Huppert, F. (2020). Well-being is more than happiness and life satisfaction: A multidimensional analysis of 21 countries. *Health and Quality of Life Outcomes, 18*(1), 192. https://doi.org/10.1186/s12955-020-01423-y

Saritas, O., & Smith, J. (2011). The big picture – trends, drivers, wild cards, discontinuities and weak signals. *Futures, 43*(3), 292–312. https://doi.org/10.1016/j.futures.2010.11.007

Schiavone, F., & Ferretti, M. (2021). The futureS of healthcare. *Futures, 134*, Article 102849. https://doi.org/10.1016/j.futures.2021.102849

Sedova, B., & Kalkuhl, M. (2020). Who are the climate migrants and where do they go? Evidence from rural India. *World Development, 129*, Article 104848.

Sherman, J. D., Thiel, C., MacNeill, A., Eckelman, M. J., Dubrow, R., Hopf, H., … Bilec, M. M. (2020). The green print: Advancement of ENVIRONMENTAL SUSTAINABILITY IN HEALthcare. *Resources, Conservation and Recycling, 161*, Article 104882. https://doi.org/10.1016/j.resconrec.2020.104882

Silva, N., Favacho, V., Boska, G., Andrade, E., Merces, N. D., & Oliveira, M. (2020). Access of the black population to health services: integrative review. *Revista Brasileira Dèlelőtt Enfermagem, 73*(4). https://doi.org/10.1590/0034-7167-2018-0834

Su, Z., Wen, J., McDonnell, D., Goh, E., Li, X., Cheshmehzangi, A., & Xiang, Y.-T. (2021). Vaccines are not yet a silver bullet: The imperative of continued communication about the importance of COVID-19 safety measures. *Brain Behavior & Immunity - Health, 12*, Article 100204. https://doi.org/10.1016/j.bbih.2021.100204

Toppinen, A., Pätäri, S., Tuppura, A., & Jantunen, A. (2017). The European pulp and paper industry in transition to a bio-economy: A Delphi study. *Futures, 88*, 1–14. https://doi.org/10.1016/j.futures.2017.02.002

Varho, V., & Huutoniemi, K. I. (2014). Envisioning solutions: Expert deliberation on environmental futures. *Transdisciplinary Sustainability Studies*.

Vasiljevic, G., & de Miranda, L. (2020). Brain–computer interface games based on consumer-grade EEG devices: A systematic literature review. *International Journal of Human–Computer Interaction, 36*(2), 105–142. https://doi.org/10.1080/10447318.2019.1612213

Verma, S., & Mishra, A. (2020). Depression, anxiety, and stress and socio-demographic correlates among general Indian public during COVID-19. *International Journal of Social Psychiatry, 66*(8), 756–762. https://doi.org/10.1177/0020764020934508

Wahl, B., Cossy-Gantner, A., Germann, S., & Schwalbe, N. (2018). Artificial intelligence (AI) and global health: how can AI contribute to health in resource-poor settings. *BMJ Global Health, 3*(4), Article e000798. https://doi.org/10.1136/bmjgh-2018-000798

Waller, A., Sanson-Fisher, R., Zdenkowski, N., Douglas, C., Hall, A., & Walsh, J. (2018). The right place at the right time: Medical oncology outpatients' perceptions of location of end-of-life care. *Journal of the National Comprehensive Cancer Network, 16*(1), 35–41. https://doi.org/10.6004/jnccn.2017.7025

Wosik, J., Fudim, M., Cameron, B., Curtis, S., Roman, M., Poon, E., … Tcheng, J. (2020). Telehealth transformation: COVID-19 and the rise of virtual care. *Journal of the American Medical Informatics Association, 27*(6), 957–962. https://doi.org/10.1093/jamia/ocaa067

Wu, L.-T., Zhu, H., & Ghitza, U. E. (2018). Multicomorbidity of chronic diseases and substance use disorders and their association with hospitalization: Results from electronic health records data. *Drug and Alcohol Dependence, 192*, 316–323. https://doi.org/10.1016/j.drugalcdep.2018.08.013

Xu, C., Kohler, T., Lenton, T. M., Svenning, J.-C., & Scheffer, M. (2020). Future of the human climate niche. *Proceedings of the National Academy of Sciences, 117*(21), 11350–11355. https://doi.org/10.1073/pnas.1910114117

Yetisen, A. K. (2018). Biohacking. *Trends in Biotechnology, 36*(8), 744–747. https://doi.org/10.1016/j.tibtech.2018.02.011

Yu, Z., Razzaq, A., Rehman, A., & Mor, R. S. (2021). Disruption in global supply chain and socio-economic shocks: A lesson from COVID-19 for sustainable production and consumption. *Operations Management Research*. https://doi.org/10.1007/s12063-021-00179-y