INTRODUCTION
Technology developed for use by patients can be used in hospitals and at home, for chronic and acute disease. The healthy population can use technology to maintain good health or to alert them to a change in health status.

Generally, technology can be divided into software and hardware. Examples of hardware are phones, computers, 3D printers, wearable devices such as smart watches, and other specialized devices and gadgets. Software examples are internal portals, phone applications, social media, and specialized software that is incorporated into hardware for proper functioning.

Through the increasing popularity of the internet and social media, it is easier than ever to access information. Exchanging information, whether good or bad, is now much faster than in the postal mail era.

HARDWARE
Hardware in the context of in-hospital care has clearly advanced, but now we are also seeing an increasing amount of hardware products being designed for patient use at home. Computers and phones are now ubiquitous and are used by patients to access health-related information. Many patients have dedicated health-related applications. Seventy-three percent of Americans own a smart phone and almost all of them carry a phone all the time. Over 102 million wearable devices were sold in 2016 - a 25% increase over the year before [1]. Present day wearable technology is in the form of dedicated fitness wearables or smartwatches that replace regular watches with the added function of a fitness wearable device.

Wearable technology has the potential to transmit data to a central station and be constantly read and analysed.
Patients and physicians can receive alerts in case of emergency and the device could send the precise location of the patient. This type of technology is used more commonly in hospital settings, but it is spreading to at-home use. With advances in technology, it is thought that intelligent, more sophisticated wearables in the future will allow for constant monitoring of health status and provide instant feedback.

Technology is very helpful and will continue to aid patients in management of their chronic illnesses. It allows them to be more independent, and to spend less time in hospitals and clinics. Technology aids in helping healthy people to stay healthy, in monitoring eating habits, analyzing macronutrient consumption, their level of metabolites, physical activity, sleep etc. What today is science fiction, tomorrow will be reality.

Specialized health devices, such as blood pressure cuffs and glucometers are widely used by patients for at-home monitoring of health status. Presently, diabetic patients are able to measure their glucose levels several times a day with small, portable glucometers. With technological advances, there is the possibility to combine a micro insulin pump, incorporated with sophisticated software to monitor activity and food consumption with constant glucose monitoring. It will be possible to precisely mimic pancreatic function in delivering insulin. Patients with various illnesses will be able to have lab tests done at home in a similar fashion as diabetics monitoring their glucose levels and then have instant feedback to determine the next therapeutic step.

Wearables now monitor activity, sleep, heart rate, $O_2$ saturation, and oxygen consumption. Food consumption monitoring is still done manually. Patients must keep diaries (electronic or on paper) and fill out questionnaires. These diaries and questionnaires are highly subjective and prone to error. Compliance and consistency are barriers. Monitoring food consumption and activity level is helpful in the treatment and prevention of obesity, which is a major health problem. The lowest rate of obesity in the United States is 22.6% in Colorado, and highest in West Virginia with a rate of 38% [2]. It can also be helpful in patients whose illnesses have specific dietary restrictions or dietary recommendations. Devices that would monitor real time food consumption and caloric intake combined with present day activity monitoring could make a huge difference. Prototypes for monitoring food intake using different techniques already exist and are being tested [3]. In the future, a wearable device that will be able to monitor hydration and consumption of protein, carbohydrates, and fat by skin sensors, micro wireless tooth-mounted sensors or sensors inside the GI tract. These sensors will be able to monitor glucose and electrolyte levels and perhaps even hormone and metabolite levels [4].

There is no question that advances in hardware have great potential in improvement of patient health if implemented and used properly. However, with improper use, bad design, or malicious action from corporations, there is a great risk to patient health.

Theranos was a corporation that developed a device called “Edison”. Theranos claimed that this device could preform multiple automatic blood tests using small amounts of blood volumes obtained from a finger prick. This was thought to be breakthrough technology. The company was founded in 2003 by 19-year-old Stanford student dropout Elisabeth Holmes. The company quickly grew by partnering with Safeway, Walgreens, and Cleveland Clinic and in 2013 was worth 10 billion dollars. Elizabeth Holmes became the youngest female billionaire [5]. The Theranos blood tests were used by clinical drug trials sponsored by GlaxoSmithKline and Pfizer. In 2015, The Wall Street Journal reported that Theranos was secretly using traditional blood analyzers and that the tests done by Theranos Edison devices were not accurate. In 2016, a criminal investigation was started for misleading investors. The same year, the Journal of Clinical Investigation published a study showing that 68% of Theranos blood tests had significant interservice variability. Theranos bankrupted and in 2018 ceased to exist. Indeed, greed for corporations or individuals does not result in the best patient care.

Hardware developed for patients by health professionals or with the input of health professionals generally benefits patients. If the technology is found to be unhelpful or illegitimate through scientific scrutiny, it is eliminated. Often though, hardware is developed for pure commercial gain with no input from health professionals and there is no scientific verification. Hardware with fake claims is marketed for as long as profitable, even after no benefit is proven by scientific studies.

The Polish naturopath Jerzy Zieba sells a water “crystalizer” called “Visanto” for around 1000 dollars. He claims without any scientific proof that his device returns magnetic memory to water. By drinking this water one can counteract negative effects of polluted magnetic fields by electric devices like phones, TVs etc. A similar device called Vitalizer Plus is sold for 500 dollars in USA. Online one can buy countless devices with fake claims. These include: “The Rebuilder” for nerve damage, “Hulda Clark Zapper”, “Super Zappicator”, “AutoZap 5 Integrated Wellness System”, “Magnetic Polarizer”, “Ozone generator” and for 2400 dollars, “Dr Clark’s 21 day Late Stage Cancer Cleanse” - a kit of 60 supplements and a Zapper which is accompanied by 634 page long pdf brochure titled “The Cure for All Advanced Cancers”. The author Hulda Clark who was not a medical doctor but a naturopath, stresses at the beginning that this is not a mere treatment for cancer but a true cure and she stresses that her cure is based on her scientific research [6]. The FDA stated that Clark’s Devices seem to be fraudulent [7]. In 2004, court judgment ordered the foundation to refrain from making false claims. The company added a short disclaimer stating that it is not scientifically proven and it is only for information. However the product is still selling despite lack of scientific proof. Dr Clark died in 2009, but this did not stop her heir from selling her product.

SOFTWARE

Software is helpful in providing information to patients and making that information easily accessible. It can be used for patients in the management of chronic illnesses,
reminders and preparation for appointments, and for contact with health professionals. Too often information that is available is not accessed by patients because portals or applications are not engaging, are not user friendly and difficult to navigate, give too detailed information or are too superficial.

In the USA, 76% of households have access to Internet (in Poland 73%) [8]. All smartphones now are connected to internet. The mobility of a tool that can access information anywhere and is user friendly is very important. Dedicated apps are better than portals for mobile devices. Personalization of apps and data engages patients, is more specific and more helpful than general information. For example, general information on a colonoscopy procedure is less useful than the same information presented in a personalized manner. Information based on a patient’s data will give instructions on how to prepare for the procedure. The instructions will be different for a patient with diabetes. With that in mind, it is more useful to give specific information for a diabetic and not overwhelm the patient with irrelevant information. A dedicated app will remind the patient when to start preparation and when to leave for an appointment. If the app already knows how the patient will travel, it can give detailed instruction on which bus to take or to book an Uber. This is much faster and more user friendly than going onto a hospital portal to read instructions for a colonoscopy which will include too much irrelevant information.

Healthcare institutions that sent automated text messages with appointment reminders noted decline of no shows by 20% which was very cost effective. The user friendliness is very important and has to be adjusted to the patient’s ability and comfort level with technology. In the UK, 12 million people lack basic digital skill [9].

An example of software that can be loaded onto a user’s smart phone is the mobile app Achievement. The app connects to other health and fitness apps on the user’s phone and gives points for activity. When the user earns 10,000 points they are rewarded with 10 dollars that can be donated to charity or deposited to the user’s account. The data is used for research but is a great motivator for the user to stay active and healthy.

In March 2018, the Patient Engagement and Experience Summit had a panel of experts who discussed engaging patients and creating a good experience for them. Problems identified included technology developed without a plan in mind, creating more negative than positive effect, as well as language and vocabulary not adjusted to the audience. The focus was on the “what” and not the “how” and “why” in development. Sometimes information is provided in a horrible format. Fitness apps and chatbots make it easier for patients to self-diagnose, but on the other hand, can encourage overtreatment. Mobile apps have much more use when accompanied by coordination by healthcare professionals.

Problems arise when technology is developed by programmers or hardware designers without health professional input or patient input, and when it lacks proper evaluation by a health professional. Target population, usefulness, reliability, impact on population, and side effects of the technology should be evaluated by health professionals. Commercial success unfortunately is not a proof of usefulness from the healthcare point of view.

Even useful technology will leave patients and physicians behind without ongoing long-term support. Companies can quickly abandon production and subsequently support if they saturate the market, and then move to the next new technology for better profit.

There is also a risk that a specific technology wants to solve too many problems and can easily become confusing and too complex for easy use. Any software can be inefficient because with too many tasks, none can be done very well. The result is the creation of a new problem instead of solving problems in the first place.

**SOCIAL MEDIA**

The use of social media makes it easy for people to share experiences with their friends, their friends of friends, as well as strangers. There is growing literature on use of social media by people with chronic illnesses. Social media platforms allow for patients to share their experiences living and dealing with illness, and to connect with others with the same illness. Patients with relatively rare diseases can connect with another patient with the same illness for the first time. As with many internet sources, it is now difficult for patients to sort through the reliability of information available on the internet. With discussion boards often providing contradicting information, it can be easy to become overwhelmed or misguided. For that reason, social media platforms that include oversight and input from health professionals are thought to be useful tools for providing information, sharing knowledge, and ultimately facilitating self-management in disease. Social media is an invaluable tool for some patients who do not have contact with patients who are in their shoes. It can provide support during disease flares [10].

An example of negative impact of social media on patients’ perceptions, knowledge, and attitudes is the topic of vaccination. Tanushree et al examined four years of data related to vaccination captured on twitter [11]. Their focus was on a group of users that became new anti-vaccination proponents despite strong pro-vaccine recommendations from authoritative organizations like the Centers for Disease Control (CDC). They analyzed more than 3 million tweets and found that this group, compared to a group of persistent anti-vaccination proponents shared a similar distrust of government. This suggests that the group of new anti-vaccination proponents were predisposed to anti-vaccination attitudes and more prone to accept anti-vaccination rhetoric. Anti-vaccination rhetoric contained more direct language and more anger than pro-vaccination language. This group also showed more solidarity, were resistant to correction and prone to conspiracy thinking. A survey of almost 2500 parents showed that those who refused vaccination of their children were more likely to receive the information
online compared to those vaccinating their children. They expressed low trust in government and had more confidence in alternative medicine than in health care professionals [12, 13]. It seems that the core anti-vaccination groups are well-organized and aggressive and are spreading their point of view. The use of trolls, fake accounts pretending to be legitimate, and bots (automatic message generators) allows them to flood unsolicited anti-vaccine messages, making the impression that this is a majority view and is supported by some authorities [14]. As of now, social media has more of a negative than positive effect on rate of vaccination and there is a similar effect in other areas such as the acceptance of alternative medicine. Recent outbreaks of measles in many countries show that anti-vax movement is successful and social media has some part in their success [13]. Attempts of traditional education by health authorities to correct their view are counterproductive and leads to more resistance. There is need of a new approach for educating and convincing these groups [15–17].

Technology that targets patients is also helpful for hospitalized patients. It can improve patient’s satisfaction, safety, as well as outcome. Interactive learning is the most common reported use of technology to engage hospitalized patients [18]. Amazon’s Alexa or other interactive voice-controlled systems are used in patients’ rooms. Patients can access their medical records, information about their treatment, post-treatment instructions, or other information about the hospital and available resources without the need to use call buttons for nurses or doctors [19, 20].

Patients often are not satisfied with hospital food or the timing of meal delivery, causing a lot of food waste. When patients in Shore Medical Center could use tablets to order meals they felt more in control. Patient satisfaction increased by 10% and the hospital saved money. It also improved patient nutrition since patients could order what they liked. All meals were based on each patient’s dietary restrictions and allergies [20].

We do not know what the possible technologies of the future bring us. Technology is being developed now that was unimaginable before. Scripps Research Translational Institute is developing deep learning tools using artificial intelligence to process and analyze data of whole genomic sequences and continuous physiologic sensors, with potential to prevent illness. In deep learning, neural networks are formed with each layer of information and the machine learns by adding layers to the knowledge of the previous layers. For example, digital sensing predicting atrial fibrillation may decrease the risk of stroke [21].

CONCLUSION
Technology has a very positive effect when it is designed and controlled by health professionals. Patients must be protected from sources of information that are unreliable or malicious. Technology that is used concurrently by patients and health professionals for monitoring health and has direct interaction between patients and health professionals improves patients’ satisfaction, quality of life, and has a positive effect on health statistics. Uncontrollable use of technology, social media and internet access to unreliable sources without verification has more negative than positive effect. Regulation sometimes are necessary but often they are not very effective and even reinforce mistrust in government. Knowing the risks will help to counteract the negative effects. Therefore, there is need for more research on how to successfully educate patients. Traditional education relying on authority is not currently successful.

REFERENCES


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Received: 18.04.2019
Accepted: 14.05.2019