

Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Information Technologies



Diploma Thesis

Health watch: Proposal of a new prototype

Professor:
Ing. Miloš Ulman, Ph.D.

Student:
Visart Shahu

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

DIPLOMA THESIS ASSIGNMENT

Visart Shahu

Informatics

Thesis title

Health watch: design of a new prototype

Objectives of thesis

The main aim of the thesis is to research, propose, and to design a prototype that improves the quality of life through the health parameters measurements through wearable devices.

The partial objectives of the thesis are such as:

- to make an overview of the current state of the art of wearable devices,
- to analyze advantages and disadvantages of current wearable devices,
- to design a prototype of the health watch and evaluate the proposal.

Methodology

Methodology of the thesis is based on study and analysis of information resources. The practical part of the thesis is focused on designing a prototype by using scientific methods such as analysis, synthesis, comparison and engineering methods such as prototyping. The practical usage of the proposed device will be envisioned by a series of use cases. Based on the literature review and the prototype, a final evaluation, further suggestions and conclusions will be made.

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Keywords

Health watch, Wearable devices, Medical devices, Medical development, Healthcare, Monitoring watch, Design.

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Matthew Chin Heng Chua, Design and development of an integrated health (i-health) monitoring watch, Dec. 2016, ISBN: 978-1-5090-3329-4

Nathan Eagle, Kate Greene, Using Personal Data in a Privacy-Sensitive Way to Make a Person's Life Easier and Healthier, 2014, ISBN : 9780262324564

Simi Susan Thomas, Viswam Nathan, Chengzhi Zong, BioWatch: A Noninvasive Wrist-Based Blood Pressure Monitor That Incorporates Training Techniques for Posture and Subject Variability, Date of Publication: 20 July 2015, ISSN: 2168-2194,

Timibloudi S Enamamu, Nathan Clarke, Paul Haskell-Dowland, Smart watch based body-temperature authentication, Oct. 2017, ISBN: 978-1-5090-4642-3

Xi Liu, Lei Liu, Steven J. Simske, Human Daily Activity Recognition for Healthcare Using Wearable and Visual Sensing Data, Oct. 2016, ISBN: 978-1-5090-6117-4

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The Diploma Thesis Supervisor

Ing. Miloš Ulman, Ph.D.

Supervising department

Department of Information Technologies

Electronic approval: 11. 9. 2018

Ing. Jiří Vaněk, Ph.D.

Head of department

Electronic approval: 19. 10. 2018

Ing. Martin Pelikán, Ph.D.

Dean

Prague on 23. 03. 2019

Declaration

I declare that I have worked on my diploma thesis titled " Health wearable device: Proposal of a new prototype" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the diploma thesis, I declare that the thesis does not break the copyrights of any other person.

In Prague on 29.03.2019

VISART SHAHU

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Health watch: Proposal of a new prototype

Abstract

With the help of Internet of Things, Wearable devices are becoming a bridge between the healthcare system and patients. In our days the traditional healthcare is not able to fulfill everyone's needs and emergencies. Therefore, this thesis will go through a literature review about the current situation of the healthcare system, what are the new challenges and why healthcare is essential. Also, in this chapter, an overview of the current situation with a focus on the advantages and disadvantages of these wearable devices will be covered. The practical part starts with an analysis of the market by targeting a sample population and by sharing with them a survey. The results of the survey have been analyzed through explanatory data analysis. The survey was a motivation to go further and propose a new prototype which will be dedicated only to the healthcare system. It will also cover an overview of some of the main functionalities and types of sensors that will be used in this prototype. The goal of this thesis is to come to the conclusion that this wearable device will be able to shift the healthcare system from curative to preventive.

Keywords: Health watch, Wearable devices, Medical devices, Medical development, Healthcare, Monitoring watch, Design.

Zdravotní nositelná zařízení: návrh nového prototypu

Abstrakt

Za pomoci Internetu věci se “wearables” stávají mostem mezi systémem zdravotní péče a pacienty. V současnosti není tradiční zdravotní péče schopná plnit potřeby všech. Tato práce poskytuje přehled literatury týkající se současného stavu zdravotního systému, nových výzev a významu zdravotní péče. Zahrnuje také přehled současné situace se zaměřením na výhody a nevýhody těchto nositelných zařízení. Praktická část začíná analýzou trhu se zaměřením na vzorek obyvatelstva a jeho průzkumem. Výsledek průzkumu byl analyzován prostřednictvím datové analýzy. Průzkum byl také motivací k tomu navrhnout nový prototyp zařízení, které by bylo zaměřeno výhradně na oblast zdravotní péče. Dále se práce věnuje přehledu některých z hlavních funkcí a typům senzorů, které budou užity u tohoto prototypu. Cílem této práce je dojít k závěru, že toto “wearable” zařízení by bylo schopno přinést velkou změnu pro systém zdravotní péče od léčebné k preventivní.

Klíčová slova: zdravotní hodinky, nositelná zařízení, zdravotní zařízení, vývoj ve zdravotnictví, zdravotní péče, monitorovací hodinky, design.

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1. Introduction

Nowadays health care is one of the most critical priorities and takes us a considerable period, which sometimes turns into concern for us. To improve health patients are willing to try all services provided by Countries or Organizations. This could lead them either to the right treatment or to fatal mistreatment. Since traditional health care is not able to fulfill everyone's need having a different infrastructure is more than needed. As such, since the technology is present and an essential asset in our lives, the number of patients who require to benefit from monitoring devices is increasing. Unfortunately, it is predicted that the number of patients in hospitals will rise worldwide. This is because the population is aging rapidly. According to UNFPA (United Nations populations fund), 12.3 percent of the global population is over 60 years old. In 2050, the number will increase by 22 percent. Adding to this in 2016, 56.9 million deaths were registered, and more than 15.2 million deaths are caused by Ischemic heart disease and stroke which are the world's biggest killers. In the top ten courses of death, also Chronic obstructive pulmonary, Chronic obstructive pulmonary, Diabetes, Road injuries, Tuberculosis are included. Health Care system has highly developed monitoring equipment which aims to facilitate lifestyle. Smart Health is the key for improving our life by using technology. However, what is more, important is that through these devices, smart health concerns have been shifted from curative to preventive. We live in innovating area; therefore, this thesis describes the challenges of creating a potential solution such as, a wearable device that can prevent a severe concern. This technology is based on sensors that will improve the quality of life through the health parameters measurements. This thesis will also cover the challenges on how people will react or adopt the usage of this device and which is more important, is this opportunity going to improve the quality and safety of the patient in the future.

2. Objectives and Methodology

2.1 Objectives

The main aim of the thesis is to research, propose, and to design a prototype that improves the quality of life through the health parameters measurements through wearable devices.

The partial objectives of the thesis are such as:

- to make an overview of the current state of the art of wearable devices
- to analyze the advantages and disadvantages of current wearable devices
- to design a prototype of a health watch and evaluate the proposal

2.2 Methodology

The methodology of the thesis is based on study and analysis of information resources. The practical part of the thesis is focused on designing a prototype by using scientific methods such as analysis, synthesis, comparison and engineering methods such as prototyping. A series of use cases will envision the practical usage of the proposed device. Based on the literature review and the prototype, a final evaluation, further suggestions, and conclusions will be made.

3. Literature Review

Smart Health nowadays is believed to be a tremendous protentional to change the way of how health care works. This is due to the influence of technology in our lives and the health care system. The past two decades smart health seeks to be more efficient to provide the citizens with the right treatment. With the help of the Internet of Things, smart health is coming with new concepts, such as wearable devices. This literature review will be divided into two chapters. In the first chapter smart health will be the subject and will cover definitions, the current situation of healthcare and the impact of technologies in this system. In the last chapter, this thesis will analyze the current situation of the wearable devices, their functionalities, advantages and disadvantages, the current market situation and the future of wearable devices.

3.1 Smart Health

Smart health could be defined as a new health care system supported by technology. According to (patient@home) smart health is the combination of health care and smart health technology. Due to the latest development in the field of medical, smart health has been focused on improving the livelihoods of citizens, patients, and the medical team itself. We can say that this transition is bringing an improvement to our lives. This move has also led to the development of several monitoring devices aimed at monitoring the health status of the patient. Smart health, in general, is intended to find any possible solution by using digital devices that can operate remotely. In the report that (Prabha Sundaravadivel, researchgate, 2018) did for smart health, highlight the importance of this relationship with technology. Furthermore, in this report, the focus is on the classification regarding the market for smart health, based on management, service, techniques used and end users.

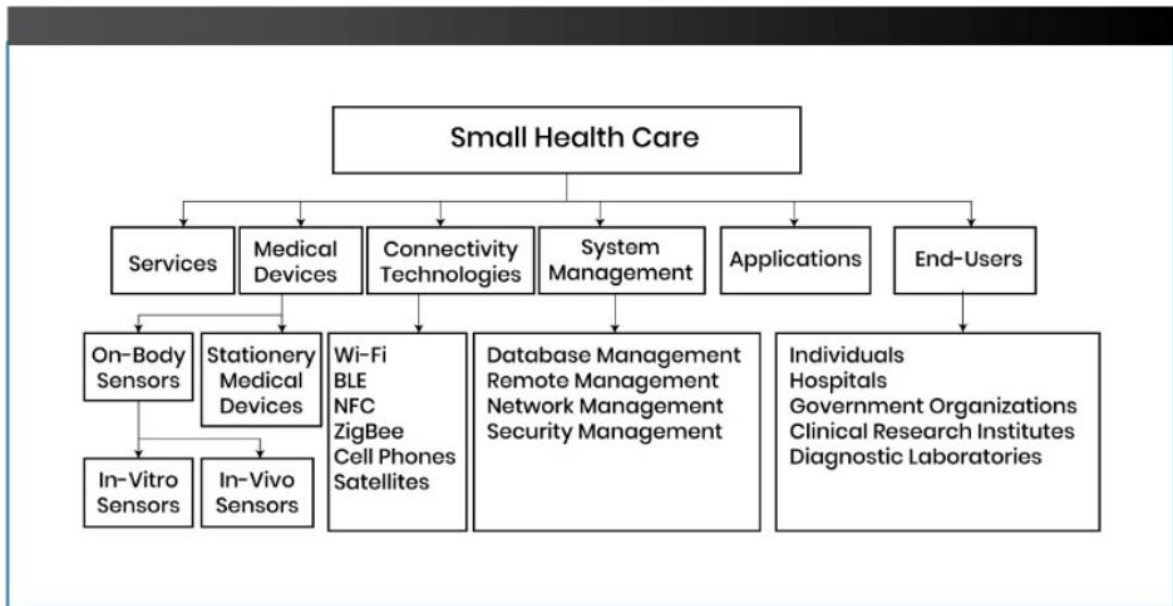


Figure 1- Classification of Smart Health Care(Sundaravadivel, et al., 2018)

As we can see in the figure above, smart health is divided into six sectors, making the system very complicated. There is a reason that the first sector is service; taking care of the patient is the heart of the smart health system followed by medical devices. This sector is divided into two subcategories, on-body sensor, and stationary medical devices. Also, on-body sensors are divided into the in-vitro sensor and in-vivo sensors. Connectivity technologies play a huge role in the smart health care system and are divided into several categories.

1. **Wi-Fi** is a system of wirelessly that use radio waves, allows devices to connect without using cables. This technology is based on IEEE 802.11b (Wekhande, 2006). Nowadays WIFI has been used as an access point which allows our devices to connect fast and secure. Behind this technology stands a software that can control the range, frequencies, and antenna.
2. **BLE** ins another type of connectivity in the wireless family known as Bluetooth Low Energy. According to (Townsend, 2018) Ble is a light-weight subset of classic Bluetooth and was introduced as part of the Bluetooth 4.0 core specification. Another connectivity type in this subcategory is NFC known as Near Field Communication. This technology was launched in 2004 by Nokia and since then has been developed rapidly. BLE also is convenient for any software, such as iOS, Android, Windows and Linux
3. **NFC** allows data are transferring in a short range with high frequency, and it can provide speed up to 424 kbps (Trivedi, 2015). For the first time this technology was

introduced in 2004 and since then, has been the central part for cell phones and smartphones. This due to the cheap chip that this sensor poses.

4. **ZigBee** stands among connectives in this list. This wireless sensor can connect with other machines based on a protocol designed to provide a secured connection. (Tomar, 2011) in his article Introduction to Zigbee Technology describe this sensor as the most populated wireless mesh networking.
5. **Cell Phones** play an essential part in our lives since 1973. For decades this technology helped us to have better communication. This is the reason why a cell phone is part of the list regarding the connectivity. It is considered one of the best inventions for the society and has brought the world closer. This, since this technology, allows communicating in long distance using waves and antennas.
6. **Satellites** or as we know in a different term as ground stations play a considerable role in telecommunication. This technology use of large reflector antennas for communication at a significant distance.

System management is an essential part of telecommunication and according to the picture above, is divided into five sub-categories that are strictly related to each other. Individuals need more specialized service to monitor body parameters and take proper care. Hospitals with the help of state organizations aim to increase the quality of the service by making it possible to open laboratory or clinics to analyze in detail the various diseases. The last part of this chain is the diagnostic laboratories that serve to provide a better overview of the current patient situation.

- a. **Database management** is a system that contains data and keeps them in a structured way. According to (Gunjal, 2003) It is a software that in some way allows data storage to be contained. It also aims to provide and make possible the return of deleted data. The most important thing is that this system prevents any breach of privacy and security breach.
- b. **Remote management** is a software that allows us to control our devices from one point to another via the internet. This software is mainly used in IT departments to help and support other devices in a short or long distance.
- c. **Network management** is a system that allows us to monitor and control devices, applications, tools in a proper way.

- d. **Security management** is considered as a high value and very critic feature for the whole IT infrastructure. According to (Sahar Al-Dhahri, 2017) security management is a process for storing data confidentially and privately.

Another important sector is that this diagram is an application. This software is very flexible which performs a specific function or feature for the benefit of the user. It is also connected with a database and is suitable for any system or devices such as a smartphone, laptop or tablet. The last sector of this diagram is end-user, and it is divided into five subcategories.

3.1.1 Why smart health is important?

Healthcare always has been and will remain a priority in our lives, ranging from daily activities to hospital services. With the constant influence of technology, it has become easier to monitor body parameters. According to (Prabha Sundaravadivel, 2018) for the healthcare system is becoming very difficult to support all the patient in need. This is since the population is increasing every day the population is aging rapidly. Furthermore (Fund, 2015.) write that 12.3 percent of the global population is over 60 years old. In 2050, the number will increase by 22 percent. Adding to this, (WHO, 2018) in 2016 56.9 million deaths were registered, and more than 15.2 million deaths are caused by Ischemic heart disease and stroke which are the world's biggest killers. In the top ten courses of death, also Chronic obstructive pulmonary, Chronic obstructive pulmonary, Diabetes, Road injuries, Tuberculosis are included.

Top 10 global causes of deaths, 2016

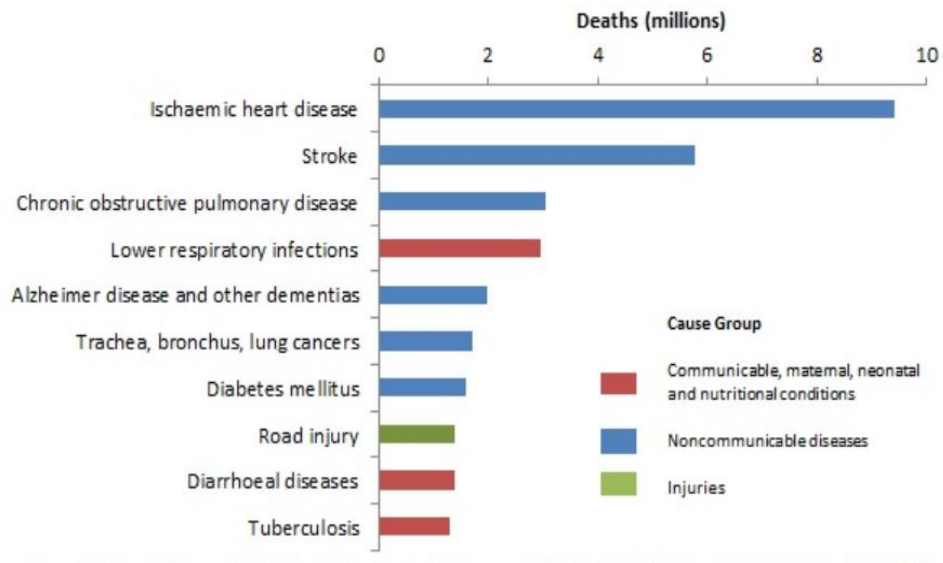


Figure 2 - Top 10 global causes of deaths, 2016(Organization, 2018)

Another key indicator for the patient is the quality of the healthcare industry. With the help of technology, smart health has as a purpose to provide better quality for the patient in need. Also, smart health tends to standardize and automate existing operations. According to (patient@home) with those changes, is a significant advantage for the system to adopt new devices that will replace the old one. Adding to this Internet of things (Gulraiz Joyia, 2017) writes that society, consumers and business with the help of technology are benefiting every day and having a better quality of services regarding healthcare.

Furthermore in this report is focused on the advantages that healthcare through the internet of things would benefit. With the improvement of IoT, several benefits can be found by implementing smart healthcare. Monitoring devices will be more sophisticated; the doctor will manage patient easier; the quality of service will be increased. There is no doubt that healthcare is changing rapidly, and companies are investing every year in this system. According to (Deloitte, 2018) in 1999 for the scientist it was difficult to generate a draft of a human genome sequence. In a total took them five months and approximately 300 million \$. In nowadays with the improvement of technology thought IoT this report could be generated in a few days with less than 1000\$ and could drop in upcoming years in less than 1 \$.

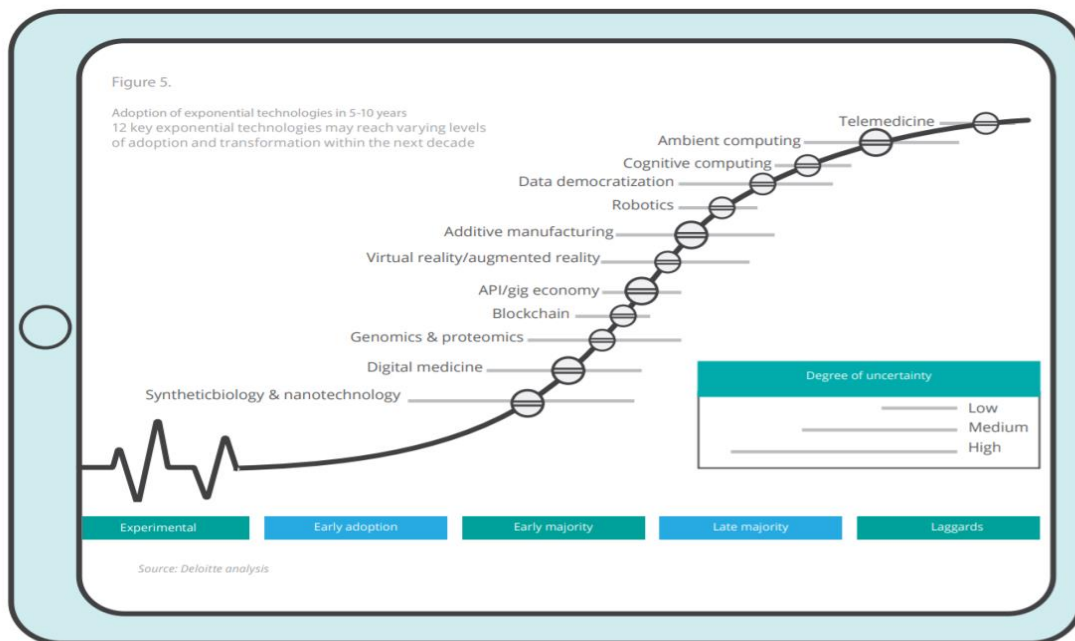


Figure 3 - Adoption of exponential technologies in 5-10 years(Deloitte, 2018)

According to the picture provided by Deloitte, in 5 years the whole technology in medicine will change and is going to be focused on 12 key points. Those 12 key points are categorized into three levels, low, medium and high. Synthetic biology and nanotechnology are going to have a high impact followed by Digital medicine, Genomics & proteomics, virtual reality, telemedicine, ambient computing, and additive manufacturing categorized as medium impact. The last category regarding the impact includes blockchain, robotics, and cognitive computing. All these changes will bring a better infrastructure for medicine and will serve the patient more quality and precision.

3.1.2 Current Situation in Smart Health

Many Countries all over the world are trying to switch the whole system from healthcare to smart care. The way how we deliver health services is completely changed from digital technology. Also, there are several changes that smart health will face in upcoming years. Deloitte, one of the biggest companies for professional services in the world launched a report regarding the current situation of this industry and the challenges that smart health is facing. According to (Deloitte, 2018) Global health will increase at an annual rate

of 4.1% from 2017-2021 and up to 1.3% in 2012-2016. Both aging and rising populations, developing market expansion, advances in medical treatments will drive spending growth

- Health care spending will continue to change, ranging from \$11,356 in the United States to just \$53 in Pakistan in 2021.

- Between 2016 and 2021 the life expectancy is estimated to increase by more than a full year and from 73 to 74.1 years. This will bring the number of people aged over 65 to more than 656 million, or 11.5% of the total population.

- Although the battle against infectious diseases is far from over, countries are making headway through improved sanitation, better living conditions, and broader access to health care and vaccinations. The estimated number of malaria deaths

- In 2005 the number of Aids-related deaths dropped in 2..3 million. AIDS-related deaths dropped from 2.3 million in 2005 and due to rollout treatment in 2015 will be 1.1 million.

- Rapid urbanization, sedentary lifestyles, changing diets, and rising obesity levels are fueling an increase in chronic diseases—most prominently, cancer, heart disease, and diabetes—even in developing markets.

- The most significant number of people living with diabetes in the world are located in China with 114 million and India with 69 million, respectively.

- In 2040 in the population of the world is expected to rise from the current 415 million to 642 million.

- In 2017, an estimated 50 million people worldwide lived with dementia and are forecasted that after 20 years this number will be doubled.

Even though all countries and companies are trying to switch the system in order to have a better service for patients, this report is focused on the key issues that the smart health industry is facing. Adding to this, below you can find those critical issues illustrated into a picture from (Deloitte, 2018)

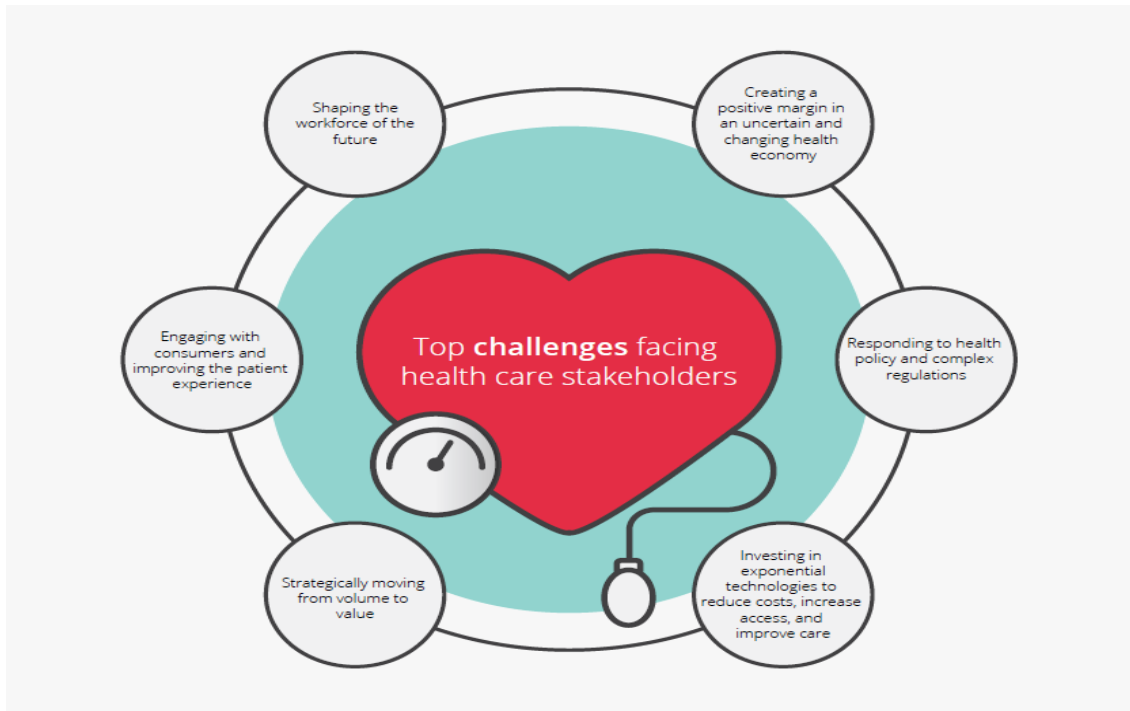


Figure 4 - Key issues in global health care (Deloitte, 2018)

As we can see from the picture, the challenges are divided into six key points. In the first point, creating a decisive margin, both public and private institution are facing declining margins for years, this due to the increase in the population and aging. In the second point, responding to health policy, smart health is facing policy and regulations to provide the patient with the best service. In the third part, this picture covers the investing section. This sector is significant for this industry. Changing the whole infrastructure needs investments that aim to bring new technology. The fourth part is focused on strategy; this section seeks to bring more quality in people's lives. In the last part, this report covers the importance of engaging with customers. Using the patient experience, satisfaction and feedback this part tends to be very challenging for both, public and private industries. Adding to this, a report launched from The Economist Intelligence Unit which for 60 years it has been a source of information on business developments, economic and political trends, government regulations and corporate practice worldwide (Unit, 2016) is focused on how much countries are spending on healthcare.

Healthcare spending (% of GDP)

	2012 ^a	2013 ^a	2014 ^a	2015 ^a	2016 ^a	2017 ^b	2018 ^b	2019 ^b	2020 ^b	2021 ^b
North America	16.4	16.3	16.5	16.6	16.7	16.7	16.7	16.8	16.8	16.8
Western Europe	10.4	10.4	10.4	10.4	10.4	10.5	10.5	10.6	10.6	10.6
Transition economies	6.9	7.0	7.0	7.0	7.0	6.9	6.8	6.9	6.9	6.9
Asia & Australasia	6.8	6.7	6.6	6.6	6.7	6.8	6.8	6.8	6.7	6.7
Latin America	7.0	7.2	7.1	7.0	7.1	7.1	7.1	7.2	7.2	7.2
Middle East & Africa	5.3	5.5	5.6	5.9	5.9	5.9	5.9	5.9	5.9	5.9
World ^c	10.2	10.2	10.2	10.4	10.5	10.5	10.6	10.6	10.5	10.4

Figure 5 - Healthcare spending (% of GDP)(The Economist Intelligence Unit , 2016)

Based on the data provided by the economist, in general, most world countries, tend slightly increase the amount of spending in healthcare. In the first place stand North America with constant expenditures from 2012 to 2021. In the second place in Western Europe with 10.4 in 2012, it is followed by Transitions economies in the third place. Asia and Australia together are placed in fifth place with average spending from 2012 to 2021 with 6.7 %. In the last three spots in Latin America with an average of 7%, followed by the Middle East and Africa with 5.7%.

3.1.3 Healthcare in the Czech Republic

The Czech Republic is located in the middle of Europe. Its capital and largest city, with 1.3 million inhabitants, is Prague. Over the last few years, healthcare has improved considerably by approaching high-standard countries. Life expectancy is an essential indicator for showing the current situation of healthcare and how it works. For a better overview of the current situation of the life expectancy let us see the following picture below.

Figure 1. Life expectancy has improved to just below the EU average

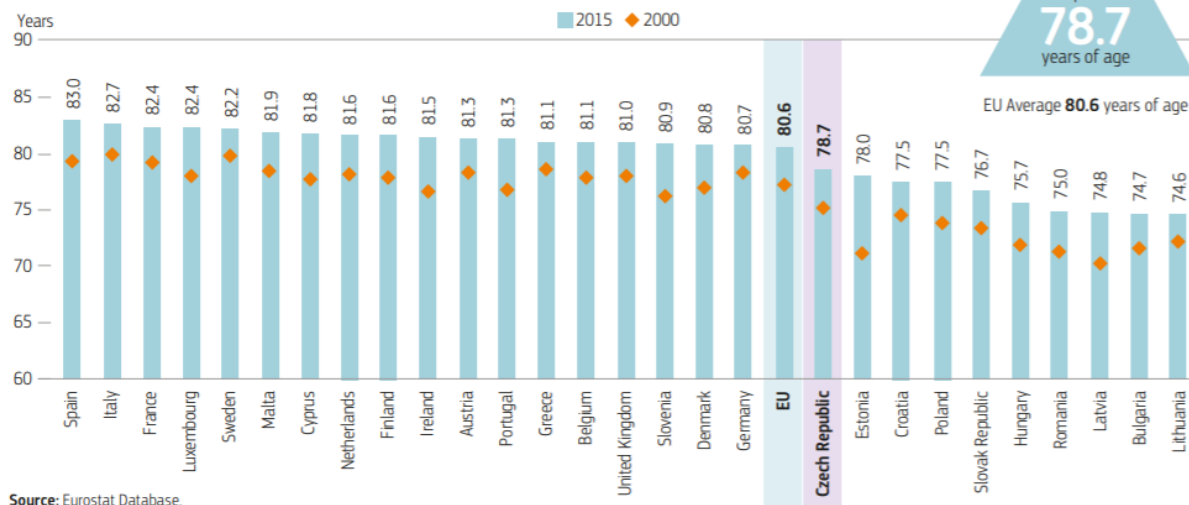


Figure 6 Life expectancy in the Czech Republic (European Commission, 2017)

From the picture provided by (European Commission, 2017) the life expectancy in the Czech Republic is 78.7 years of age, and it has changed from 2000 to 2015 by approaching the EU average. Adding to this, the most significant contributors to mortality are cardiovascular diseases followed by cancer. Furthermore, in the following picture provided by (European Commission, 2017) we will have a better overview of the current situation.

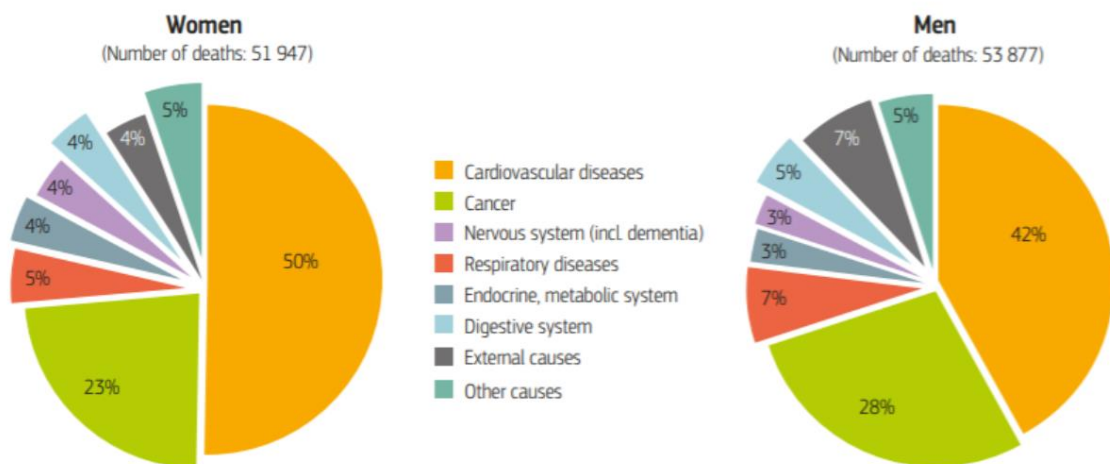


Figure 7 - The causes of death in the Czech Republic (COMMISSION, 2018)

Cardiovascular diseases lead the death cause with 50 % for the women and 42% for men followed by cancer 28% for men and 23% for women. Another cause is the nervous system with 3% for men and 4% for women. On the other hand, deaths from respiratory diseases cover 7% for men and 5% for women.

3.1.3.1 Efficiency of healthcare

Despite the significant challenges the Czech Republic is undergoing, of course, a significant focus on the health care industry is considered. According to the Public health expenditures in 2010 were CZK 291.956 million (7.96% of GDP). Indeed, the focus of government has been on improving public services, mainly on privatizing the hospitals in order to increase the level of services. Due to these packets, the indicators express an increase in efficiency. A key factor affecting the weakness of the primary care system is the increasing shortage of healthcare providers, especially in general practice. Data from 2011 and 2013 suggested that nearly 52% of patients who visited a Czech emergency department did so because primary care was not available, compared with an average of around 27% in the EU. (The Economist, 2018)

Another focus for the government is the expenditure on the healthcare system. In the following picture is the history of the health expenditure as a percentage of GDP from 2000 to 2016.

Country	2000	2005	2010	2016
Australia	7.6	8.0	8.5	9.6
Austria	9.2	9.6	10.1	10.4
Belgium	7.9	9.0	9.9	10.4
Canada	8.3	9.1	10.6	10.6
Chile	7.0	6.6	6.8	8.5
Czech Republic	5.7	6.4	6.9	7.3
Denmark	8.1	9.1	10.4	10.4
Estonia	5.2	5.0	6.3	6.7
Finland	6.8	8.0	8.9	9.3
France	9.5	10.2	10.7	11.0
Germany	9.8	10.3	11.0	11.3
Greece	7.2	9.0	9.6	8.3
Hungary	6.8	8.0	7.6	7.6
Iceland	9.0	9.2	8.8	8.6

Figure 8- Health expenditure as a % of GDP 200-2016 (The Economist, 2018)

As we can see from the picture above the government keep rising the expenditure from 2000 with 5.7 % till 2017 with 7.3%. Also, from the picture we can notice that from 2005 till 2010 due to the world financial crises the movement did not increase the expenditure significantly.

3.1.3.2 SWOT Analysis for Healthcare in the Czech Republic

In the report that (Fitchsolutions, 2019) conducted for healthcare in the Czech Republic a swot analysis was developed. Furthermore, this analysis is described in the following paragraph.

Strengths

The Czech Republic has a highly developed market for medicines where all brands are patented with the standard of the European Union.

Weaknesses

All businesses that want to be part of the Czech Republic market in terms of medical care will face intense competition. This due to the standardized prices that companies have set based on the products.

Opportunities

Increasing the level of spending with long-lasting potential has brought a new standard in the medical field. The Czech Republic is considered to be a significant potential in the field of biotechnology which meets the European standards.

Threats

The government will continue to control tight pricing policies. This pilot scheme is a collaboration between the government and hospitals. Also, other central European countries are considered competitive for medical products.

3.1.3.3 The future of healthcare in the Czech Republic

According to (European Commission, 2017), the OECD and the European Observatory on Health Systems and Policies, the Czech health care system could provide higher value for

money, clearly indicating that no successful implementation has yet been seen of a general replacement policy. Also, a March 2018 document published by the Ministry of Finance stressed that the medium-term sustainability of the Czech health insurance system is highly dependent on continued strong economic growth and is at risk if growth slows down. Based on the picture below, it is expected that the Czech Republic government will significantly increase investment in the field of medicine by giving a maximum focus.

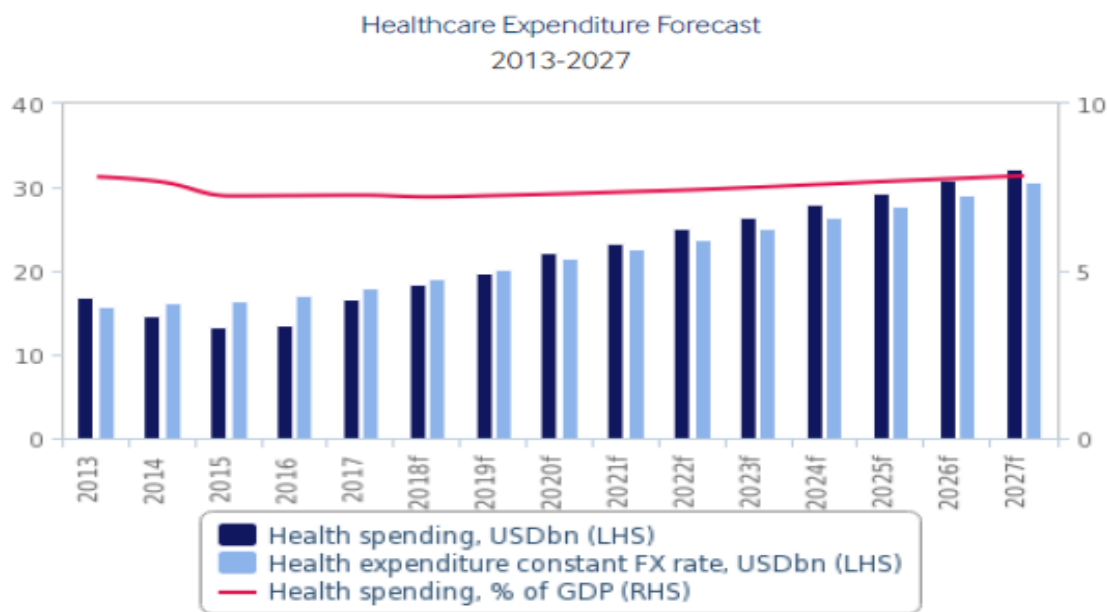


Figure 9- Healthcare Expenditure Forecast (Fitchsolutions, 2019)

Between 2017 and 2022, an annual Growth Rate Rate is forecasted to increase with 6.5%, or CZK 366.84 billion. Over the expected period of 10 years, health care will reach 620.07 billion CZK and in 2027 compound annual growth rate will increase by 5.4%. By comparing ten years, health care in 2017 was 7.3%, and in 2027 it will increase steadily by 7.8%

3.1.4 The Future of Smart Health

Replacing the traditional healthcare system is the main focus for all institutions, private and public. Many companies are trying to build a better future for the world and presenting the way and efficient for hospitals, homes, and institutions. For hospitals, that in our days is not providing the best service; a promising future is coming due to more innovative and more sophisticated medical devices coming from the smart health market. In 2020 according to (Aitken, 2015) the world's population will have more access to medicine, where over 50% of the world's population will increase doses by more than one. Also, \$ 1.4 trillion will be

invested in medicine, 29-32% more than in 2015. Furthermore, to have a better overview of the future of smart health let us look at the following picture below:

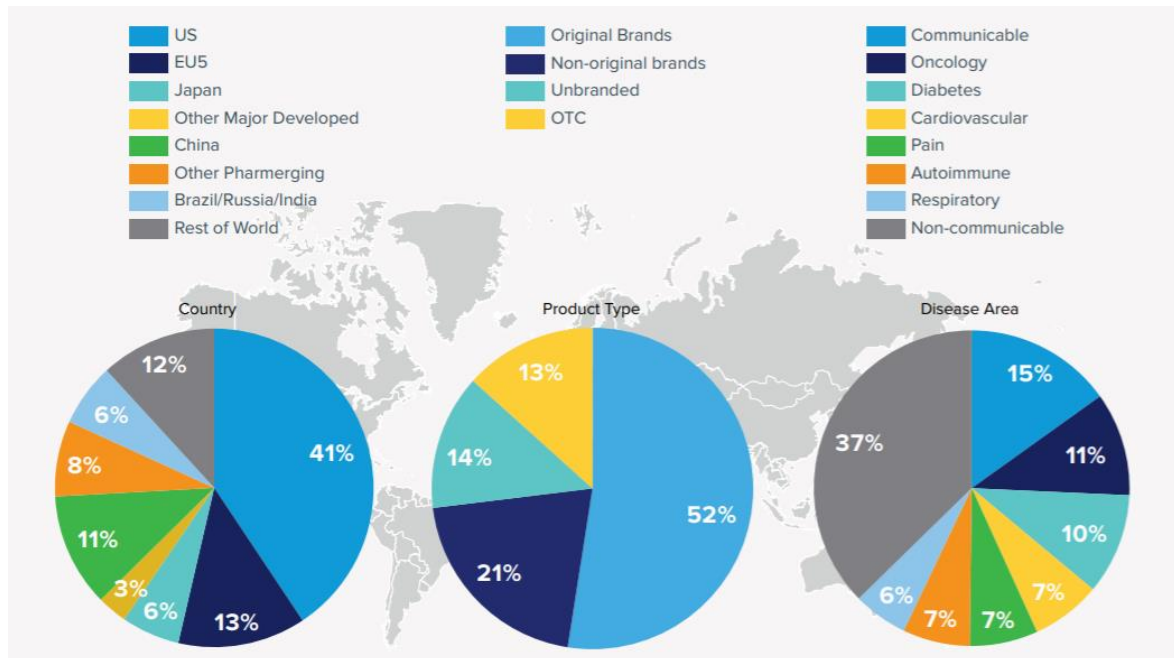


Figure 10 – 2020 medicine spending by geography, product, and disease (IMS INSTITUTE, 2015)

As we can see from the information above, the US will invest 41% in this industry, followed by Europe at 13%, China 11%. Brazil, Russia, and India will spend only 6% on healthcare. Regarding product type, countries will invest 52% for original brands and 21% in non-original brands. In the field of disease, the main focus will be on non-communicable with 37%, followed by communicating with 15%. Adding to this, countries and companies will try to improve and develop a new infrastructure to fulfill patient needs. According to (Deloitte, The future awakens Life Sciences and Health Care Predictions 2022, 2017) the future of smart health is very challenging. Adding to this, Deloitte predicted that in 2022 the situation would be:

- A new generation of wearable devices will be in the market, by monitoring the body parameters 24 hours.
- People will be able to manage their health with the help of mobile applications
- The technology used for medicine such as bio-sensing purpose will be cheaper and more sophisticated
- Virtual assistance will be adopted for older people

- The patient will be able to share the health condition with the hospital, using data sharing
- A system called Gamification will be able to help to understand the behavior of the patient
- The patient will be able to create or to be part of a shared group to share a medical experience
- Many people will use telemedicine as the first contact for a doctor

Another key indicator to improve patient health will be technology. This will bring many transformations in the health care system.

Transformation of healthcare through digital technologies

Digital conversion enables new strategies and services in healthcare, giving the opportunity to support more the patient. Among services, artificial intelligence and data visualization all these together will bring a new concept of health care. Wearable devices are developing with such rapidity that will serve the patient as the primary communication with the doctor. According to (Deloitte, 2018 Global health care outlook | The evolution of smart health care, 2018) in 2020 robots will take place as assistance by taking notes of the patient requirements automatically. Also, robots and artificial intelligence will play the role of a nurse by coordinating the patient activates; this will reduce the time consuming for the entire system. Communication will be covered by software that will be able to schedule and organize and support multiple methods such as voice call, secured messages, and alert notifications. All these functions mostly will serve as a back office. Biotelemetry will be present in every home to provide the patient with more care and instantly monitor the health. In hospitals, radio- frequency is going to optimize the use of sources.

3.2 Internet of Things

Over the last years, monitoring wearable devices have been developed to collect data and to transmit this information for medical purposes. In our day is the Internet of Thing is an

important topic; this is due to the influence that technology has in our lives. IoT it is not just a single technology but a concept that changes day by day, and it is going to evolve shortly. According to (Ali, Ali, & Badawy, 2015) to define IoT, it is not easy, but formally, it can be defined as the interaction between objects and the internet of things. IoT can create quick communication and make everything work together, such as wearable devices, cell phones, machines, and cars. Accordingly, IoT is divided into four categories (McRae, Ellis, & Kent, 2018)

1. The device must be capable of collecting and transmitting data: IoT devices need to exist in environments in which information can be collected and either sent to another device or directly to the Internet.
2. The device must have the ability to operate with action-based responses: IoT devices can be programmed to act according to conditions.
3. The device must have the ability to receive information: IoT devices must be able to receive information from the network.
4. The device must be able to support communication: IoT devices by nature belong to a network of devices that can communicate with each other through other nodes in the same system.

3.2.1 A brief story of Internet of Things

- According to ((UNICEF), 2015) In 1832 An electromagnetic telegraph was created by Baron Schilling in Russia.
- In 1926 Nikola Tesla in an interview with Collier's magazine:
"When wireless is perfectly applied the whole earth will be converted into a huge brain, which it is, all things being particles of a real and rhythmic whole.....and the instruments through which we shall be able to do this will be amazingly simple compared with our present telephone. A man will be able to carry one in his vest pocket." (postscapes, 2018)
- In 1999 For the first time the term of the Internet of things was introduced by Kevin Ashton

"I could be wrong, but I am fairly sure the phrase 'Internet of Things' started life as the title of a presentation I made at (Forbes, 2014)

- In 2008 the *first European IOT Conference* held when for the first time more than 50 companies launch the *IPSO Alliance* to promote the use of Internet Protocol (IP) The FCC voted 5-0 to approve opening the use of the 'white space' spectrum. (postscapes, 2018)

3.2.2 New Architecture of the Internet of Things

Nowadays IoT in bringing new ideas and solutions for different types of technologies. Regarding the data it is complicated to analyze it because of their complexity; this affects finding the information that may be useful to a company. On the other hand, data security has become a concern for health care. Nowadays there is a possible change of IOT architectures.

3.2.2.1 Big Data

This phenomenon is continually growing as organizations remodel their operational processes to rely on live data with hope to drive effective marketing

Techniques improve customer engagement, and to potentially provide new products and services. With the latest variations brought by the innovations of technology, many hospitals and clinics have created a new standard in terms of data exchange. Many inside and outside devices make it possible to gather information regarding the patient's health condition. In order to have a more specialized collaboration between patients and clinics, there are many challenges ahead.

- Multi-modal data: For clinics, it is essential that the data be structured in order to have easier access. Many devices make it possible to transmit the data but not in the right way, leaving defects and ambiguities. The formats of this information are different, ranging from images to pdf reports. This is due to older models of devices and sensors not suitable for dealing with such a function. Another concern is the distribution of those dates in different social networks that compromised their security
- Complex background knowledge: A medical report is critical because it contains accurate information about a patient's health condition. From these data, it is possible to diagnose a

disease and then perceive it for more specialized treatment. Also, these data are the primary indicator to complete a report regarding medical knowledge. Often the clinic faces the difficulty of processing large data files and sometimes it is impossible to analyze them due to the flaws this information contains.

- **Privacy:** Many laws and safeguards make data protection possible. These data containing information on the patient's health condition are classified as very sensitive. Also, from ongoing attacks on cyber attacks, often the infrastructure has not been enough to stop this phenomenon. For patients, this has led to uncertainty in the use of wearable devices, which makes this challenge a priority that needs to be changed.

3.2.2.2 Cloud Platform

Cloud computing is an increasingly popular paradigm for accessing computing resources. In practice, cloud service providers tend to offer services that can be grouped into two categories: software as a service, and infrastructure as a service. According to (Kulkarni, Khatawkar, & Gambhir, 2011) Cloud computing is the Internet cloud-based development, and use of computer technology computing Cloud serves to store all data and other services via the Internet. It is used to describe both a platform and type of application. Apps use powerful cloud server servers that set up applications or web services. Anyone who has access to the Internet and an appropriate internet connection can be part of the cloud platform with the help of a standard browser. According to (Accenture, 2019) those are the benefits of a cloud platform:

- Organizations can save more money due to the cost of the Cloud platform
- Cloud Platform gives you the ability to store more data
- You can access this data at any time without the need for a hard drive
- It is very flexible and comfortable other than other physical platforms

3.3 Wearable Devices

Wearable Devices are known as devices that can measure body parameters throughout the day. In addition to serving as intelligent devices, one of the other functions is the processing of data obtained from daily activity. These activities serve to provide a better experience for

the client. These devices have become part of our day and will continue to be such for a long time. The companies we have started to produce such devices of varying size, powerful sensors to provide the necessary information about the environment and your current state of mind regarding the body parameters. Also, these devices with Bluetooth or Wi-Fi communications systems give more detailed information about your emotional state, location, and actual health. There are many models of wearable devices. Such devices make it possible to measure body parameters and adjust tire based on daily activities. They also serve to follow the steps taken from one destination to another. All models can connect with wi-fi or Bluetooth in order to share data. Wearables are becoming widely used. According to (Huffingtonpost, 2017) Nowadays it is easier to have information about the current condition of the body. This thanks to the monitoring equipment. In 2018 the number of users reached 130 million and in the coming years is expected to increase. All of these data are collected from various devices such as a smartwatch, smart glass and wearable devices that target the same service. It is worth mentioning that professionals are more willing to use those devices rather than customers. Many such devices are in today's market that serves as accessories or as components for smartphones or computers. Devices such as Watch Apple, Google Glass are the first devices that were introduced to this gadget and immediately got an interest from consumers. Year after year, new designs are being introduced by adapting to different colors and shapes from many companies. According to (MICRO, 2017) There are three extensive categories that we can use to describe wearable devices:

- In Devices: The characteristics of In Wearable devices are their sensors, which make data processing and parameter measurement possible. These sensors are used more for monitoring purposes that serve to track daily activities such as sports and gyms. All this data is available online for users, and it can be downloaded in pdf format. Also, medical devices are included in this category, devices that measure heart rate, blood sugar levels, and many other parameters.
- Out devices: Unlike In devices, these devices can extract the information for other equipment. As an example are smartphones that makes it possible to find information from the internet for other devices, such as guides or manuals.
- 'IN and OUT' devices. The last category is a mix between those devices mentioned above. Nowadays we can find many types of equipment in the market that provides services based on the collection and extracting the information. These devices not only improve daily

activities but also allow us to exchange data with other devices as well. The features of these devices are the measurement of parameters, internet navigation, the use of GBS and the ability to use them for calls.

3.3.1 Current Situation of Wearable Devices

In our day's modern technologies are providing us with new inventions every day. This due to the increasing numbers of users all over the world. For a better overview, the following picture describes the number of connected wearable devices worldwide from 2016.

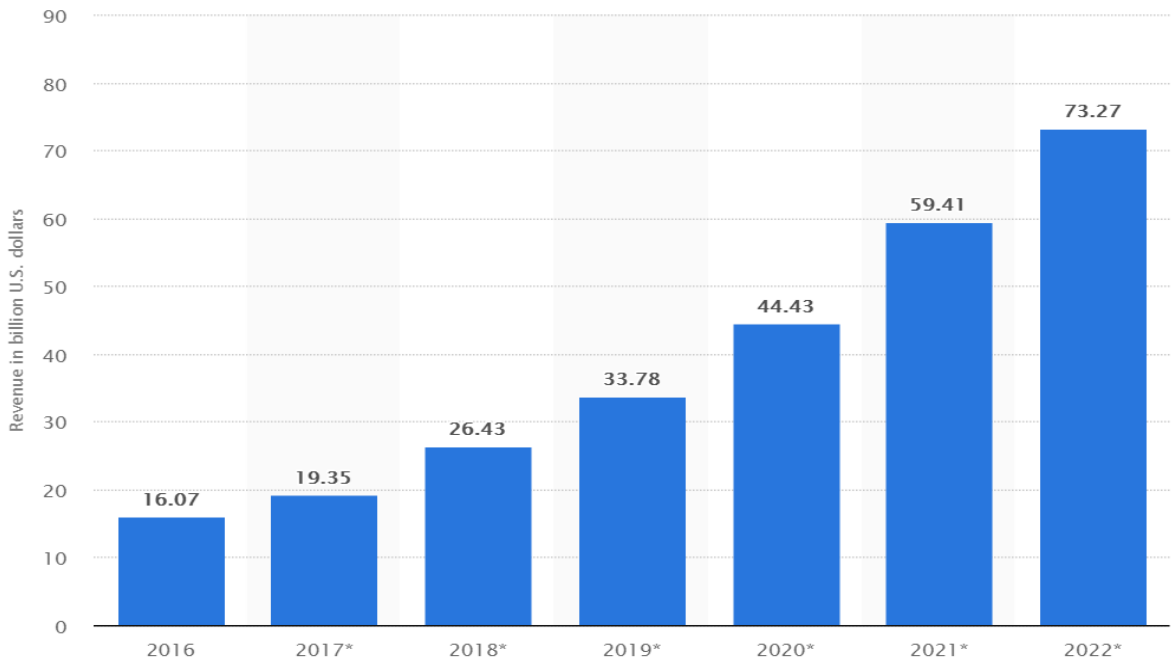


Figure 11 – Number of connected wearable devices worldwide from 2016 to 2022 (Statista, 2018)

According to (Statista, 2018) from 2016 numbers of users increased rapidly till 2019. In this report in 2016 customers all over the world spend 16.07 billion dollars, and in 2019 it is almost doubled. Also, it is predicted that in 2022 this value will reach 73.27 billion dollars. This shows how remarkably fast the market for wearables is currently growing. One of the primary functions in those wearable devices is measuring the body parameters such as blood pressure, heart beating and is considered as an effective way of monitoring the daily activities. There is a variety of these smart products that can measure body parameters or track daily activities.



Figure 12- Current situation of wearable devices [source: own]

ASUS Vivo watch BP

The Vivo Watch BP has multiple sensors to track many facets of your physiology. There is an accelerometer, dubbed the G sensor, for activity and sleep tracking, and has included a trio of sensors to deliver accurate heart rate and blood pressure monitoring. Also, this device uses imaging to detect heart rate, while a set of EKG sensors tracks blood flow using your fingertip and wrist. (Black, 2018)

Omron HeartGuide

Omron's heartguard is a device that has the focus of measuring blood pressure. This device is able to transfer all the daily activities, monitored parameters such as the blood pressure to another smart device or is possible to download it in a pdf format and share it with the doctor. (Omron, <https://omronhealthcare.com>, 2018)

Garmin Forerunner 935

The Forerunner 935 is a very sophisticated device that provides information on physical health. The product's specialty is monitoring heartbeats throughout the day. Another feature is that this equipment works like a barometer, altimeter, and compass. Garmin claims that with this device it is possible to process data on daily activities and then degrade the clients

to let them know if they have passed their daily expectations. This equipment also works for sports such as cyclists and swimming (Mitter, 2018)

Zephyr BioPatch

Zephyr BioPatch is a device other than the ones mentioned above. The product's specialty is that it can be linked directly to the chest and makes it possible to monitor the heartbeat continuously. Also, this device serves to measure the level of breathing, daily activity. All data is sent in real time to doctors in their smartphone. For an anomaly, this device allows remote monitoring and timely intervention of doctors. It also creates an alarm if the condition of the patient is acute. (Mitter, 2018)

All those devices above have as a common purpose by providing service regarding the health condition to the customer. However, none of them are sharing this data to the hospitals.

3.3.2 Classification of Wearable Devices

Wearable devices are very complex devices that can be classified based on sensors, size, function, appearance, and other parameters.

Smartwatch

Smartwatches are devices similar to smartphones that have the function of providing telephone services such as call, SMS or video chat. Also, a smartwatch contains applications that enable heart monitoring and day-to-day activities. Another feature of this device is its access to the internet and the content of the sensors. Within a smartwatch, there is a sensor that serves as a GPS to show the exact location, sensors that serve to measure the outside temperature. Many companies produce this product; such as Apple, Samsung, and Google (Stroud, n.d.)

Smart glasses

It is a device that aims to orient the permeant in uneven situations. With this device, it is possible to navigate online, have information on current health conditions, route navigation

and is possible to send messages in text format. Another feature of this device is the leaves that serve to enlarge the texts by calculating the distance in order to have a clearer picture. This technology is very sophisticated and contains a series of sensors. (Matthews, 2018)

Fitness tracker

This technology is different from the other equipment mentioned above. A wrist-worn device serves as a body massager during a sporting activity. Parameters such as footsteps, heartbeat, sleep duration, distances described and current body condition. This device is connected to a smartphone through Bluetooth. Another feature of this device is the ability to download dates on a smartphone. (Using Fitness Trackers and Smartwatches to Measure Physical Activity in Research: Analysis of Consumer Wrist-Worn Wearables, 2018)

Smart clothes

Clothes monitoring was introduced in 1980. Nowadays this technology is much more advanced. Smart clothing is based on sensors that make data collection possible in terms of body parameters. With these sensors, parameters such as heart rate, body temperature, and current muscle status. Then these data are transmitted to the smartphone via Bluetooth. (Birringer, et al., 2009)

All of these wearable devices mentioned above have the purpose of measuring the parameters of the body in different formats. What is important to note is, what happens to all this data after a daily activity. Where do these data go and can they be used by hospitals as a safe source of information? Let us consider a simple scenario: If a user who has collected all the daily data and at some point, they suffer from an anomaly. Would the information collected from the wearable devices be descriptive enough for the doctor to take action? Also, would the hospital recognize this information as a safe source? In the article that (Sung, 2018) wrote about the difficulties of getting out the data in the format of RHR (Electronic health record). For some wearable devices in order to have an electronic health record, the only way to get this information is to contact the manufacturer directly. Another way is by using an application dedicated to this wearable device, but still, even here there is no communication with the hospital.

3.3.3 Wearable Medical Device

There are many definitions of medical wearable devices. For these purposes, these devices have to monitor body parameters and improving the lifestyles of individuals. Using these devices, patients in need can perform examinations, analyses and other tests that serve to give an accurate conclusion. Recently many devices have been produced that have the same functions. These devices use sensors to analyze body parameters. Also, another feature of these devices is data processing, by tracing the daily activities more accessible. These sophisticated devices can monitor heart disease, diabetes, and long-term desires as well.

Sensors of Wearable Device

There are many devices in the market today that has the function of measuring body parameters. These measurements are made possible using sensors which are installed inside the wearable devices. These sensors are also essential components for better performance. There are many types of sensors that have different features from each other. Here are four types of sensors that can be found on wearable devices: environmental sensors, biosensors, location tracking sensors, and other sensors.

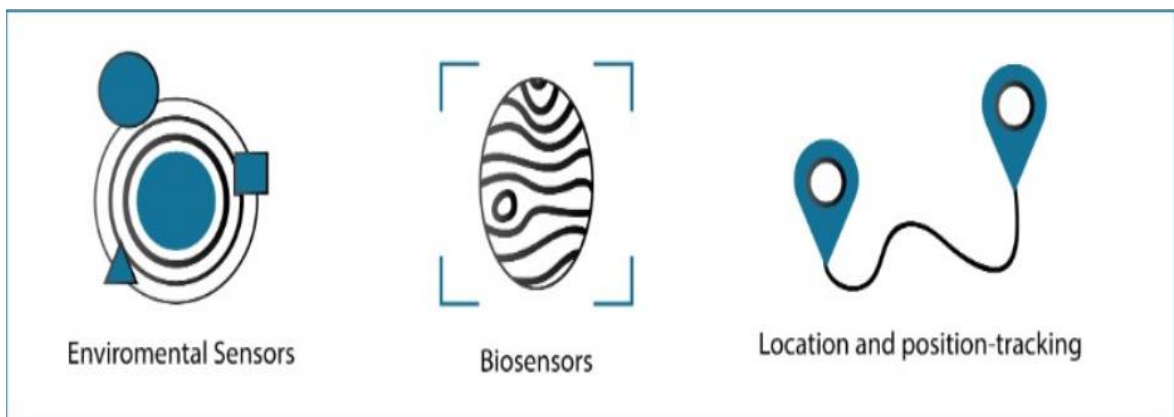


Figure 13- Sensors of the wearable device[source: own]

Environmental sensors:

According to Environmental information can help provide relevant contextual information for improving the sensitivity and specificity of signals derived from the sensors that directly measure motion. For example, high levels of pollen, dander, mold, or dust may lead to exacerbation of asthma that can change mobility patterns. More broadly, environmental

sensors can detect anomalous situations that may give rise to unusual behavior. Sleep patterns in older adults with neurodegenerative disorders can be impacted by high-intensity environments where there are changes in lighting, from beeping of a battery in a fire alarm that needs to be replaced to rapid changes in the temperature and humidity and can, in turn, change daily mobility patterns.

Biosensors:

According to (Darsanaki, Azizzadeh, Nourbakhsh, Raeisi, & Aliabadi, 2013) Biosensors can essentially serve as low-cost and highly efficient devices for this purpose in addition to being used in another day to day applications. The biosensor is a device that consists of two main parts: Bioreceptor is a biological component (tissue, microorganisms, organelles, cell receptors, enzymes, antibodies, nucleic acids) that recognizes the target analyte. Another part is a transducer, a physicochemical detector component that converts the recognition event into a measurable signal. The function of a biosensor depends on the biochemical specificity of the biologically active material.

Location- and position-tracking

Location- and position-tracking sensors (i.e., GPS, altimeter, magnetometer, compasses, and accelerometers) are the most common type of sensors on wearable devices, such as activity trackers, smartwatches, and even medical wearables where they are used to check the physical activity and health of patients. A GPS module is a three-axis sensor used in spatial navigation that can determine location, altitude, and speed at any time and in most weather conditions.

3.3.4 Values and Risks of Wearable Devices

Wearable devices are becoming essential partners in our life recently. Also, those devices can guide to track daily activities. However, not always those devices can fulfill our needs. Like any device that is in the market or is being designed, there are many questions about the functions. Also, another concern is the advantages and disadvantages of these products. According to (Humavox, 2016) Advantages of wearable devices are:

Staying Connected: These devices serve to connect with any other smart product, like the smartphone of any brand. With this device, it is possible to answer incoming calls, write and send an SMS, or navigate to the internet. It is also possible to measure body, outside temperature and to control other smart parameters from a distance or remotely. With the help of some sensors, it is possible to track the distance between one point to another.

Data Accuracy: Health is a priority, and many insurance companies are thinking of offering wearable equipment to monitor body parameters during sports activities. By using these devices, it is possible to monitor the parameters online, by adjusting it with your profession. It is also possible with these devices to prevent a cardiac attack or other risks that can complicate the health. By the end of the day, it is possible to download or send another device to save.

Efficiency: Wear devices are designed to provide safety and efficiency in our lives. Another feature of these devices is the ability to track GPS tracking for tracking other devices. With this GPS you can also navigate the map to find the road more smoothly and efficiently. Another feature is the information that can be obtained from various applications regarding the traffic situation

Given the possibilities that wearable technology holds for medicine, it is no wonder that information about the subject is on high demand. According to (Peltola, 2017) since healthcare wearables continuously collect the user's personal health information in real time, and individual's personal health information is more sensitive than other types of information such as demographic and general transaction information healthcare wearables should be re-graded as a high privacy concern product. Therefore, the main concern is divided into three categories, Data privacy, Connectivity, and Functionalities.

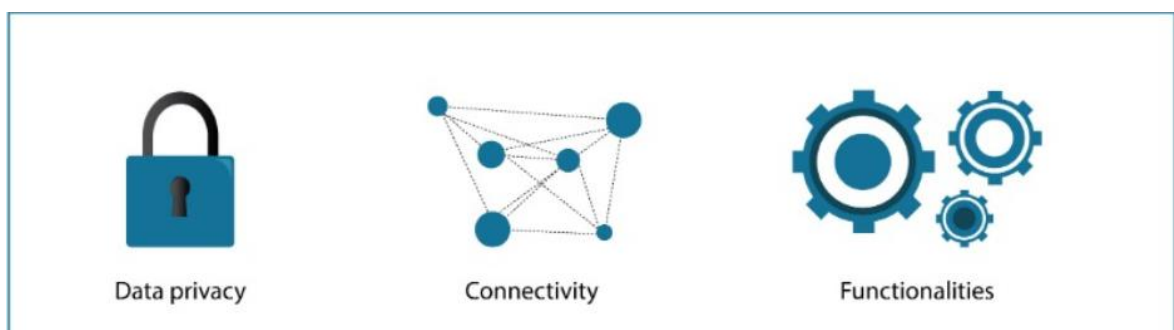


Figure 14- Concerns of the wearable device [source: own]

Every time you use a service, buy a product online, register for email, go to your doctor, pay your taxes, or enter into any contract or service request, you have to hand over some of your data. According to (LOU, 2010) authentication is a security service that can prevent data injections. Another concern is confidentiality; this can bring to the customer data leaking during the storage of the information and can compromise the security in this device. Connectivity is among the main issues that customers are questioning recently. Several wireless communication systems deal with the specific issues of body-centric communication using a device like a radio terminal placed on the skin surface of the human body. Short battery life has been one of the major challenges of wearables.

3.3.5 Electronic Health Records

Electronic Health Records are electronic versions that serve to preserve all data taken from body-parameters monitoring devices. With this service, the health care system claims to increase the quality of services significantly. Electronic Health Records now are part of wearable devices and can be accessed through dedicated software. Also, what is more important, in order to prevent any cyber attack of these sensitive data, many governments have introduced special legislation requiring the use of electronic records.

Definition

The electronic health record is a digital version of the paper charts that includes all the medical history of the patient such as heart rate, blood pressure, level of oxygen in the blood, medications and past medical history that can be established only if the electronic version. (Garets, et al., 2006)

The history of electronic health records

Healthcare system has undergone many changes year by year. This is due to the influence of the technologies in this industry. In our days the electronic health record is an effective way of tracking all the medical history. However, according to (Marquez, 2017) the history of the electronic health record begins in the middle of 1960s Lockheed developed the first electronic system. After this innovation in the 1970s, the government started using this technology as a pilot program for the Department of Veteran Affairs in the US. By the 1980s

more clinics started to use HER as a medical practice. The complete history of HER changed in 2004 with the creation of Office of the National Coordinator (ONC). In 2005 President Bush said in the National Institute of Health “We have got a 21st-century medical practice but a 19th-century paperwork system. Electronic medical records are going to be one of the great innovations in medicine.” (Seymour, 2014) Today this technology is used as an essential feature in wearable devices.

The impact of Electronic Health Record

Healthcare always has been a priority in our lives, ranging from daily activities to hospital services. With the constant influence of technology, it has become easier to monitor and track the body parameters. Adding to this, according to (Washington, et al., 2013) a survey was conducted in 2012 by the Department of Health and Human Services, as a conclusion with the implementation of the HER hospitals admitted that they received 3.1 billion dollars in payments. In the article that (Gallagher Healthcare, 2018) wrote about the transaction made from paper to electronic health record. Here are the benefits of the HER according to Gallagher Healthcare:

- **Improved Quality of Care:** By using digital services, it is much easier to read notes of an electronic health report compared to a doctor's handwriting. In this way, misinterpretations are avoided, and the quality of service will increase.
- **Convenience and Efficiency:** Using a digitalized service, medical staff can manage the time more efficiently without having to spend hours on medical papers.
- **Saving Space:** Electronic data can be stored on hardware or on various cloud platforms to enable efficient access. This eliminates large data storage cabinets and also expands office spaceflight. By digitizing, these data can be accessed at any time and any moment.
- **Patient Access:** With HER systems it is possible to access data from patients at any time. Through this interface, it is possible to view the history of medical reports anytime
- **Financial Incentives:** Using a security certificate, it is possible to pay online every HER issued by medical institutions.

Disadvantages of Electronic Health Record

When it comes to technologies, it should be considered the disadvantages in order to avoid any type of misunderstanding. According to

- Setting up and maintaining the electronic health record is expensive
- By using this technology, the clinic emphasizes more on billing rather than providing an excellent service to the clients
- Systems are vulnerable to cyber-attacks; this sensitive data might fall into the wrong hands
- Not all doctors have access to computers; this can bring to a impede the doctor-patient relationship

3.3.6 Future of Wearable Devices

Much progress has been made about wearable devices since they were first introduced to the general public. Year after year, the technology industry brings radical changes in the field of medicine, giving hospitals the opportunity to have a more qualitative service. There are many products on the market that are aimed at improving the lifestyle. These products not only become part of our lives but also a certain element that gives us the ability to monitor body parameters in 24 hours. However, how will the future of these devices be? Will the industry continue to produce more sophisticated equipment? How will the future of the Healthcare system be?

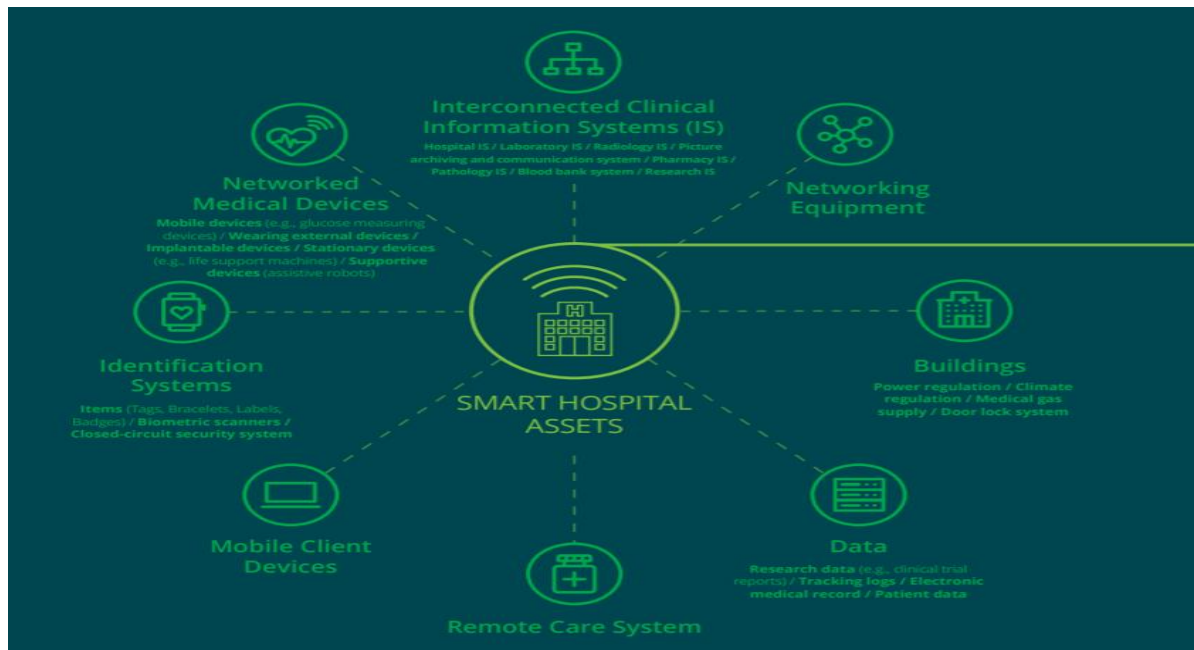


Figure 15- Future of wearable devices (Deloitte, 2017)

According to (Deloitte, The future awakens Life sciences and health care, 2017) the whole industries will be more focused on the health care system, being more specific in smart hospitals. Also, this article writes the importance of connecting all components such as smart building, network infrastructure, remote care system to provide a better service that will focus on smart health monitoring. Starting from Smart buildings, shortly building will communicate with each other, will share the current situation of the patient from the house to hospital. The network will be the central connectivity, providing the best and secure connection. All devices, such as wearable devices will be connected with the hospital, by sharing the data and the current situation of the body parameters. 481/5000 Another innovation, it will be the collaboration of clinics with each other; in this way, it is easier to diagnose patients and provide the appropriate medical treatment. This unification will be made possible by the advanced network infrastructure that aims to keep the data safe. All the equipment that will be connected to the hospital will initially pass through an authentication test, thus avoiding all security strains. Also, in the report that (ANALYTICS, 2018) did, has forecasted that the companies would be more focused on the health care system.

4. Practical Part

As mentioned in the objectives and methodology chapter of this thesis, this practical part includes two main goals: First, the design and the implementation of a survey which scope is to help understand the market better and the possible interest of different people, with different demographics and behavioral background. The second goal which is covered in the practical part is the real design and the prototype of this new product recommendation.

4.1 Survey design and implementation

This survey is designed with the purpose of including as much as possible in understanding the market needs when it comes to health wearable devices. It was completed from 90 different people, and it was shared via different mediums like email, social media, amongst colleagues. The people who have completed it are chosen randomly and having such a significant sample; they have different demographic characteristics and different approaches and interest levels when it comes to the usage of wearable devices designed for the health care solely.

The survey, as a best practice and recommendations, is designed and formulated in such a way that it makes it clear and understandable the reason behind it and why it is of primary importance in filling it. The tool used for creating it, is Google Form, due to its usability, good technical performance, free usage and easy to understand. It includes a short description at the top of it of what, and why so that everyone can understand what they are filling and why. Since this proposal is part of a master thesis written for a Czech University, the scope is to target as many people living in the Czech Republic as possible. The first section includes questions related to *demographical information* about each participant. As mentioned above, the scope is to understand the Czech market, so there is a question whether the person lives here or not. Other questions include gender split, age categories, education categories, and employment.

The second section includes question-related to *Understanding the current situation* and usage of the wearable devices. This is needed to get an overview of how people from different categories are using their wearable devices if they are using them at all. The third section involved a more profound understanding but *exploring the market*. Direct questions

are being asked to the participants on how they would feel and what their approach would be in introducing this new model of monitoring health device. The table below includes all the questions, with the possible answers on the right and the type of question it is. There are 17 questions in total which belong to different sections.

4.1.1 Analysis of the questionnaire results

As mentioned above, this survey aims to target people living in the Czech Republic, as the proposal for this new prototype will be done here. However, from the pie chart below, the participants, due to the way the questionnaire was shared (mostly via social media), are 91% from the Czech Republic and 9% from other countries. This means that they are 82/90 who live in the Czech Republic. Even if the targeted market is here, all the following analysis will consider everyone as there are only eight people not living here, a number that does not affect the statistic much.

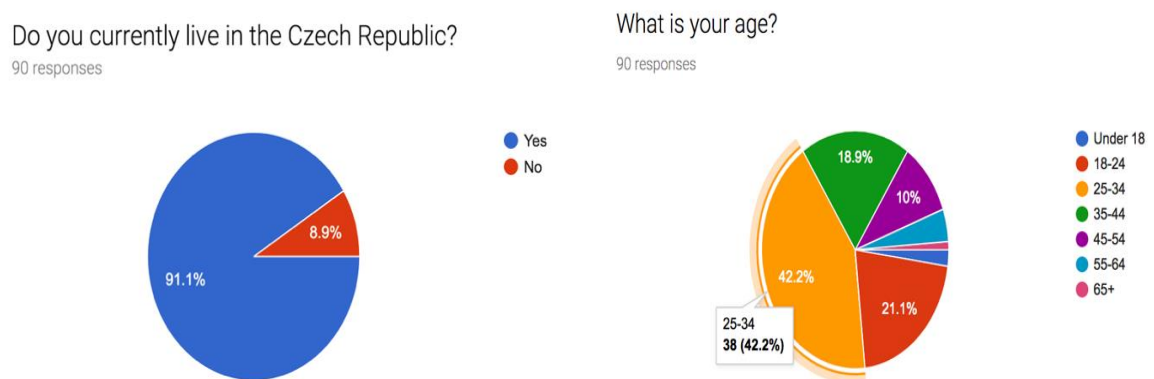
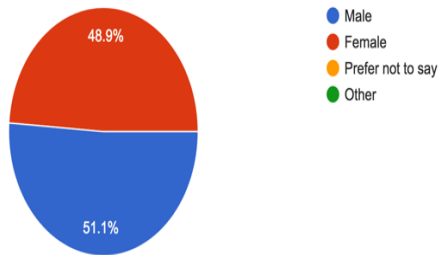


Figure 16 Country and age category distribution of participants [source: own]

From the age distribution, the highest volume of participants is age 25-34, followed from 21% who are between 18-24 and 19% who are 35-44. From this 42% of the age 25-34, 21 participants are female, and 17 are male. Also, from the second pie chart below, it is evident that most of the participants have a master's degree.

What is your gender?
90 responses



What is your education level?
90 responses

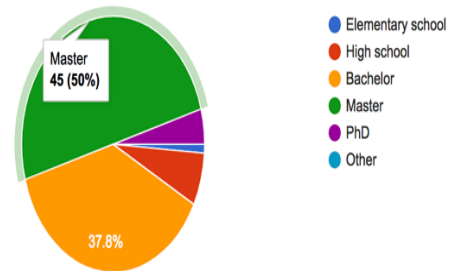


Figure 11- Gender split and education level categories [source: own]

Analyzing the remaining demographic information, 50% of the participants are employed full-time and from further analysis developed aside, 30 people from all participants who work full-time, have a master’s degree. The questions related to demographic information are 5 in total, and their results will be further discussed in combination with the questions from the other sections.

What is your current employment status?
90 responses

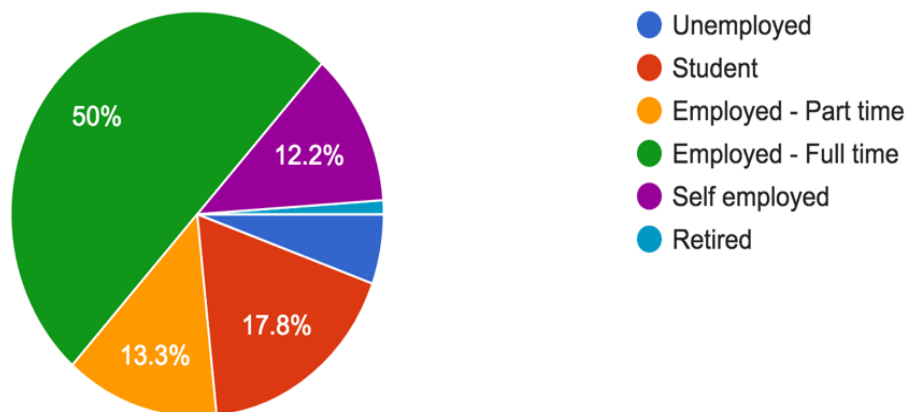


Figure 17 Educational Level Distribution [source: own]

Understanding the current situation

From the results, 58% of the people do use a wearable device, and 42% do not. This translates in 52 participants out of 90 who have a wearable device and 38 do not. From the 52 who use such device, the split among men and women is 50%, so 26 of them who use it are men, and the same for women. The same can be stated from the second graph below on the right when asked the type of wearable device they use in case they have one. From 52 of the people who actually have a wearable device, 22 of them use the Fitness Tracker, and 29 of them use the Smartwatch. Only one of them reported being using a medical wearable device. When asked further, the person stated that the watch had also other features related to sport, so that would be moved to the generic Smart Watch category.

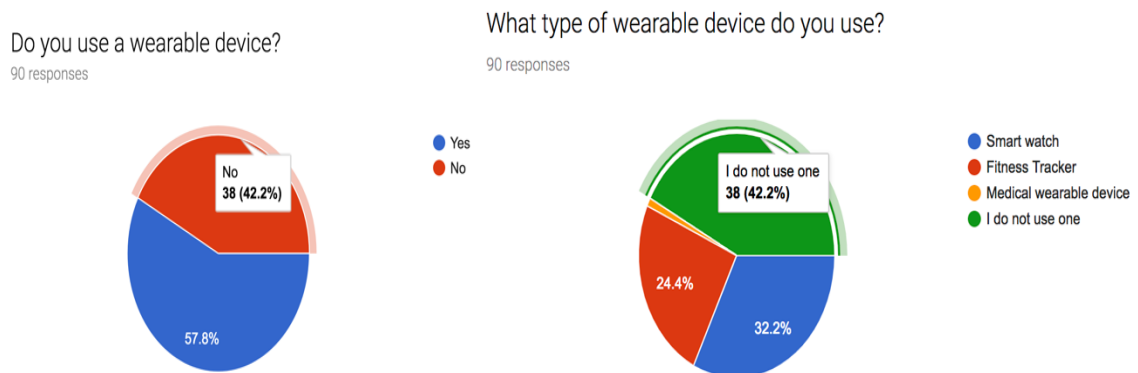


Figure 18 Usage or not of the wearable device distribution and type of it [source: own]

When asked for what purpose they used their current wearable device, the possible answers are shown below:

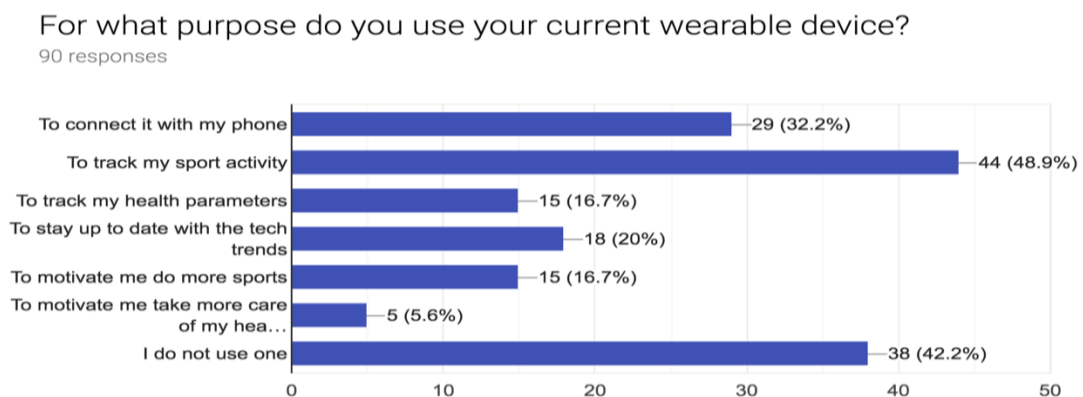


Figure 19 Reason for using a wearable device [source: own]

Most of the participants have chosen *To track my sport activity* as the main reason for using such a device, following with 32% of all participants who have chosen *to connect it with my phone*. From all the 52 people who do use one, only 3 use them for connecting to the phone only, 13 to track the sports activity only and only 2 to track the health parameters as the sole reason. The remaining 34 people use such a device for a combination of two or more of these reasons.

The last graph below helps to come to the conclusion that most of the participants who have a wearable device are at an average level satisfied with their product, following with 18% of them who states that they are far above the average satisfied. The next section tries to cover a deeper understanding and exploring the market.

Does your current wearable device fulfill all your necessities?

90 responses

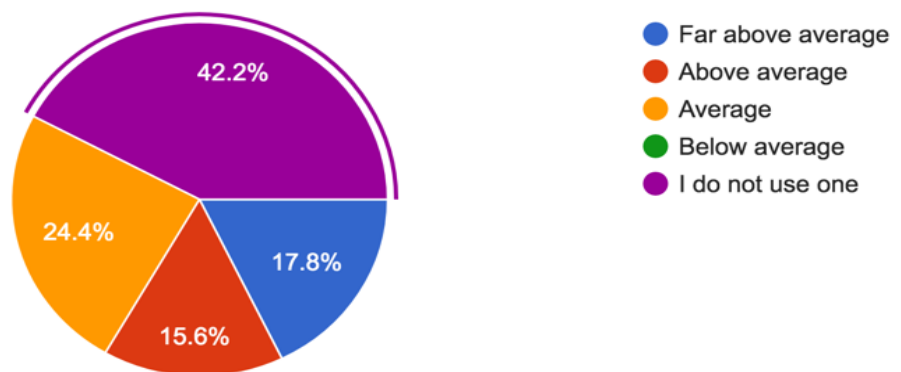


Figure 20 Satisfaction level from the current device [source: own]

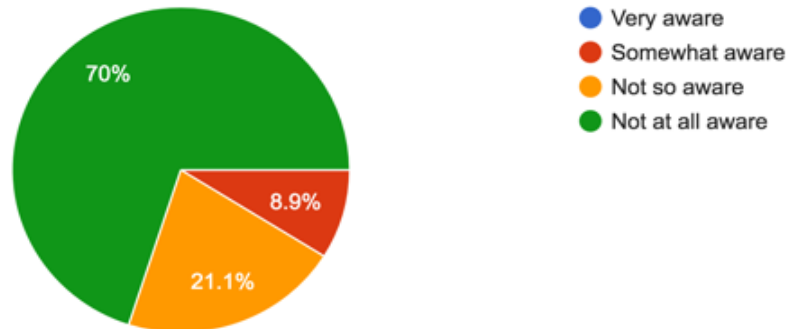
Exploring the market

When trying to understand and explore the market, in order to get a full picture of the possible interest of the people in this new device, the first question to ask is whether or not they are aware of any other existing device which is dedicated to health care only. From the responses collected, 63 out of 90 participants were not at all aware, 19 declared to be not so aware, and only eight responded to be somehow aware. From this result, the understanding

is that the population sample took into analysis has almost no information related to a device with health care features only.

Do you know any wearable device that is dedicated to healthcare only?

90 responses



Would you consider important using a wearable device only for medical purposes?

90 responses

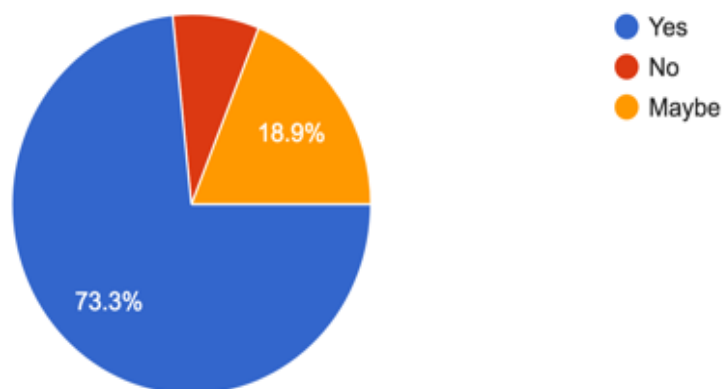


Figure 21 Knowledge and interest in health watch device [source: own]

In addition to this, 73% - 66 participants responded that they consider essential the usage of such a device. The remaining part stated that they would not be interested or maybe, for the sole reason that they would prefer to have these functionalities integrated with other functionalities as well. Whether as a separate device or connected to multiple functions device, the whole population sample expressed an interested and importance in having a health watch device.

The bar chart below shows the share of responses of what would be the most critical features(features) for them to have in this newly proposed device. 77 out of 90 participants

said that the *Monitoring of the body parameters* is essential for them. From these 77 people, only 6 chose this as a solo response, as the other ones combined it with one of the other alternatives too. This gives a better understanding of the interest of participants, and a conclusion can be drawn that there is a massive interest in a health device mostly for Monitoring body parameters, but also for Sending a direct alert to the hospital in case of health emergencies. Only 5/90 people responded that they are not interested in neither one of them, but rather to completely other features not related to health care.

We are currently introducing a new prototype for a wearable device. Which of the following features do you think is more important to have?

90 responses

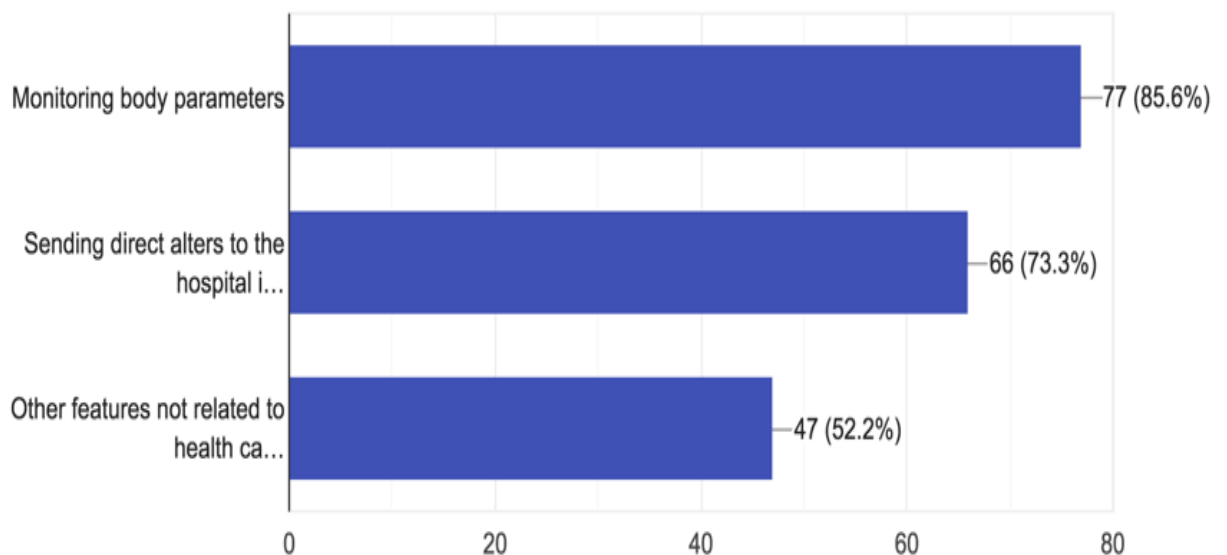


Figure 22 Important features to have in a new wearable device proposed [source: own]

When trying to explore more aspects and interest from the people, they were asked if they agreed that this new prototype would have a positive impact on maintaining real-time information on their health parameters. Between 61% who would strongly agree and 28% who would agree, there are only ten people in total who were either neutral or would strongly disagree. What is essential, is that 50% of the participants who would rather strongly agree or agree, were female and the other half male. This gives an understanding that both genders were equally interested in the functionalities being proposed.

Using a monitoring wearable device has a positive impact on maintaining real-time information on your health parameters.

90 responses

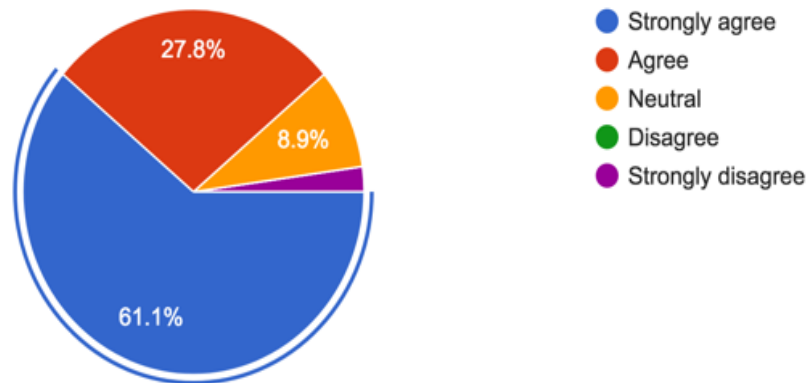
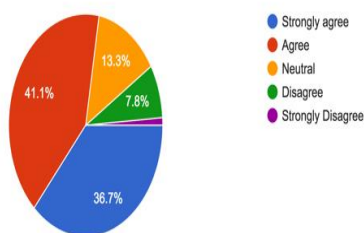


Figure 23 Feature 1 of the proposed health watch [source: own]

People were then asked whether they agreed with the intention of this new product to improve the first-aid rate from the hospitals in case of emergencies and how much they saw this doable. From a total of 90 people, only 70 of them rather agreed or strongly agreed. The remaining ones were either neutral or disagreed at this possible achievement. There is a reason of this, as it is clear that not all the technical details and functionalities can be explained within one questionnaire so not having the right information often makes people have disbelief in something new being offered.

Using a monitoring wearable device will improve the first aid rate from the hospital in case of an emergency.

90 responses



Using a wearable device dedicated to health monitoring will reduce the short-term costs of medical assistance.

90 responses

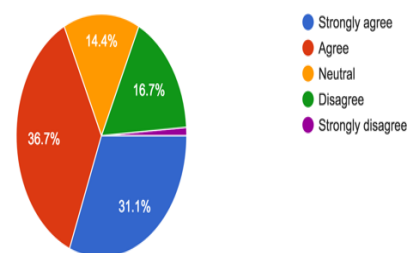


Figure 24 Possible improvements proposed [source: own]

The second pie chart above on the right gives the response rate on whether the participants agreed or not that this new device could reduce the short-term costs of medical assistance. Only 68% of the sample either agreed or strongly agreed with this vision which translates to

61 people in total. The conclusion drawn is a misbelief due to the lack of information which will be covered in detail in the next subchapter of this practical part.

There was also a question related to how they would be willing to share the data with the hospital so that the hospital could access real-time information and alerts in case of emergencies. Only 68% said yes, which means that 29 people were either reluctant or hesitant to share their data. This also makes sense, as the awareness for data sensitivity and protection has increased exponentially and has made people more aware of how to share their data. To get a full picture of how data sharing and security will work, this will also be covered in the next subchapter. The response rate on this question is shown below, left chart.

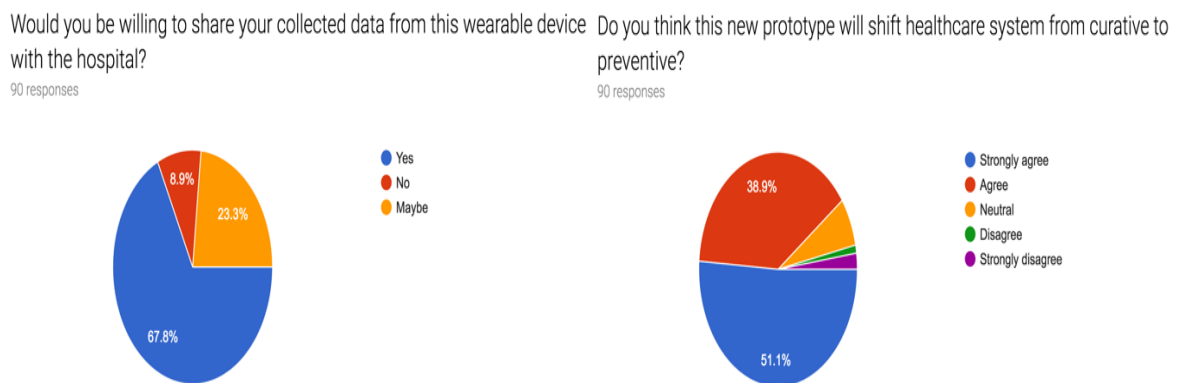


Figure 25 Last features proposed [source: own]

Last, the final question covers the primary objective of this new health watch which is to shift the healthcare and smart health system from curative to preventive. Eighty-one participants responded that they either agree or strongly agree and only 10% was disbelief. The ones who disagreed or were neutral are the same people that were also reluctant for each of the features described previously. What is also important, is the fact that from these 81 participants, 64 of them would use a health watch dedicated only to health care. This motivates to write the next section which will cover and explains all part of the design, functionalities, and securities.

4.2 Design of the prototype proposed

Nowadays health care is one of the main concerns for us. To have proper treatment, patients are willing to try all services provided by hospitals and clinics. Since traditional health care is not able to fulfill everyone's need having a different infrastructure is more than needed. Based on the results from the questionnaire it is clear that there is a gap between wearable devices and hospitals. Also, a wearable device dedicated only for medical purposes is missing in the current market. This thesis will propose a new solution by designing a wearable device only for medical purposes. This device will be able to monitor body parameters such as blood pressure, level of glucose, heart rate and level of oxygen by using sensors. By monitoring and gathering the information needed, this device will share all the data with the hospital by using different types of connectivity and storing them in the cloud platform. The goal of this wearable device is to shift the healthcare system from curative to preventive.

4.2.1 The new prototype

This wearable device will be dedicated only for medical purposes and will have as a focus measuring the parameters of the body and sending all this data to the hospital by using different types of connections. Powerful sensors will measure parameters such as blood pressure, heart rate, level of glucose and level of oxygen. By the end of the day or in case of an anomaly this device can send a report in the form of alert to the nearest hospital. In this case, the user will receive the first aid with the proper medicine. In the following page is the prototype proposed.

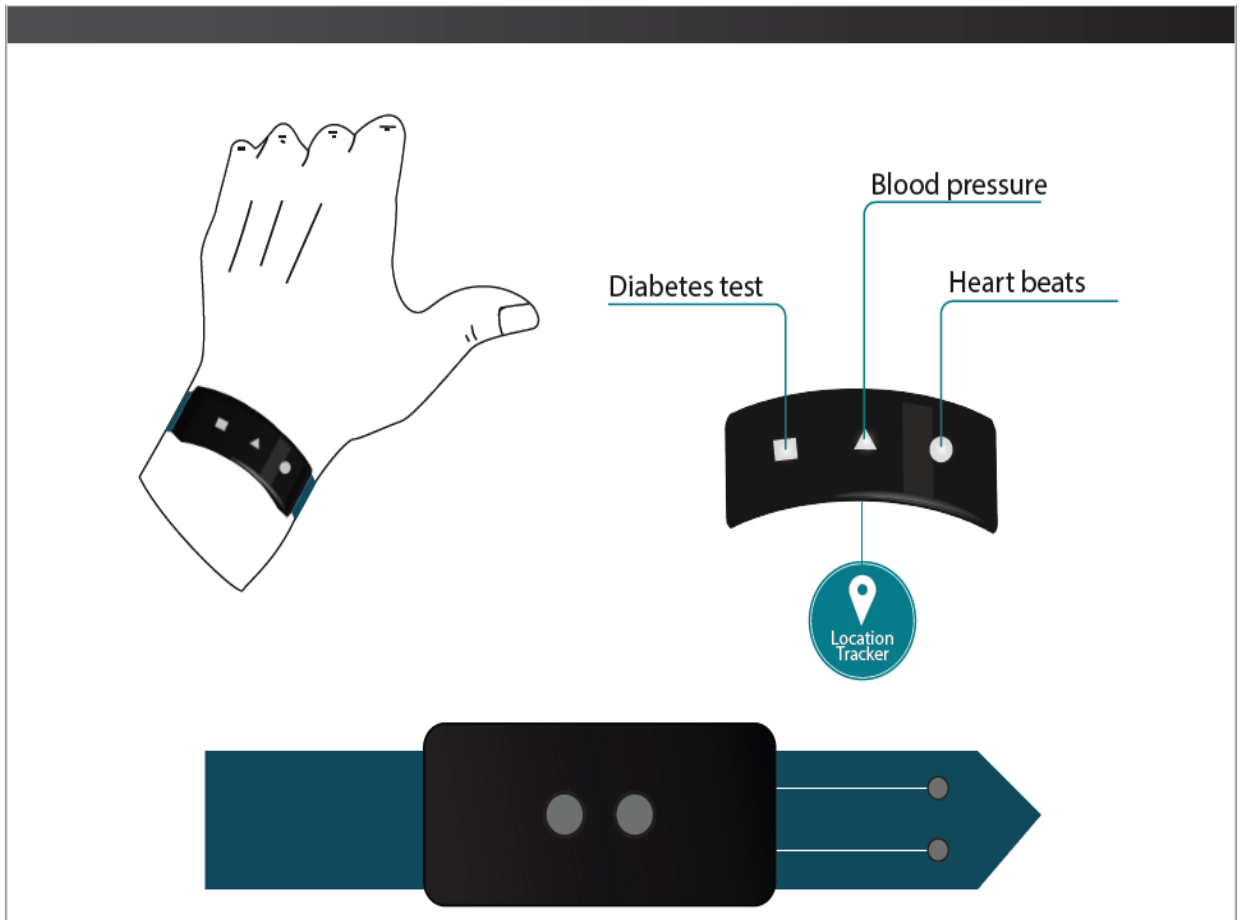


Figure 26 The new prototype [source: own]

As we can see from the picture above this wearable device has a simple display screen just for monitoring purposes and to choose the service desired. All the sensor will be active for 24 hours and will store the data automatically in the cloud platform. It is very comfortable, and it comes in different colors as well.

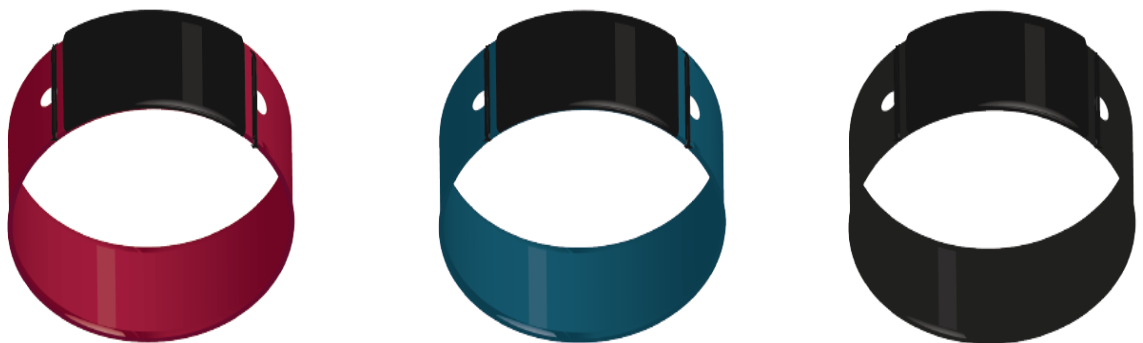


Figure 27 Different colors of the prototype [source: own]

4.2.2 Sensors of the wearable devices

In this wearable device are used sophisticated sensors that can monitor, frequently detect and respond immediately in case of an anomaly. Those sensors play an important role in monitoring the physiological parameters and send a signal in the form of alert to the near hospital with the current location as well. In order to have a better overview of the sensor installed in these wearable devices, let us take a look at the picture below.

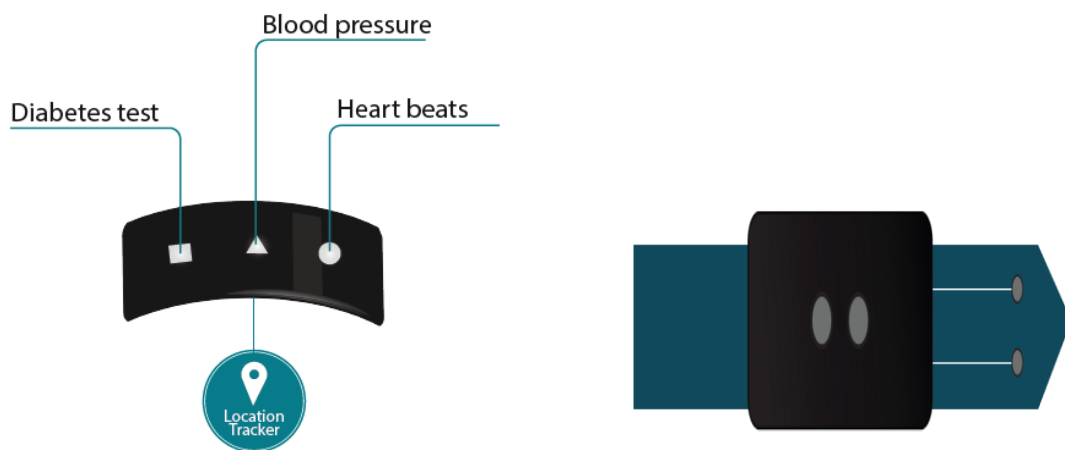


Figure 28 Sensors [source: own]

This wearable device will use an optical sensor for measuring blood pressure called Green led. This sensor using LED technology has profound subcutaneous decompensation capabilities and can measure blood pressure, high blood pressure, or hypertension. The blood pressure values are divided into 4 phases; each of them has different parameters. In the first phase, the normal blood pressure value is 90 over 60 and is considered as low blood pressure. In the second phase, the values are between 120 over 80; these parameters are considered normal. If the blood pressure values reach above 140 over 90, then the blood pressure is high. Hypertension is the last stage that reaches values above 140 over 90; at this stage, the intervention of medical services is needed. Another sensor that uses Led technologies will be present form measurement purposes. This sensor called PPG (photoplethysmography) uses the light to understand the number of heart rates. (NeuroSky, 2015) The average heart rate values range from 60 to 100 rates per minute. If the heart rates are under 60 is considered as more effective heart operation, which means that the cardiovascular system is stable. For

example, an athlete has an average of 40 beats per minute. On the other hand, if the heartbeats are more frequent and weigh more than 100 beats per minute, then this indicates an anomaly of the cardiovascular system. (Edward R. Laskowski, 2018) Another feature of this sensor is measuring the level of oxygen as well, another feature in this wearable. Both of these sensors will be programmed to monitor and detect any anomaly during the day. The average blood oxygen values are approximately 75 to 100 (mmHg). The values that reach the figures in 60 are considered as low values, and oxygen harvesting is needed. The average values range of oxygen pulse is from 95 to 100. If the value is lower than 90, then this is considered low value. (2018)

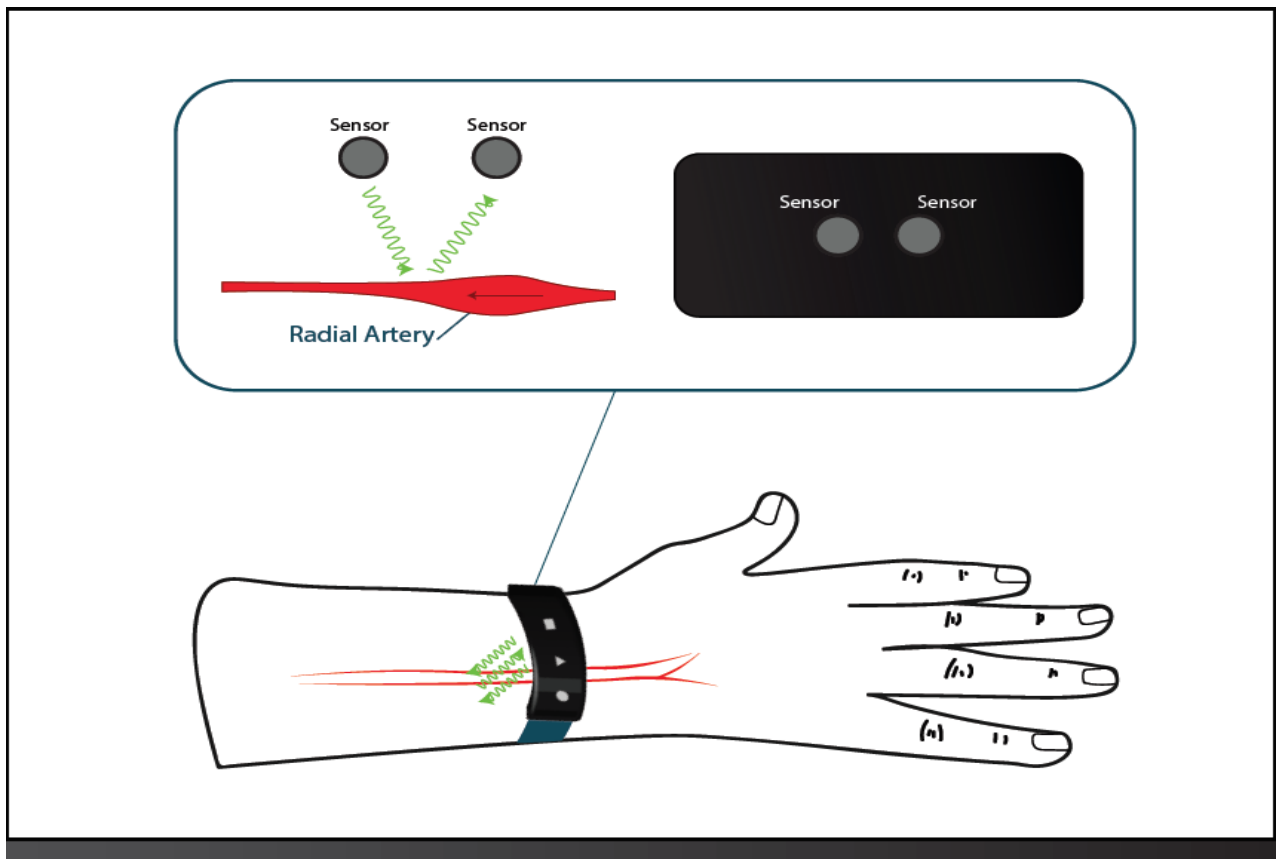


Figure 29How sensors works [source: own]

In order for the patient to be as accurate as possible and not to be affected by any external factor, this device will have a very powerful sensor called BHI160BP (Sensortec, 2019). This sensor can pass the signal even if the GNSS is blocked or in closed areas as a node. Along with this sensor, 3D orientation will be possible, making it possible to improve

localization, which is very important in this product. Diabetes, one of the biggest killers in terms of diseases, will be monitored by a biosensor that will be present in this product. This sensor will be responsible for measuring the level of glucose in the blood and will guide the patient to take the right dose of insulin in order to reduce the level of health risk significantly. According to (Mayoclinic, 2018) The normal blood sugar level is less than 100 mg / dL (5.6 mmol / L). If the blood glucose level is between 100 to 125 mg / dL (5.6 to 6.9 mmol / L), it is considered the prediabetes phase sin. If the sensor detects a value higher than 126, then the user is advised to visit the hospital. The reason why all these sensors will be implemented in this wearable device is the ability to consume low energy, meaning that the battery will last longer. A microcontroller will control all the sensors. Furthermore, the picture below explains how those sensors are connected with the microcontroller.

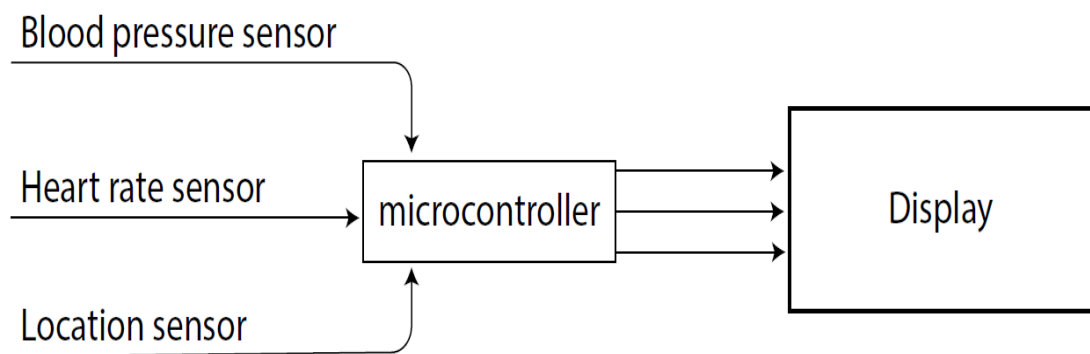


Figure 30 Sensors and microcontroller [source: own]

4.2.3 Connectivity

This prototype requires a stable and robust connection to monitor online parameters and to send a signal to the nearest hospital or clinic in case of an emergency. Also, this device will be designed to use three types of connections in order to transmit the correct data. The primary technology that will be used to transmit signals and data is WI-Fi. In order to have a better transmission, an advanced infrastructure is more than needed. Wifi is a cutting-edge technology with waves.

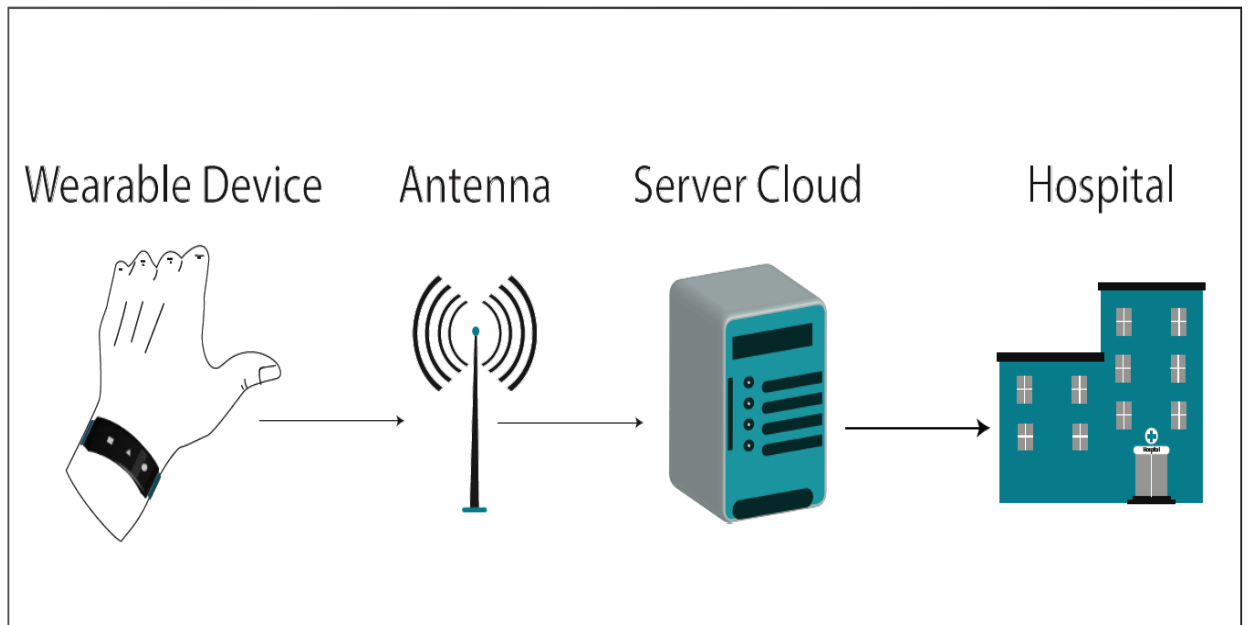


Figure 31 Connectivity works [source: own]

In order to send a signal to the hospital or clinic, this communication is done through giant antennas that will allow an extensive reach so that everyone can access them. Another backup communication will be through the phone waves. These waves can be accessed using a SIM card. Bluetooth will also be present for short communications.

4.2.4 Battery

The battery is one of the biggest challenges when it comes to design a wearable device. Since the sensors and the GPS will stay active for 24 hours a powerful battery is needed. In this prototype is going to be implemented a rechargeable battery called lithium polymer. In the following table are described the characteristics of this battery provided by (Lipolbattery, 2019)

Battery type	Model	Capacity	Dimension	Voltage	Wires
LiPo Battery	LP882934	850mAh	34 x 29 x 8.8mm	2.5V to 4.2V	AWG 26, 50mm x 2

Table 1 Characteristics of Lithium Polymer

4.2.5 Security

Based on the questionnaire analyzed above the security was among the biggest concerns. One of the reasons is the worry of losing data. In order to have a secured transmission and connectivity, this device will be focused on two-step authentication. This process involves two methods as a secured bridge between hospitals and the device.

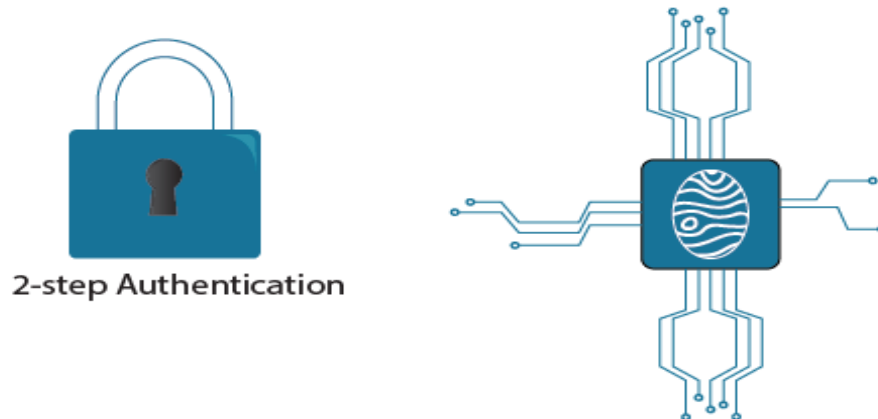


Figure 32 Security [source: own]

Once the user creates an account and receives the confirmation a second step is required. In this step, the user can connect the device with the smartphone or another smart device as well. After the second confirmation, the user is able to use the device and to store the data in the cloud platform.

4.2.6 Storage / Server cloud

Part of this network architecture will be a server cloud as well. This platform can store a large amount of data, and it is possible to access them at any time. In this case, there is no need for the information to be stored in the wearable device as the dedicated cloud platform will automatically store it. This prototype will use SAP cloud platform to connect end to end processes in order to have agile and flexible communication. By using this technology; the user can share with the hospital the data needed for consulting or any types of concerns. This will be possible with SAP Agile Data Preparation, a feature that can protect the data and ensure secure communication. (SAP, 2019) As mentioned above in the security section in order to access this data, a 2-step authentication is needed. This will prevent any cyber-attack from

outside. However, even though cloud storage is cheap in order to save the space and to remove data that will not be relevant this wearable device will have as a feature data retention. This configurable policy can remove data that are older than six months or based on the configuration that cannot be relevant anymore. In this case, there is no need to remove all unnecessary data, and the storage will be free for the upcoming one.

4.2.7 Hospitals

The purpose of this thesis is to shift the healthcare system from curative to preventive. When our body is facing with an anomaly and the first this comes to our mind is to call the ambulance, or to call our relatives for a quick response. At this moment the time is against us, and a full description of the current situation is missing. Therefore, this thesis includes the hospitals to be part of this new implementation.

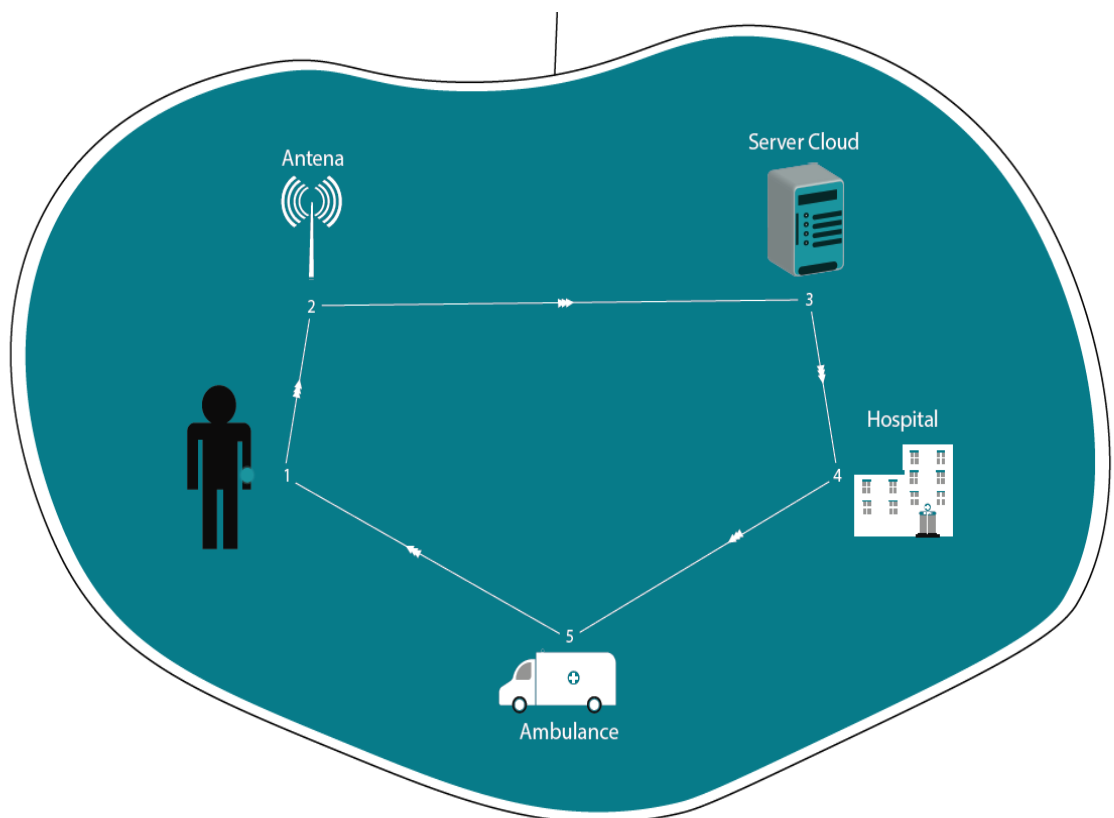
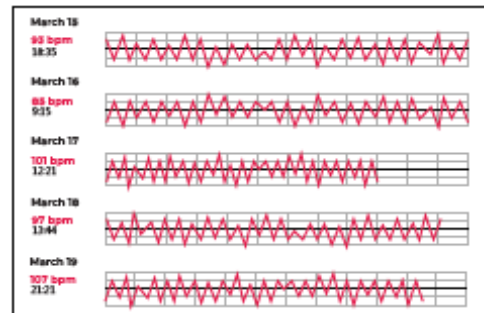
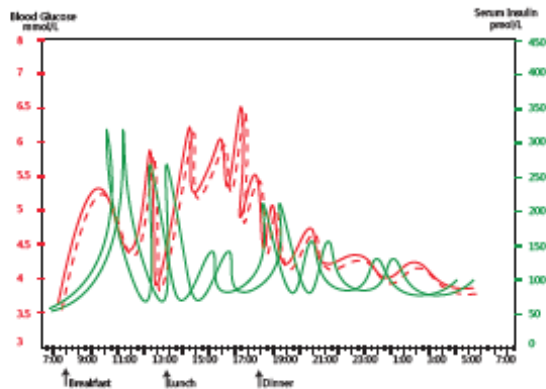


Figure 33 In case of an emergency [source: own]

In case of an emergency, the sensors will detect an anomaly by calculating the parameters and will prepare a full report of the user's health situation. From this point, the nearest hospital will receive a signal in the form of alarm with all data attached and the current location as well. This report will contain an overview of blood pressure, heart rate, level of glucose and level of oxygen altogether in electronic format and it can be downloaded in PDF. This information will be valuable for the doctors to estimate the user's current situation and to send the ambulance with the medicine needed. At this point, all this information will be considered as a safe source of information. Also, this report will contain the user ID and the user name. In this case, it will be easier to identify the user and to provide them with the proper medicine. In the following page is an example of the report that can be provided by this wearable device in case of an anomaly. This type of report could be generated anytime from the user and the doctor if the user agreed on sharing the data.

Report

Username:
User id:
Parametres:



Category	Systolic BP(mmHG)		Diastolic BP (mmHG)
Optimal	<120	and	<80
Normal	120-129	and	80-84
High Normal	130-139	or	85-89
Hypertension			
Stage 1	140-159	or	90-99
Stage 2	160-179	or	100-109
Stage 3	>=180	or	>=110



Your Current Location

Figure 34- Report of the wearable device [source: own]

4.2.8 Business Model

This model will be based on a description of the product and its functionalities. Also, it includes an overview of costs detailed in the following tables.

Prototype: This prototype is designed to measure the body parameters only for medical purposes. It contains four sophisticated sensors that serve for:

- Measuring the blood pressure
- Measuring the heart rate
- Measuring the level of glucose in the blood

- Measuring the level of oxygen in the blood

Sensors: Sensors play an important role in monitoring the physiological parameters; therefore for this product is chosen the best sensors in the market in order to provide a high level of service. In the following table is an overview of the sensors used in this device and the cost of them.

Type of Sensor	Quantity	Price in Kč	Source
Green led sensor	1	260,00	(Digikey, 2019)
PPG (photoplethysmography) sensor	1	200.10	(Digikey, 2019)
BHI160BP sensor	1	275,60	(Mouser, 2019)

Table 2 The Pirce in Kc of sensors

Data-Sharing/Cloud platform: This technology will be part of this prototype by storing all the data needed. This platform can store a large amount of data every day, and it is possible to access them at any time. Also, it is possible to download in the form of a report all the data or share it with the hospital.

Category	Billing Block Size	Price in Kč	Source
Instances	1	787,972	(SAP, 2019)

Table 3 The price in KC of Cloud Platform

Wearable Device parts and tools: Since this prototype will be designed only for medical porpuses there are no much components on it.

Category	Quantity	Price in Kč	Source
Display Screen	1	454.66	(Adafruit, 2019)
Battery	1	433.01	(lipolbattery, 2019)

Table 4 The price in Kc for Part and Tools

Interface: The user can track the recorded data in an interface dedicated only to this prototype. In this interface, the user is able to check the current situation of the body parameter and to check the previous records that happened days ago. For a better understanding let's see the picture in the following page.

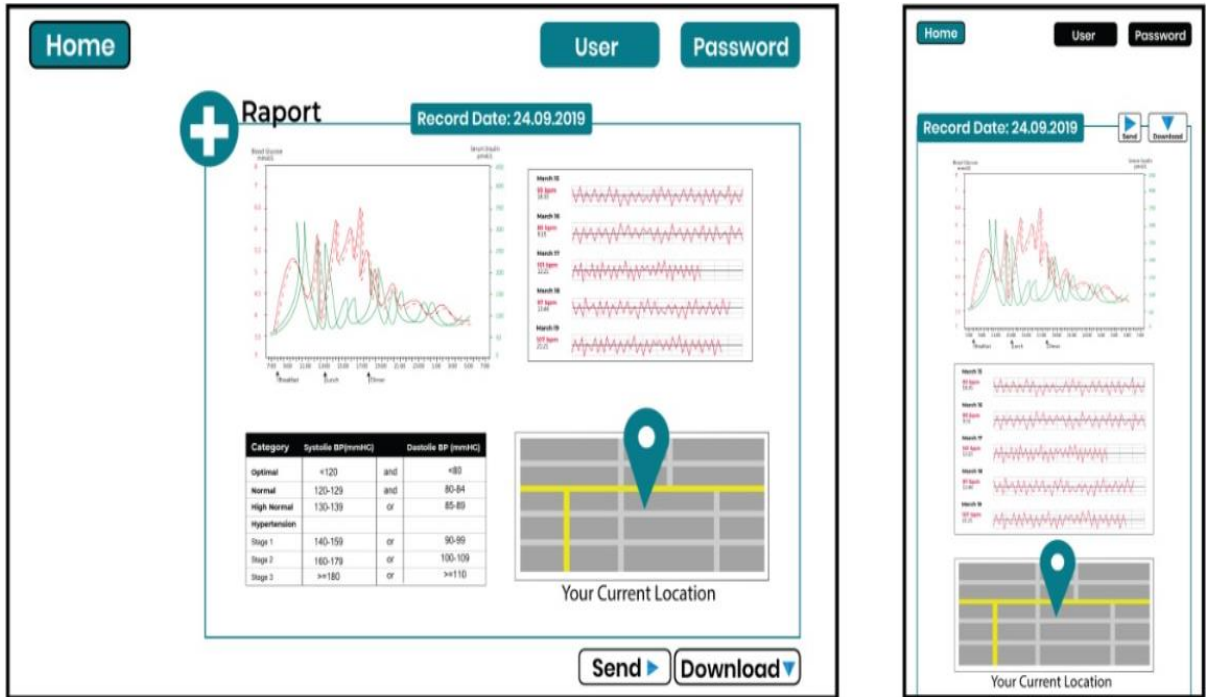


Figure 35 The interface of the new prototype [source: own]

The user can check all the history of the medical report in this interface. By using the calendar as a filter, it is possible to check previous data. Also, this electronic health record can be downloaded in pdf format or by using the send feature; this EHR can go directly to the hospital.

The use can check the records with the smartphone as well. This interface is designed to be adapted for any type of smartphone or tablets.

First Implementation: Before this project will go-live is very important to go through a test first. The first test implementation will be covered only a small area in order to monitor the behavior of the prototype and the whole infrastructure. In this area will be implemented two big antennas that will serve as the primary communication with the hospital. This connection will be dedicated only to this prototype in order to have a secured connection. In order to have a better overview of the covered area with this proposed technology, let us take a look of the picture in the following page.

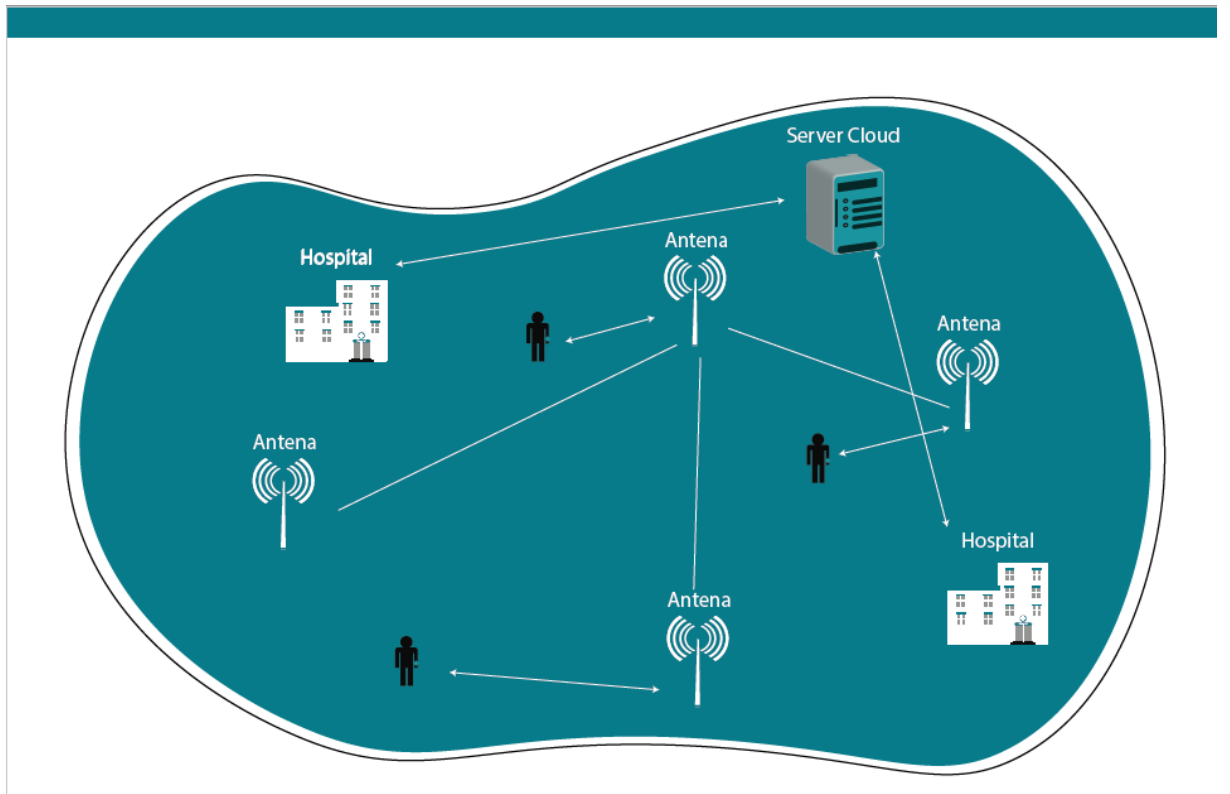


Figure 36 - First implementation

Based on the picture above, the wearable device will be connected via wi-fi by sharing signals with antennas. Antennas serve as a bridge between the prototype and the hospital. As it mentions in this thesis, all data will be stored in cloud platform by providing a secured communication.

5 Results and Discussion

5.1 Purpose

The purpose of this thesis is to analyze the current situation of the healthcare system, what are the new challenge and why is essential is our life. Also, this thesis is focused on an overview of the wearable devices. What are the advantages and disadvantage? Based on the results of the survey a wearable device dedicated only to the healthcare system is more than needed. Also, users are willing to share their data in order to have a better service. The goal of this prototype is to shift healthcare from curative to preventive.

5.1.1 SWOT Analysis

In order to analyze the planning process of the new prototype, a SWOT (strengths, weaknesses, opportunities and threats analysis) method is needed. This method stands for analyzing the internal and external effects and what is the impact of this wearable device in the market. (Fallon, 2018)

Strength of the wearable device

This wearable device is focused only for medical purposes. The following points will describe the advantages of this new prototype:

- Can measure the body parameters 24hours.
- It has powerful sensors.
- The battery lasts for more than a week.
- The communication with the hospital is safe and secured.
- All data are stored in the cloud platform.
- It is possible to download the RHR (Electronic Health Record) anytime and anywhere.

Weaknesses of the wearable device

Even though this wearable device is focused only for the healthcare system, it also has its disadvantages. These will be described in the following points:

- There are no features for navigating on the internet.

- For all the people for might be interested in having this product, but they also would want the capabilities of the smartphone or smartwatch this will not to be possible.
- It is not possible to receive calls or messages
- It comes with only one design

Opportunities for the new product

Based on the report that (Statista, 2018) provided, it is forecasted that wearable devices sales will continue to increase year by year. By 2019 the amount is 33.78 billion U.S. dollars and in 2022 will reach 73.27 billion U.S. dollars. For the Czech Republic, the segment amount in 2019 will reach 13 million U.S. dollars and in 2023 revenue is forecasted to show an annual growth rate by 7.9 %.

Threats for this prototype

One of the biggest challenges of this new prototype will be the competition coming for other companies. According to (Deloitte, 2017) industries will be more focused on the health care system, being more specific in wearable devices dedicated only to the health care system. Another threat to be considered is the cyber risks and data breaches. Since the wearables will become very common, they will also become bigger targets for hackers. (Drolet, 2016)

5.1.2 PEST analysis

With the help of PEST (Political, Economic, Social and Technological) methodology it is possible to understand the external and internal factors that can influence the new prototype proposed. (Post, 2018)

Political

The Czech Republic is ranked among the best countries in Union Europe regarding the healthcare system. In 2017 the index scored 726 points out of 1000. This placed the country ranked 16th out of 35. (Björnberg, 2017). In 2018 the country landed in 14th place with 731points out of 1000. From another point of view according to (COMMISSION, 2018) the Czech Republic spends less on healthcare than the EU average (7.2 % of GDP versus 9.9 %

of GDP) and the population is aging. Also, in terms of portions, expenditure earmarked for inpatient care was 26.3 %, compared to the EU average of 29.5 %. Another point mentioned in this report is the lack of staff in the healthcare system. This can be an impact on the new prototype proposed.

Economy

According to (Karsten, et al., 2018) in their article, the focus is on the wearable devices. Also, they came to a conclusion that wearables devices can reduce the healthcare cost for a country. This is due to the fact that technology is affecting the healthcare system and the lack of staff in the hospitals.

Social

Since the first day when wearable devices are introduced, it has had a continuous impact on society. From 2012 until 2018 wearable devices the number of sales has rapidly increased from 0.75 billion U.S. dollars to 5.8 billion U.S. (Statista, 2018) From this report it is easy to understand that the impact of wearable devices is positive, and it will continue to stay like this.

Technological

From a technological point of view, wearable devices are playing a huge role in this infrastructure. Since this prototype is based on technology one of the risks is technophobia. This phobia is highly known in the world and can affect many people. It consists of fear of technology and complex devices. This can bring a negative impact and perception for the new prototype proposed.

6 Conclusion

With the help of Internet of Things, the healthcare system is changing rapidly. Technology is an important indicator of our lives by providing us many choices to measure body parameters. This due to the gaps that the healthcare system is facing recently. The methodology of this paper is based on studying the current situation of the healthcare system and also an overview of the current state of the art of wearable devices. Another focus in the literature review was to gather information and to find gaps between existing wearable devices and healthcare system. In order to evaluate and have a better overview of the wearable devices in the current market, a survey was conducted. In this survey, there were 90 participants from whom 82 were from the Czech Republic. From the survey, the highest volume of participants were 25-34 years old, males and people who are not currently using a wearable device. In order to understand the results of the survey, data visualization has been used as part of the data analyses. After analyzing the first demographic information, the final question covers the goal of this new health watch, which is to shift the healthcare and smart health system from curative to preventive. Eighty-one participants responded that they either agree or strongly agree and only 10% were in disbelief. What is also important, its the fact that from these 81 participants, 64 of them would use a heath watch dedicated only to health care. Bearing in mind the results of the survey, a new prototype dedicated only to the healthcare system is proposed. This proposal aims to improve the quality of life by measuring the parameters through a wearable watch. This new prototype is based on three powerful sensors that will work for 24 hours. Those sensors are able to measure the body parameters such as Blood Pressure, Level of glucose in the blood, Heart rate and the level of oxygen as well. Another sensor will serve for tracking the current location. This sensor can pass the signal even if the GNSS is blocked or in closed areas as a node. Finally, to analyze the advantages and disadvantage of this new prototype in the market two different methodologies such as SWOT and PEST are used.

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8 Appendix

<i>DEMOGRAPHIC INFORMATION</i>			
#	Question	Answer Type	Answer Alternatives
1	Do you currently live in the Czech Republic?	Boolean	<ul style="list-style-type: none"> • Yes • No
2	What is your age?	Categorical /Multiple choice	<ul style="list-style-type: none"> • Under 18 • 18-24 • 25-34 • 35-44 • 45-54 • 55-64 • 65+
3	What is your gender?	Categorical /Multiple choices	<ul style="list-style-type: none"> • Male • Female • Prefer not to say • Other
4	What is your education level?	Multiple choices	<ul style="list-style-type: none"> • Elementary school • High school • Bachelor • MasterPhD • Other
5	What is your current employment status?	Multiple choices	<ul style="list-style-type: none"> • Unemployed • Student • Employed - Part-time • Employed - Full time • Self-employed • Retired
<i>UNDERSTANDING CURRENT SITUATION</i>			
6	Do you use a wearable device?	Boolean	<ul style="list-style-type: none"> • Yes • No
7	What type of wearable device do you use?	Multiple choices	<ul style="list-style-type: none"> • Smartwatch • Fitness Tracker • Medical wearable device • I do not use one
8	For what purpose do you use your current wearable device?	Checkbox	<ul style="list-style-type: none"> • To connect it with my phone • To track my sport activity

			<ul style="list-style-type: none"> • To track my health parameters • To stay up to date with the tech trends • To motivate me do more sports • To motivate me take more care of my health • I do not use one
9	Does your current wearable device fulfill all your necessities?	Scale	<ul style="list-style-type: none"> • Far above average • Above average • Average • Below average • I do not use one
<i>EXPLORING THE MARKET</i>			
10	Do you know any wearable device that is dedicated to healthcare only?	Scale	<ul style="list-style-type: none"> • Very Aware • Somewhat aware • Not so aware • Not at all aware
11	Would you consider important using a wearable device only for medical purposes?	Boolean	<ul style="list-style-type: none"> • Yes • No
12	We are currently introducing a new prototype for a wearable device. Which of the following features do you think is more important to have?	Checkbox	<ul style="list-style-type: none"> • Monitoring body parameters • Sending direct alters to the hospital in case of health emergency • Other features not related to health care
13	Using a monitoring wearable device has a positive impact on	Scale	<ul style="list-style-type: none"> • Strongly agree • Agree

	maintaining real-time information on your health parameters.		<ul style="list-style-type: none"> • Neutral • Disagree • Strongly disagree
14	Using a monitoring wearable device will improve the first aid rate from the hospital in case of an emergency.	Scale	<ul style="list-style-type: none"> • Strongly agree • Agree • Neutral • Disagree • Strongly disagree
15	Using a wearable device dedicated to health monitoring will reduce the short-term costs of medical assistance.	Scale	<ul style="list-style-type: none"> • Strongly agree • Agree • Neutral • Disagree • Strongly disagree
16	Would you be willing to share your collected data from this wearable device with the hospital?	Multiple Choice	<ul style="list-style-type: none"> • Yes • No • Maybe
17	Do you think this new prototype will shift healthcare system from curative to preventive?	Scale	<ul style="list-style-type: none"> • Strongly agree • Agree • Neutral • Disagree • Strongly disagree

The original survey was created using online version of excel and uploaded in onedrive. The survey is available in the link below:

https://docs.google.com/forms/d/1LloZLP0Gs1DSwrh2j_QLZ4skjP2IwIyrjFfU4rq75FE/edit

Wearable devices for Healthcare

*Required

Demographic Information

Do you currently live in the Czech Republic? *

- Yes
- No

What is your age? *

- Under 18
- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65+

What is your gender? *

- Male
- Female
- Prefer not to say
- Other

What is your education level? *

- Elementary school
- High school
- Bachelor
- Master
- PhD
- Other