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## Υπεύθυνη Δήλωση

«Δηλώνω υπεύθυνα ότι η συγκεκριμένη μεταπτυχιακή εργασία για τη λήψη του Μεταπτυχιακού Διπλώματος Ειδίκευσης στη Διοίκηση Επιχειρήσεων, έχει συγγραφεί από εμένα προσωπικά και δεν έχει υποβληθεί ούτε έχει εγκριθεί στο πλαίσιο κάποιου άλλου μεταπτυχιακού ή προπτυχιακού τίτλου σπουδών, στην Ελλάδα ή στο εξωτερικό.

Η εργασία αυτή έχοντας εκπονηθεί από εμένα, αντιπροσωπεύει τις προσωπικές μου απόψεις επί του θέματος. Οι πηγές στις οποίες ανέτρεξα για την εκπόνηση της συγκεκριμένης μεταπτυχιακής αναφέρονται στο σύνολό τους, δίνοντας πλήρεις αναφορές στους συγγραφείς, συμπεριλαμβανομένων και των πηγών που ενδεχομένως χρησιμοποιήθηκαν από το διαδίκτυο».

### Όνοματεπώνυμο

ΤΣΙΟΥΝΙΑ ΑΙΚΑΤΕΡΙΝΗ

### Υπογραφή



## Ευχαριστίες

Η παρούσα διπλωματική εργασία, εκπονήθηκε στο Διαπανεπιστημιακό Πρόγραμμα Μεταπτυχιακών Σπουδών στη Διοίκηση Επιχειρήσεων – “ATHENS MBA”, του Εθνικού Μετσόβιου Πολυτεχνείου και του Οικονομικού Πανεπιστημίου Αθηνών.

Αποτελεί το τελευταίο στάδιο πριν από την ολοκλήρωση των σπουδών μου στην συγκεκριμένη σχολή και θα ήθελα να ευχαριστήσω θερμά τον επιβλέποντα μου Κο Καρδάρά Δημήτριο, για τις πολύτιμες συμβουλές και τις οδηγίες του σε όλο το χρονικό διάστημα της εκπόνησης της εργασίας τόσο σε πρακτικά όσο και σε θεωρητικά θέματα.

Με Εκτίμηση,

Τσιούνια Αικατερίνη

Αθήνα, Ιανουάριος 2018

## Summary

### 1 Introduction

Health is not a luxury; it's a right of everyone. It's the fundamental ability that all of us requires to perceive, feel and act effectively, and is therefore a key element in the person's development but also in the environment to which he/she belongs. This is why we need to find ways to offer top quality healthcare services based on monitoring 24/7 and immediate medical assistance. The development of new technologies, especially the Internet and wireless sensor networks, known as the Internet of Things (IoT), allow a global approach to the development of the healthcare system. Medical science offers to the patients a plenty of high-tech diagnostic options, innovative treatment methods and information that require difficult decisions. This leads to e-health system that provides valuable information about all stakeholders (patients, medical and paramedical staff and health insurances). These decisions affect their quality of life, their wider family and society in general.

Although the IoT systems are still in their initial stages; have as vision to establish an innovative healthcare system, based on human needs and always having as fundamental aim to improve quality of healthcare services and to ensure better health and better quality of life for all.

#### 1.1 Purpose

The aim of this study is to investigate in detail the role of IoT in healthcare, to analyze its uses, opportunities and challenges that we may face. Although the use of the Internet of Things is still at an early stage in Greece, it promises great growth, especially in the healthcare sector.

## 1.2 Methodology

In order to study more specifically whether the IoT will improve the quality of healthcare provided in Greece and in which way; we have to describe the entire path which a prospective patient has to follow:

- I. at first the procedure of a patient who enters the hospital for a routine check-up/ of a chronic disease sufferer visiting the hospital for check-up update
- II. in addition the surgical procedure
- III. and finally the procedure of recovery after surgery or hospitalization

as they currently work in Greece (flowchart as is) and how they could be improved with the contribution of the IOT (flowchart to be); using also multicriteria analysis to assess this contribution.

Nobody can understand all of the questions and concerns a patient and their family has unless they have been patients themselves. The best way for hospitals to better serve their patients is to put themselves in the patient’s condition and understand their needs. Only in this way, they can provide useful information which improves the healthcare and the patient experience.

## 1.3 Main Conclusions

The citizens’ role in the healthcare sector, either as consumers of healthcare services or as patients, is rapidly changing. The citizens are no longer considered passive recipients of medical decisions, but well-informed partners in the treatment process.

The IoT is continuously changing our life and completely influences the healthcare by finding new ways of connecting people, apps and devices to interact to each other and provide the best health care solutions to the patients. The IoT offers a plenty of high-tech diagnostic options, innovative treatment method, fewer errors which mean increased efficiency and lower costs and information that requires difficult

decisions. These decisions affect the quality of life of the patients, their families and society in general.

### **1.4 Structure of the paper**

The paper includes 6 chapters, in order to draw the final conclusions. The structure of the paper is the following:

#### Chapter 1

The context of the thesis began is presented in the first chapter.

#### Chapter 2

The concept of "Internet of Things" is presented in order to understand its uses in everyday life, especially in the healthcare sector.

#### Chapter 3

This chapter further analyzes the use of smart devices and connected devices as well as the functions they perform.

#### Chapter 4

This chapter analyzes the entire path which a prospective patient in Greece has to follow to be treated (Flowchart as is).

#### Chapter 5

This chapter analyzes how the previous path could be improved with the contribution of the IOT (Flowchart to be) and using a multicriteria analysis we compare the surgery process AS IS to the surgery process TO-BE, (IoT based process).

#### Chapter 6

The main benefits of IoT in the health care system as well as some of the challenges and risks that may arise are presented in detail in the last chapter.

#### Chapter 7

It is the final chapter of the thesis which lists the final conclusions.



## Σύνοψη

### 1 Εισαγωγή

Η υγεία δεν αποτελεί προνόμιο λίγων, αλλά δικαίωμα και ανάγκη όλων. Αποτελεί το βασικό στοιχείο για την ανάπτυξη του ατόμου, αλλά και του περιβάλλοντος στο οποίο ανήκει. Όραμα μας είναι να καταστεί ένα πρότυπο σύστημα υγείας με άμεση αναφορά στον άνθρωπο και τη ζωή και βασικό άξονα την αντίληψη ότι η παροχή υψηλού επιπέδου υπηρεσιών υγείας δεν είναι πολυτέλεια αλλά ανάγκη και δικαίωμα κάθε ασθενούς. Αυτός είναι ο λόγος για τον οποίο πρέπει να βρούμε τρόπους να εξασφαλίσουμε την κατάλληλη υγειονομική περίθαλψη βάσει παρακολούθησης 24/7 και άμεσης ιατρικής βοήθειας. Η ανάπτυξη νέων τεχνολογιών, ιδίως του Διαδικτύου και των ασύρματων αισθητήρων, γνωστή ως “Internet of Things” (IoT), επιτρέπει μια συνολική προσέγγιση στη βελτίωση του συστήματος υγειονομικής περίθαλψης. Αυτό οδηγεί στο σύστημα ηλεκτρονικής υγείας που παρέχει πολύτιμες πληροφορίες για όλους τους ενδιαφερόμενους (ασθενείς, ιατρικό και παραϊατρικό προσωπικό, δημόσια και ιδιωτική υγεία). Ακολουθεί εκτεταμένη περίληψη στην ελληνική στο παράρτημα.

#### 1.1 Σκοπός

Σκοπός του παρόντος εγγράφου είναι να διερευνήσουμε λεπτομερώς το ρόλο του IoT στην υγειονομική περίθαλψη, να αναλύσουμε τις χρήσεις του, τις ευκαιρίες καθώς και τις προκλήσεις που ενδέχεται να αντιμετωπίσουμε. Παρόλο που η χρήση του «Internet of Things» βρίσκεται ακόμη σε πρώιμο στάδιο στον Ελλαδικό χώρο ωστόσο υπόσχεται μεγάλη ανάπτυξη, ιδιαίτερα στον κλάδο της υγείας.

#### 1.2 Μεθοδολογία

Προκειμένου να μελετηθεί ειδικότερα κατά πόσο το IoT θα βελτιώσει την ποιότητα της υγειονομικής περίθαλψης που παρέχεται στην Ελλάδα και με ποιον τρόπο, θα

καταγράψουμε τις διαδικασίες που πρέπει να ακολουθήσει ένας υποψήφιος ασθενής :

1. Ο οποίος εισέρχεται στο νοσοκομείο για ένα τυπικό check up καθώς και ενός ατόμου που πάσχει από μια χρόνια ασθένεια και επισκέπτεται τακτικώς το νοσοκομείο.
2. Ο οποίος θα υποβληθεί σε χειρουργείο
3. Και τέλος η διαδικασία που πρέπει να ακολουθήσει κάποιος μετά από μια χειρουργική επέμβαση ή νοσηλεία.

όπως συμβαίνουν τώρα στη χώρα μας (διαγράμματα ροής as-is) και θα πώς θα μπορούσαν να βελτιωθούν με τη συμβολή του IoT (διαγράμματα ροής to-be). Κανείς δεν μπορεί να κατανοήσει όλες τις ερωτήσεις και τις ανησυχίες ενός ασθενούς και της οικογένειάς του. Προκειμένου να αναγνωριστούν οι διάφορες σπατάλες - wastes, που εμφανίζονται στις διαδικασίες ροής και δυσχεραίνουν την κατάσταση επιφέροντας καθυστερήσεις, δυσανασχέτηση, λάθη και μη τήρηση του προγράμματος, επιβάλλεται η καταγραφή των υπαρχουσών διαδικασιών σε διαγράμματα ροής. Επίσης μέσω της πολυκριτηριακής ανάλυσης που θα ακολουθήσει μετέπειτα θα αξιολογηθεί η συνεισφορά του IoT στην βελτίωση των παρεχόμενων υπηρεσιών υγείας και θα συγκριθούν περαιτέρω οι διαδικασίες as-is και to-be η οποία βασίζεται στο IoT.

### 1.3 Κύρια Συμπεράσματα

Η εφαρμογή του IoT στην υγειονομική περίθαλψη στο Ελληνικό Σύστημα Υγείας θα μπορούσε να αποφέρει πολλά οφέλη, βοηθώντας στην έγκαιρη και σωστή θεραπεία των ασθενών στοχεύοντας στην εξατομικευμένη θεραπεία, μειώνοντας το κόστος και αξιοποιώντας τους ανθρώπινους πόρους με τη λιγότερη δυνατή προσπάθεια.

Όσο πιο γρήγορα αφομοιωθεί το IoT στο ελληνικό σύστημα υγείας τόσο πιο γρήγορα μπορούμε να αναμένουμε καλύτερη ποιότητα υγειονομικής περίθαλψης και εν γένει καλύτερη ζωή.

## 1.4 Διάρθρωση της εργασίας

Η διπλωματική εργασία περιλαμβάνει 6 κεφάλαια, κατά την σειρά που πραγματοποιήθηκαν οι απαραίτητες για την ολοκλήρωση της εργασίας ενέργειες, με σκοπό την εξαγωγή των τελικών συμπερασμάτων. Η διάρθρωση του κειμένου έχει ως εξής:

### Κεφάλαιο 1

Παρουσιάζεται το πλαίσιο στο οποίο κινήθηκε η διπλωματική εργασία.

### Κεφάλαιο 2

Παρουσιάζεται η έννοια του “Internet of Things” προκειμένου να κατανοήσουμε τις χρήσεις του στην καθημερινότητα και ειδικότερα στον τομέα της υγείας.

### Κεφάλαιο 3

Στο κεφάλαιο αυτό αναλύεται περαιτέρω η χρήση των έξυπνων συσκευών και διασυνδεδεμένων συσκευών καθώς και των λειτουργιών που εκτελούν.

### Κεφάλαιο 4

Καταγράφονται οι διαδικασίες που πρέπει να ακολουθήσει ένας υποψήφιος ασθενής, όπως συμβαίνουν τώρα στη χώρα μας (Διαγράμματα ροής as-is).

### Κεφάλαιο 5

Καταγράφονται οι διαδικασίες, βελτιωμένες πλέον με τη συμβολή του “Internet of Things” (Διαγράμματα ροής to-be) και μέσω της πολυκριτηριακής ανάλυσης γίνεται σύγκριση των δυο διαδικασιών (της υφιστάμενης καθώς και της μελλοντικής με τη χρήση του Internet of Things)

### Κεφάλαιο 6

Παρουσιάζονται εκτενώς τα κυριότερα οφέλη του IoT στο σύστημα υγειονομικής περίθαλψης καθώς και ορισμένες προκλήσεις και κίνδυνοι που ενδεχομένως εμφανιστούν.

### Κεφάλαιο 7

Αποτελεί το τελευταίο κεφάλαιο της διπλωματικής εργασίας στο οποίο παρατίθενται τα τελικά συμπεράσματα στα οποία κατέληξε η εργασία.

## 2 Understanding the IoT

In the Internet of Things (IoT), all devices now gather information; share it between devices and save it in the cloud. We can share gathered information with each other to analyze, report, break up and create results. There are many ranges where this technology can be used and shared. Today, automobiles share and report performance, problems and needed repairs. Public transportation reports arrival times in various stations as do bus stops on local streets of Athens report the ETA of each service.

A very important use of this technology is in senior care. Today, seniors remain safe in their homes while wearing safety monitors around the neck or wrist. At the touch of a button emergency services are notified and sent to aid a senior in distress within minutes. In addition technology sends reports on health, heart rate, pulse, blood pressure to medical centers that monitor the patient. This technology not only improves on type of care but very importantly reduces the cost of care for all whether living in urban or rural areas. Daily, new systems come about improving on the collection and monitor of health data and reporting to medical centers anywhere and at any distance.

There is no telling at the present how the Internet of Things (IoT) is going to revolutionize healthcare into the future. We already see how it is dramatically lowering costs and improving the quality of healthcare. Wireless sensor based systems now gather patient’s medical data that could not previously be analyzed by a medical group to deliver care where it wasn’t previously available and accessible.

The technologies of IoT for healthcare are the following:

- Sensors that collect patient data. Some of them are environmental and collect data from the environment of the patient and others measure the vital parameters of the patient.
- Microcontrollers that process, analyze and wirelessly communicate the data

- Microprocessors that enable rich graphical user interfaces
- Healthcare specific gateways through which sensor data is further analyzed and sent to the cloud.

(Maksimovic M. et al., 2015)

IoT related healthcare systems today are based on the essential definition of the IoT as a network of devices that connect directly with each other to capture and share vital data through a secure service layer that connects to a central command and control center in the cloud.

Let's examine in this paper how people collect, record and analyze data not just in healthcare but in almost every industry today. Today computers and therefore, the internet, are almost wholly dependent on human beings for information. The problem is, people have limited time, attention and accuracy and all that means that they are not very good at capturing data about things in the real world. The solution for not losing all that useful data is to connect all the devices directly with each other and to empower them to gather information on their own, without human intervention.

The creation of IoT, in which devices connect directly to data and to each other, is important for two reasons:

1. Advances in sensor and connectivity technology are permitting devices to collect, record and analyze data that was not accessible before. In healthcare, this means that collecting data over time on a patient can be used in preventive health care, allow prompt diagnosis of acute complications and promote understanding of how a therapy helps to improve patient parameters.
2. The ability of devices to gather data on their own removed the limitations of human intervention and human entered data, limiting error and automatically providing the data doctors need in the time and the way they need it to provide diagnosis and treatment. Fewer errors mean accuracy,

increased efficiency lower costs and in summary reduces the risk of error. Fewer errors do mean increased efficiency and lower costs in virtually any industry. It is of particular importance in healthcare where clear data translates to pure analysis and lowers risks of the wrong diagnosis thus saving lives and lowering costs.

## 2.1 The IoT in our life

Despite the fact that a very small percentage of things are connected today, various businesses and industries are creating the foundation for IoT infrastructure:

Examples are:

- Home and building automation.

Today we can monitor our homes from any distance. The HOME app as applied by Apple is one of these systems. While away from home, one can turn lights on and off, adjust the heating and cooling systems of their house and answer the doorbell from any distance in the world. This information helps systems that have to especially do with energy to adjust power sources to specific areas and this will be more widespread as we move into the future.

- Automotive design and manufacturing: Cars manufactured in recent years provide and control information having to do with the vehicle and performance. Data is collected and shared with manufacturers and vehicle owners on maintenance monitoring, fuel and mileage efficiency, driver security that link to the cloud and share data to create efficient and safer automobiles. Cars can now set their own maintenance scheduling and alert the owners on specific issues that need attention. Today they send information to the cloud on performance and are beginning to drive themselves, freeing the driver of potential hazards when they perform to the maximum. All this furthers IoT into other areas.

- Public transportation and smart cities: In Athens we see today that buses are providing data and are carrying GPS systems which report data about bus locations, exact time of arrival and therefore at each bus stop passengers can see the time remaining for their bus to arrive as well as at train stations.
- IoT concepts have already been adopted in areas such as energy (e.g. smart lighting, smart grid) and industrial automation. As more connections are made, the value to businesses and the global economy will only go up.

The vision for the future is going beyond IoT to IoE or the Internet of Everything.

## 2.2 IoT in Action in Healthcare

- Clinical Care: In-hospital patients can be closely monitored as to their physiological status using a IoT driven monitoring system which is noninvasive. This information uses sensors to collect comprehensive data on the physiological status of an inpatient, sends this information to the cloud for analyzation and review and then forwards this analyzed data to the patient’s caregivers and healthcare professionals who can then analyze this data and use it in the immediate and long term care of the patient. This replaces the need for health care professionals to make frequent bed side visits to each patient to do routine checks on vital signs, rather providing a flow of second to second information on the patient. This constant data monitoring simultaneously improves the quality of care to each individual requiring medical care, it is proactive in delivering care through alert systems therefore lowering the cost of medical care as a caregiver is not required to actively collect data and information for analysis.

The best solution is having a health monitor easy to use for clinical environments that collects patient data and wirelessly transmits for display or notification purposes. This system allows the medical professional to monitor a patient wherever he may be and provide care from any distance based on the information and data received. This provides a clear picture of patient status 24/7.

-Remote monitoring: There are people all over the world that do not have access to health care professionals and effective health care monitoring. They live in remote areas at great distances from hospitals and medical care. Now with IoT, there is the possibility where the monitoring can come to the patient rather than the patient going to a medical facility.

These powerful wireless medical systems can effectively collect patients' health data and transmit it to the medical professionals assigned to the patients' care. These systems collect, analyze and apply complex algorithms and then share it through wireless connectivity allowing caregivers to make exact and correct health recommendations.

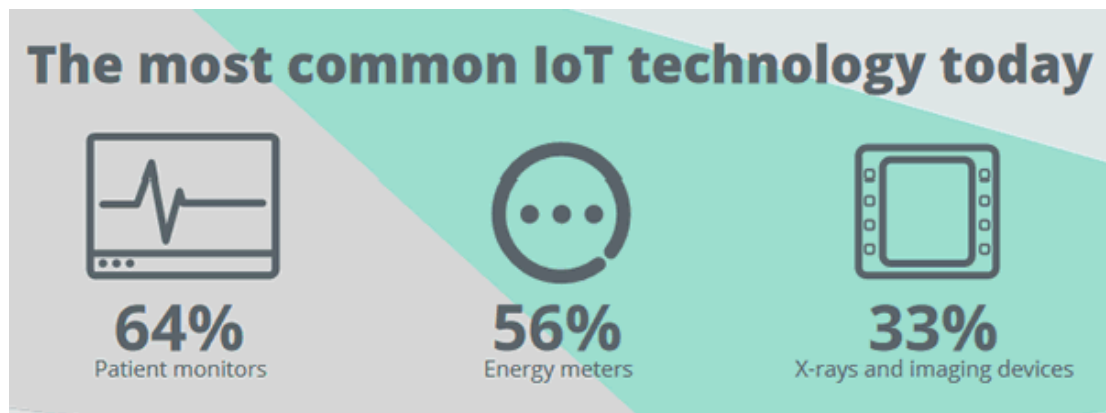
Data aggregation devices like this will soon become commonplace and will not only collect healthcare data but also manage other sensor networks within the home from smart energy, consumer electronics, home automation and security systems in addition to healthcare.

- Early intervention and prevention: Healthy, active people today use health data apps to record and monitor their daily activities and well-being. An alert system of this type not only alerts first responders but also family members through their smartphones. In the same way, a hiker or bike rider or any person who is athletically active and alone, can carry one of these systems in the event of an accident regardless of age or health. Smart watches, phones and wearable clips can carry information and report location. There are all sorts of wearable technology available on today's market. There are new technologies emerging daily.



**Figure 1**

*The most common IoT technology today*



Πηγή: (<https://www.i-scoop.eu/internet-of-things-guide/internet-things-healthcare/>)

### 3 Use cases and major evolutions

The use of the Internet of Things in Healthcare (industry, personal healthcare and healthcare payment applications) has increased sharply in a lot of Internet of Things use cases. At the same time, we see how other healthcare IoT cases are increased and the healthcare situation is accelerating, even if they are still a lot of obstacles.

Until now, most IoT initiatives in healthcare have been revolving around improving care as remote monitoring and tele-monitoring as main applications. A second area where there are many initiatives is the monitoring and maintenance of assets, using IoT. This is done on the level of medical devices and healthcare assets, the level of people and the level of non-medical assets (e.g. hospital assets).

However, these applications and cases of use are just the beginning and, at the same time, are far from omniscient. The most advanced and integrated approaches in the digital transformation of healthcare are being used with regard to aspects of health data, where the Internet is playing an increasing role, as is the case with specific applications such as smart pills, smart home care, robotics and real-time health systems.

The successful use of the IoT in the previous examples of health care is based on several technologies of general application. Without them, it would be impossible to achieve the usability, connectivity and capabilities required for applications in areas such as health monitoring.

Smart sensors, combining a sensor and a microcontroller, make it possible to use the power of the IoT for healthcare by accurately measuring, monitoring and analyzing a variety of health status indicators. These could include basic vital signs such as heart rate and blood pressure, as well as levels of glucose or oxygen saturation in the blood. Smart sensors can even be integrated into pill bottles and connected to the network to indicate whether a patient has taken a scheduled dose of medication. For

smart sensors to work effectively, the microcontroller components must have several essential capabilities:

- Low-power operation is essential to keeping device footprint small and extending battery life, characteristics that help make IoT devices as usable as possible.
- Integrated precision-analog capabilities make it possible for sensors to achieve high accuracy at a low cost.
- Graphical user interfaces improve usability by enabling display devices to deliver a great deal of information in vivid detail and by making it easy to access that information.

Gateways are the information nodes that collect sensor data, analyze it and then transmit it to the cloud through wide area network (WAN) technologies. The gateways can be designed for clinical or home settings and in this case, they may be part of larger connectivity resource that also manages energy, entertainment and other systems in the home. Wireless networking eliminates the physical limitations on networking which are imposed by the traditional.

It isn't really a surprise that this is an ongoing evolution, which on other levels, also includes phenomena such as smart beds, smart hospital, the aggregation and real-time availability of data from healthcare devices and assets regarding specific patients, and the advent of robots in a hospital environment for routine tasks as we will see in details below. (<https://www.i-scoop.eu/internet-of-things-guide/internet-things-healthcare/>)

### **3.1 Health monitoring and telehealth**

Today's major use case of remote health monitoring from an IoT spending perspective is outside the settings of hospitals or other healthcare facilities. There is a tendency of shifting hospital care or emergency care environments to private environments such as the patient's home, whenever this is possible.

It's a matter of budget, it's a matter of returning the patient to his normal environment that he is used to and feels comfortable to live in, as soon as possible and it's an efficient way to reduce the workload of healthcare workers who in many countries and many periods simply can't cope. In some countries the lack of funding and, as a result, shortage of medical and paramedical staff, especially in periods where most illnesses are in dependence, is a disaster. Remote health monitoring, which thanks to the Internet of Things can easily offer its services everywhere also up to an extent, helps solving the rise of chronic diseases; but not just that: Remote health monitoring is also ideal when patients live in remote areas or are just too old to move around.

There is a broad range of specialized medical devices as for example wearables and biosensors available today that enable remote health monitoring.

Remote health monitoring also offers healthcare stakeholders the possibility to detect patterns, leveraging the data coming from these wearables and other devices. This enables new insights and visualizations of patterns as the combination of (big) data, analytics, IoT and so forth tends to do.

### **3.1.1 Smart Hospital**

The hospital is an asset and device-intensive environment with a wide range of medical equipment and related health care objects that can be connected and monitored in order to achieve tangible benefits. In such asset-intensive environments which at the same time are extremely information-intensive, ample possibilities and potential outcomes emerge when applying IoT and related sets of technologies.

In a cross-industry perspective we can certainly also mention smart buildings and facility management here. If there is one place where the various building parameters (temperature, humidity, air regulation, specific environmental controls, security and so forth) need to be optimal, it for sure is the hospital.

Patients and their loved ones are most likely to feel anxious, stressed out and even helpless and intimidated from being in a hospital; making their stay an unpleasant experience. If we can minimize that discomfort, even a little, we are doing a lot to increase the well-being and care of the patients.

We could imagine a hospital setting where patients can interact easily and naturally to a cognitive concierge in their hospital room that will be able to answer questions, adjust their environment, and anticipate their preferences.

We could also imagine a smart system combined with the Internet of Things which interact through objects in a senior’s home, learn and anticipate their habits and needs, and offer guidance or encouragement at the right time and place. With cognitive care at home, elderly people who live alone can be more independent, can receive reminders for appointments and medications, can have access to health care services through voice, plus their family and caregivers can feel assured that will be alerted of any issues or changes to senior’s health or well-being.

The amazing thing about this technology is that it can answer questions and execute requests that are very specific to the context of the user. This is possible because IoT can combine information across building systems, patient records, CRM systems, and administrative records.

IoT is great at working with unstructured data, like voice, text, or image recognition. It can design patterns and memorize preferences for follow-up visits, allowing for a personalized, engaging, and interactive patient experience. The most precious advantage is that patients are enveloped by a friendly, cognitive, and personalized environment of care when they need it most. (Ryerson N.et al., 2014)

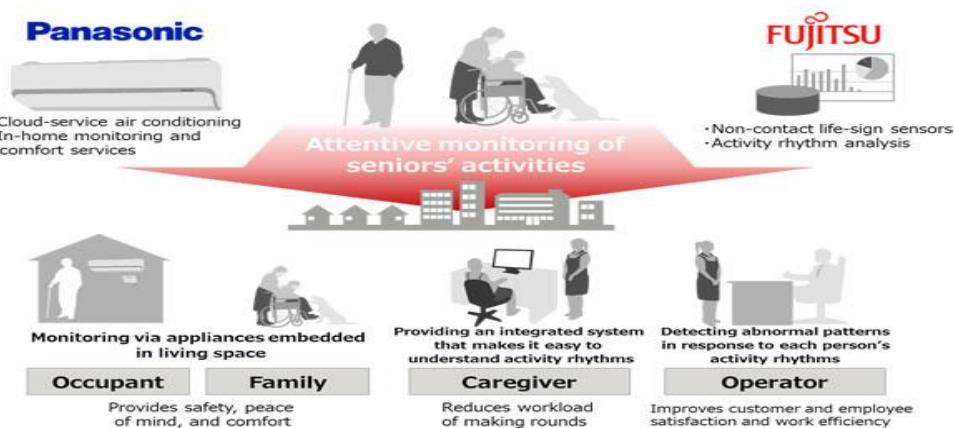
### 3.1.2 Smart House

In the short future the smart house will consist of cloud-service air conditioners and non-contact life-sign sensors in a new approach to monitoring.

This is why two big companies (Panasonic and Fujitsu) have already announced that they join having as a goal to create an in-home monitoring service for the elderly that integrates Panasonic's cloud-service air conditioners and Fujitsu's non-contact life-sign sensors. Cloud-service air conditioners are used to monitor the environmental surroundings of the senior or patient, such as temperature and humidity, while non-contact life-sign sensors are used to detect lifestyle information about occupants, such as their sleeping condition and whether they are at home. This real-time feedback of living spaces and occupants will be collected by Panasonic's monitoring system and provided to caregivers, with the goal of realizing alert notifications, for example dangerously high temperatures when in a room, frequent instances of awakening during sleep that uniquely specify the problems, needs and changes that need to be done for each person. In addition, the caregivers will have the control of the air conditioning to be in accordance with the occupant's habits. As a result, the monitoring service remotely tracks the status of senior citizens and manages air conditioning to reduce the resources required to perform safety checks. It also contributes to living spaces that are safe and give peace of mind to residents and their families.

**Figure 2**

*Overview of in-home monitoring services for the elderly*



Πηγή: (<http://www.fujitsu.com/global/about/resources/news/press-releases/2015/0625-01.html>)

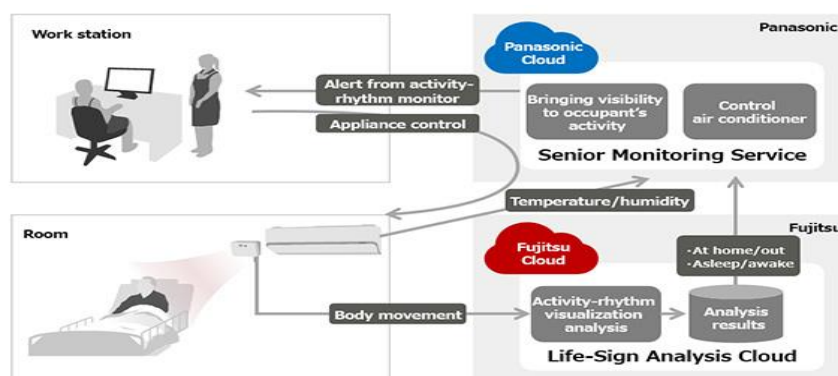
Due to the increase in elderly population the caregiving sector is confronting a reducing of caregivers, creating a need for ways to reduce their workloads. Even apart from physical assistance with bathing and going to the bathroom, caregiving is labor intensive, such as monitoring the status of seniors passing time in their rooms, and making nightly rounds with limited staff. While monitoring sensors have been installed in floors in some facilities, a large number of sensors results in very frequent alerts are making the implementation problematically ineffective at actually reducing workloads.

These factors have led to the need for an advanced method of monitoring senior residential facilities which can offer peace of mind and safety for seniors and a lighter workload for caregivers. Network-connected "smart appliances" are providing services with air conditioners which allow for remote power control and checking of temperature and humidity.

Now the companies have joined forces, jointly developing a new monitoring service that integrates their respective technologies to reduce the workload on caregivers. This new service is now undergoing an operational trial to demonstrate its effectiveness.

**Figure 3**

Overview of Trial System



Πηγή:

<http://www.fujitsu.com/global/about/resources/news/press-releases/2015/0625-01.html>

Using cloud-service air conditioners, data on room temperature and humidity are obtained, and the data are collected by Panasonic's monitoring system.

With sensors that use non-contact life-sign sensing technology developed by Fujitsu Laboratories Ltd., microwave radar is used that can detect minute body movements within a 3-meter range. Data collected on body movements are analyzed using Fujitsu's cloud to extract information on the occupant, such as whether the occupant is at home or out, or whether the occupant is asleep or awake, which is then provided to the Panasonic monitoring system.

The data collected in the Panasonic monitoring system can be confirmed by a caregiver on a monitor, as information on the occupant. Also, alert can be set for individual occupants, and concerns such as a room reaching a temperature that poses the risk of heatstroke or frequent periods of wakefulness during sleep can be detected in order to issue alerts that are based on an individual's activity patterns. In addition, a system for automatically controlling air conditioning in response to the occupant's habits will be provided. Bringing together the advanced technologies from these two companies will make it possible to manage living spaces and monitor the conditions of occupants, including occupants who do not rely on the support of caregiver rounds.

<http://www.fujitsu.com/global/about/resources/news/press-releases/2015/0625-01.html>

### **3.1.3 Smart Bed**

With the occurrence of patients falling out of bed, bed ridden patients' skin integrity, pulmonary concerns, and caregiver injury on the rise, hospitals are looking for products that help reduce these risks and improve outcomes.

Hospital beds are where most patients spend the majority of their time, so the new concept of “smart beds,” help patients stay safe, while “smart” capabilities help nurses analyze information and improve patient care. The beds connect to a



network to send patient data and help nurses monitor patient statistics such as movement and weight changes.

One major focus of “smart bed” advances is securing patients’ physical integrity and comfort throughout a potentially lengthy hospital stay. Though patient safety has always been a focus, the IoT has made patient satisfaction and comfort even more important.

Sensors are used to help prevent patient falls. The sensor is placed under the mattress of any type of bed. Rather than just letting nurses know when a patient is getting out of bed, the technology also creates reports of patient movement that nurses can look at for patterns.

The best solution is to create a "smart" hospital bed that would communicate with other devices for example X-rays or blood-pressure monitors in order to be able to constantly check out patient's health and automatically make necessary adjustments.

For example, the "smart" beds could be used to measure and reduce the risks of apnea: If the bed determines that a patient can't breathe, it will automatically change positions until the condition improves. Maybe it would be more efficient to make the beds having a "broad use," including blood-pressure measurements, respiratory feedback, heat-infrared monitoring and X-ray analyses, both in hospitals and homecare situations. (Stevens K, 2011)

#### **3.1.4 Smart devices for elderly**

Living alone can be a daily challenge for seniors. Some don't have family nearby or do not have family at all, so they worry that if they fall or suffer a medical emergency and can't get to the phone to seek help, no one will know.

That’s why hundreds of police agencies in small towns, suburbs and rural areas are checking in on seniors who live alone by placing an automated call to them every day. The calling systems, which are fairly inexpensive and easy to use, provide an important service to protect the security of people with special needs, health or aging individuals while living at home.

These alert systems with the push of a button put a person on the other end to get the information and action quickly taken to provide care for the individual whether to put them in touch with a physician, an ambulance or first responders.

Telephone check-in programs can help all these people remain independent in their homes and give them and their family members’ peace of mind. For example, it helps ensure for the elderly person or their family that a phone call is being made every morning, that everything is okay.

Seniors who sign up for telephone reassurance programs decide the time of the day they want to be called. They also are typically required to give police the name and phone number of an emergency contact.

Participants get a recorded phone call that asks them to press a certain digit in order to confirm that they are okay. If they don’t answer the phone, they’ll get another recorded call, and sometimes additional ones. If they still don’t answer, police usually will try to get in touch with their emergency contact before dispatching an officer to the home to check on them.

Seniors who know they’re going to be out when the phone rings at the specified time are supposed to notify police in advance. But sometimes they forget, and dispatchers end up sending out a unit on a false call.

### 3.2 The role of wearables

Wearable devices are currently at the heart of just about every discussion related to the Internet of Things. The requirement for self-health monitoring and preventive medicine is increasing due to the dramatic rise of elderly peoples’ population. Developed technologies are truly able to reduce the overall costs for prevention and monitoring. This is possible by constantly monitoring health indicators in various areas, and in particular, wearable devices are considered to carry this task out. These wearable devices and mobile apps now have been integrated with telemedicine and telehealth efficiently, to structure the medical Internet of Things.

On a wearable level we also see an increasing use of specialized wearables across all parts of the body (next generation hearing aids, implantable wearables, skin patches, smart contact lenses, etc.)

Wearables, with the help of improved technology have been developed greatly and are considered reliable tools for long-term health monitoring systems. These are applied in the observation of a large variety of health monitoring indicators in the environment, vital signs, and fitness and are now used for a wide range of healthcare observation. One of the most important components of data collecting elements is the sensor. During recent years with improvement in semiconductor and solid state circuits’ technology, sensors have made investigation of a wide spectrum of parameters closer to realization. (<https://www.i-scoop.eu/internet-of-things-guide/internet-things-healthcare/>)

### 3.3 Robotics in Healthcare

While there are concerns for machines replacing people in the workforce, the benefits are increasing. A machine doesn’t need food or sleep, doesn’t get physically

tired; mentally fatigued, doesn't get sick, moody or have prejudices that we humans so often have; could change the way we treat people who are ill and vulnerable. Here are some interesting examples of robotics in healthcare:

➤ Robotic Assistance for a Better Life

Robots in healthcare can do much more than drawing blood. With a remote controlled unit, caretakers can interact with their patients; check on their living conditions and the need for further appointments. This would help efficiency a great deal by eliminating the time consuming home visits. Of course, it is expectable and inevitable, that companies producing and maintaining these systems will have to make greater efforts to ensure patients' medical privacy. As with every such device, it must be near impossible to access for non-authorized personnel. With the proper safeguards in place these robots can greatly improve the lives of caretakers and patients alike.

➤ Telemedical Network is Key in Accessibility

Chances are you have been in a situation before where, if an accident were to happen, medical professionals would not have been able to reach you in time. To some of us in the developed world it's a rare occurrence. But even in 2016 billion live outside of the reach of conventional emergency services. With this, network patients in remote areas have access to high-quality emergency consultations for stroke, cardiovascular, and burn services. On the patient's side it can be accessed on a tablet or personal computer, and clinicians can also use the same type of devices as best suits their needs.

➤ The Power of Exoskeletons

We have seen them in movies and video games and now they are here for real, for military and medical applications: exoskeletons. With the help of these devices, paralyzed people, patients in rehabilitation of stroke or spinal injuries or with frail physiques due to pathological issues, can walk again. Exoskeletons can enhance strength in order to allow a nurse to lift an elderly patient. While they have many

exciting uses, it is important to remember that currently are costly to be made and their power supply’s electrical storage and time of usage (usually they are battery powered) need to be improved, so at least at first they will not be available for everyone. In some cases insurance companies cover their cost. Because of the mentioned factors, the advantage of having and using an exoskeleton, has the potential to deepen already existing social and economic inequalities.

➤ Robots in the supply chain

The great thing about robots is that they can be built to be so durable that they can overtake tasks that for humans would be simply too dangerous. There is a robot which is designed for testing chemical protection clothing. It moves freely and can even adjust suit temperature and simulate sweating to provide realistic conditions. Such solutions not only minimize the risk to human testers, in the long run mechanization of the supply chain makes production cheaper as well.

➤ Robots come in all shapes and sizes

This robot, despite its size, is just as impressive as a super strong carrier one. When swallowed, it’s controlled by a technician with the help of magnetic fields it can patch up wounds in the stomach lining or safely remove foreign items such as swallowed toys.

There are numerous projects in the works to develop microbots and nanobots that can easily be injected via a needle in a vein or inserted to various body cavities; and travel through bodily fluids in order to deliver medications with great accuracy, to targeted tissues, or even to repair damaged cells. Though most of these are only theories today, tomorrow we very well could be fighting off infections with the help of nano-robots that are built to mimic our white blood cells, only doing a much faster and effective job of destroying bacteria.

➤ Pharma – robotics

As with nurses, pharmacists are burdened with duties that could be eliminated by utilizing the advancing robotics in healthcare. Heavy lifting, as always, is a big help, but a robot could process information much faster and much more accurately than humans. This way it could make more precise recommendations after sifting through the patient’s available medical data. This pharma-robotic could work as an ATM does; so no matter time of day patients can get access to their prescriptions. If robots were used for such tasks, pharmacists would have the time and the incentive to participate in the social aspect of healing: educate people of preventive measures, give practical advice and therefore make sure that healthcare truly becomes caring.

➤ Companion Robots

Certain robot companions with advanced artificial intelligence software and interactive abilities can serve as a social partner in order to alleviate loneliness or treat mental health issues. Some of them even have touch sensors, cameras and microphones, thus their owners can get into discussions with them, ask them to find a great concert for that night or just remind them about their medications. (<http://medicalfuturist.com/robotics-healthcare/>)

**Figure 4**

*Robotics in healthcare*



Πηγή: (<http://medicalfuturist.com/robotics-healthcare/>)

### 3.5 Enabling IoT Devices to Work Together

If we achieve to have the same communication zone between the devices, the doctors, nurses and of course the patients, we could reduce the medical errors which are caused by lack of communication of the devices to each other.

What we have to do is enabling all the devices to work together. We need to achieve the required compatibility for establishing the right communication protocols. It's obvious that connecting all devices, apps, data and so forth opens up a new world of opportunities, as the Internet of Things in general does.

The Internet of Healthcare Things includes the devices and connected assets which we mentioned before. However, if we really want to look at it from a whole perspective, it's far from here and major challenges need to be tackled: health device interoperability, integrated systems connecting patients and healthcare workers, secure standards and so on. Of course we need to go beyond the healthcare or medical 'things' aspect and look at the broader picture.

However, if we look at it at a technological level, we see the need for further changes and improvements in the field of consumer and healthcare and the professional health sector where wearables, several biosensors and so forth are also increasingly important for professional use in large health care facilities. In that linking of prospects on both parties, new healthcare provider and healthcare payer models arise, including rather consumer-oriented wearables and at the same time more professional devices.

[\(https://www.i-scoop.eu/internet-of-things-guide/internet-things-healthcare/\)](https://www.i-scoop.eu/internet-of-things-guide/internet-things-healthcare/)



## 4. Health care system in Greece

In the next years, in global scale, there will be an increase in the number of inter-connected devices, their locations, and of course the functions that they will perform. Also in Greece, we will see server-based applications that will be linked to secure networks and will be able to monitor the patient's health status; by providing all of its clinical ongoing condition's data so that the doctors and the nursing staff have an immediate overview of the situation. This will provide better care for patients in a much shorter time.

In homes, offices and other workplaces, sensors will be monitoring each of us so there will be early warnings if anything is going to go wrong with our health. The data gathered can be used to improve our quality of life, identify needs and provide specific requirements if it will be utilized in an appropriate way.

In order to study more specifically whether the IoT will improve the quality of healthcare provided in Greece and in which way; we have to describe the entire path which a prospective patient has to follow:

- I. at first the procedure of a patient who enters the hospital for a routine check-up/ of a chronic disease sufferer visiting the hospital for check-up update very often.
- II. in addition the surgical procedure
- III. and finally the procedure of recovery after surgery or hospitalization

as they currently work in Greece (flowchart as is) and how they could be improved with the contribution of the IOT (flowchart to be).

Nobody can understand all of the questions and concerns a patient and his/her family has unless they have been patients themselves. The best way for hospitals to better serve their patients is to put themselves in the patient's condition and

understand their needs. Only in this way, they can provide useful information which improves the healthcare and the patient experience.

#### **4.1 Situation (Flowchart) for Healthcare as-is**

If we map out the entire process in a hospital and see all the steps patients going through, we realize that in the end, the patient had to interact with up to ten or twelve people. Each person, at the call center, reception, clinics or the hospital, fills different functions and is needed for all the procedures: checkup, treatment for chronic diseases, pre-surgery, surgery or post-surgery.

If we assume the waiting time that a patient has to spend to complete the whole procedure, we will observe that he/she has to wait a lot of time. Throughout this complicated procedure there a lot of times where the patient could feel anxious, confused, or uncomfortable. Certain transitions where misunderstandings are happening between different team members of the hospital should be noted as well. For example, there is no communication between all the teams and the patient has to repeat again and again the same information and fill out multiple forms with a lot of personal information, yet upon his/her arrival at the hospital on surgery where he/she has to fill out similar forms with the exact same information again, as we will see in more details below. The contribution of IoT in all procedures would improve a lot the quality of healthcare and at the same time hospitals and patient could enjoy huge savings.

##### **4.1.2 Procedure of a patient who enters the hospital for a routine check-up**

Especially, if we are thinking of people who suffer from chronic diseases, for example patients with pre-diabetes or with borderline high blood pressure due to smoking and obesity, who have to be at the hospital very often, a decrease of wait times is a big issue which has to be solved.

Let’s map and understand the main delays in the process of a patient who comes at the hospital for a routine check-up or for a patient who is suffering from a chronic disease and comes very often at the hospital:

- Book an appointment.
  - Is the patient satisfied with the booking process of the appointment?
  - If yes, was the time of the appointment kept without a significant delay?
  
- Speed of service
  - Is the patient satisfied with the speed of the administrative services?
  - Is the patient satisfied with the waiting time for his/her consultation with the doctor?
  - Is the patient satisfied with the waiting times for his/her diagnostic examination?
  
- Facilities- Environment
  - Is the patient satisfied with the facilities and the environmental in the hospital?
  
- Quality of the medical services
  - Did the doctor explain things clearly to the patient about his condition and therapeutic plan, in a language he could understand?
  - Did the doctor listen to the patient carefully, understand his condition and spend sufficient time on his consultation?

- Quality of the support services
  - Is the nursing staff polite, helpful and careful?
  - Are the other healthcare professionals and the administrative staff kind and helpful?

Mapping the current flowchart we should distinguish processes/ steps into three categories depending on the value they create in the whole procedure:

- In those that really create value for the client-patient.
- In those that although they do not create value, they are necessary for the process, for example the steps where the patient has to fill out a lot of paperwork with personal and environmental data could be useless for the patient itself, but it is very useful for the medical staff.
- And to those that they don't create any value and should be removed from the production process because they are waste. For example, the delays of the appointments make the patients angry by the long waiting times, so they have to be omitted from the process, using the Internet of Things.

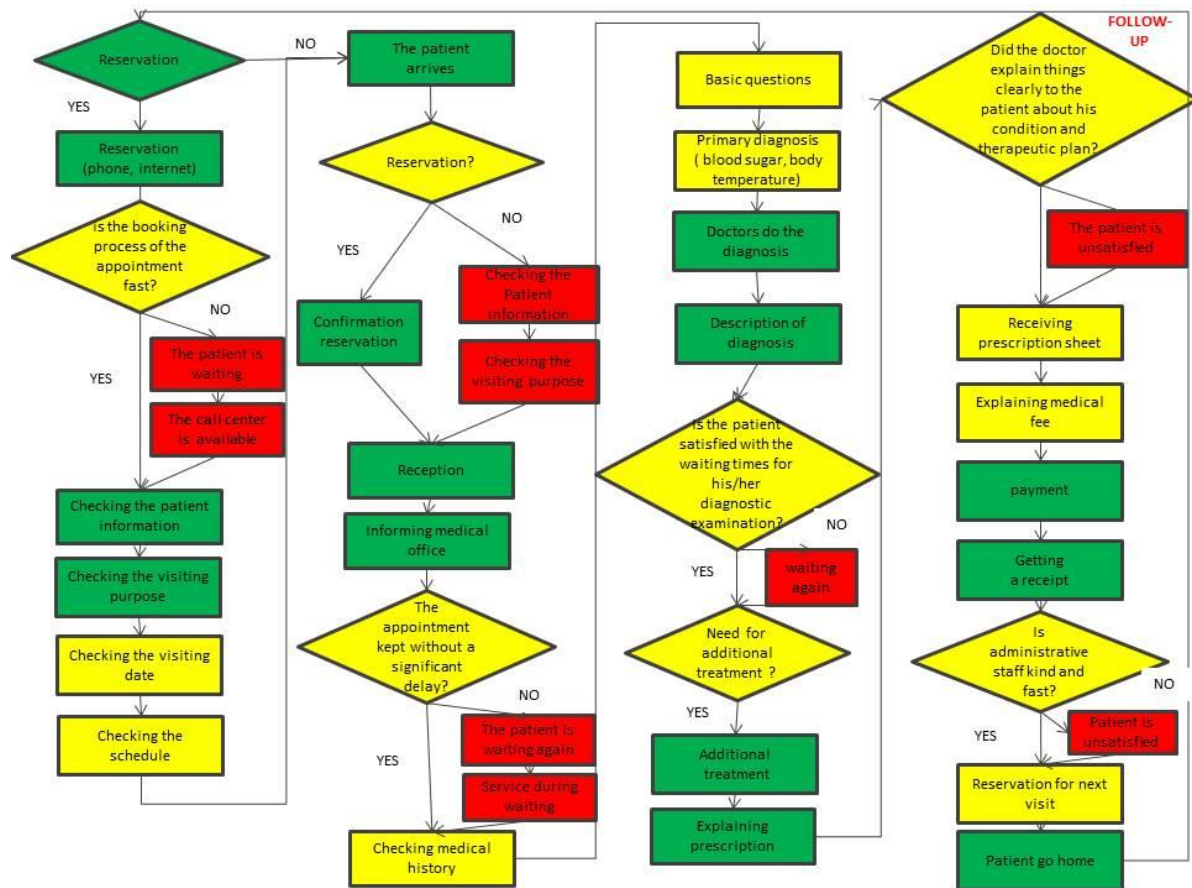
The delays due to waste (waiting, transport, motion) which do not offer any value are shown in red color. On that procedure, waiting time is the biggest problem and it should be solved.

The steps that do not offer value but cannot be omitted are shown in yellow and the steps that add value are shown in green as we will see in the following flowchart.

(See figure 5, pg. 37)

Figure 5

Flowchart for Check-Up AS IS



Steps that add value: green

Steps that do not offer value: red

Steps that do not offer value but cannot be omitted: yellow

The factors which delay the procedure are various:

- The booking process of the appointment is delayed.
- The appointment is in delay so the patient has to wait.
- Repeat of the same questions at the patient about his personal signs
- Waiting times is also a big issue for the consultation with the doctor as well as the diagnostic examination to be completed.
- Troubleshoot documents filled by older individuals
- Delay to fill in documents.
- Lack of data in medical records.
- Long distances for the patient to move from the one department of the hospital to the other.
- The patient can't understand what the doctors tell him or forget the therapeutic plan the doctor prescribed.
- The nursing and the administrative staff is nervous and overwhelmed from the work

Of course, the best we could do is preventing illness than treating it. To come as close as possible to that goal, preventive and wellness care focuses on two types of health consumers: generally healthy individuals, and individuals at risk for specific chronic diseases. Medical technology related to these areas is largely designed around portable and at-home devices. Thus far, most IoT-enabled devices have been wearables such as activity monitors and other measurement devices such as digital scales and digital thermometers, with an element of data-based service such as an app to track results. These devices have seen tremendous growth in recent years.

However, these devices remain largely outside typical care channels. One common IoT-enabled wellness monitor, for example, creates, transmits, analyzes, and stores data but in a database not linked to, and incompatible with, traditional health records. All this detailed and helpful information is unavailable or even unknown to doctors unless patients volunteer it and, indeed, physically bring it along to a doctor’s visit. So there is a difficulty in the flow of data in the case of an aggregated state of health.

Integrating prevention and wellness monitors with existing electronic health-records systems is the key to taking full advantage of IoT-enabled devices’ capabilities and keeping people healthier longer.

Especially for the people who suffer from chronic diseases, often incurable, the IoT could be very useful. Once a patient falls prey to a chronic disease, the need for continuous health monitoring becomes most vital than in a typical case of prevention and wellness. A number of device designers, manufacturers and distributors are aiming to tackle this challenge through integrating the relevant streams of data needed to accurately monitor the health of a patient with a given condition.

A number of IoT-enabled devices (stationary, wearables, implantable) are available to patients and providers to monitor diabetes, heart conditions, and other ailment. These devices effectively and accurately; monitor clinical data (e.g., blood glucose or heart rate), adherence data (e.g., taking medications as prescribed), and consumer health data (e.g., physical activity). Feedback to patients can help them engage and make better health and wellness choices in real time, decreasing the need for costly doctor visits, tests, and hospitalizations and reducing the rate of disease progression.

Taking into account all that is said before, patients who have chronic diseases are less likely to develop complications as the data collected and the analysis provided can be diagnosed in exact time to provide a diagnosis and immediate care if not just earlier care than what existed in the past prior to IoT applications.

For example, patients being treated with digitalis who suffer from cardiovascular diseases could be monitored around the clock preventing drug overdose or misuse. Arrhythmias that were previously only seen on an EKG are now immediately detected and this EKG data indicating heart hypoxemia therefore initiates earlier detection of cardiac issues. The data enables a preventive approach to healthcare by leading people to make healthier lifestyle choices as well as lowering healthcare costs.

The primary challenge in real-time medical care is linking these devices so they can communicate reliably and securely. While blood-glucose and heart-rate sensors are widely available, they are rarely set up to export their data to a system that integrates and shares information with all involved parties (patient, doctors, nurses) and also transfer this ongoing and updated data to an integrated IoT system. Solving these communication issues can ease the shift to greater home care and increased patient involvement in care, driving better outcomes for patients and reduced cost for all. (Cousin M. et al., 2015)

#### **4.1.3 Procedure for entering a patient in the operating room**

In the field of medical health services, surgical procedures are one of the most complex and most important hospitals' cases. All the surgical clinics (orthopedics, general surgery, cardiovascular surgery, neurosurgery, etc.) are scheduled according to a daily program that has been pre-determined the past days but they also have to deal with emergency incidents when a patient is being admitted for acute – care treatment.

The increased demand of surgeries in combination with the lack of resources (materials, nursing and medical staff, etc.) and the bureaucracy, make the process of a surgical procedure quite complex.



For initiating a patient’s operating procedure; the following steps are taking place:

- Transferring a patient to the operating room
- Transferring a patient into the surgical room
- Anesthesia
- Performing Surgical procedure
- Transfer patient to recuperate
- Stay on recuperation until he fully recovers
- Transfer the patient to a room or ICU if required

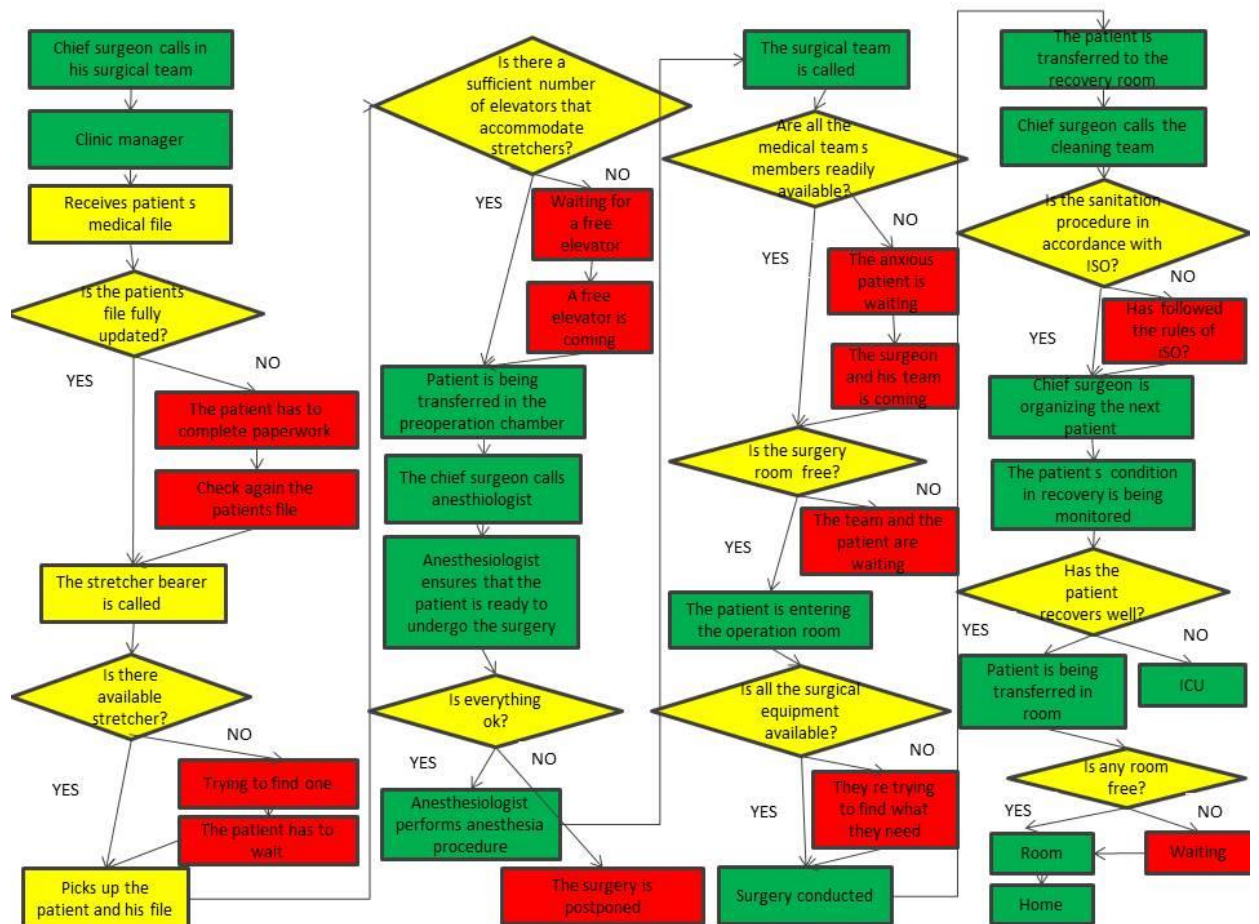
In order to identify the difficulties and delays that occur during the pre- surgery, surgery and post-op surgery and make the situation more difficult, delaying and disregarding the surgical program, it is necessary to map out the current procedure as it is in a flowchart.

Mapping the flowchart as it is, we should distinguish again the steps to complete the whole procedure into three categories depending on the value they create:

- In those that really create value for the client-patient.
- In those that although they do not create value are necessary for the provision of services, for example the transfer of the patient from the clinic to the surgery, has not any value for the patient itself as a process, but it cannot be completely omitted.
- And to those that they don’t create any value and should be removed from the production process because they are waste. For example, to be the surgical room fully prepared or to be clean, it’s off course very important and for the healthcare of the patient but it’s a waste of time for the patient to wait for all these procedures to be completed and this is why they have to be removed from the process, using the Internet of Things. (See Figure 6, pg. 42)

Figure 6

Flowchart for the Surgery Procedure AS IS



Steps that add value: green

Steps that do not offer value: red

Steps that do not offer value but cannot be omitted: yellow

The factors which delay the procedure are the following:

- Transferring a patient to the operating room.
- Lack of staff for patient’s pre surgical preparation
- Not appropriate fasting imposed prior to each surgery
- Non-timely delivery of the required pre-operational medical check-ups from the appropriate departments to the patient's clinic.
- lack of some of the required examinations or more exams than those which are necessary
- Not a timely delivery of a suitable stretcher for patient transportation.
- The architecture of hospital areas is such, that the handling and transportation of stretchers is difficult and the occupied corridors hinder fast and smooth flow.
- Long distances from the operating room.
- Insufficient number of elevators that accommodate stretchers.
- Improper use of elevators intended only for medical staff; by visitors.
- Introducing Patient to the Operating Room.
- Anesthesiologist Delay
- Long documents to be completed before importing patient to surgical room
- Troubleshoot documents filled by older individuals
- Delay to fill in documents that should already be pre-filled.
- Lack of data in medical records.
- Transferring a patient into the surgical chamber
- Not timely update to complete the previous process

- Inappropriate provision or lack of necessary equipment and materials required for surgery.
- Delay of a cleaning team to sanitize the operating room from previous procedures.

- Anesthesia

- Anesthesiologist’s unavailability
- Malfunctions in the anesthetic gas supply system

Performing Surgical procedure

- Problems in the operating room (wear and tear)
- Lack of surgical rooms
- Insufficient number and proper specialization of staff
- Lack of resources, medical tools, equipment.

- Transfer patient to recuperation room

- Lack of coordination between surgery and recuperation.
- Lack of stretcher bearer
- Lack of a stretcher for transferring patient to the recovery area

- Stay on recuperation until it fully recovers

- Post-operative complications requiring re-introduction of the patient.
- Problems of patient’s recovery that prolong their time in the room.

- Transferring the patient to the room or the intensive-care unit, if it is required.
  - Untimely delivery of a stretcher for patient transference to a room
  - In the case of ICU, an inadequate bed allocation for patient hospitalization
  - Long distance from the operating room
  - Density of visitors and relatives in the corridors that hinder the handling of the stretchers.

We observe that also during this procedure, wait times are a big issue. On the day of surgery, during pre-operation, many people find themselves waiting for up to a couple of hours just to begin their surgeries. The exact time a patient is stuck in a waiting room varies, but can be longer than he/she expect. This is a sign of a communication gap, and in order to fill it the hospital staff must know what to say in order to calm a patient.

It is obvious that the factors that cause delays and difficulties in a surgical procedure, are many and create several problems for the patient (who is already stressed out), as well as for the hospital's schedule, because every delay means overtime for the staff, waste of materials, excessive material storage and difficulty of coordinating the surgery's process.

Especially in the occasion of an emergency, doctors have to have immediate access to patient's medical history and compare it to the current data (e.g., current vital signs) with a need for near-instant analysis (e.g., reviewing the current research on treatment options). A provider most likely requires quick access and retrieval of all these information in order to arrive to an accurate diagnosis and recommend a course of action.

Where med tech applications in wellness and chronic care aim to empower patients to look after their own health, in the acute-care setting, the more obvious value lies

in provider-assisting applications. For example, some providers are already experimenting with systems that wirelessly link all of the various sensors measuring vital signs in the emergency or intensive-care units. These systems aim to lessen the monitoring burden on providers in fast-paced environments, with analytics identifying hidden correlations between vital signs, helping to find out real changes in condition that require immediate action. (Cousin et al., 2015)

Again, sensors, which only create data, are only the first step. The most critical and difficult stage comes later: How can the IoT could analyze all these data and help identify meaningful details so that a provider can make better-informed and improved clinical decisions thus providing the right treatment.

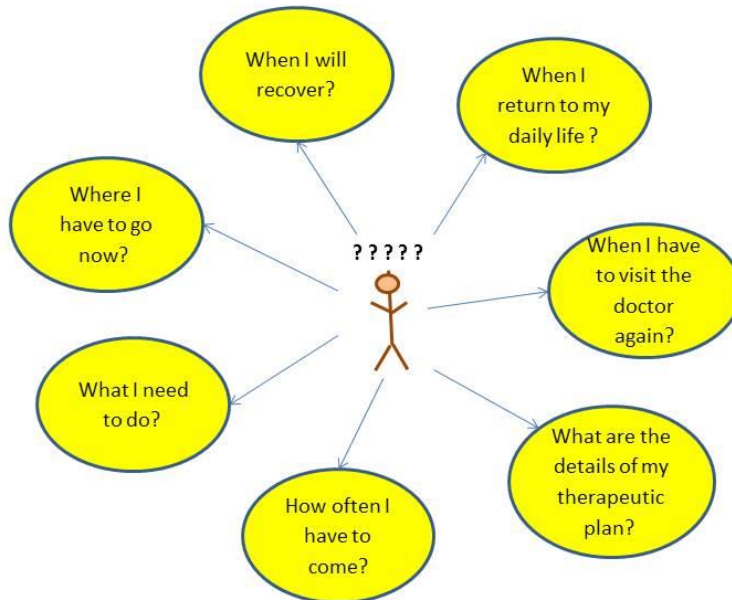
#### **4.1.4 Procedure for the post-acute care of the patient**

Another part of the process, where the patient receives a lot of information and feels anxious and overwhelmed of the information, is the post-acute care period, the procedure that follows after the surgery, or after hospitalization. Transitions occur at times such as entering and leaving the surgery room, and in and out of rehab. These are areas for example; when a patient prepares to leave the hospital they usually have some general questions:

- Where I have to go now?
- What I need to do?
- How often I have to visit the doctor?
- What are the details of my therapeutic plan?
- When I will recover?
- When I return to my daily life and my old habits?

**Figure 7**

*Flowchart for the Post- Acute Care AS IS*



All these questions could make a patient feeling nervous and anxious in the high-stressed environment of a hospital.

A lot of times, he/she forgets to ask the doctor about the prescribed medication of the following days or when the doctor gives advices or explains how the patient has to take the prescribed medication, the patient is not concentrated on what the doctor is telling because he/ she is anxious and nervous.

All these misunderstandings can delay the effectiveness of the recovery period and sometimes could also cause worse problems on the health of the patient from that the patient already has.

This information could be made more readily available by improving staff communication in the hospital, but the easiest solution would be something to empower the patient to have this information readily available at all times like an app on his mobile phone, as we will see in more details below.

## 5 Using Big Data analytics and Cloud to improve the Healthcare

In this chapter we will see how we could improve the journey of a patient using the Internet of things. The purpose is improving the quality of the healthcare and at the same time, saving money and having a patient centered approach.

The basis for success this improvement involves:

- Improving the value of each step
- Removing any waste from the process

### 5.1 Improving the procedure of a check-up using the Cloud

First of all, for the patients who are coming at the hospital for a routine check-up or for whom who are suffering from chronic diseases, instead of coming to the hospital so often and wasting time and energy; they could use an appropriate app which includes everything a patient has to know. (See Figure 11, pg. 62)

Whether if we want to manage and change a chronic illness condition or to adopt a healthier way of living and a more qualified lifestyle, an application for mobile phones could help people to reserve, change or cancel an appointment, access to medical reports or even to ask for more prescriptions, in a very fast and easy way. This application would help the people to save a lot of time, so if the application's interface is friendly, patients will have the ability to use it because they are used in other applications they have already used in their daily life. Patients will have the ability to find what they want; when they want it and use the capabilities that are provided with the minimal effort. The application could also remind them when they have scheduled the appointment with the doctor so they won't forget it.

Forgetting the appointment is a common problem that has happened to everyone. An application which reminds the patient about the appointment with the doctor



would help him/her to remember the important appointment dates with the doctor or the visit day in the hospital. Reminding the appointment day is very helpful for both patients and physicians to know their schedule, and for the hospital because any cancellation which is not directly announced to the doctor and the hospital is a cost that another patient might have served at the same time. (See Figure 11, pg. 62)

If we want the application to be accepted from all the patients, it must be easy to be used and understood. The time and the effort a patient needs to learn how to browse and use the hospital mobile application is directly related to the level of cognition he/she feels with the application and also related to the level of satisfaction he/she will encounter. But if we could provide to the patients a high level of satisfaction from this application, they were more likely to continue using it if the interface of the app is simple and patient-friendly. Designing and developing an application personalized to the needs of patients would help them so much.

Except of using an application only for daily use such as scheduling or changing an appointment the most important for the quality of the healthcare of a patient is using wireless monitoring system through smart phones and developing an application which includes and connect all the useful information about a patient and his surroundings. This application uses sensors to collect comprehensive data on the physiological status of an inpatient, sends this information to the cloud for analyzation and review and then forwards this analyzed data to the patient’s caregivers and healthcare professionals who can then analyze this data and use it in the immediate and long term care of the patient. Smartphone applications monitor patient health all the days and all the time with real-time wireless real-time update on patient status and send them to the cloud.

This replaces the need for the patients to do routine checks on vital signs or for whom with chronic diseases to make frequent visits to the hospital.

Let’s see in details how this application could add value in the process of the healthcare:

- The first step is the collection of database in order to have a fully updated medical history of each patient. Sensors will collect patient data such as: personal information (name, surname, age and gender of every patient), past medical history, medications and lab results, lifestyle and also data of their first degree relatives and some useful information about them (diseases, heredity, if a relative has died and the cause of it) elements that will serve to have a complete history for each patient. Some of the sensors will be environmental and will collect data from the environment of the patient; so the data base will includes information about the lifestyle and the activities of a patient and measurements about the vital parameters of the patient such as temperature, heartbeat, pressure, sugar.
- In order to improve the database and have better predictions; we use microcontrollers that process, analyze and wirelessly communicate the data. If we want to improve prediction and early treatment of diseases; a clustering has to be conducted.

There is plenty of information gained in health care systems. However, there is a shortage of hidden relationships and trends in the data. The most important is to predict people affected by various diseases. Data mining techniques could be used to analyze medical data between the human populations. Clustering is the process of categorizing data files in one of the predefined sets in order to extract rules and data standards that could be used for forecasting.

- With the help of microprocessors rich graphical user interfaces are enabled. These interfaces aim to distinguish one user from another. In case that there is already a user profile, then it will be updated. Only in this way, a patient centered approach and a personalized health information could be achieved for each patient.

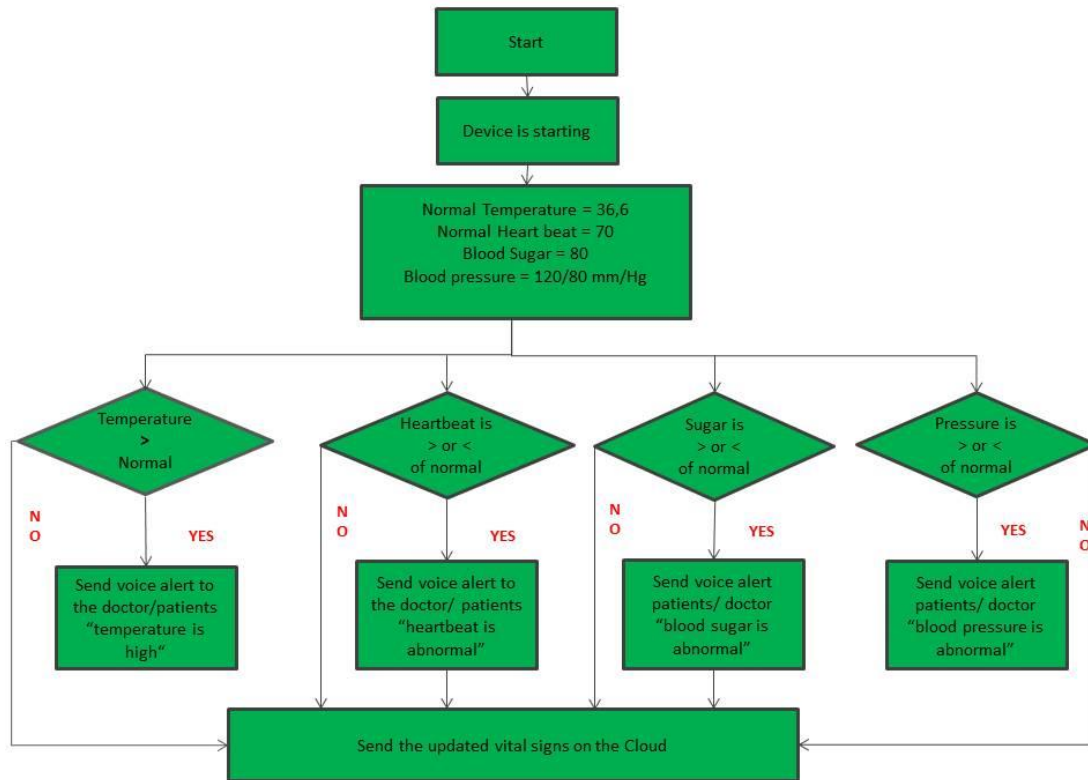
Healthcare specific gateways through which sensor data is further analyzed and sent to the cloud. (Maksimovic M. et al., 2015)

The proposed app is providing a flow of minute to minute information on the patient. It's consists of a smartphone filter system that receives the patient's health data from smartphone applications and compares it to the data base which includes the usual signs of the various health parameters of each patient. If the incoming health signs on the filter are found to be unusual, then an alert SMS is sent to the doctors with whom the patient is associated with and to the relatives and a copy of the file is also sent to the Cloud running an ERM system maintained by the hospital. (See Figure 8, pg. 52)

The patient may be in an emergency and may not realize that he/she is a danger. The filter recognizes that the patient may be in risk based on historical and current values of the data being detected. If the filter determines the condition as critical, an analytic report is sent to the doctor through an SMS, along with the patient's location, sensed by the GPS sensor running on the smartphone and at the same time an ambulance is called to take the patient and go to the nearest hospital which can treat the patient faster, using a recommendation system as we will see below. (See Figure 9, pg. 53)

Figure 8

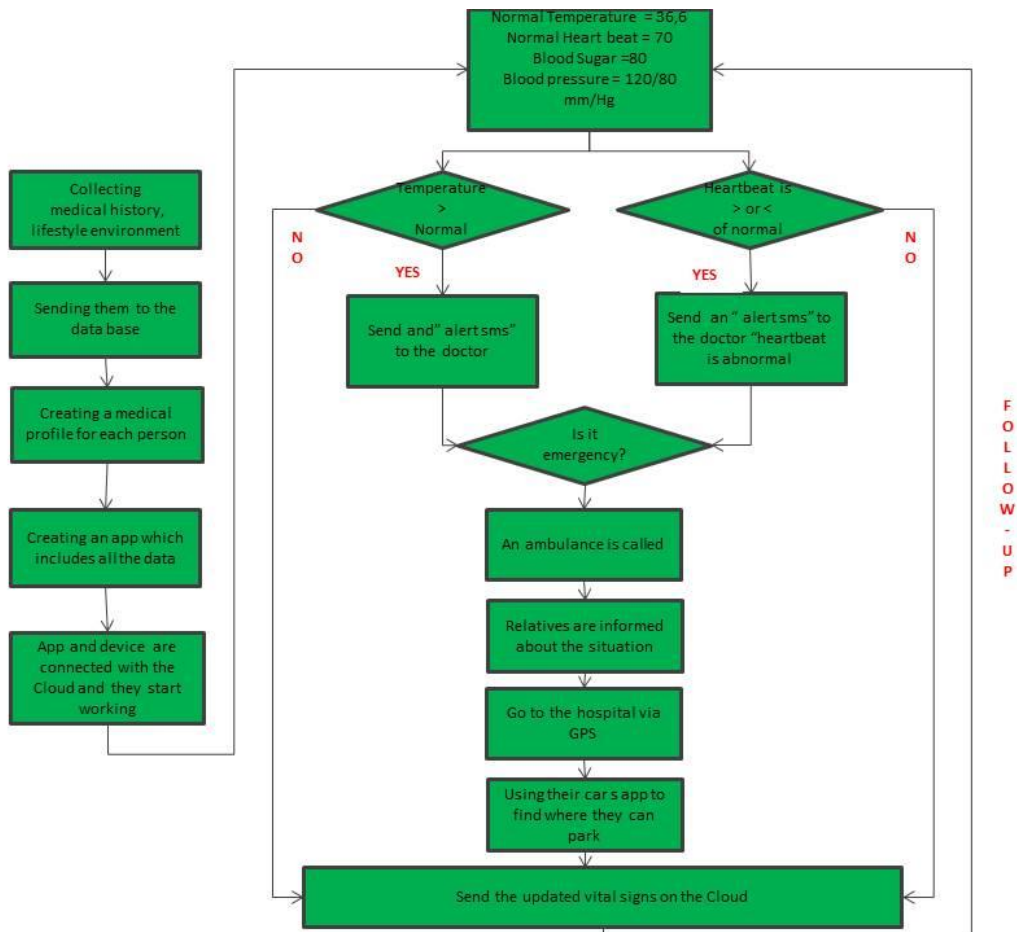
Flowchart showing the events using the IoT



This system, as we see in the following flowchart, focuses on collecting vital signs of patient’s health and alerts doctors to take immediate action in case of emergency. Data is then sent in Cloud so that data can be accessed via the Internet from anywhere, anytime. Cloud computing is the use of computing resources (hardware and software) provided as a service over the Internet. Cloud has abundant processing power, large amount of storage which can be scaled according to application needs. Modern technology is being shifted to Cloud based platform as it is suited for long-term data storage.

Figure 9

Flowchart for a check-up TO BE



This constant data monitoring simultaneously improves the quality of care to each individual requiring medical care, it is proactive in delivering care through alert systems therefore lowering the cost of medical care as a caregiver is not required to actively collect data and information for analysis. The real vision for the future is that the Cloud in collaboration with all these various smaller applications which we mentioned above will converge to form a whole one.

## 5.2 Improving the procedure of a patient who is entering the operating room

Proper steps to eliminate wastes and improving the quality of care are the following:

- Improving staff communication, collaboration between clinics and surgeries and better preparation of the patient would improve a lot the value of the healthcare but the best solution would be to standardize the procedures and be known to the patients via their mobile phone. This would be achieved by creating a smartphone app that would contain all the necessary information that must accompany the patient throughout the procedure, allowing patients to know what to do in each step.

The proposed app is providing all the information the patient need to know about the process mapping in a hospital. It's consists of a smartphone system that receives the hospital's data included all the department's data of the hospital and sent it to a platform of data analysis which includes the real time data collected from all the departments in order the patient be aware of the steps which has to follow in the whole procedure and have a better diagnosis and treatment provided that there is stronger stakeholder communication.

Having a smart application that informs patients about how each department of a hospital works and the steps they can expect while being processed and treated could improve their experience and make them feel more familiar with the surroundings of the hospital and the whole procedure.

- Reduce unnecessary staff movements

If we are thinking about what it would mean for nurses around the world if they had robotic assistants for all simple jobs such as patient documentation, bedding and bureaucracy so they can concentrate more on helping patients.

Nurses spend about 3 hours from workload to patient documentation rather than patients. The most frequent interaction during hospital stay is between patients and nurses. The medical staff draws blood, checks the vital signs, checks the condition, and takes care of patient hygiene, if is needed. They are often overwhelmed by physically and intellectually exhausting duties and the result is often an unpleasant experience for all the involved. Having a smart device that connects them to their patient and to multiple medical devices will solve the problem. This smart application will have an interface that allows nurses to monitor patient data anytime and anywhere. With just one click you have the vital signs of the patient on the screen. A continuous automated flow of information will allow the nurse to monitor more patients, efficiently.

Robotic nurses could also help with repetitive work. In this way, the staff will have more energy to deal with issues that require human decision-making. Some robots could even get the blood sample instead of nurses spend all these turnaround time for blood tests etc.

- Adequate and appropriate keeping, storing and saving of surgical records so the number, type and particularities of the planned surgeries are known at all times, thus, there was a better scheduling of the surgical procedures.

In addition, live emergency room and waiting room screens could show in live waiting times for each patient according to the severity of their treatment and divide them into "severe injuries", "moderate injuries" and "not severe injuries".

In this way patients could calculate the time they need to complete the procedure and they would feel calmer.

The best solution is creating a smartphone app that would serve not only the patients who are already in the hospital but also the patients who are going to go to the hospital, allowing them to check local hospitals before leaving their home and seeing where they might get treated soonest.

The proposed app consists of a smartphone system that receives the patient’s data and sent it to the data base which includes the real time data collected from all the privatized and the government hospital in order the patient choose in which hospital will have the faster treatment and which hospital has more free beds. Then the relatives using theirs car’s navigation system find the faster traffic route to get there and via the app they could even be informed where they can park.

And the patient goes to the hospital where there are free beds. We could imagine the family around a hospital bed. The patient turns to a speaker: “I am cold! Please make it a bit warmer in the room. Oh, and please raise the blinds for more light.” As if by magic, the room complies with the request. The patient then asks “What’s for lunch today?” and hears a menu of options. A visitor then asks “Please tell me about the doctor looking after my friend” or “What are the visiting hours tomorrow?” It is not far to foresee that cognitive-assisted services will supplement all manners of care in offering a more personalized experience.

- Standardization of surgical kits per operation that leads to better sterilization and minimization of waste.

Again a Robot could contribute to that because robots don’t need vacation, rest, lunch breaks or sleep. They can work all the time and every day without a break. With a new generation of them more agile and flexible than ever they increase productivity in all kind of factories.

- Apply a room cleaning protocol that helps ensure the required high degree of sanitization and at the same time helps minimize the time required to clean the room.

One of the most dangerous events is the infection which a patient could acquire in the hospital and is supposed to be one of the main causes of death in hospitals. This is why we need to find a way to abandon them. Again a robot could disinfect any space in a healthcare facility quickly and efficiently using high intensity ultraviolet light. This robot is more effective in causing cellular damage to microorganisms than



other devices designed for disinfection. It reduces the number of hospital acquired infections. It's yet another example of how robotics in healthcare helps hospital staff to decrease workload and will lead to a much friendlier and safer environment.

- Surgeon robots could contribute to better results.

Surgery is an unpleasant experience at best. Waiting lists can be large depending on available human resources and resources. A robot called "da Vinci" helps to solve the problem. It has been used in a wide variety of fields from general surgery to urological surgery. The surgeon is in complete control of the system at any time, however, as the machine has more flexibility, smaller incisions make them to have easier and more precious access in the problem areas.

Da Vinci surgical systems are designed to help physicians perform surgical procedures through a high-resolution three-dimensional imaging console. Robotic surgical systems use special instruments, including a mini surgical camera and high-precision tools (scissors and scalp) to make surgery possible through just a few small incisions in the patient's body. The system can bend and rotate these tools in ways that are impossible to perform the human hand and thus can perform a more accurate surgical procedure deep within the patient's body.

Until now, the use of robots in surgery has been mainly applied to urological and uterine surgeries and less to interventions such as heart. The next-generation robots will "have" sensations such as touch while they will constantly learn through the processing and storage of data from each operation they are involved in. Robotic technologies help doctors make better diagnoses and provide superior quality treatments. From surgical procedures to rehabilitation therapies, robots have already begun performing complex procedures, which, in many cases, could not be achieved with "bare" human hands. So over expensive and flexible "hands" will be a type of medical consultant at the time of surgery, contributing significantly to increasing success rates .

- Access to the MRI scan whenever the doctors have to.

This means dramatically reduced costs for the hospital, if we are thinking how much do these high –value machines and exams cost. Although they are very costly for both patients and hospital, they are necessary for the proper diagnosis and the proper treatment.

The IoT allows medical devices - sensors to communicate with each other and other devices in the Cloud. In this way when new unstructured data is coming to the Cloud, it can be combined with other data which there is already in the Cloud and recombined with software to detect any anomalies. For MRI, PET, CAT Scan and other devices, stopping small problems from getting big problems crashing expensive heavily used equipment is the ultimate value of predictive maintenance. Hospitals are large places with a lot of people, and things, and monitoring of assets is quite difficult but necessary to remain competitive.

For example, in the case of a surgery the unstructured data would be very useful because if that data from the same process is combined and recombined with data from other devices, MRI/ PET scans, pharmaceutical research, blood systems and hundreds of healthcare systems, thus the Internet of Things contributes to the improvement of health care.

Thanks to the IoT, we are able to capture all these unstructured data and create structured data that stakeholders in hospitals, manufacturers and individual doctors can learn from it. As a result using all this critical data coming from the sensor, we could answer a lot of questions:

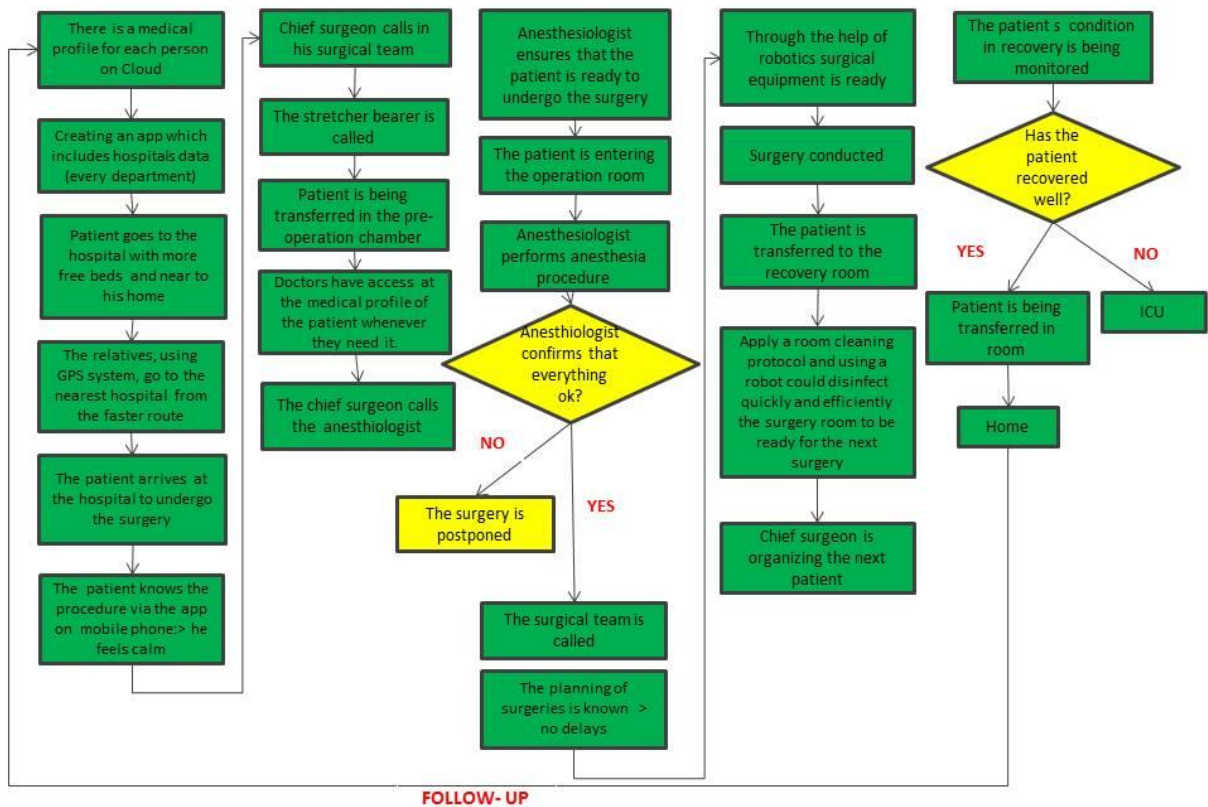
- How does this device work?
- Under what circumstances does this device work?
- How long time did the surgery took?

- Which surgeons did it more efficiently and had better results?
- Who surgeons need to be trained more?

As a result of this solution, training surgeons for the use of equipment significantly improve the results for patients.

**Figure 10:**

*Flowchart for the surgery procedure TO BE*



Unstructured data combined with other data which exists in Cloud help us to harness all the benefits of such heavily used equipment, reducing the cost of the hospital. The most important thing is that patient’s healthcare is improving dramatically through connected devices, subject always to privacy and security.

And for those hospitals that distribute critical care, no one should wait for magnetic resonance; imaging the magnetic to collapse what problems could cause. They can fix the smallest problem before it collapses.

By simply observing the unstructured data sent by a hospital, we can see which part is defective and fix it before it stops functioning. No one should wait for MRI to be destroyed. Hospitals can enjoy tremendous savings through proper maintenance on all heavily used expensive equipment.

### **5.3 Improving the procedure for the post-acute care of a patient**

As we mentioned before, one of the most complicated procedure for the patient is that of post-acute care because it's quite difficult for a doctor to explain the treatment during a ten-minute meeting, while it is equally difficult for a patient to comprehend and remember all this information at the same time. The result is that 80% of the information given to a patient during his or her consultations is deleted from their memory when they leave the hospital. This is why; it's very useful to create an application which explains to the patients and their relatives step by step the patient journey in a hospital because the patients should always be able to access information about their treatment at anytime and anywhere.

Instead of giving pages and leaflets to patients for their treatment who might lose them after some hours, it would be much easier and efficient for both sides {patients and doctors) to digitize the treatment information so the patients can access when they need it the most and anywhere they are. An application which informs patients about everything they need to get acquainted, making them feel calm and improve their quality of care. (See Figure 11, pg. 62)

Let's see in details how this application could add value in the process of the healthcare:

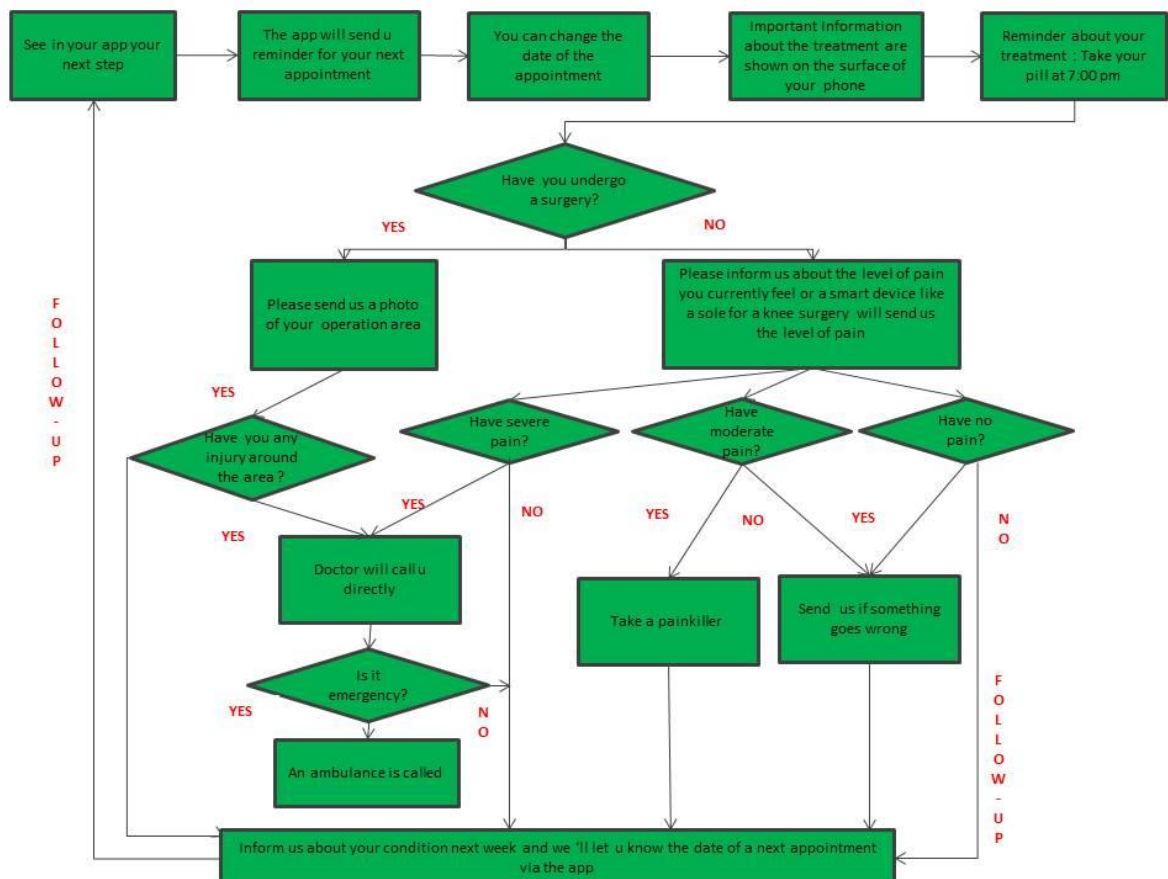
- Using a fully dynamic timetable this application could educate patients about the next steps in their treatment. Unlike printed patient leaflets, information is delivered in stages and only when it's relevant, so the patient doesn't feel confused and so anxious.
- Sending notifications to provide useful information, updates, and reminders to enable patients about their treatment could help them so much. Common examples of push notifications include fasting after surgery, home preparation, or exercise patients need to do after a surgery.
- The app will have a very friendly user face to be easily used by all the patients. A guide is the first thing users see when they are downloading the app which helps them to better understand what the application does and how to use it. In the case the users have questions at a later stage, the onboarding guide could answer them all the questions they have.
- Asking patients for information about how they are feeling, about the pain levels or other experiences they have, could also be used as a feedback to see if the patients will continue to get the same prescription.
- All the information contained in the application will be accessible to anyone who has downloaded it. The use of the patient education platform is completely anonymous and does not require personal information so it's very safe.
- Using also visual content like videos would help patients and their relatives to understand better what exactly they have and understand better their treatment. For example, medical staff photos, surgical video tours or rehabilitation exercises seminars could help a lot the patients as their family.
- The application will be fully personalized for each patient, depending on his/her treatment and his /her characteristics. It will contain the name, phone number, address, patient information and all the information which is exists in the Cloud and in this way it's easy for the family and the doctor to find the patient when it's emergency.
- The app will learn from the patients by following their commitment. Within the content management system, a clear toolbar with usage statistics could

help the patient to analyze and improve the information in his/her application.

- This app could also offer a platform without any integration into the hospital information systems. The content of the application can be easily managed internally by physicians, nurses or communications staff. This gives the ability to change or add new treatment and to communicate or ask something the doctor in real time.

Figure 11

Flowchart for the post-acute care TO BE



Process mapping, patient stories, and review of patients' notes highlighted multiple delays and examples of patients who "stuck" and missed the opportunity to discharge, especially after moving between chambers or groups. Especially for the elderly, this could be associated with deterioration and further unnecessary days or weeks in the hospital.

Moving to an assessment model, where patients who need post-operative care are discharged as soon as they are medically fit, with assessment and care packages put in place with the patient at home.

Guidelines and penalties for the same patient who reentering to a hospital within 30 or 90 days after treatment underline both the reduction in re-admissions in acute settings and the provision of safer and more effective after acute care in lower-cost and lower-cost settings. As a result, applications are linking the patients with the providers and the caregivers. For example, after a knee surgery, simple sensors placed inside the soles of the shoes could produce data that measures the pressure supported by each foot during daily ride, pace, or pacing around. In addition to combining these sensors with accelerometers that measure the patient's pace would provide sufficient information to detect imbalances or instability, contribute to assessing changes in patient activity levels, and assess the effectiveness of the rehabilitation program.

Also for checking the patients if they are taking their prescribed medication after an illness or a surgery, a smart pill is inserted in the patient and informs the doctor as to how that patient is taking their prescribed medication. All this information technology is directed in providing medical information through the Cloud on the performance of pharmacology, medical performance as related to the behavior of each patient. This is surgically placed under the skin of the patient to monitor whether they take their medication at the proper time and other health data and sends it to the medical professional handling the patient such as to alert them if a medication is forgotten, misused or overly used and the effect of this medication on

the patient. It is certain that this technology will be carried further in the diagnosis and treatment of patients as needed.

The mechanics of post-acute monitoring resemble those of chronic-disease care. Post-acute management services exist for a number of conditions and have leveraged remote monitoring technologies for a while, especially in home settings, where more and more care is expected to shift. More advanced technologies are in development that will enable more precise and effective monitoring in the post-acute (and chronic care) settings, specifically around catching complications early (e.g., infection) and promoting compliance. (Cousin M. et al, 2015)

As a conclusion, any form of waste of time, space, materials, and human resources should be minimized in order to gain our goal which is better access to healthcare, quality of healthcare and lower cost of the healthcare.

## 5.4 Recommendation System for Healthcare

In order to support the user recommendation system for healthcare services; we could create a dynamic online community that would facilitate not only the direct communication between the scientific community and the citizens but also among people who experience similar health problems or have the same concerns about their health. Using this platform, users could share and exchange their experiences.

An informed patient who has experienced a health issue can actually help someone who is confronted with the same problem by sharing his / her experiences, practical advice from his daily routine, and also providing emotional support where necessary and useful.

Combining the user profile and the associated characteristics of them, doctors and other users could provide recommendations to patients individually. A personalized recommendation on prevention and corrective actions, the causes of the disease, behavioral prediction, and health information could be provided. The filtering



platform can be used to predict a user's health problem based on the profiles of another user with similar problems and make him to be aware of it the soonest.

Based on user characteristics and preferences, this platform could provide personalized recommendations to users. These recommendations can support them to take better decisions, go to the doctor the soonest, exchange information about the doctors and improve their well-being.

## **5.5 Multicriteria analysis in order to measure the impact of IoT in Health services quality**

In this sub-chapter we will try propose an evaluation model by combining the process modeling and multi-criteria analysis process of the analytical hierarchical process (AHP) in order to measure the impact of IoT in healthcare services. The workflow process modeling as we described in in the flowchart for the surgery procedure As-Is (See Figure 6, pg. 42) is supposed to provide the basis for systematically looking at the opportunities arising from the development of the Internet of Things. A patient entry, surgery and health care service will be selected as a case of study. This is why, based on the surgery procedure we had described on chapter 4.1.3, we will try to measure the impact of IoT using multimedia criteria as we will see below.

### **5.5.1 Aim of multicriteria analysis**

The Analytic Hierarchy Process is used:

- At first to specify which of the criteria is the most important and how much?
- Furthermore, using again the AHP we compare the surgery process AS IS to a surgery process TO-BE, (IoT based process) and which of these processes is the most preferable over the other and how much.

**5.5.2 Methodology**

Five experts with many years of experience in the Healthcare, 2 general surgeons, 1 cardiothoracic surgeon and 2 vascular surgeons have evaluated the importance of the criteria, as we will see in details below and the preference over the alternatives.

The purpose of this survey was explained to all the interviewers. Each surgeon was informed in advance about the aim of this research, the meaning of each criteria and the duration of the interview.

Data of all the questionnaires was collected and analyzed further to have the conclusions. Both of two processes, as-Is and To-Be based on IoT procedures are compared according to the AHP model.

The five dimensions of quality of health services which measure the patient’s satisfaction are: tangibility, reliability, responsiveness, confidence and empathy. (Scholefield, 2007)

For the surgery procedure, reliability, responsiveness, time to complete admittance and diagnosis accuracy are selected as criteria, the explanation of which appears in Table 1:

**Table 1**  
*Criteria which impact the Quality of Health services*

| Criteria                    | Explanation  |
|-----------------------------|--|
| Tangibility                 | <ul style="list-style-type: none"> <li>➤ Excellent health services hospital would have up-to-date facilities. Examples are: buildings, equipment, X-ray department, laboratories etc.</li> <li>➤ The physical facilities of excellent health services hospitals would be visually attractive e.g. reception area, corridors, wards, out-patient department, signs, car park.</li> <li>➤ Materials associated with the hospital’s service such as appointment card, brochures, directions, documentation should also be of good quality.</li> </ul> |
| Time to complete admittance | <ul style="list-style-type: none"> <li>➤ Excellent hospitals complete the admittance as fast as possible.</li> </ul>   |
| Diagnosis Accuracy          | <ul style="list-style-type: none"> <li>➤ Excellent hospitals carry out services without errors of diagnosis.</li> </ul>  |

|                       |  |
|-----------------------|--|
| <p>Reliability</p>    | <ul style="list-style-type: none"> <li>➤ Excellent hospitals provide their services at the time they promise to do so, e.g. be punctual regarding the time of operations, medical investigations, treatment, food etc.</li> <li>➤ Excellent hospitals carry out services e.g. medical exams, right the first time.</li> <li>➤ Excellent hospitals provide error-free documentation e.g. correct medical records.</li> <li>➤ Excellent hospitals help patients to access the service in precisely the way they want, eliminating for example unnecessary and time consuming activities.</li> <li>➤ Hospital staff in excellent hospitals tells patients exactly when services will be performed e.g. date of the operation, progress laboratory results.</li> </ul> |
| <p>Responsiveness</p> | <ul style="list-style-type: none"> <li>➤ Hospital staff in excellent hospitals gives prompt service to patients, e.g. make appointments quickly, return phone calls quickly, and resolve problems quickly.</li> <li>➤ Hospital staff in excellent hospitals is always willing to help patients, e.g. willing to answer questions, provide advice.</li> <li>➤ Hospital staff in excellent hospitals are never too busy to respond to patients requests, e.g. are responsive to complaints, provide patients with information.</li> </ul>  |

AHP is used to show the views of medical experts and to quantify the relative importance of applying IoT to a surgical procedure. The preferences between alternative parameters are given equally, moderately, strongly, very strongly or extremely preferred. Comparisons per pair can be represented as:

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ a_{21} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & 1 \end{bmatrix} = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ 1/a_{12} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \dots & 1 \end{bmatrix} \quad (1),$$

where  $a_{ij}$  represents the value that experts compare the criterion  $i$  with the criterion  $j$ . The relative weights of the criteria in this matrix are estimated by comparing the priority of the criteria. Therefore, the eigenvalues and eigenvectors are estimated using the following equation:

$$\mathbf{A} \cdot \mathbf{w} = \lambda_{\max} \cdot \mathbf{w}, \quad (2),$$

where  $\mathbf{w}$  is the eigenvector of the matrix  $\mathbf{A}$ , and  $\lambda_{\max}$  is the largest eigenvalue of the matrix  $\mathbf{A}$ . The reliability of judgments is tested by calculating the Consistency Index ( $CI$ ) and the Consistency Ratio ( $CR$ ) that are respectively defined as:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (3),$$

$$CR = \frac{CI}{RI} \quad (4),$$

where  $n$  is the number of criteria being compared in this matrix, and  $RI$  is the Random Index.

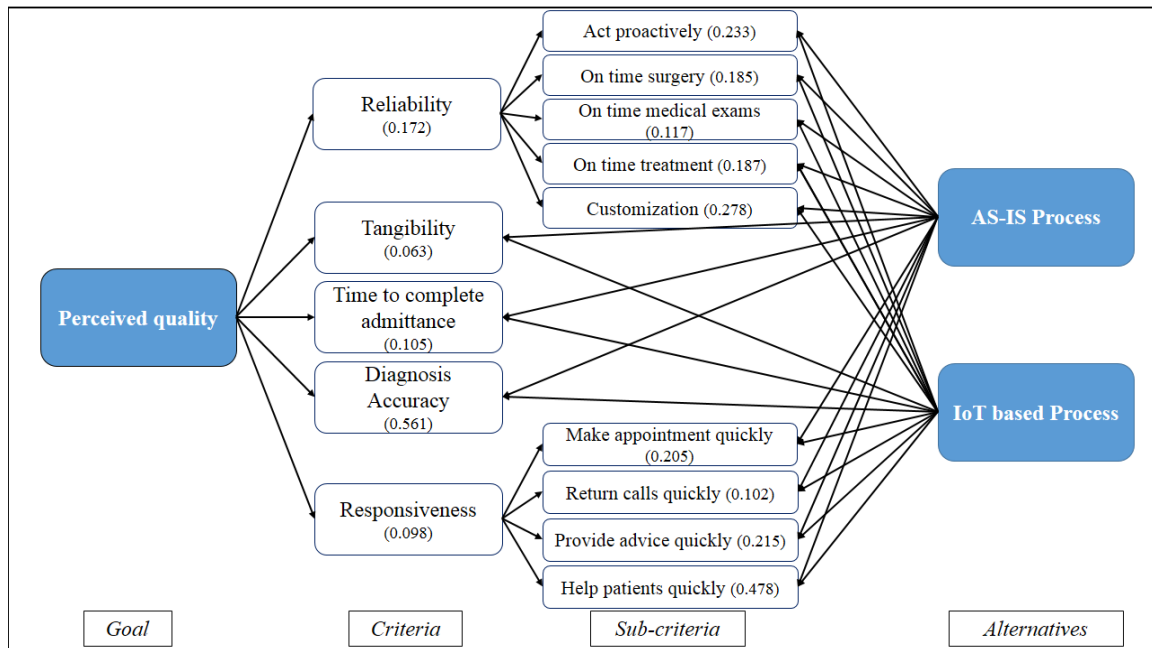
### 5.5.3 Results of multicriteria analysis

The AHP model is shown in Figure 12. The weights and the importance of each criterion and subcriteria are presented in Table 2. As we observe the accuracy of the diagnosis is the most important criterion when referring to its contribution to the quality of healthcare services. After credibility is following and the time to complete acceptance is third. Now, if we see it from the point of reliability, adaptation is the most important factor as helping patients is the most important response criterion.

A very important criterion is also the security, which although is very important in the process, it was not one of the criteria chosen due to the fact that there was no real data. The selection of the five criteria was indicative.

**Figure 12**

*Analytical Hierarchy Model*



**Table 2**

*Weights of criteria and sub-criteria*

| Criteria                    | Weight | Rank | Sub-criteria          | Weight | Rank |
|-----------------------------|--------|------|-----------------------|--------|------|
| Reliability                 | 0.172  | 2    |                       |        |      |
|                             |        |      | Act proactively       | 0.040  | 3    |
|                             |        |      | On time surgery       | 0.032  | 5    |
|                             |        |      | On time medical exams | 0.020  | 7    |
|                             |        |      | On time treatment     | 0.032  | 4    |
|                             |        |      | Customization         | 0.048  | 1    |
| Tangibility                 | 0.063  | 5    |                       |        |      |
| Time to complete admittance | 0.105  | 3    |                       |        |      |
| Diagnosis Accuracy          | 0.561  | 1    |                       |        |      |
| Responsiveness              | 0.098  | 4    |                       |        |      |
|                             |        |      | Make appointments     | 0.020  | 8    |
|                             |        |      | Return calls          | 0.010  | 9    |
|                             |        |      | Provide advice        | 0.021  | 6    |
|                             |        |      | Help patients         | 0.047  | 2    |

**Table 3**

*Comparison of as-is process and to-be per criterion*

| Criterion                   | AS-IS process |                |         | IoT based process |                |         |
|-----------------------------|---------------|----------------|---------|-------------------|----------------|---------|
|                             | Score         | Weighted Score | Ranking | Score             | Weighted Score | Ranking |
| Reliability                 | 0.349         | 0.060          | 2       | 0.651             | 0.112          | 1       |
| Tangibility                 | 0.151         | 0.010          | 2       | 0.849             | 0.054          | 1       |
| Time to complete admittance | 0.192         | 0.020          | 2       | 0.808             | 0.085          | 1       |
| Diagnosis Accuracy          | 0.205         | 0.115          | 2       | 0.795             | 0.446          | 1       |
| Resposiveness               | 0.273         | 0.027          | 2       | 0.727             | 0.071          | 1       |
| Quality of Service          |               | 0.232          | 2       |                   | 0.768          | 1       |

If we compare the as-is process and the process to-be based on the IoT we observe the preference from all the surgeons to IoT process due to the positive impact- value that the IoT could have on the quality of healthcare services. If we see all the criterias in Table 3, we observe that the IoT could add value to the whole process and improving the reliability, the tangibility, the time to complete the admittance, the diagnosis accuracy, the responsiveness and in general the quality of service.

As a conclusion, if we could take advantage of all the benefits the IoT offers, we would have a new system, a system based on real human needs.

## 6 Benefits and Difficulties of Applying the IoT

### 6.1 Benefits

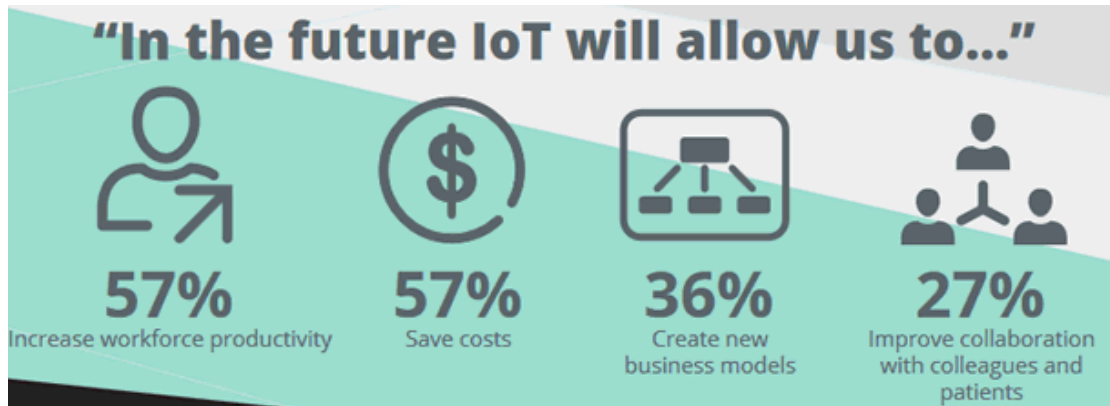
The IoT is continuously changing our life and completely influences the healthcare by finding new ways of connecting people, apps and devices to interact to each other and provide the best health care solutions to the patients. The IoT is offering new methods, automated workflows and new tools which contribute to integrate all the processes in the healthcare system, to offer better care to the patients, as well as fewer costs for both patients and hospitals. (See Figure 13, pg. 73)

The major benefits of the Internet of Things in the healthcare systems include the following:

- Lower costs. When healthcare providers benefit from the connectivity of health care solutions, patient monitoring can be done in real time, thus significantly reducing unnecessary visits by doctors. In particular, home care facilities that are progressing are guaranteed to reduce stays in the hospital for long period and readmissions to the hospital.
- Fewer errors mean accuracy, increased efficiency, lower costs and in summary reduce the risk of error.
- Fewer errors do mean increased efficiency and lower costs in virtually any industry.
- And of course radically reduced costs for all the involved members.
- Significant reduction of materials and thus more economical and more affordable medical packages for patients.
- Improved health care solutions through cloud computing which have the ability to access in real-time information that allows them to take better decisions as well as provide a more efficient evidence-based treatment. This ensures that health care is timely and the results of treatment are improved.

- Improved Disease decision making. When patients are constantly monitored and doctors/ nurses have access to real-time data whenever they want and wherever they are, the diseases are treated before they are getting worst.
- Greater patient safety undergoing surgery and improved services.
- Fewer errors. Cause to the exact data collection, the automated workflows combined with data-based decisions, we observing reducing of delays, waste, reducing system costs and the most important, minimizing errors.
- Greater credibility for the hospital.
- Improved Patient Experience. The connectivity of the health system through the Internet of Things has as aim the patient centricity. Preventive therapies, improved diagnosis accuracy, early intervention by doctors and improved therapeutic results lead to responsible and more effective care creative a more trustful environment for the patients.
- Reduce the inconvenience of patients who until now have had difficulty in closing the date of a visit or a surgery. Co-ordination will serve more surgical incidents per day with the same or even fewer resources.
- Minimize waiting time for patients and reduce discomfort.
- Better co-operation with clear identification and specification of each person's duties and responsibilities.
- Improving working conditions thus achieving higher quality of services provided to patients, because medical, nursing and administrative staff, is the image of a hospital passed outwards to public’s eye.
- Better managing of drugs - Drugs and the management of them are significant cost for the healthcare sector. This is why, IoT processes and devices, are aiming to manage better these costs.
- Saving material resources through standardization of processes and through the contribution of robots.



**Figure 13***Benefits of Internet of Things*

Πηγή: (<https://www.i-scoop.eu/internet-of-things-guide/internet-things-healthcare/>)

We have mentioned some benefits that affect the developments of the IoT in healthcare and are focused on increasing the quality of healthcare, increasing innovation, increasing productivity, creating new more effective workflows and better co-operation, promoting the whole organization and saving costs.

Most of them are following the general healthcare factors and the healthcare market, such as population aging, changing behavior of consumers-patients and patients’ demands such as patient-centricity and the improvement of healthcare quality.

If we see globally the tendency for the healthcare in the next years, we observe that the following trends will prevail:

- High demand for remote health monitoring.
- Increased consciousness for consumer healthcare.
- The growing popularity of healthcare providers/ wearables.

The current consumer is autonomous, uses mobile and wants to be update. He/ she wants to have access to the information whenever he/she wants. The ability to act

on this information is a key component of any successful digital interaction and in the sector of the healthcare.

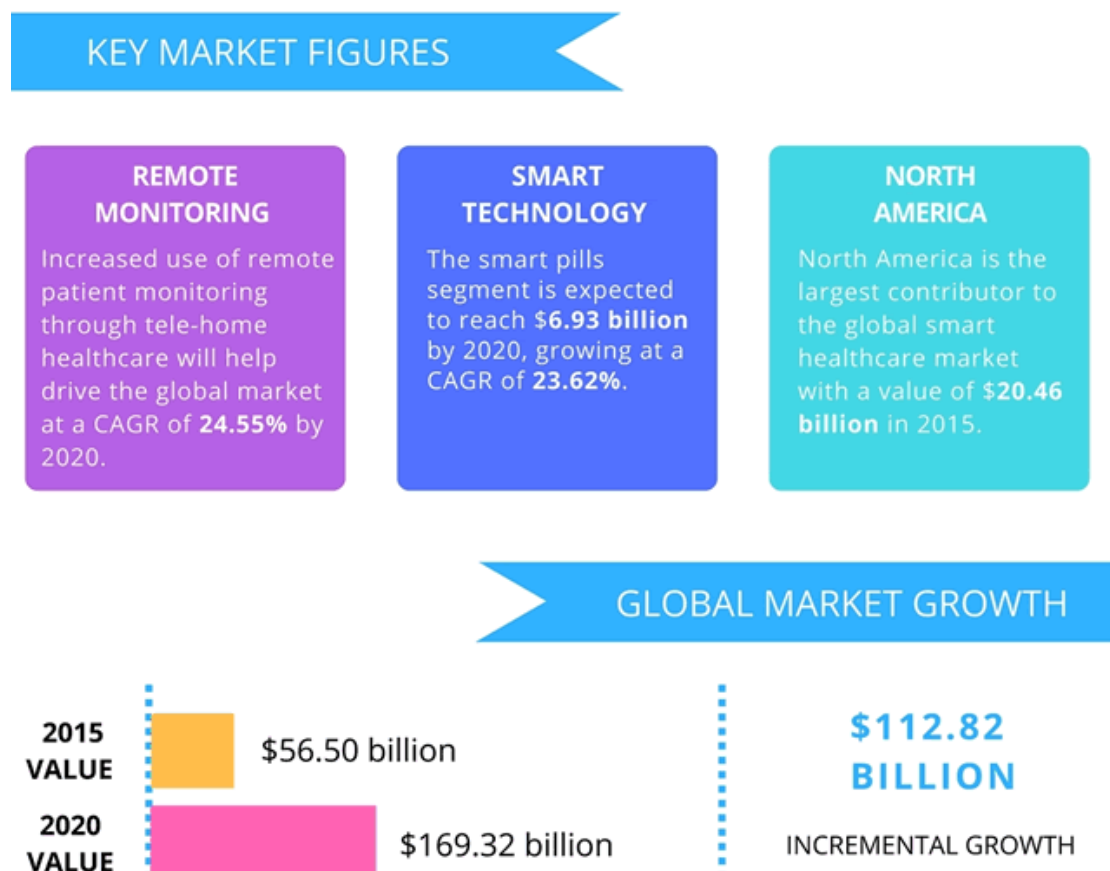
Overall smart healthcare market value by 2020 is estimated to be \$169.32 billion by 2020. A major part of it will be for remote patient monitoring.

As the following graph shows from the press release, increased use of remote patient monitoring will help increase the global market by 24.55% CAGR by 2020. Also, the emergence of smarter technologies is playing a role. The only part of smart pills is expected to reach \$ 6.93 billion by 2020 with a CAGR of 23.62%.

The total value of the smart healthcare market by 2020 is estimated to be \$ 169.32 billion by 2020. A large part of it will involve remote patient monitoring.

**Figure 14**

*Top market Drivers*



Πηγή: Technavio, (2016). *Smart Healthcare –Top Market Drivers and Trends*<https://www.technavio.com>

In order to take advantage of all these benefits of the Internet of Things and have the expected benefits or in other words “achieving the best”, all stakeholders must work with dedication, loyalty and adaptability to the new process.

Due to the fact that it will gradually lead to a change of attitude and culture of the company, it is likely that there will be some staff reactions that can be avoided by understanding the improvement of working conditions as well as improving the morale of human resources. It needs a proficient, flexible, open minded leader who has the ability to lead everyone to the common vision. The key to success is the trust among all stakeholders and the proper education/training of medical staff. The culture change program will help for the smoother adaption.

However, the principles of efficient production should constantly be adapted to new circumstances. It will be an endless cycle of improvement. The feedback is very important here. It is vital to record what progress is being made and the statistics' points that are lagging or making the smooth process difficult have to be corrected. We always have to have the vision and the goal of increasing the value of the provided services

## 6.2 Risks

Although the Internet of Things is an evolution in the healthcare, it also has some challenges due to the fact that health data is a personal and a very sensitive issue. Therefore, when health information is being shared inappropriately it could be very dangerous.

In addition, the digitization of all these data and the subsequent extension of use are likely to press the data centers which need experts people to work on them. The continuous monitoring of the patients wherever they are; especially for whom who are suffering from chronic diseases in combination with the increased use of wearables increase the demand for more data centers and more experts people to work on them. In addition to that, the inability of medical services to exchange data

with each other requires the development of all devices to “speak” in the same language. This means an upgrade to all the connected devices and off course a big cost.

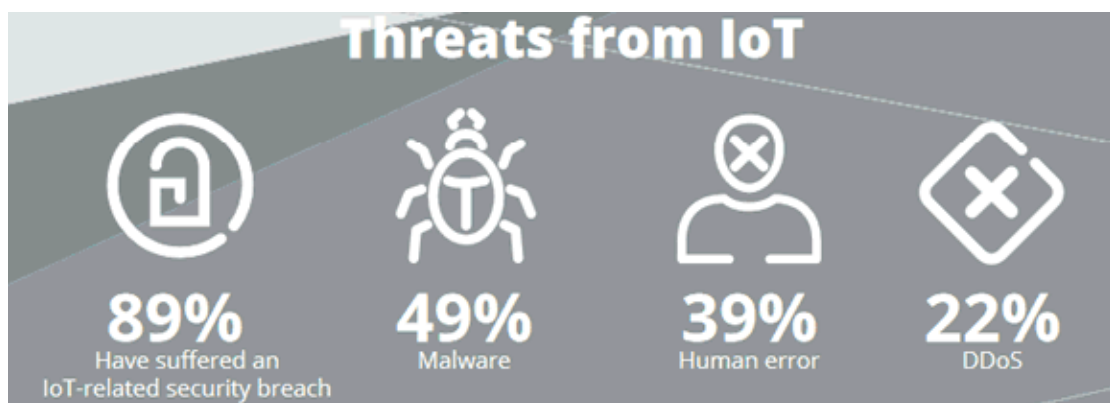
Data security as we will see below is also another big issue that has to be solved because as the data will be increased as the risk is likely to be increased. The volume of data is going to increase significantly so we have to find ways to protect is as we can.

The Internet of Things includes a lot of applications that require the Cloud in combination with tools to run. These tools are vital to ensure that network compliance is controlled and to ensure early warning of abnormalities including user access, network traffic, system failures, and change management activities.

Although the IoT has to harness a lot of difficulties, it’s here to stay, as its popularity is going to grow significantly as all of us have as purpose a more patient-centricity environment and a quality of healthcare. The Internet of Things in health care is linked to connectivity, ensuring that information is available to anyone and anywhere. Therefore, it is planned to be increased in hospitals, in the houses and everywhere even difficult is it.

**Figure 15**

*Threats of Internet of Things*



Πηγή: (<https://www.i-scoop.eu/internet-of-things-guide/internet-things-healthcare/>)

### 6.2.1 Attention for people data

A big challenge for the using of the IoT in the Healthcare has to do with the personal data. Health care information is a very personal and sensitive issue and the collection of data required must be done very carefully. The point is to improve the patients' lives and organize health care in various aspects, such as the ability for physicians, specialists, nurses and staff to make better and more efficient decisions faster.

This is why; designing a very security and privacy system is very important and must be part of every case of using the project, the work, or the development of the Internet.

We have to have always in our mind that the aim of IoT is improving the well-being, saving money and off course improving the quality of healthcare and not using it for wrong reasons.

This is why, personal healthcare data should be treated differently from the point of view of safety and compliance.

Particular attention should be paid to the personal data required for IoT health programs. Various arrangements around the world lead to a compliance agenda, but data security for healthcare needs to go beyond compliance.

At the same time, healthcare organizations must pay greater attention to compliance, certainly in areas where stricter regulations exist, such as the EU GDPR, where personal health data, as well as genetic and other medical and biological data pay particular attention and is considered as very personal and sensitive.

It is clear that any IoT project that includes personal health data should take account of these rules and the terms of legality, intent, consent and dissemination. In fact, every IoT project must have security and privacy when planning when it comes to personal data.

However, the positions of every country on protecting and leveraging health data are very different if we compare the initiatives and regulations around the world.

### 6.2.2 Security

When referring to the health; a hacker could even be a murderer.

Goals and methods are usually agnostic for the industry, from health care to the bank to intelligence. Attackers always want the same things: steal information, manipulate data, disrupt the service with attacks, and use ransom to achieve their goals. However, while in other industries the risks are economic and rumors, human health is at stake in terms of health services and Internet-connected devices.

And as healthcare becomes more complex, the risks are intensifying. Take for example the mechanical learning have already entered into medical practice as they automate some basic medical decision-making processes. Hackers are well aware of this, which frames the intention of assault as "manipulation of the medical decision". In other words, imagine an attack that handles training data by providing false inputs into the system that eventually lead to the wrong medical decision. A hacker can change inputs to the algorithm - for example, deforms the results of a blood test and the “computerized medical advisor” could prescribe medication that can harm or even kill the patient. This could even lead to death.

These systems should be supervised by expert systems and rules (medical expert rules) that provide a level of control and mark suspicious activities that may represent malicious behavior.

Again, remember that the players behind the attacks on health care do not differ from other industries. Hackers, national actors, criminal organizations are all likely murderers, each one of their own motives and intentions.

Moreover if we are thinking of the industry which is fragmented, the risk is increasing. IoT healthcare devices, such as wearables, implantable sugar monitoring

devices, and blood pressure monitors are part of a complex computer ecosystem that presents a major threat area for attackers to exploit.

These devices are based on communication between different databases, storage and control on different networks, and operated by different people with different levels of confidence and knowledge in cyberspace, including at the patient's home, hospitals, clouds, and so on.

These complex relationships make every element and system more vulnerable. This was evident in the 2017 attack on the UK healthcare system, which was essentially forced to close a complete system. Functions were canceled, ambulances were held and documents, such as patient records, were not available in England and Scotland. Because of the fact that the attacks are various and very difficult to locate them directly, we have to create a security ecosystem that:

- Detects suspicious movements effectively
- Carries out investigations to confirm the intention
- Automates the prevention or mitigation actions

These three steps are complex. This security architecture must learn how to receive safely signals from various devices, servers, and services at home, hospitals and patient clouds and then analyze them centrally in real time, while at the same time "connecting the dots" to reveal possible malicious intentions. Only in this way, we could improve safety and take active measures.

One very important issue we have to deal with is to protect the privacy of the health care of the elderly and the disabled.

- People with disabilities should know who owns their health data.
- Permission of disabled people to use a relative/ a doctor or a caregiver their personal data.
- Anonymity or pseudonymization to hide real identities of people with disabilities by hiding a person's identity into sub-identities.
- Privacy of the site to keep the user's locations, devices, etc. private.

- Privacy for IoT devices.
- Emphasis on privacy by the beginning of the design of the application.

In order to be active, this ecosystem must be at the center of cooperation and coordination of all the stakeholders. Once a new advanced attack has been identified and analyzed, the appropriate defense strategy has to be shared and implemented in various environments, including all the hospitals. These do not necessarily have the same security tools and are probably not operated by the same security vendors. Therefore, sharing defense models requires a new level of "defense strategy translators" so that they can adapt quickly and well to any relevant environment.

Solving these issues requires a global effort that defines healthcare as a "critical infrastructure" and applies security technologies that include advanced security analyzes, orchestration and automation capabilities. These new systems are called next-generation event information and management systems.

The world of IoT, especially in healthcare has to create security systems because although we are vulnerable, we don't have to be victims. (Chesla Avi, 2017)



## 7 Conclusion

Given the concerns about the privacy and the data security, it is necessary to have a secure environment of the scope of the requirements that need to be adapted to work successfully in the field of the healthcare. The data is available in the Cloud and gives the ability to the doctors/ nurses in real-time to reduce the risk of medical treatment and general liability concerns.

Apart from the advantages the IoT offers to the patients and their families, it also plays an important role for the hospitals helping them to reduce the costs and increase the profitability.

For patients and their families, that means that their doctors will know much more about their treatment to get the best the best decisions for any procedure whether it's a cardiac bypass, a surgery, a heart transplant or even a simple blood test. These decisions affect the quality of life of the patients, their wider family and society in general.

In order for the proposal to be implemented, it is important for all the parties involved, to work together, to collaborate with many departments which were functioning until now in solo rather than team players, (as well as bringing forth new win-win strategies). All the parties have to work together **as a market value chain**.

It is logical that there will be some reactions as old habits and old culture have to change for the shake of progress, but this is something expectable and we can deal with it **through the culture change program**.

Simultaneously, for reducing bureaucracy, it is necessary to upgrade the information systems; in order to supply a valuable set of information relevant to all the stakeholders (patients, medical and nursery staff, and health insurance) regardless

their current location, thus reducing the time of waiting and appropriate medical planning for both patients and their families.

Change for all of us is often scary, and robotics in healthcare is a big innovation because it has the potential to do so much good: to bring medical care to regions where even today there is none to be found, to make the production and distribution of pharmaceuticals cheaper and more efficient, to lighten the load of medical professionals, to help people walk again. But if we want to gain all these benefits and avoid the potential dangers of such a technological revolution we have to be aware of every step that science does so we can be better prepared and adapt ourselves to the not-so-distant future where robots play a crucial role and work closely with us.

The Processes we described are like production line in an industry (human resources, resources, technology, RND etc.). At the same time, however, it is different in terms of the desired result, which is not just maximizing profit and minimizing or eliminating waste (including unnecessary delays, re-work, inappropriate procedures and errors) but above all, maximizing the level and the quality of the healthcare provided to patients, improving the quality of processes and maximizing the adding value to patients. The key to achieve that goal is viewing the whole process from the patient’s perspective and improving **an end to end process**.

Applying the IoT in the healthcare in Greek hospitals could bring many benefits, by helping to provide the required services in a timely and orderly manner, using the needed materials by targeting economy of usage and utilizing human resources with the least effort, giving value to both patients’ and medical providers’ time and fewer costs.

In few years from now, we could imagine a surgery room where there are only a few screens and all the devices speak to each other and thousands of medical systems in and out of the hospital walls which are all connected. All this innovation will

increase our quality of healthcare and in general quality of our life and at the same time will reduce hospital’s costs and will increase health outcomes.

The consequences of the knowledge we have gained and the positive health outcomes are so apparent that we can hardly imagine from this early stage of IoT all the possible benefits that we could have in the near future. However, the sooner IoT Analytics is adopted in the hospitals, the earlier patients could expect better quality of healthcare and better and healthier lives. This is only the beginning of a new era.

## References

Latha K., Ambika M. (2015). Intelligence Based Recommendation System for Healthcare: A Patient centered Framework. *Conference Paper*. DOI: 10.18797/CAASR/ICIET/2015/11/27/19

Jubi R., Abhijeet B. (2015). HealthCare Monitoring and Alerting System Using Cloud Computing. *International Journal on Recent and Innovation Trends in Computing and Communication* ISSN: 2321-8169, 3 (2), 102-105

Raid L, Ji Zhang, Xiaohui Tao, Yan Li, Vincent S. Tseng. (2016). An Intelligent Personalized Recommender System for Heart Disease Patients in a Tele-Health Environment. *Conference paper. Part of the Lecture Notes in Computer Science book series* (LNCS, volume 10086)

Stepaniak, P. S., Heij, C., Mannaerts, G. H., Quelerij, M. de & Vries, G. de. Modeling (2009). Procedure and Surgical Times for Current Procedural Terminology-Anesthesia-Surgeon Combinations and Evaluation in Terms of Case-Duration Prediction and Operating Room Efficiency: A Multicenter Study. *Anesth. Analg.* 109, 1232–1245.

Scholefield, H. Embedding quality improvement and patient safety at Liverpool (2007) Women’s NHS Foundation Trust. *Best Pract. Res. Clin. Obstet. Gynaecol.* 21, 593–607

Sungyoung Oh, BS, Jieun Cha, BS, Myungkyu Ji, MS Hyekyung Kang, BS, Seok Kim, MS, Eunyong Heo, MS, Jong Soo Han, MS,<sup>3</sup> Hyunggoo Kang, MS,<sup>4</sup> Hoseok Chae, MS, Hee Hwang, PhD, and Sooyoung Yoo, PhD . (2015). Architecture Design of Healthcare Software-as-a-Service Platform for Cloud-Based Clinical Decision Support Service. *Health Inform Res.* 21(2): 102–110.doi: [10.4258/hir.2015.21.2.102](https://doi.org/10.4258/hir.2015.21.2.102)

The Health Foundation. (2013). Improving patient flow. How two trusts focused on flow to improve the quality of care and use available capacity effectively? *Learning report*, pp. 22-30.

Akash Miriyala. (2013). *How Hospitals Can Map the Patient & Family Experience*. Accessed September 26, 2017. Available on: <http://epatientexperience.com/how-hospitals-can-map-the-patient-family-experience/>

Chesla Avi, (2017). When an attack means murder: The IoT healthcare security vulnerability. *IoT Agenda*. Accessed December 30, 2017. Available on: <http://internetofthingsagenda.techtarget.com/blog/IoT-Agenda/When-an-attack-means-murder-The-IoT-healthcare-security-vulnerability>

Cousin M, Castillo-Hi T., Snyder G, (2015). “Devices and diseases: How the IoT is transforming medtechThe Internet of Things in the medical devices industry”. *Article*. Accessed November 29, 2017. Available on: (<https://www2.deloitte.com/insights/us/en/focus/internet-of-things/iot-in-medical-devices-industry.html>)

Dave Evans, (2011). The Internet of Things. How the Next Evolution of the Internet is Changing Everything. Accessed December 12, 2017. Available on: [https://www.cisco.com/c/dam/en\\_us/about/ac79/docs/innov/IoT\\_IBSG\\_0411FINAL.pdf](https://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf)

Deloitte. *No appointment necessary. How the IoT and patient-generated data can unlock health care value.* Accessed November 20, 2017. Available on: <https://www2.deloitte.com/tr/en/pages/life-sciences-and-healthcare/articles/internet-of-things-iot-in-health-care-industry.html>

Deloitte. *Devices and diseases: How the IoT is transforming medtech.* Accessed November 20, 2017. Available on : <https://www2.deloitte.com/tr/en/pages/life-sciences-and-healthcare/articles/internet-of-things-iot-in-health-care-industry.html>

Greenstein B., (n.d.). How Watson IoT may transform your next hospital stay? *Article in IBM.* Accessed November 22, 2017. Available on : <https://dupress.deloitte.com/dup-us-en/focus/internet-of-things/iot-in-medical-devices-industry.html>

i-SCOOP. *Internet of Things (IoT) in healthcare: Benefits, use cases and evolutions.* Accessed September 26, 2017. Available on: <https://www.i-scoop.eu/internet-of-things-guide/internet-things-healthcare/>

IMF. *Robotics in Healthcare.* Accessed December 6, 2017. Available on: <http://medicalfuturist.com/robotics-healthcare/>

Jayan Cm., (2016). IoT Enabling Smart Hospitals. *Nibodha*. Accessed December 18, 2017. Available on: <http://www.nibodha.com/blog/iot-enabling-smart-hospitals/>

Kevin Stevens. (2011). “Smart Bed” Could Improve Efficiency. *Article in “The Hospitalist”*. Accessed November 29, 2017. Available on:

<https://www.the-hospitalist.org/hospitalist/article/124917/smart-bed-could-improve-efficiency>

Maksimovic M., Vucjovic V., Perisic B. (2015). A Custom Internet of Things Healthcare System. *Conference Paper*. Accessed October 1, 2017 Available on : [file:///C:/Users/Katerina/Downloads/ACustomInternetofThingsHealthcareSystem%20\(1\).pdf](file:///C:/Users/Katerina/Downloads/ACustomInternetofThingsHealthcareSystem%20(1).pdf)

Mathias C., Tadashi C., Glenn H. (2015) Devices and diseases: How the IoT is transforming medtech The Internet of Things in the medical devices industry. *Article in Deloitte Insights*. Accessed October 20, 2017. Available on: [http://www.slate.com/blogs/the\\_eye/2013/12/04/emergency\\_room\\_design\\_can\\_digital\\_updates\\_reduce\\_patient\\_frustration.html](http://www.slate.com/blogs/the_eye/2013/12/04/emergency_room_design_can_digital_updates_reduce_patient_frustration.html)

Nordlinger C., (2015). The Internet of Things and the Operating Room of the Future Accessed October 12, 2017. Available on:

<https://medium.com/@chrisnordlinger/the-internet-of-things-and-the-operating-room-of-the-future-8999a143d7b1>

Patient journey app, (n.d.). Accessed December 18, 2017. Available on:  
<https://patientjourneyapp.nl/>

Readwrite. *6 benefits of IoT for hospitals and healthcare*. Accessed December 12, 2017. Available on:  
<https://readwrite.com/2016/07/18/top-6-benefits-internet-things-iot-hospitals-healthcare-facilities-ht1/>

Ryerson N , Writer S., (2014) . "Smart beds" improve safety. *Issue of DOTmed HealthCare Business News magazine*. Accessed November 29, 2017. Available on:  
[https://www.dotmed.com/news/story/22656?p\\_begin=0](https://www.dotmed.com/news/story/22656?p_begin=0)

Scranton M, (2017). Why Most Hospital Apps Fail? *Medical web experts*. Accessed December 12, 2017. Available on:  
<https://www.medicalwebexperts.com/blog/why-most-hospital-apps-fail-but-yours-doesnt-have-to/>

Technavio, (2016). Smart Healthcare – *Technavio Publishes Top Market Drivers and Trends*<https://www.businesswire.com/news/home/20161227005146/en/SmartHealthcare-%e2%80%93-Technavio-Publishes-Top-Market%20>

The Eye. *Can Digital Updates on Emergency Room Wait Times Reduce Patient Rage?*  
Accessed October 1, 2017. Available on:  
[http://www.slate.com/blogs/the\\_eye/2013/12/04/emergency\\_room\\_design\\_can\\_digital\\_updates\\_reduce\\_patient\\_frustration.html](http://www.slate.com/blogs/the_eye/2013/12/04/emergency_room_design_can_digital_updates_reduce_patient_frustration.html)



Fujitsu. *Panasonic and Fujitsu Begin Joint Testing of an In-Home Monitoring Service for the Elderly*. Accessed October 16, 2017. Available on:

<http://www.fujitsu.com/global/about/resources/news/press-releases/2015/0625-01.html>

### **Abbreviations**

IoT = Internet of Things

ERP = Enterprise Resource Planning

ETA = Estimated Time of Arrival

ICU = Intensive Care Unit

WSN = Wireless Sensor Networks

AHP = Analytic Hierarchy Process

## Παράρτημα

### Εκτεταμένη Περίληψη στην Ελληνική

#### Σύνοψη

##### 1.1 Εισαγωγή

Η υγεία δεν αποτελεί προνόμιο λίγων, αλλά δικαίωμα και ανάγκη όλων. Αποτελεί το βασικό στοιχείο για την ανάπτυξη του ατόμου, αλλά και του περιβάλλοντος στο οποίο ανήκει. Όραμα είναι να καταστεί ένα πρότυπο σύστημα υγείας με άμεση αναφορά στον άνθρωπο και τη ζωή και βασικό άξονα την αντίληψη ότι η παροχή υψηλού επιπέδου υπηρεσιών υγείας δεν είναι πολυτέλεια αλλά ανάγκη και δικαίωμα κάθε ασθενούς. Αυτός είναι ο λόγος για τον οποίο πρέπει να βρούμε τρόπους να εξασφαλίσουμε την κατάλληλη υγειονομική περίθαλψη βάσει παρακολούθησης 24/7 και άμεσης ιατρικής βοήθειας. Η ανάπτυξη νέων τεχνολογιών, ιδίως του Διαδικτύου και των ασύρματων αισθητήρων, γνωστή ως “Internet of Things” (IoT), επιτρέπει μια συνολική προσέγγιση στη βελτίωση του συστήματος υγειονομικής περίθαλψης. Αυτό οδηγεί στο σύστημα ηλεκτρονικής υγείας που παρέχει πολύτιμες πληροφορίες για όλους τους ενδιαφερόμενους (ασθενείς, ιατρικό και παραϊατρικό προσωπικό, δημόσια και ιδιωτική υγεία).

##### 1.2 Σκοπός

Σκοπός του παρόντος εγγράφου είναι να διερευνήσουμε λεπτομερώς το ρόλο του IoT στην υγειονομική περίθαλψη, να αναλύσουμε τις χρήσεις του, τις ευκαιρίες καθώς και τις προκλήσεις που ενδέχεται να αντιμετωπίσουμε. Παρόλο που η χρήση του «Internet of Things» βρίσκεται ακόμη σε πρώιμο στάδιο στον Ελλαδικό χώρο ωστόσο υπόσχεται μεγάλη ανάπτυξη, ιδιαίτερα στον κλάδο της υγείας.

##### 1.3 Μεθοδολογία

Προκειμένου να μελετηθεί ειδικότερα κατά πόσο το IoT θα βελτιώσει την ποιότητα της υγειονομικής περίθαλψης που παρέχεται στην Ελλάδα και με ποιον τρόπο, θα καταγράψουμε τις διαδικασίες που πρέπει να ακολουθήσει ένας υποψήφιος ασθενής :

4. Ο οποίος εισέρχεται στο νοσοκομείο για ένα τυπικό check up καθώς και ενός ατόμου που πάσχει από μια χρόνια ασθένεια και επισκέπτεται τακτικώς το νοσοκομείο.
5. Ο οποίος θα υποβληθεί σε χειρουργείο
6. Και τέλος η διαδικασία που πρέπει να ακολουθήσει κάποιος μετά από μια χειρουργική επέμβαση ή νοσηλεία.

όπως συμβαίνουν τώρα στη χώρα μας (διαγράμματα ροής as-is) και θα πώς θα μπορούσαν να βελτιωθούν με τη συμβολή του IoT (διαγράμματα ροής to-be). Κανείς δεν μπορεί να κατανοήσει όλες τις ερωτήσεις και τις ανησυχίες ενός ασθενούς και της οικογένειάς του. Προκειμένου να αναγνωριστούν οι διάφορες σπατάλες - wastes, που εμφανίζονται στις διαδικασίες ροής και δυσχεραίνουν την κατάσταση επιφέροντας καθυστερήσεις, δυσανασχέτηση, λάθη και μη τήρηση του προγράμματος, επιβάλλεται η καταγραφή των υπαρχουσών διαδικασιών σε διαγράμματα ροής . Επίσης μέσω της πολυκριτηριακής ανάλυσης που θα ακολουθήσει μετέπειτα θα αξιολογηθεί η συνεισφορά του IoT στην βελτίωση των παρεχόμενων υπηρεσιών υγείας και θα συγκριθούν περαιτέρω οι διαδικασίες as-is και to-be η οποία βασίζεται στο IoT.

#### **1.4 Κύρια Συμπεράσματα**

Η εφαρμογή του IoT στην υγειονομική περίθαλψη στο Ελληνικό Σύστημα Υγείας θα μπορούσε να αποφέρει πολλά οφέλη, βοηθώντας στην έγκαιρη και σωστή θεραπεία των ασθενών στοχεύοντας στην εξατομικευμένη θεραπεία, μειώνοντας το κόστος και αξιοποιώντας τους ανθρώπινους πόρους με τη λιγότερη δυνατή προσπάθεια.

Όσο πιο γρήγορα αφομοιωθεί το IoT στο ελληνικό σύστημα υγείας τόσο πιο γρήγορα μπορούμε να αναμένουμε καλύτερη ποιότητα υγειονομικής περίθαλψης και εν γένει καλύτερη ζωή.

### **1.5 Διάρθρωση της εργασίας**

Η διπλωματική εργασία περιλαμβάνει 6 κεφάλαια, κατά την σειρά που πραγματοποιήθηκαν οι απαραίτητες για την ολοκλήρωση της εργασίας ενέργειες, με σκοπό την εξαγωγή των τελικών συμπερασμάτων για τη συμβολή του «Internet of Things» στη βελτίωση των παρεχόμενων υπηρεσιών υγείας και ειδικότερα την ομαλότερη διεξαγωγή των διαδικασιών στον τομέα της υγείας στον Ελλαδικό χώρο καθώς και των κινδύνων που ενδέχεται να εμφανιστούν. Η διάρθρωση του κειμένου έχει ως εξής:

#### Κεφάλαιο 1

Παρουσιάζεται το πλαίσιο στο οποίο κινήθηκε η διπλωματική εργασία.

#### Κεφάλαιο 2

Παρουσιάζεται η έννοια του “Internet of Things” προκειμένου να κατανοήσουμε τις χρήσεις του στην καθημερινότητα και ειδικότερα στον τομέα της υγείας και αναλύεται περαιτέρω η χρήση των έξυπνων συσκευών.

#### Κεφάλαιο 3

Καταγράφονται οι διαδικασίες που πρέπει να ακολουθήσει ένας υποψήφιος ασθενής, όπως συμβαίνουν τώρα στη χώρα μας (Διαγράμματα ροής as-is).

#### Κεφάλαιο 4

Καταγράφονται οι διαδικασίες, βελτιωμένες πλέον με τη συμβολή του “Internet of Things” (Διαγράμματα ροής to-be) και γίνεται και πολυκριτηριακή ανάλυση δεδομένων προκειμένου να μελετήσουμε την επίδραση του IoT στην ποιότητα των παρεχόμενων υπηρεσιών υγείας.

#### Κεφάλαιο 5

Παρουσιάζονται εκτενώς τα κυριότερα οφέλη του IoT στο σύστημα υγειονομικής περίθαλψης καθώς και ορισμένες προκλήσεις και κίνδυνοι που ενδεχομένως εμφανιστούν.

## Κεφάλαιο 6

Αποτελεί το τελευταίο κεφάλαιο της διπλωματικής εργασίας στο οποίο παρατίθενται τα τελικά συμπεράσματα στα οποία κατέληξε η εργασία.

## **2 Εισαγωγή στην έννοια του “Internet of Things”**

Στο Διαδίκτυο των πραγμάτων (IoT), όλες οι συσκευές συλλέγουν πληροφορίες οι οποίες μοιράζονται μεταξύ των «έξυπνων» συσκευών και αποθηκεύονται στο Cloud. Ας εξετάσουμε τον τρόπο με τον οποίο οι άνθρωποι συλλέγουν, καταγράφουν και αναλύουν δεδομένα όχι μόνο όσο αναφορά στον τομέα της υγειονομικής περίθαλψης αλλά σε όλες σχεδόν τις βιομηχανίες σήμερα. Τόσο οι υπολογιστές όσο και το Διαδίκτυο εξαρτώνται σχεδόν εξ ολοκλήρου από τους ανθρώπους για τη συλλογή των πληροφοριών. Το πρόβλημα είναι ότι οι άνθρωποι έχουν περιορισμένο χρόνο, συγκέντρωση και ακρίβεια και κατά συνέπεια είναι δύσκολο να γίνει καταγραφή όλων των δεδομένων που συμβαίνουν. Η λύση για να μην χάνεται όλη αυτή η πληροφορία είναι να συνδεθούν όλες τις συσκευές απευθείας ώστε να συλλέγονται οι πληροφορίες, χωρίς ανθρώπινη παρέμβαση.

Η δημιουργία του IoT είναι σημαντική για δύο λόγους:

1. Οι πρόοδοι στην τεχνολογία αισθητήρων και συνδεσιμότητας επιτρέπουν στις συσκευές να συλλέγουν, να καταγράφουν και να αναλύουν δεδομένα που έως τώρα δεν ήταν προσιτά. Στην υγειονομική περίθαλψη, αυτό σημαίνει ότι η συλλογή δεδομένων σε βάθος χρόνου σε έναν ασθενή μπορεί να χρησιμοποιηθεί στην προληπτική υγειονομική περίθαλψη, να επιτρέψει την έγκαιρη διάγνωση οξέων επιπλοκών και να βοηθήσει στην κατανόηση του τρόπου με τον οποίο μια θεραπεία βοηθά στη βελτίωση της υγείας ενός ασθενούς.

2. Η ικανότητα των συσκευών να συλλέγουν δεδομένα μειώνει την ανθρώπινη παρέμβαση, περιορίζοντας σημαντικά τα λάθη. Λιγότερα λάθη σημαίνουν μεγαλύτερη ακρίβεια, αυξημένη αποτελεσματικότητα, χαμηλότερο κόστος και μειώνεται ο κίνδυνος σφάλματος.

### **3. Διαδικασίες Υγειονομικής Περίθαλψης στον Ελλαδικό Χώρο**

Τα επόμενα χρόνια, σε παγκόσμια κλίμακα καθώς και στην Ελλάδα, θα υπάρξει αύξηση του αριθμού των διασυνδεδεμένων συσκευών καθώς και των λειτουργιών που θα εκτελούν. Ως εκ τούτου αναμένονται υψηλότερης ποιότητας παρεχόμενων υπηρεσιών υγείας σε πολύ μικρότερο χρονικό διάστημα και με μικρότερο κόστος.

Σε σπίτια, γραφεία και άλλους χώρους εργασίας, οι αισθητήρες θα παρακολουθούν τις ζωτικές λειτουργίες καθενός ώστε να υπάρξουν έγκαιρες προειδοποιήσεις αν συμβεί κάτι ασυνήθιστο στην υγεία. Τα δεδομένα που θα συλλέγονται θα χρησιμοποιούνται για τη βελτίωση της ποιότητας ζωής μας, για τον προσδιορισμό των αναγκών και για την παροχή ειδικών απαιτήσεων.

Προκειμένου να μελετηθεί ειδικότερα κατά πόσο το IoT θα βελτιώσει την ποιότητα της υγειονομικής περίθαλψης που παρέχεται στην Ελλάδα και με ποιον τρόπο, θα καταγράψουμε τις διαδικασίες που πρέπει να ακολουθήσει ένας υποψήφιος ασθενής

- I. Ο οποίος εισέρχεται στο νοσοκομείο για ένα τυπικό check up καθώς και ενός ατόμου που πάσχει από μια χρόνια ασθένεια και επισκέπτεται τακτικώς το νοσοκομείο.
- II. Ο οποίος θα υποβληθεί σε χειρουργείο
- III. Και τέλος η διαδικασία που πρέπει να ακολουθήσει κάποιος μετά από μια χειρουργική επέμβαση ή νοσηλεία.

όπως συμβαίνουν τώρα στη χώρα μας (διαγράμματα ροής as-is) και θα πώς θα μπορούσαν να βελτιωθούν με τη συμβολή του IoT (διαγράμματα ροής to-be).

Κανείς δεν μπορεί να κατανοήσει όλες τις ερωτήσεις και τις ανησυχίες ενός ασθενούς και της οικογένειάς του αν δε μπει στη θέση του. Προκειμένου να αναγνωριστούν οι διάφορες σπατάλες - wastes, που εμφανίζονται στις διαδικασίες ροής και δυσχεραίνουν την κατάσταση, επιφέροντας καθυστερήσεις, δυσανασκέτηση και μη τήρηση του προγράμματος, επιβάλλεται η καταγραφή της υπάρχουσας διαδικασίας σε διαγράμματα ροής .

### **Διαγράμματα Ροής**

Εάν χαρτογραφήσουμε όλες τις διαδικασίες και όλα τα βήματα που πρέπει να διανύσουν οι ασθενείς σε ένα νοσοκομείο, συνειδητοποιούμε ότι στο τέλος ο ασθενής πρέπει να επικοινωνήσει με 10-12 άτομα (τηλεφωνικό κέντρο, υποδοχή, ιατρικό και παραϊατρικό προσωπικό).

Ο χρόνος αναμονής που ο ασθενής πρέπει να σπαταλήσει για να ολοκληρωθεί μια διαδικασία είναι μεγάλος και σε όλη αυτή τη σύνθετη διαδικασία υπήρχαν πολλές φορές όπου ο ασθενής αισθάνεται άγχος, σύγχυση ή άβολα. Επίσης ορισμένες φορές δεν υπάρχει επικοινωνία μεταξύ όλων των εμπλεκόμενων και ο ασθενής πρέπει να επαναλαμβάνει ξανά και ξανά τις ίδιες πληροφορίες και να συμπληρώνει πολλαπλές φόρμες με ίδιες προσωπικές πληροφορίες.

Η συμβολή του IoT σε όλες τις διαδικασίες θα βελτίωνε πολύ την βελτίωση των παρεχόμενων υπηρεσιών και ταυτόχρονα θα μείωνε σημαντικά το κόστος.

### **3.1 Διαδικασία ενός ασθενούς που εισέρχεται στο νοσοκομείο για ένα τυπικό Check-up καθώς και ασθενούς με χρόνια πάθηση που επισκέπτεται τακτικά το νοσοκομείο**

Ειδικότερα για τα άτομα που πάσχουν από χρόνιες παθήσεις, πχ διαβήτη, πίεση, άτομα τα οποία πρέπει να επισκέπτονται συχνά το νοσοκομείο, η μείωση των χρόνων αναμονής αποτελεί ένα σημαντικό θέμα το οποίο πρέπει να λυθεί άμεσα. Ας χαρτογραφήσουμε τις κύριες καθυστερήσεις στη διαδικασία ενός ασθενούς που έρχεται στο νοσοκομείο για ένα τυπικό check up ή για έναν ασθενή που πάσχει από μια χρόνια πάθηση και επισκέπτεται συχνά το νοσοκομείο.

- Καθυστέρηση κλεισίματος ραντεβού
- Αργή εξυπηρέτηση
- Καθυστέρηση των διοικητικών υπηρεσιών
- Μεγάλος χρόνο αναμονής για να δει ο ασθενής το γιατρό
- Μη σαφής κατανόηση του θεραπευτικού πλάνου και της λήψης φαρμάκων.
- Ιατρικό, νοσηλευτικό και διοικητικό προσωπικό νευρικό, πνευματικά και σωματικά κουρασμένο

Μέσω της χαρτογράφηση του τρέχοντος διαγράμματος ροής θα διαχωρίσουμε τα βήματα ανάλογα με την αξία που δημιουργούν σε όλη τη διαδικασία:

- Σε αυτά που πραγματικά δημιουργούν αξία για τον πελάτη-ασθενή.
- Σε αυτά τα οποία αν και δεν δημιουργούν αξία, είναι απαραίτητα για τη διαδικασία, όπως πχ τα βήματα όπου ο ασθενής πρέπει να συμπληρώσει προσωπικές πληροφορίες μπορεί για τον ίδιο τον ασθενή να μην είναι χρήσιμα , αλλά είναι πολύ χρήσιμες πληροφορίες για το ιατρικό προσωπικό.
- Και σε εκείνα τα βήματα που δεν δημιουργούν καμία αξία και πρέπει να εξαλειφθούν (αναμονές/ καθυστερήσεις/ άσκοπες μετακινήσεις)

Οι καθυστερήσεις πχ δεν προσφέρουν καμία αξία και πρέπει να εξαλειφθούν εμφανίζονται με κόκκινο χρώμα. Σε αυτή τη διαδικασία, ο χρόνος αναμονής είναι το μεγαλύτερο πρόβλημα και πρέπει να μειωθεί σημαντικά.



Τα βήματα που δεν προσφέρουν αξία αλλά δεν μπορούν να παραλειφθούν της διαδικασίας εμφανίζονται με κίτρινο χρώμα και τα βήματα που προσθέτουν αξία εμφανίζονται με πράσινο, όπως θα δούμε στο παρακάτω διάγραμμα ροής. (Βλ. Εικόνα 5).

Οι παράγοντες που καθυστερούν τη διαδικασία είναι διάφοροι:

- Η διαδικασία κράτησης του ραντεβού καθυστερεί.
- Το ραντεβού καθυστερεί οπότε ο ασθενής πάλι πρέπει να περιμένει.
- Επαναλαμβάνονται οι ίδιες ερωτήσεις στον ασθενή σχετικά με τα προσωπικά του δεδομένα (ον/μο, ηλικία, ιστορικό κλπ)
- Οι χρόνοι αναμονής για τη διεξαγωγή των διαγνωστικών εξετάσεων είναι επίσης μεγάλοι.
- Τα άτομα μεγαλύτερης ηλικίας δυσκολεύονται στη συμπλήρωση των εγγράφων.
- Καθυστέρηση για τη συμπλήρωση των εγγράφων.
- Έλλειψη δεδομένων σε ιατρικά αρχεία.
- Μεγάλες αποστάσεις για τον ασθενή να μετακινηθεί από το ένα τμήμα του νοσοκομείου στο άλλο.
- Ο ασθενής δεν μπορεί να κατανοήσει τι λένε οι γιατροί
- Το νοσηλευτικό και το διοικητικό προσωπικό είναι κουρασμένο και δεν είναι ευγενικό.

### **3.2 Διαδικασία εισαγωγής ασθενούς στο χειρουργείο**

Στο χώρο παροχής ιατρικών υπηρεσιών υγείας, οι χειρουργικές επεμβάσεις αποτελούν μία από τις πολυπλοκότερες και κρίσιμότερες πράξεις του νοσοκομείου.

Εξυπηρετούνται αφενός τα προγραμματισμένα περιστατικά από κάθε χειρουργική κλινική (ορθοπαιδική, γενική χειρουργική, καρδιοχειρουργική, νευροχειρουργική κλπ) σύμφωνα με τα οποία έχει διαμορφωθεί και το πρόγραμμα των χειρουργείων, αφετέρου τα επείγοντα τα οποία παρεμβάλλονται εμβόλιμα στο ήδη διαμορφωμένο πρόγραμμα.

Η αυξημένη ζήτηση σε συνδυασμό με την έλλειψη πόρων (υλικών, νοσηλευτικό και ιατρικό προσωπικό κλπ) και τη γραφειοκρατία που επικρατεί, καθιστούν τη διαδικασία μιας χειρουργικής επέμβασης αρκετά πολύπλοκη.

Η διαδρομή που ακολουθεί ο ασθενής που πρόκειται να χειρουργηθεί, από τη στιγμή που θα μεταφερθεί από την κλινική στην οποία βρίσκεται στα χειρουργεία, θα υποβληθεί στην χειρουργική επέμβαση και θα επιστρέψει στο δωμάτιο της κλινικής ή στη Μονάδα Εντατικής Θεραπείας αν το επιβάλλει η κατάσταση, αποτελεί την διαδικασία εισαγωγής του ασθενούς στο χειρουργείο.

Μέσω της χαρτογράφησης του τρέχοντος διαγράμματος ροής θα διαχωρίσουμε και στη διαδικασία του χειρουργείου τα βήματα ανάλογα με την αξία που δημιουργούν σε όλη τη διαδικασία: (Βλ Εικόνα 6)

*Μεταφορά ασθενούς στο χειρουργείο.*

- Έλλειψη προσωπικού για την προετοιμασία του ασθενούς
- Μη τήρηση νηστείας ασθενούς που επιβάλλεται πριν από κάθε χειρουργική επέμβαση
- Μη έγκαιρη παράδοση των εξετάσεων από τα αρμόδια τμήματα στην κλινική του ασθενούς.
- Μη διεξαγωγή του συνόλου των απαιτούμενων εξετάσεων.
- Εκτέλεση εξετάσεων παραπάνω απ όσες είναι απαραίτητες.
- Μη έγκαιρη διάθεση τραυματιοφορέα
- Μη έγκαιρη διάθεση κατάλληλου φορείου για τη μεταφορά του ασθενούς.
- Η αρχιτεκτονική των χώρων διακίνησης είναι τέτοια ώστε δυσχεραίνεται η διακίνηση των φορέων και η μεγάλη πυκνότητα πληθυσμού παρεμποδίζει την διακίνηση των φορέων.

- Μεγάλη απόσταση από το χειρουργείο.
- Ανεπάρκεια αριθμού ανελκυστήρων μεταφοράς φορείων.
- Χρήση ανελκυστήρων που απευθύνονται στους φορείς και από το κοινό.

*Εισαγωγή Ασθενούς στο χειρουργείο.*

- Καθυστέρηση Αναισθησιολόγου
- Μακροσκελή έγγραφα που πρέπει να συμπληρωθούν πριν την εισαγωγή
- Αντιμετώπιση δυσκολίας εγγράφων από άτομα ηλικιωμένα
- Καθυστέρηση συμπλήρωσης εγγράφων που θα έπρεπε να είναι ήδη προ συμπληρωμένα.
- Έλλειψη στοιχείων στον ιατρικό φάκελο.

*Μεταφορά ασθενούς εντός της χειρουργικής αίθουσας*

- Μη έγκαιρη ενημέρωση για την ολοκλήρωση της προηγούμενης διαδικασίας
- Μη έγκαιρη διάθεση απαραίτητου εξοπλισμού και υλικών που απαιτούνται για την εγχείρηση.
- Καθυστέρηση συνεργείου καθαρισμού για καθαρισμό του προηγούμενο χειρουργείο.

*Χορήγηση Αναισθησίας*

- Μη έγκαιρη διάθεση αναισθησιολόγου
- Βλάβες στο σύστημα παροχής αναισθητικών αερίων

*Εκτέλεση Χειρουργικής Επέμβασης*

- Προβλήματα στους χώρους του χειρουργείου (φθορές)
- Έλλειψη χειρουργικών αιθουσών
- Μη επάρκεια αριθμού και ειδίκευσης προσωπικού
- Έλλειψη πόρων , ιατρικών εργαλείων, εξοπλισμού.

*Μεταφορά ασθενούς στην ανάνηψη*

- Έλλειψη συντονισμού μεταξύ χειρουργείου και ανάνηψης.
- Έλλειψη τραυματιοφορέα
- Έλλειψη φορείου για μεταφορά στο χώρο της ανάνηψης

*Παραμονή στην ανάνηψη έως ότου ανανήψει πλήρως*

- Μετεγχειρητικές επιπλοκές που επιβάλλουν επανεισαγωγή του ασθενούς.
- Προβλήματα στην ανάνηψη του ασθενούς που επιμηκύνουν το χρόνο παραμονής του στο χώρο.

*Μεταφορά του ασθενούς στο δωμάτιο ή στη ΜΕΘ, αν αυτό επιβάλλεται.*

- Μη έγκαιρη διάθεση τραυματιοφορέα
- Μη έγκαιρη διάθεση φορείου για μεταφορά ασθενούς στο δωμάτιο
- Στην περίπτωση της ΜΕΘ μη έγκαιρη διάθεση κλίνης για τη νοσηλεία του ασθενούς
- Μεγάλη απόσταση κλίνης από το χειρουργείο
- Πυκνότητα επισκεπτών και συγγενών στους διαδρόμους που παρεμποδίζουν την διακίνηση των φορείων.

Καθίσταται λοιπόν φανερό ότι οι παράγοντες που μπορεί να επιφέρουν καθυστερήσεις και δυσχέρεια στη διεξαγωγή της ομαλής διαδικασίας του χειρουργείου και μπορεί να οδηγήσουν μέχρι και στην ακύρωση του χειρουργείου είναι πολλοί και δημιουργούν προβλήματα αφενός στον ασθενή που είναι ήδη σε επιβαρυσμένη κατάσταση αφού έχει μπει ήδη σε μια διαδικασία προεγχειρητικού ελέγχου και σε κατάσταση άγχους, αφετέρου από οικονομικής σκοπιάς, οι καθυστερήσεις μεταφράζονται σε υπερωρίες για το προσωπικό, σπατάλη υλικών, σε υπερβολική αποθήκευση υλικών καθώς οι συνθήκες λειτουργίας δεν επιτρέπουν την εκτίμηση των πραγματικών αναγκών.

Σε περίπτωση δε ακύρωσης χειρουργείου, προκύπτει επιπλέον επιβάρυνση του νοσοκομείου αφού επιμηκύνονται οι μέρες νοσηλείας του ασθενούς στην κλινική και καθυστέρηση του επόμενου χειρουργείου.

Απ όλα τα παραπάνω συνεπάγεται ότι η ορθή διαχείριση της ροής ασθενούς στο χειρουργείο αποτελεί επιτακτική ανάγκη.

Κάθε μορφή σπατάλης χρόνου, χώρου, υλικών, ανθρώπινου δυναμικού, θα πρέπει να ελαχιστοποιείται ώστε να έχουμε το βέλτιστο αποτέλεσμα κόστους - ποιότητας παρεχόμενων υπηρεσιών.

### **3.3 Διαδικασία ενός ασθενούς μετεγχειρητικά / μετά από νοσηλεία**

Ένα άλλο μέρος της διαδικασίας, όπου ο ασθενής λαμβάνει πολλές πληροφορίες και αισθάνεται σύγχυση και φόρτιση είναι η διαδικασία που ακολουθεί μετά από ένα χειρουργείο, η μετεγχειρητική διαδικασία ή μετά από τη νοσηλεία σ ένα νοσοκομείο. (Βλ Εικόνα 7)

Αυτές είναι π.χ. όταν ένας ασθενής ετοιμάζεται να φύγει από το νοσοκομείο, διερωτάται:

- Πού πρέπει να πάω τώρα;
  - Τι πρέπει να κάνω;
  - Πότε πρέπει να επισκεφθώ ξανά τον γιατρό;
  - Ποιες είναι οι λεπτομέρειες του θεραπευτικού μου σχεδίου;
  - Τι οδηγίες πρέπει να ακολουθήσω;
  - Πότε θα επιστρέψω στην καθημερινότητα και στις παλιές μου συνήθειες;
- Όλες αυτές οι ερωτήσεις θα μπορούσαν να κάνουν τον ασθενή να αισθάνεται ακόμα πιο νευρικός και ανήσυχος στο υψηλού άγχους ενός νοσοκομείου. Πολλές φορές, ξεχνάει να ρωτήσει τον γιατρό για το φάρμακο που του έχει συνταγογραφηθεί για τις επόμενες ημέρες ή όταν ο γιατρός εξηγεί πώς ο ασθενής πρέπει να πάρει το συνταγογραφούμενο φάρμακο, ο ασθενής δεν επικεντρώνεται σε αυτό που λέει ο γιατρός γιατί είναι ανήσυχος και νευρικός.

## **4 Χρήσεις των «Big Data analytics» and «Cloud» ώστε να βελτιωθούν οι παρεχόμενες υπηρεσίες υγείας**

Στη συνέχεια θα δούμε πώς μπορούμε να βελτιώσουμε το «ταξίδι-διαδικασίες» ενός ασθενούς, χρησιμοποιώντας το “Internet of Things”. Σκοπός είναι η βελτίωση της ποιότητας των υπηρεσιών υγείας με άμεση αναφορά στον άνθρωπο και ταυτόχρονα η εξοικονόμηση χρημάτων.

Για την επίτευξη αυτών των στόχων απαιτείται:

- Βελτίωση της αξίας κάθε βήματος
- Απαλοιφή όσων βημάτων δεν προσφέρουν αξία

### **4.1 Βελτιώνοντας τη διαδικασία ενός ασθενούς που εισέρχεται στο νοσοκομείο για ένα Check-up**

Πρώτα απ' όλα, για τους ασθενείς που έρχονται στο νοσοκομείο για τακτικό έλεγχο ή για αυτούς που πάσχουν από χρόνιες παθήσεις, αντί να έρχονται στο νοσοκομείο τόσο συχνά και να σπαταλούν χρόνο και ενέργεια, θα μπορούσαν να χρησιμοποιούν μια κατάλληλη εφαρμογή που περιλαμβάνει όλα τα βήματα και τις διαδικασίες που είναι απαραίτητες.

Ο σχεδιασμός και η ανάπτυξη μιας εφαρμογής εξατομικευμένης στις ανάγκες του κάθε ασθενούς θα συνέβαλλε πολύ στον παραπάνω στόχο.

Εκτός από τη χρήση μιας εφαρμογής μόνο για καθημερινή χρήση, όπως ο προγραμματισμός ή η αλλαγή ραντεβού, είναι απαραίτητη η διασύνδεση όλων των έξυπνων συσκευών μεταξύ τους, συνδέοντας έτσι όλες τις χρήσιμες πληροφορίες που σχετίζονται με τον ασθενή και το περιβάλλον του. Χρησιμοποιούνται αισθητήρες για τη συλλογή δεδομένων που σχετίζονται με τη φυσιολογική κατάσταση ενός ασθενούς, αποστέλλονται αυτές οι πληροφορίες στο Cloud για ανάλυση και ανασκόπηση και στη συνέχεια διαβιβάζονται τα αναλυθέντα δεδομένα

στους παρόχους ιατρικών υπηρεσιών και στην συνέχεια αυτά χρησιμοποιούνται για την άμεση ή μακροχρόνια φροντίδα του ασθενούς. Οι εφαρμογές στα smartphones –smart watches παρακολουθούν την υγεία των ασθενών 24/7 σε πραγματικό χρόνο. Αυτό αντικαθιστά την ανάγκη των ασθενών να διενεργούν συνεχείς ιατρικούς ελέγχους ή τους ασθενείς με χρόνιες παθήσεις να επισκέπτονται συχνά το νοσοκομείο.

Ας δούμε λεπτομερώς πώς η εφαρμογή αυτή θα μπορούσε να προσθέσει αξία στη διαδικασία της υγειονομικής περίθαλψης:

- I. Το πρώτο βήμα είναι η δημιουργία μιας βάσης δεδομένων προκειμένου να έχουμε ένα πλήρως ενημερωμένο ιατρικό ιστορικό για κάθε ασθενή. Οι αισθητήρες θα συλλέγουν δεδομένα ασθενών όπως: προσωπικές πληροφορίες (όνομα, επώνυμο, ηλικία και φύλο του κάθε ασθενούς), ιστορικό, φάρμακα και εργαστηριακά αποτελέσματα, τρόπο ζωής και στοιχεία των συγγενών πρώτου βαθμού, στοιχεία που θα χρησιμεύσουν για να έχουν ένα πλήρες ιστορικό για κάθε ασθενή. Μερικοί από τους αισθητήρες θα συλλέγουν δεδομένα από το περιβάλλον του ασθενούς, έτσι ώστε η βάση δεδομένων να περιλαμβάνει πληροφορίες σχετικά με τον τρόπο ζωής και τις δραστηριότητες ενός ασθενούς καθώς και μετρήσεις για τις ζωτικές παραμέτρους του ασθενούς, όπως θερμοκρασία, σφυγμούς, πίεση, σάκχαρο κλπ.
- II. Προκειμένου να είναι πλήρης η βάση δεδομένων και να υπάρξουν καλύτερες προβλέψεις, χρησιμοποιούνται μικρό-ελεγκτές που επεξεργάζονται, αναλύουν και επικοινωνούν ασύρματα με τα δεδομένα. Εάν θέλουμε να βελτιώσουμε την πρόβλεψη και την έγκαιρη θεραπεία των ασθενειών, θα τα ήταν σκόπιμο να γίνει μια ομαδοποίηση-κατηγοριοποίηση. Υπάρχουν πολλά πληροφοριακά στοιχεία που αποκτώνται στα συστήματα υγειονομικής περίθαλψης, ωστόσο υπάρχει έλλειψη «κρυφών» συσχετίσεων ανάμεσα στα δεδομένα. Το πιο σημαντικό είναι να προβλέψουμε τα άτομα που πάσχουν από διάφορες ασθένειες. Η ομαδοποίηση είναι η διαδικασία κατηγοριοποίησης αρχείων δεδομένων σε

ένα από τα προκαθορισμένα σύνολα για την εξαγωγή κανόνων και προτύπων δεδομένων που θα μπορούσαν να χρησιμοποιηθούν για την πρόβλεψη.

- III. Έπειτα με τη βοήθεια μικροεπεξεργαστών ενεργοποιούνται οι γραφικές διεπαφές χρήστη. Αυτές οι διεπαφές αποσκοπούν στη διάκριση ενός χρήστη από τον άλλο. Σε περίπτωση που υπάρχει ήδη ένα προφίλ χρήστη, τότε θα ενημερωθεί αυτό. Μόνο με αυτόν τον τρόπο, θα μπορούσε να επιτευχθεί εξατομικευμένη πληροφόρηση για την υγεία κάθε ασθενούς.

Η προτεινόμενη εφαρμογή παρέχει μια ροή πληροφοριών του ασθενούς λεπτό προς λεπτό. Αποτελείται από ένα σύστημα φίλτρων που λαμβάνει τα δεδομένα υγείας του ασθενούς και τα συγκρίνει με τη βάση δεδομένων που περιλαμβάνει τα συνήθη δεδομένα των διαφόρων παραμέτρων υγείας κάθε ασθενούς. Εάν διαπιστωθεί ότι τα εισερχόμενα δεδομένα είναι ασυνήθιστα, τότε αποστέλλεται ένα SMS στο γιατρό/ συγγενείς με τους οποίους συνδέεται ο ασθενής και ένα αντίγραφο του αρχείου αποστέλλεται επίσης στο Cloud με το σύστημα ERM που διατηρείται από το νοσοκομείο. (Βλέπε Εικόνα 8)

Ο ασθενής μπορεί να βρίσκεται σε κατάσταση έκτακτης ανάγκης και μπορεί να μην έχει συνειδητοποιήσει ότι υπάρχει κίνδυνος. Το φίλτρο αναγνωρίζει ότι ο ασθενής μπορεί να κινδυνεύει με βάση τις ιστορικές και τρέχουσες τιμές των δεδομένων που ανιχνεύονται. Εάν το φίλτρο καθορίσει την κατάσταση ως κρίσιμη, μια αναλυτική αναφορά αποστέλλεται στον γιατρό μέσω SMS, μαζί με την τοποθεσία του ασθενούς, που γίνεται αισθητή από τον αισθητήρα GPS που έχει το smartphone του ασθενούς και ταυτόχρονα καλείται ένα ασθενοφόρο για να πάει ο ασθενής στο πλησιέστερο νοσοκομείο το οποίο μπορεί να θεραπεύσει τον ασθενή γρηγορότερα. (Βλέπε Εικόνα 9)

Αυτό το σύστημα, όπως βλέπουμε στο διάγραμμα ροής, επικεντρώνεται στη συλλογή ζωτικών σημείων για την υγεία του ασθενούς και για τους γιατρούς που ειδοποιούνται άμεσα να λάβουν δράση σε περίπτωση έκτακτης ανάγκης. Στη



συνέχεια αποστέλλονται τα δεδομένα στο Cloud, έτσι ώστε τα δεδομένα να είναι προσβάσιμα μέσω του Διαδικτύου από οπουδήποτε και οποτεδήποτε.

Αυτή η συνεχής παρακολούθηση δεδομένων βελτιώνει ταυτόχρονα την ποιότητα της περίθαλψης σε κάθε άτομο που απαιτεί ιατρική περίθαλψη, είναι προληπτικό στην παροχή φροντίδας μέσω συστημάτων συναγερμού μειώνοντας έτσι το κόστος της ιατρικής περίθαλψης.

#### **4.2 Βελτιώνοντας τη διαδικασία ενός ασθενούς που θα υποβληθεί σε χειρουργική επέμβαση**

Τα κατάλληλα βήματα για την εξάλειψη των σπαταλών και τη βελτίωση των παρεχόμενων υπηρεσιών είναι τα εξής:

- Η βελτίωση της επικοινωνίας του προσωπικού, η συνεργασία μεταξύ κλινικών και η καλύτερη προετοιμασία του ασθενούς θα βελτιώσουν πολύ την αξία της υγειονομικής περίθαλψης, αλλά η καλύτερη λύση θα ήταν να τυποποιηθούν οι διαδικασίες και να γίνουν γνωστές στους ασθενείς μέσω του κινητού τους τηλεφώνου. Αυτό θα επιτευχθεί με τη δημιουργία μιας εφαρμογής που θα περιέχει όλες τις απαραίτητες πληροφορίες που θα πρέπει να συνοδεύουν τον ασθενή σε όλη τη διαδικασία, επιτρέποντας στους ασθενείς να γνωρίζουν τι πρέπει να κάνουν σε κάθε βήμα.

Η προτεινόμενη εφαρμογή παρέχει όλες τις πληροφορίες που χρειάζεται να γνωρίζει ο ασθενής για την ολοκλήρωση μιας διαδικασίας στο νοσοκομείο. Αποτελείται από ένα σύστημα έξυπνων συσκευών που λαμβάνει τα δεδομένα των νοσοκομείων, ώστε ο ασθενής να γνωρίζει τα βήματα η οποία πρέπει να ακολουθήσει ολόκληρη τη διαδικασία και να έχει καλύτερη διάγνωση και θεραπεία, με την προϋπόθεση ότι υπάρχει ισχυρότερη επικοινωνία των ενδιαφερομένων μερών.

Έχοντας μια έξυπνη εφαρμογή που ενημερώνει τους ασθενείς για το πώς λειτουργεί κάθε τμήμα ενός νοσοκομείου και τα βήματα που μπορούν να περιμένουν κατά την επεξεργασία και τη θεραπεία τους, θα μπορούσαν να βελτιώσουν την εμπειρία τους

και να τους κάνουν να αισθάνονται πιο εξοικειωμένοι με το περιβάλλον του νοσοκομείου και με όλη τη διαδικασία.

- Μείωση των περιττών κινήσεων του προσωπικού

Ας αναλογιστούμε τι θα σήμαινε για τους νοσηλευτές να έχουν ρομποτικούς βοηθούς για όλες τις απλές εργασίες, ώστε να μπορούν να επικεντρωθούν περισσότερο στην παροχή βοήθειας στους ασθενείς.

Οι νοσηλευτές/τριες καταναλώνουν περίπου 3 ώρες από το ωράριο τους για γραφειοκρατικές διαδικασίες των ασθενών και όχι για τους ασθενείς. Η συχνότερη αλληλεπίδραση κατά τη διάρκεια της νοσηλείας είναι μεταξύ ασθενών και νοσοκόμων. Το παραϊατρικό προσωπικό παίρνει αίμα, ελέγχει τα ζωτικά σημεία, ελέγχει την κατάσταση και φροντίζει για την υγιεινή του ασθενούς, αν χρειαστεί. Είναι συχνά σωματικά και πνευματικά εξαντλημένοι και το αποτέλεσμα είναι συχνά μια δυσάρεστη εμπειρία για όλους τους εμπλεκόμενους. Έχοντας μια έξυπνη συσκευή που θα συνδέει τον ασθενή τους και με πολλαπλές ιατρικές συσκευές θα λύσει το πρόβλημα. Αυτή η έξυπνη εφαρμογή θα έχει μια διασύνδεση που επιτρέπει στις νοσοκόμες να παρακολουθούν τα δεδομένα των ασθενών οποτεδήποτε και οπουδήποτε. Με ένα μόνο κλικ θα έχει πρόσβαση στα ζωτικά σημεία του ασθενούς στην οθόνη. Μια συνεχής αυτοματοποιημένη ροή πληροφοριών θα επιτρέψει στη νοσοκόμα να παρακολουθεί περισσότερους ασθενείς, αποτελεσματικά.

Οι ρομποτικές νοσοκόμες θα μπορούσαν επίσης να βοηθήσουν στις τυπικές εργασίες. Με αυτόν τον τρόπο, το προσωπικό θα έχει περισσότερη ενέργεια για να αντιμετωπίσει ζητήματα που απαιτούν ανθρώπινη λήψη αποφάσεων. Ορισμένα ρομπότ θα μπορούσαν ακόμη και να πάρουν το δείγμα αίματος κλπ.

- Επαρκής και κατάλληλη φύλαξη, αποθήκευση και αποθήκευση των χειρουργικών αρχείων έτσι ώστε ο αριθμός, ο τύπος και οι ιδιαιτερότητες των προγραμματισμένων χειρουργικών επεμβάσεων να είναι πάντοτε γνωστά, επομένως υπήρξε καλύτερος προγραμματισμός των χειρουργικών

Επιπλέον, αίθουσες αναμονής θα μπορούσαν να εμφανίζουν χρόνους αναμονής για κάθε ασθενή ανάλογα με τη σοβαρότητα της θεραπείας τους και να τους χωρίσουν σε "σοβαρούς τραυματισμούς", "μέτριους τραυματισμούς" και "όχι σοβαρούς τραυματισμούς".

Με αυτό τον τρόπο οι ασθενείς θα μπορούσαν να υπολογίσουν το χρόνο που χρειάζονται για να ολοκληρώσουν τη διαδικασία και θα αισθάνονταν οι ίδιοι και η οικογένειά τους πιο ήρεμοι.

Η καλύτερη λύση είναι η δημιουργία μιας εφαρμογής που θα εξυπηρετεί όχι μόνο τους ασθενείς που βρίσκονται ήδη στο νοσοκομείο, αλλά και τους ασθενείς που πρόκειται να πάνε στο νοσοκομείο, επιτρέποντάς τους να ελέγξουν από το κινητό τους τα τοπικά νοσοκομεία πριν φύγουν από το σπίτι τους και να δουν πού θα εξυπηρετηθούν πιο σύντομα.

Η προτεινόμενη εφαρμογή αποτελείται από ένα σύστημα που λαμβάνει τα δεδομένα του ασθενούς και το στέλνει στη βάση δεδομένων που περιλαμβάνει τα δεδομένα πραγματικού χρόνου που συλλέγονται από το ιδιωτικά και τα δημόσια νοσοκομεία προκειμένου ο ασθενής να επιλέξει σε ποιο νοσοκομείο θα έχει την ταχύτερη θεραπεία και το νοσοκομείο διαθέτει περισσότερα δωρεάν κρεβάτια. Στη συνέχεια, οι συγγενείς που χρησιμοποιούν το σύστημα πλοήγησης του αυτοκινήτου τους βρίσκουν την ταχύτερη διαδρομή κυκλοφορίας για να φτάσουν εκεί και μέσω της εφαρμογής θα μπορούσαν ακόμη και να ενημερωθούν πού μπορούν να σταθμεύσουν.

- Τυποποίηση χειρουργικών εργαλείων ανά λειτουργία, που οδηγεί σε καλύτερη αποστείρωση και ελαχιστοποίηση των καθυστερήσεων. Και πάλι ένα ρομπότ θα μπορούσε να συμβάλει σε αυτό γιατί τα ρομπότ δεν χρειάζονται διακοπές, ξεκούραση, μεσημεριανά διαλείμματα ή ύπνο. Μπορούν να εργάζονται όλη την ώρα και κάθε μέρα χωρίς διακοπή.

- Εφαρμογή πρωτόκολλου καθαρισμού δωματίων που βοηθά στην εξασφάλιση του απαιτούμενου υψηλού βαθμού εξυγίανσης και ταυτόχρονα συμβάλλει στην ελαχιστοποίηση του χρόνου που απαιτείται για τον καθαρισμό του δωματίου. Και πάλι ένα ρομπότ θα μπορούσε να απολυμάνει οποιοδήποτε χώρο σε μια μονάδα

υγειονομικής περίθαλψης γρήγορα και αποτελεσματικά χρησιμοποιώντας υπερϊώδη ακτινοβολία υψηλής έντασης. Είναι ένα ακόμη παράδειγμα του πώς η ρομποτική στην υγειονομική περίθαλψη βοηθά το προσωπικό να μειώσει το φόρτο εργασίας και θα οδηγήσει σε ένα πολύ πιο φιλικό και ασφαλέστερο περιβάλλον.

- Τα χειρουργικά ρομπότ θα μπορούσαν να συμβάλουν σε καλύτερα αποτελέσματα. Η χειρουργική επέμβαση είναι μια δυσάρεστη εμπειρία στην καλύτερη περίπτωση. Οι κατάλογοι αναμονής μπορούν να είναι μεγάλοι ανάλογα με τους διαθέσιμους ανθρώπινους πόρους και πόρους. Ένα ρομπότ που ονομάζεται "Da Vinci" βοηθά στην επίλυση του προβλήματος. Έχει χρησιμοποιηθεί σε μια ευρεία ποικιλία τομέων από τη γενική χειρουργική μέχρι την ουρολογική χειρουργική. Τα χειρουργικά συστήματα Da Vinci έχουν σχεδιαστεί για να βοηθούν τους ιατρούς να εκτελούν χειρουργικές επεμβάσεις μέσω μιας τρισδιάστατης κονσόλας απεικόνισης υψηλής ανάλυσης. Οι ρομποτικές τεχνολογίες βοηθούν τους γιατρούς να κάνουν καλύτερες διαγνώσεις και να παρέχουν υπηρεσίες ανώτερης ποιότητας. Από τις χειρουργικές επεμβάσεις έως τις θεραπείες αποκατάστασης, τα ρομπότ έχουν ήδη αρχίσει να εκτελούν πολύπλοκες διαδικασίες, οι οποίες σε πολλές περιπτώσεις δεν μπορούσαν να επιτευχθούν με «γυμνά» ανθρώπινα χέρια.
- Πρόσβαση στους μαγνητικούς τομογράφους όποτε το χρειάζονται οι γιατροί. Αυτό σημαίνει σημαντική μείωση του κόστους για το νοσοκομείο, εάν σκεφτούμε πόσο κοστίζουν αυτές οι εξετάσεις. Αν και είναι πολύ δαπανηρές τόσο για τους ασθενείς όσο και για το νοσοκομείο, είναι απαραίτητες για τη σωστή διάγνωση και την κατάλληλη θεραπεία.

Το IoT επιτρέπει στις ιατρικές συσκευές - αισθητήρες να επικοινωνούν μεταξύ τους και με άλλες συσκευές στο Cloud. Με αυτόν τον τρόπο όταν έρχονται νέα αδόμητα δεδομένα στο Cloud, μπορούν να συνδυαστούν με άλλα δεδομένα που υπάρχουν ήδη στο Cloud και με τη χρήση λογισμικού βοηθούν στην ανίχνευση οποιωνδήποτε ανωμαλιών.

Ως αποτέλεσμα, χρησιμοποιώντας όλα αυτά τα κρίσιμα δεδομένα που προέρχονται από τον αισθητήρα, θα μπορούσαμε να απαντήσουμε σε πολλές ερωτήσεις:

- ✓ Πώς λειτουργεί αυτή η συσκευή;
- ✓ Σε ποιες περιπτώσεις λειτουργεί αυτή η συσκευή;
- ✓ Πόση ώρα κράτησε η χειρουργική επέμβαση;
- ✓ Ποιοι χειρουργοί το έκαναν πιο αποτελεσματικά και είχαν καλύτερα αποτελέσματα;
- ✓ Ποιοι χειρουργοί πρέπει να εκπαιδευτούν περισσότερο;

#### **4.3 Βελτιώνοντας τη διαδικασία ενός ασθενούς μετεγχειρητικά / μετά από νοσηλεία**

Μια από τις πιο περίπλοκες διαδικασίες για τον ασθενή είναι αυτή που ακολουθεί μετά από μια χειρουργική επέμβαση ή μετά από νοσηλεία επειδή είναι αρκετά δύσκολο για έναν γιατρό να εξηγήσει τη θεραπευτικό πλάνο κατά τη διάρκεια μιας συνάντησης δέκα λεπτών που έχει συνήθως με τον ασθενή , ενώ είναι εξίσου δύσκολο για τον ασθενή να κατανοήσει και αφομοιώσει αυτές τις πληροφορίες. Το αποτέλεσμα είναι ότι το 80% των πληροφοριών που δίνονται στον ασθενή διαγράφονται από τη μνήμη τους όταν φεύγουν από το νοσοκομείο. Για αυτό το λόγο είναι πολύ χρήσιμο να δημιουργηθεί μια εφαρμογή που εξηγεί στους ασθενείς και τους συγγενείς τους βήμα προς βήμα το ταξίδι του ασθενούς μέσα κ εκτός νοσοκομείου, διότι οι ασθενείς θα πρέπει πάντα να μπορούν να έχουν πρόσβαση σε πληροφορίες σχετικά με τη θεραπεία τους οποτεδήποτε και οπουδήποτε. Αντί οι γιατροί να δίνουν σελίδες και φυλλάδια στους ασθενείς για τη θεραπεία τους που θα μπορούσαν να τα χάσουν μετά από μερικές ώρες, θα ήταν πολύ ευκολότερο και αποτελεσματικότερο και για τις δύο πλευρές (ασθενείς και γιατροί) να ψηφιοποιήσουν τις πληροφορίες περί θεραπείας, ώστε οι ασθενείς να μπορούν να έχουν πρόσβαση όταν το χρειάζονται και οπουδήποτε κι αν βρίσκονται. Μια εφαρμογή που ενημερώνει τους ασθενείς για όλα όσα χρειάζονται τους κάνει να αισθάνονται ήρεμοι. (Βλ. Σχήμα 11)

Ας δούμε λεπτομερώς πώς η εφαρμογή αυτή θα μπορούσε να προσθέσει αξία στη διαδικασία της υγειονομικής περίθαλψης:

- Χρησιμοποιώντας ένα πλήρως δυναμικό χρονοδιάγραμμα, αυτή η εφαρμογή θα μπορούσε να γνωστοποιεί στους ασθενείς τα επόμενα βήματα στη θεραπεία τους.
- Η αποστολή ειδοποιήσεων για την παροχή χρήσιμων πληροφοριών θα βοηθούσε πολύ τους ασθενείς. Τα συνήθη παραδείγματα γνωστοποιήσεων περιλαμβάνουν τη νηστεία μετά τη χειρουργική επέμβαση, την προετοιμασία στο σπίτι ή τις ασκήσεις ασθενών που πρέπει να κάνουν μετά από χειρουργική επέμβαση.
- Η εφαρμογή θα έχει ένα πολύ φιλικό πρόσωπο χρήστη που θα μπορεί εύκολα να χρησιμοποιηθεί από όλους τους ασθενείς.

Επίσης με την τηλεϊατρική οι ασθενείς δε χρειάζονται να μένουν πλέον πολλές μέρες στο νοσοκομείο.

Ως αποτέλεσμα όλων των παραπάνω, οι εφαρμογές θα συνδέουν τους ασθενείς με τους ιατρούς τους. Για παράδειγμα, μετά από χειρουργική επέμβαση στο γόνατο, απλοί αισθητήρες τοποθετημένοι μέσα στα πέλματα των παπουτσιών θα παράγουν δεδομένα που μετρούν την πίεση που ασκεί κάθε πόδι κατά την καθημερινή βόλτα, ρυθμό ή βηματισμό. Εκτός από το συνδυασμό αυτών των αισθητήρων με τα πιεσόμετρα που μετρούν το ρυθμό του ασθενούς θα παρέχουν επαρκείς πληροφορίες για την ανίχνευση ανισορροπιών ή αστάθειας, θα συμβάλλουν στην εκτίμηση των αλλαγών στα επίπεδα δραστηριότητας των ασθενών και θα αξιολογούν την αποτελεσματικότητα του προγράμματος αποκατάστασης.

Επίσης, για τον έλεγχο των ασθενών εάν παίρνουν τα συνταγογραφούμενα φάρμακά τους μετά από ασθένεια ή χειρουργική επέμβαση, θα εισάγεται ένα έξυπνο χάπι στον ασθενή και θα ενημερώνει τον γιατρό σχετικά με τον τρόπο με τον οποίο ο ασθενής παίρνει το συνταγογραφούμενο φάρμακο. Αυτά τοποθετούνται χειρουργικά κάτω από το δέρμα του ασθενούς για να παρακολουθούν εάν οι ασθενείς παίρνουν τα φάρμακά τους στην κατάλληλη στιγμή και άλλα δεδομένα υγείας και τα στέλνουν στον ιατρό του ασθενούς έτσι ώστε να τους ειδοποιήσει αν ένα φάρμακο ξεχαστεί, ή να γίνει υπερδοσολογία και την επίδραση αυτού του φαρμάκου στον ασθενή.

Είναι βέβαιο ότι αυτή η τεχνολογία θα συνεχιστεί στη διάγνωση και τη θεραπεία των ασθενών, όπως απαιτείται και οποιαδήποτε μορφή σπατάλης χρόνου, χώρου, υλικών και ανθρώπινου δυναμικού θα πρέπει να ελαχιστοποιηθεί προκειμένου να επιτευχθεί ο στόχος μας; η καλύτερη πρόσβαση στην υγειονομική περίθαλψη, η βελτίωση των παρεχόμενων υπηρεσιών υγείας και το χαμηλότερο κόστος της υγειονομικής περίθαλψης.

#### **4.4. Πολυκριτηριακή Ανάλυση προκειμένου να αξιολογηθεί η Συμβολή του ΙοΤ στη βελτίωση των παρεχόμενων υπηρεσιών υγείας.**

Σε αυτό το υποκεφάλαιο θα αναλύσουμε ένα πρότυπο αξιολόγησης συνδυάζοντας τη διαδικασία μοντελοποίησης διαδικασιών και πολυκριτηριακής ανάλυσης(AHP), προκειμένου να μετρηθεί η συνεισφορά του ΙοΤ στις υπηρεσίες υγειονομικής περίθαλψης. Η διαδικασία της χειρουργικής επέμβασης θα αποτελέσει την περίπτωση μελέτης. Αυτός είναι ο λόγος για τον οποίο, με βάση τη διαδικασία χειρουργικής επέμβασης που περιγράψαμε σε προηγούμενο κεφάλαιο, θα προσπαθήσουμε να μετρήσουμε τον αντίκτυπο του Διαδικτύου χρησιμοποιώντας διάφορα κριτήρια.

Χρησιμοποιείται η διαδικασία της πολυκριτηριακής ανάλυσης ώστε:

- Να καθορίσουμε ποιο από τα κριτήρια είναι το πιο σημαντικό και πόσο πιο σημαντικό;
- Επιπλέον, χρησιμοποιώντας ξανά το AHP, να συγκρίνουμε τη διαδικασία χειρουργικής επέμβασης όπως υφίσταται σήμερα και τη χειρουργική διαδικασία ΤΟ-ΒΕ, βασισμένη στο ΙοΤ.

Πέντε χειρουργοί με πολυετή εμπειρία, 2 Γενικοί Χειρουργοί, 1 καρδιοθωρακοχειρουργός και 2 αγγειοχειρουργοί αξιολόγησαν τη σημασία των κριτηρίων.

Κάθε χειρουργός ενημερώθηκε εκ των προτέρων σχετικά με τον σκοπό αυτής της έρευνας, την έννοια κάθε κριτηρίου και τη διάρκεια της συνέντευξης.

Τα δεδομένα όλων των ερωτηματολογίων συλλέχθηκαν και αναλύθηκαν περαιτέρω. Για τη χειρουργική επέμβαση, η αξιοπιστία, η ανταπόκριση, ο χρόνος για την εισαγωγή του ασθενούς και η ακρίβεια της διάγνωσης επιλέχθηκαν ως κριτήρια.

Το μοντέλο AHP παρουσιάζεται στην Εικόνα 12. Τα βάρη και η σημασία κάθε κριτηρίου και υποκριτηρίων παρουσιάζονται στον Πίνακα 2. Παρατηρούμε ότι η ακρίβεια της διάγνωσης είναι το πιο σημαντικό κριτήριο όταν αναφερόμαστε στη συμβολή του στην ποιότητα των υπηρεσιών υγειονομικής περίθαλψης. Ακολουθεί η αξιοπιστία και ο χρόνος για την ολοκλήρωση της αποδοχής. Ένα πολύ σημαντικό κριτήριο είναι επίσης η ασφάλεια, η οποία, αν και είναι πολύ σημαντική στη διαδικασία, δεν ήταν ένα από τα κριτήρια που επιλέχθηκαν λόγω του γεγονότος ότι δεν υπήρχαν πραγματικά δεδομένα. Η επιλογή των πέντε κριτηρίων ήταν ενδεικτική.

Αν συγκρίνουμε τη διαδικασία ως προς τη διαδικασία όπως υφίσταται τώρα και τη διαδικασία με βάση το IoT παρατηρούμε την προτίμηση όλων των χειρουργών για τη διαδικασία του IoT λόγω της θετικής επίδρασης που έχει η IoT στην ποιότητα των υπηρεσιών υγειονομικής περίθαλψης.

Αν μπορούσαμε να επωφεληθούμε από όλα τα οφέλη που προσφέρει το IoT, θα έχουμε ένα νέο σύστημα, ένα σύστημα βασισμένο σε πραγματικές ανθρώπινες ανάγκες.



## 5 Οφέλη και δυσκολίες από τη χρήση του “IoT”

### 5.1 Οφέλη

Το IoT αλλάζει συνεχώς τη ζωή μας και προσφέρει νέες μεθόδους, αυτοματοποιημένες ροές εργασίας και νέα εργαλεία που συμβάλλουν στην ενσωμάτωση όλων των διαδικασιών στο σύστημα υγειονομικής περίθαλψης, στην καλύτερη φροντίδα των ασθενών, καθώς και στη μείωση του κόστους τόσο για τους ασθενείς όσο και για τα νοσοκομεία.

Τα κυριότερα οφέλη του IoT στα συστήματα υγειονομικής περίθαλψης είναι τα ακόλουθα:

- Βελτιωμένες λύσεις υγειονομικής περίθαλψης μέσω του Cloud οι οποίες έχουν τη δυνατότητα πρόσβασης σε πληροφορίες σε πραγματικό χρόνο που τους επιτρέπει να λαμβάνουν καλύτερες αποφάσεις. Αυτό διασφαλίζει ότι η υγειονομική περίθαλψη είναι έγκαιρη και βελτιώνονται τα αποτελέσματα της θεραπείας.
- Βελτιωμένη λήψη αποφάσεων για τη νόσο αφού οι ασθενείς παρακολουθούνται συνεχώς και οι γιατροί / νοσηλευτές έχουν πρόσβαση σε δεδομένα σε πραγματικό χρόνο.
- Λιγότερα λάθη σημαίνουν ακρίβεια, αυξημένη αποτελεσματικότητα χαμηλότερα κόστη και μειώνεται σημαντικά ο κίνδυνος σφάλματος.
- Χαμηλότερο κόστος για ασθενείς και νοσοκομεία. Η παρακολούθηση των ασθενών μπορεί να γίνει σε πραγματικό χρόνο, μειώνοντας έτσι σημαντικά τις περιττές επισκέψεις των γιατρών. Ειδικότερα, μέσω της τηλεϊατρικής, των έξυπνων σπιτιών/ κρεβατιών και πολλών άλλων συσκευών μειώνεται σημαντικά η διαμονή στο νοσοκομείο
- Σημαντική μείωση των υλικών και ως εκ τούτου πιο προσιτές τιμές για τους ασθενείς.
- Βελτίωση των συνθηκών εργασίας και ως εκ τούτου υψηλότερη ποιότητα παρεχόμενων υπηρεσιών στους ασθενείς αφού το προσωπικό, ιατρικό, νοσηλευτικό και διοικητικό, είναι ο καθρέφτης του νοσοκομείου.

- Καλύτερη συνεργασία με σαφή προσδιορισμό και οριοθέτηση των καθηκόντων και των υπευθυνοτήτων του καθενός.
  
- Μεγαλύτερη αξιοπιστία του νοσοκομείου.

Για να επιφέρει το IoT τα οφέλη που αναμένονται θα πρέπει να συνεργαστούν όλοι οι εμπλεκόμενοι με αφοσίωση, πίστη και προσαρμοστικότητα στη νέα διαδικασία. Επειδή σταδιακά θα επιφέρει και αλλαγή νοοτροπίας και κατ’ επέκταση της κουλτούρας, είναι πολύ πιθανόν να υπάρξουν ορισμένες αντιδράσεις του προσωπικού οι οποίες μπορούν να αποφευχθούν μέσω της κατανόησης της βελτίωσης των συνθηκών εργασίας καθώς και την βελτίωση του ηθικού του ανθρωπίνου δυναμικού. Το κλειδί για την επιτυχία αποτελεί η εμπιστοσύνη μεταξύ όλων των εμπλεκόμενων και η διαρκής αναπροσαρμογή στα νέα δεδομένα. Θα είναι ένας αέναος κύκλος βελτίωσης (kaizen). Θα πρέπει να καταγράφεται η όποια πρόοδος σημειώνεται καθώς και τα σημεία που υστερούν και δυσχεραίνουν την ομαλή διαδικασία ώστε να διορθωθούν και να υπάρχει πάντα το όραμα και ο στόχος για αύξηση της αξίας των παρεχόμενων υπηρεσιών υγείας

## 5.2 Κίνδυνοι

Παρόλο που το IoT αποτελεί την εξέλιξη της υγειονομικής περίθαλψης, έχει και ορισμένες προκλήσεις λόγω του γεγονότος ότι η υγεία αποτελεί ένα προσωπικό και πολύ ευαίσθητο ζήτημα. Η ασφάλεια των δεδομένων αποτελεί το πιο σοβαρό ζήτημα και πρέπει να προστατευτεί.

Επιπλέον, η ψηφιοποίηση όλων αυτών των δεδομένων και η συνεχής παρακολούθηση των ασθενών όπου και αν βρίσκονται, ειδικά για τους ασθενείς που πάσχουν από χρόνιες ασθένειες σε συνδυασμό με την αυξημένη χρήση έξυπνων συσκευών, αυξάνουν τη ζήτηση για περισσότερα κέντρα δεδομένων και εξειδικευμένα άτομα για να εργάζονται σε αυτά.

Το Internet of Things περιλαμβάνει πολλές εφαρμογές που απαιτούν το Cloud σε συνδυασμό με εργαλεία για να λειτουργήσει και να επιφέρει τα αναμενόμενα αποτελέσματα. Αυτά τα εργαλεία είναι ζωτικής σημασίας για να διασφαλιστεί ο έλεγχος και η ασφάλεια. ( πχ hacking)

Παρόλο που το IoT έχει να αντιμετωπίσει πολλές δυσκολίες, είναι εδώ για να βελτιώσει τις παρεχόμενες υπηρεσίες του πολυτιμότερου μας αγαθού, της υγείας μας.

## **6 Συμπεράσματα**

Οι διαδικασίες που περιγράψαμε παραπάνω μοιάζουν με μια γραμμή παραγωγής σε μια βιομηχανία (ανθρώπινοι πόροι, πόροι, τεχνολογία, RND κ.λπ.), ωστόσο διαφέρει σημαντικά το επιθυμητό αποτέλεσμα, το οποίο δεν είναι απλώς η μεγιστοποίηση του κέρδους και η ελαχιστοποίηση ή η εξάλειψη των σπαταλών), αλλά κυρίως η μεγιστοποίηση της ποιότητας της υγειονομικής περίθαλψης που παρέχεται στους ασθενείς με κέντρο αναφοράς τον άνθρωπο και την υγεία του.

Η εφαρμογή του IoT στην υγειονομική περίθαλψη στα ελληνικά νοσοκομεία θα μπορούσε να αποφέρει πολλά οφέλη, βοηθώντας στην έγκαιρη και σωστή θεραπεία των ασθενών στοχεύοντας στην εξατομικευμένη θεραπεία, μειώνοντας το κόστος και αξιοποιώντας τους ανθρώπινους πόρους με τη λιγότερη προσπάθεια.

Όσο πιο γρήγορα αφομοιωθεί το IoT στο ελληνικό σύστημα υγείας τόσο πιο γρήγορα μπορούμε να αναμένουμε καλύτερη ποιότητα της υγειονομικής περίθαλψης και εν γένει καλύτερης ζωής.