Use of analytics in Internet of Medical Things

Applied analytics and Methods II

AA-5222-21

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**Abstract**

The project aims to find the difference in the health data profile between the active users and passive users, by gathering the information from the trackers and analyzing the data through qualitative and qualitative analysis. And this project also hovers around increasing the accuracy of the decision-making for investigating the severity of the heart disease, using real-time data captured by health trackers connected with the internet of things. There will be two different analyses done, to understand and analyze the accuracy of the decision making, in finding the intensity of the heart related disease, between the active and passive users of the health tracking devices . The data is collected on a real-time basis from the people wearing health tracking devices (E.g.: Health tracking watches and mobiles) and then moved into the cloud for further analysis. This study mainly focuses on the specific data collected in real-time, related to the pulse rate and Blood pressure. In this paper, there are different case studies involved for analyzing qualitative and quantitative aspect of the data retrieved. This study investigates the three different groups which are differentiated by the age groups and examines the heartbeat trajectory between the three different groups and find the abnormality when compared with the average person’s heartbeat. The datasets I considered involve a different set of parameters for measuring the human heartbeat that involves both qualitative and quantitative analysis for better prediction. Some of the questions this report tries to answer are1) How can we predict the potential discrepancies in the human body by analyzing the human heartbeat even before they occur.2) How reliable are the heartbeat rate monitoring sensors and IoT technology for analyzing the Beats per minute.3) Is there any possibility to find the severity of heartbeat disease by monitoring the health in real-time?

Over the years the Internet of Things (IoT) has been adopted by the different sets of fields ranging from the small electrical appliances to the large commercial machinery. The reliance on the Internet of Things is growing exponentially, and so has the use of analytics to examine the collected data. According to the paper ‘Recent Advances on the Internet-of-Medical-Things (IoMT) Systems Security’ there are 5.8 billion IoT devices that work to serve the data for better functionality and better maintenance ((Ghubaish, A., Salman, T., Zolanvari, M., Unal, D., Al-Ali, A., & Jain, R. (2020)). The Internet of Medical Things is the branch of IoT which is confined only to the medical field, which deals with the data collected from the different health tracking devices for better assessment of the human body. In today’s world, IoMT devices constitute more than 40% of the IoT devices. But there are many privacies related, to transmission, data collection, and storage-related challenges that are observed.

**Overview**

# Access to better health care is one of the sustainable goals stated by the United Nations and improved prediction of human health is one of the vital things that need to be addressed, A large chunk of people are receiving bad medication because of the unavailability of the data. (Dalen, J. E., Alpert, J. S., Goldberg, R. J., & Weinstein, R. S. (2014) According to the article ‘Why Heart Disease is on the Rise in America’ by 2035,45% percentage of the people living in the united states will have at least one heart-related issue, and this can be decreased by gathering of the real-time data, examining and implementing it for predicting the disease even before it occurs. (Gorski, D. (2016)) According to the article ‘Are medical errors really the third most common cause death in the US?’ There are between 250000 to 400000 preventable deaths due to medical error. According to this article, there might be 35% to 56% of all in-hospital deaths are due to medical errors and cause 10% to 15% of all deaths in the USA. To avoid this,doctors need better access to data on the patient’s health.

The advancement of the Internet of Things in the medical field has bought great development in the assessment of the human health. (Kakria, P., Tripathi, N. K., & Kitipawang, P. (2015)) Sensors connected with the IoT technology provide better monitoring of the patient’s health remotely. It is clear by assessing numerous case studies ((Kakria, P., Tripathi, N. K., & Kitipawang, P. (2015)) (Makoul, G., Arntson, P., & Schofield, T. (1995)) and evidence on organized health care monitoring system can detect, monitor and capture patents health conditions in real-time can provide a better diagnosis when compared with the normal assessing of the human health. However, privacy-related issues are major challenges that need to be addressed.

The priority of this paper is to spread awareness to the people and spread awareness about the importance of the daily use of health tracking devices for better diagnosis of the problems. This paper outlines the two key objectives including the 1) Privacy is the pivotal thing that needs to be addressed and outline the flow of data transparently.2) Storing and analyzing the data to produce the most efficient results.3) Outlining the use of user’s data up to a certain limit for better analysis.

# There are several instances mentioned in this paper ‘7 Times Apple Watch Saved Lives’ where the health tracking devices benefitted in saving human lives (Taylor, A. (2015)). In the above article, an example stated that a 24-year-old man was alerted by his health tracking device. Since it found the discrepancy in his BPM, another example is a 62-year-old man who was suffering from a sickness, but the tracker revealed that he was about to suffer from a major heart attack and the tracker sent a caution message to the emergency team and saved his life. However, despite the advantages, there are many disadvantages that need to be addressed to forgo the challenges faced by the health trackers one of them is accessibility.

# There was a case study conducted in this paper ‘Barriers to and Facilitators of Using a One Button Tracker and Web-Based Data Analytics Tool for Personal Science: Exploratory Study’. In which people are divided into different groups based on the age, gender, and technological awareness, the technological awareness column defines the people’s awareness of the technology, the people who are aware of using tech gadgets are more inclined towards using the health trackers than the people who are not (van de Belt(2022)).

# The second challenge that needs to be addressed is the security issue there are several different frames of work and different techniques purposed in this paper ‘Recent Advances on the Internet-of-Medical-Things (IoMT) Systems Security’ (Ghubaish, A(2020)). Where it outlined the several different techniques like hierarchical access, wireless signal characteristics, CHF with XOR in which CHF is a one-way mathematical function XOR Is the exclusive OR function, gait-based technique, facial recognition, and pattern-based technique. But the one which caught my eye is using machine learning, artificial intelligence, and blockchain technology to secure the IMOT devices. These techniques can enhance the systems’ performance and provide resilience to malware attacks, such as Denial-of-Service (DoS) attacks (Dumitriu(2005)).

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**Literature review:**

We live in a world where technological advancement of inventing the thighs is at the peak stage Fitness trackers and other wearable devices are some examples of technological change. The fitness industry is growing rapidly according to this article **(McCarthy, J. (2019))** One in every five adults actively use health-related apps or wearable health trackers to monitor their health. Various health trackers monitor different aspects of the human body like SPo2 level which gives the oxygen percentage in the blood, BPM, blood pressure, etc., are being measured. On the other side, the unavailability of patent data to the doctors to diagnose a certain targeted problem is one of the major issues that need to be addressed. According to the article, the unavailability of data that is leading to the incorrect decision making in diagnosing the problem constitutes a major chunk of patients' deaths **(**Hibbard, J. H(2005)). Summing up the two different topics mentioned above the unavailability of the data issue can be addressed by the extensive use of the health data trackers which are connected to the cloud by the Internet of things (IoT). About 30 percent of all connected IoT devices are health-related devices (Ray, P. P. (2018)).

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# However, in the era of rapidly changing the use of technology, there is a certain group of people who show reluctance to use the health tracking devices, find it hard in understanding the benefit of using the wearable devices, and are unaware of using gadgets. This paper serves as the medium to bolster the user’s confidence in explaining the benefits of wearable devices by stating different case studies and articles.

# By reading numerous articles and research paper I found out that the research is Solley concentrated on in the advancement of technology in the wearable devices (Rajendran & Giridhar, S. (2021), Jena, M. K., & Ansari, I. A. (2018, October), (Singh, P. (2018)) or the reasons for the faulty judgment in the patient’s medication (Benjamin, D. M. (2003),Benner,Malloch, K., Schwed, K., & Jamison, D. (2002)). But according to the (Hibbard, J. H., Mahoney, E. R., Stockard, J., & Tusler, M. (2005)) there is little advancement in efficiently using real-time data collected round the clock by using trackers for diagnosing the problem.

Since most of the literature review is focused on measuring the Beats per Minute and Blood pressure variables. The analysis and case studies mentioned in the paper (Hibbard, J. H(2005)) conclude that monitoring or storing the individual’s health profile mainly the two predictor variables BPM and blood pressure can substantially improve the accuracy of the decision making.

**Study design**

The purpose of the study is to examine the trends between two groups of people, those who are active users of the wearable devices, and those who are passive users, and then analyze the collected data for the prediction of the occurrence of the potential disease. To accomplish this, an explanatory sequential mixed method approach will be used to survey the group the people. The first quantitative analysis will be used to analyze the collected data in the cloud server through different IoT-connected trackers. The main predictor variables that the qualitative analysis in this paper will be focusing on the age, gender, time, BPM, and blood pressure. The qualitative analysis will be more focused on the one-on-one surveys by the professionals with the users for a better understanding of the problem. The main reason for using the mixed method approach is 1) For a better understanding of the user’s health profile and 2) For a better cure of the problem by taking the professionals related to the medical field and passing collected raw data through different sets of algorithms.3) To further address the gap between the additional research questions and the implementation of algorithms.

**Research questions**

Most of the studies (Kroenke, K(1992)) state that, the analysis of the raw data cannot be constant, it varies based on the different persons' age groups, geographical location, and gender. The analysis of the raw data cannot be constant for every individual, the raw data collected from the different sets of induvial should be passed from the different sets of the algorithms for accurate prediction. This study seeks to answer the following questions and statements 1) Will there be a way to assess the patients’ health by taking age group, geographical location, and gender into consideration 2) What are the research questions that need to be posed by the professionals to the patients that carry more weight in predicting the potential disorder in the human body? 3) What are the accuracy trends noted from the previous examination of the human body health profile?4) What is additional information needed for accurate decision-making in the most effective way?

**Methodology**

The following section outlines the methodology used for the collection, analyzing, and storing of data collected from the wearables and the interviews are conducted to understand the deeper level of the user’s health profile for accurate decision making. This methodology involves a two-pronged analysis qualitative and quantitative. There will be a group of 23 people surveyed over 412 days.

***Quantitative data***

*Case study -1*

The quantitative analysis mainly represents the numerical form of the examination of data. The data will be analyzed in this study and will be collected from a group of 23 people of which 16 are female participants and 7 are male participants. All the participants adopted wearable trackers and will continue to use them for 412 days. There will be a certain programming interface used for the collection and analysis of the collected data.

For the qualitative analysis of the data, there are several predictor values will be considered for the prediction like gender, mean registered steps, the number of days the device will be used & unused, and device usage.

***Qualitative data***

*Case study -1*

The qualitative analysis of data mainly represents the non-numeric aspect of the data examination. The qualitative analysis will be consisting of 23 interview text data analyzed inductively by three authors to develop certain themes and categories. In which each question is related to providing the necessary information.

*Key informative interviews* (Case study -1)

As stated above, the following initial analysis of the survey results focused on the user experience and challenges faced by the long-term use of health-tracking wearable devices. The interviews will be conducted by the key stakeholders between the three different groups divided between the upper value of the threshold, the exact value, and the lower value of the threshold.

*Focus group discussions (*Case study -1)

In addition, the interview questions will be mainly focused on the challenges faced by the individuals regarding the long-term use of the health tracking devices, and the also focused on the stakeholder perceptive of the analysis of the data. The focused group discussion will be conducted by the medical professional, in a randomized format, and follow-up questions will be asked for a better understanding of the patents view on long-term use.

**Data analysis**

***Quantitative data analysis***

*Case study -1*

The dataset will be provided to the professions, related to information technology and the medical field in the form of an excel file. Following data cleaning, analyzing, and storing will be done. The analysis will be done with the involvement of stakeholder data and additional predictor values can be included for gaining deeper insights. The first group consists of the stage-1 people, who used the watch exactly as the threshold value. The second stage consists of the users, below the threshold value. The third stage consists of the users, who used devices greater than the threshold value.

**Methods**

There will be different predictor variables will be considered and the description will be stated below:

* **Gender**: Denotes the sex of the participant
* **Mean registered steps**: Denotes the average daily steps ss
* **Number of days used**: The number of data the participant uses the device in the time scale of 412 days
* **The number of days the device is unused**: The number of days since the user kept the device unused.
* **Device usage (%)-**The number of days the devices are being used in the time of 412 days. The results will be reported in percentage
* **Group**- Which group will the participants belong to group 1, 2 & 3.

In addition to that, the participants will be asked to report, if they come across a major health-related issue, that could potentially lead to erroneous data analysis. The professionals will be using a set of different programming software, and case studies to examine the collected data.

**Z-scores**

The participants will be divided into three different groups, the above the threshold value, equal to the threshold value, and less than the threshold value. Since the sample size is low the Z-scores will be served as the potential predictors of the analysis, The Z-scores variables can be served to find the frequency distribution on the normally distributed curve. For the initial analysis, we first look at the differences between the short-term the long-term users. The null hypothesis will be satisfied if the predictor variables of z score values fall in between the -2 to +2 in the normally distributed curve which constitutes 96 percent of the total curve. The null hypothesis states that predictor values will not serve the purpose of finding the reason. The alternate hypothesis will be satisfied if the predictor variable z -scores fall between the -3 to -2 and +2 to +3 which constitutes about the 4 percent of the normally distributed curve. The alternate hypothesis states that the predictor values will serve the purpose of finding the reason.

**Qualitative data analysis:**

This study will be a blend of numerical analysis (qualitative analysis) and non-numerical analysis (qualitative analysis). Both serve equal importance in understanding the issue. For qualitative data analysis, the questions will be posted by a set of professionals, related to the medical field to the participants. There will be a different set of questions for each group of participants. The results will be vital to understanding the behavioral aspect of the participants, and additionally, they will try to show trends between the different groups and different predictor variables.

As this study will be focused on finding the behavioral aspect of the participants' qualitative data analysis serves as the important means for analyzing the behavior. Additionally, quantitative analysis is used for investigating the data obtained from the different case studies that are needed to perform. The qualitative analysis will be used for a better understanding of human health, and to gain deeper insights into their problems.

**Case study -2**

***Methodology***

The following section will be assessing, the severity of the heart disease by analyzing the data collected from the health wearable trackers attached to the participants, to improve the decision making. There will be two different analyses, qualitative and quantitative of 100 different patients, who are suffering from heart-related disease. This section outlines the methodology for the two preliminary components of the study by performing the different kinds of tests to retrieve their health profile.

**Quantitative data**

The data analyzed in this study will be collected by a group of consultants who have a robust background in diagnosing heart disease. The data will be gathered from the 100 different patients who are facing heart-related issues from different geographical locations. The quantitative data set will be obtained from the 100 different patients' health wearable trackers. The data will be obtained on a real-time basis. The variables will be consisting of patients mapped into different categories based on the seriousness of the heart disease additionally, they will be posted a questionnaire about the general symptoms of the heart disease.

The baseline survey was not comprehensive in nature the data is collected in the controlled environment with the confined sample. Additionally, the consultants interviewed the patients to gain the deeper knowledge about their health profile. The survey tool was developed by the consultants and the technological experts to analyze the collected data efficiently. The data has been gathered in 20 different categories of the patients to understand the deeper level of their metabolism.

***Qualitative data (Case study -2)***

The qualitative study will be done on two levels one before the examination of the patient’s health on a real-time basis with the use of health trackers, and two after the examination of patients’ health. The pre-examination questionnaire is developed by analyzing the patents health and the post questionnaire is developed after analyzing the data from the health tracking devices.

***Key informative interviews***

The interviews are to be conducted in the two different stages to get a deeper knowledge of the patients’ health. As discussed above, the following initial analysis of the survey results severs as the foundation for the follow-up questions in the hierarchical order. The interviews with the patients will be conducted by a group of consultants. The decision matrix will be formed by each consultant based on the severity of the disease they are facing. The key informative interviews are focused on the individuals who are aware of the medical field and facing the problem.

***Focus group discussions***

In addition to the real-time data and the interviews focus group discussion will help in finding more insights into the health database of each individual. The focus group discussions will have selected members of a combination of consultants and technological experts. The focus group discussions will be conducted by a trained facilitator who knows both medical and information technology-related fields. Follow-up questions will be presented to each individual who is involved in the discussion.

**Data analysis**

Given the nature of the archival data mentioned above, the analysis will be descriptive. The results obtained from the examination of the dataset will serve as a potential purpose for analyzing the larger population. The following outlines the analysis steps that need to be conducted: including logistic regression, hierarchical multiple regression, bivariate regression, z-scores, and odds ratios.

***Quantitative data analysis***

The dataset will be used in this study consists of 100 different patients facing a heart-related issue and the data will be collected in 20 different categories from each patient. Additionally, the data on the BPM and the blood pressure will be collected by using health tracking devices that are provided to every single patient. The general symptoms of the heart disease will be preloaded into the database, and then compared with the answers provided to patients. The demographical information of each individual will be captured by the use of wearable devices.

**Methods**

There will be different predictor variables will be considered and the description will be stated below:

* **Linguistic variables** – This variable explains the insensitivity of the disease The higher the value the more intensive the disease.
* **BPM**-Beats per minute explain the heart rate for one minute.
* **Blood pressure**-Explains the individual blood pressure
* **General symptoms of heart disease**- This variable explains the different types of heart disease
* **CD**-This variable explains the different types of chronic diseases.
* **Current medications** -This variable explains medication that is going on to the patients to cure the heart disease.

Many indicators mentioned in the methods section have a certain range of values but some of the variables are dichotomous. Visualizations will be developed based on the results generated. A different range of tools will be used to examine, and analyze the results obtained. The appropriation of the generated results will result will be calculated to access the mean, median, mode, and standard deviation.

# There will be several different analyses will be done on the data that will be collected to help the small sample constitutes the larger sample. Since there will be a large set of predictor values collected from the smaller sample. The multiple regression analysis will help to find the most impactful predictors the binary logistic regression analysis will help the dichotomous predictor variables which help in reducing the time and expenditure.

# *Binary logistic regression*

# Given that the majority of the predictor variables are dichotomous. The binary logistic regression can be used to investigate the nature of the relationship between dichotomous criteria and a set of two or more predator variables. For initial analysis, the logistics regression model estimates the logistic regression equation. The logistic regression equation consists of the constant and a separate logistic regression coefficient for each predictor variable. The initial analysis mainly looks at the degree of dichotomous

# of the variables possess. Logistic regression produces chi-square statistic values, The statistic indicates the statical significance relationship of the dichotomous criterion variable and the predictor variables. The null hypothesis states that there is no relationship between the dichotomous criterion variable and the predictor variables. In our model above dichotomous criterion, variables are the linguistic variables and the general symptoms of the heart disease variables, and the predictor variables are severity estimation of the disease and subtypes recognition of the disease.

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# *Hierarchical Multiple Regression*

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# Most of the variables are included for analyzing severity estimation and subtypes of the disease. To determine the most important predictor variables that constitute the more percentage of decision-making hierarchical regression model is proposed. The hierarchical multiple regression allows the researchers to add predictor variables to a multiple regression equation of the pre-determined steps and create multiple models. By controlling the sequence of variables at the given step the consultants can determine whether added to the given step account for the meaning full amount of variance when compared with the previous model. In the above example to test the reliance of the predictor variables certain models are to be examined, assuming that the models are statistically significant to each other, The null hypothesis for the above hypothesis states that the predictor variables are not statistically significant to each other. The alternate states that the predictor values are statistically significant in the model.

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# Qualitative data analysis

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# Qualitative data analysis will include different sets of questionnaires, possible to predict the health status of the patient. The results will show the connection between the data obtained by timely usage of the health trackers and the severity estimation of the disease. Since most of the studies stated in this paper have proven the same. To get precise results qualitative analysis plays a vital role. The consultants examine the patients’ health by specific targeted questions that serve the potential role in determining the severity of the disease, these consultants can make better, accurate, and precise decisions that will not adversely impact the patients’ health.

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# The qualitative data will be analyzed by the stakeholders and the consultants with the use of analytical tools to gain deeper knowledge. The analysis will begin by joining the common points, from the different sets of patients and then will be finding the most important variables and set of questions that could serve as the medium for prediction of the intensity of the disease.

# Conclusion:

# Despite the study will be conducted between a small group of people it will help move the results from the smaller picture to the larger picture. The results will show the associations between the two case studies examined in the paper and shows the relation between the qualitative and quantitative aspects of the data. The goal of the study is to gain insights from the different perspectives of the people who are active users and passive users of the trackers and to find the difference in the health profile by performing a different set of analyses from the data collected from the trackers. Additionally, another test is performed taking a heart-related disease as the main plot. This test needs to be performed to spread awareness that trackers can improve accuracy and decision-making by calculating the health in real-time by taking an example. Both the studies can be used for moving from a smaller sample to a larger sample.

# In the future, the research needs to focus on diagnosing different kinds of health-related issues using qualitative and quantitative analysis in a larger sample.

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References:

Ghubaish, T. Salman, M. Zolanvari, D. Unal, A. Al-Ali and R. Jain, "Recent Advances in the Internet-of-Medical-Things (IoMT) Systems Security," in IEEE Internet of Things Journal, vol. 8, no. 11, pp. 8707-8718, 1 June1, 2021, doi: 10.1109/JIOT.2020.3045653

Dalen, J. E., Alpert, J. S., Goldberg, R. J., & Weinstein, R. S. (2014). The epidemic of the 20th century: coronary heart disease. *The American journal of medicine*, *127*(9), 807-812.

Gorski, D. (2016). Are medical errors really the third most common cause of death in the US?. *Science-Based Medicine, last modified May*, *9*.

Kakria, P., Tripathi, N. K., & Kitipawang, P. (2015). A real-time health monitoring system for remote cardiac patients using smartphone and wearable sensors. *International journal of telemedicine and applications*, *2015*.

Makoul, G., Arntson, P., & Schofield, T. (1995). Health promotion in primary care: physician-patient communication and decision making about prescription medications. *Social science & medicine*, *41*(9), 1241-1254.

Taylor, A. (2015). *Get Fit with Apple Watch: Using the Apple Watch for Health and Fitness*. Apress.

van de Belt, T. H., de Croon, A., Freriks, F., Christiansen, T. B., Larsen, J. E., & de Groot, M. (2022). Barriers to and Facilitators of Using a One Button Tracker and Web-Based Data Analytics Tool for Personal Science: Exploratory Study. *JMIR formative research*, *6*(3), e32704.

Ghubaish, A., Salman, T., Zolanvari, M., Unal, D., Al-Ali, A., & Jain, R. (2020). Recent advances in the internet-of-medical-things (IoMT) systems security. *IEEE Internet of Things Journal*, *8*(11), 8707-8718.

Dumitriu, D., Knightly, E., Kuzmanovic, A., Stoica, I., & Zwaenepoel, W. (2005). Denial-of-service resilience in peer-to-peer file sharing systems. *ACM SIGMETRICS Performance Evaluation Review*, *33*(1), 38-49.

van de Belt TH, de Croon A, Freriks F, Blomseth Christiansen T, Eg Larsen J, de Groot M  
Barriers to and Facilitators of Using a One Button Tracker and Web-Based Data Analytics Tool for Personal Science: Exploratory Study  
JMIR Form Res 2022;6(3):e32704

McCarthy, J. (2019). One in five US adults use health apps, wearable trackers. *Gallup*.

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|  |
| Rajendran, S., Chaudhari, S., & Giridhar, S. (2021). Advancements in healthcare using wearable technology. In *Computational Intelligence in Healthcare* (pp. 83-104). Springer, Cham. |
|  |  |

Jena, M. K., & Ansari, I. A. (2018, October). A critical review of wireless health monitoring devices. In *2018 Conference on Information and Communication Technology (CICT)* (pp. 1-6). IEEE.

Singh, P. (2018). Internet of things based health monitoring system: opportunities and challenges. *International Journal of Advanced Research in Computer Science*, *9*(1), 224-228.

Benjamin, D. M. (2003). Reducing medication errors and increasing patient safety: case studies in clinical pharmacology. *The Journal of Clinical Pharmacology*, *43*(7), 768-783.

Benner, P., Sheets, V., Uris, P., Malloch, K., Schwed, K., & Jamison, D. (2002). Individual, practice, and system causes of errors in nursing: a taxonomy. *JONA: The Journal of Nursing Administration*, *32*(10), 509-523.

Hibbard, J. H., Mahoney, E. R., Stockard, J., & Tusler, M. (2005). Development and testing of a short form of the patient activation measure. *Health services research*, *40*(6p1), 1918-1930.

Abdel-Basset, M., Gamal, A., Manogaran, G. *et al.* A novel group decision making model based on neutrosophic sets for heart disease diagnosis. *Multimed Tools Appl* **79,**9977–10002 (2020). <https://doi.org/10.1007/s11042-019-07742-7>

Hibbard, J. H., Mahoney, E. R., Stockard, J., & Tusler, M. (2005). Development and testing of a short form of the patient activation measure. *Health services research*, *40*(6p1), 1918-1930.

Ray, P. P. (2018). A survey on Internet of Things architectures. *Journal of King Saud University-Computer and Information Sciences*, *30*(3), 291-319.

Hibbard, J. H., Mahoney, E. R., Stockard, J., & Tusler, M. (2005). Development and testing of a short form of the patient activation measure. *Health services research*, *40*(6p1), 1918-1930.

Kroenke, K., Lucas, C. A., Rosenberg, M. L., Scherokman, B., Herbers Jr, J. E., Wehrle, P. A., & Boggi, J. O. (1992). Causes of persistent dizziness: a prospective study of 100 patients in ambulatory care. *Annals of internal medicine*, *117*(11), 898-904.

Creswell, J. W., & Creswell, D. J. (2018). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (5th ed., pp. 295). SAGE Publications, Inc.

Hatcher, L (2013). *Advanced Statistics in Research - Reading, Understanding, and Writing Up Data Analysis Results.*