



Smartwatch System for Monitoring Epilepsy

Kevin Marie

EasyChair preprints are intended for rapid dissemination of research results and are integrated with the rest of EasyChair.

April 30, 2020

1. Abstract

This project is based on the neurological disorder called epilepsy. This disorder is associated with repetitive seizures as stated by Dr. Dekker (Dekker, 2002). A vast amount has been having difficulty living with this disorder in terms of management and a normal lifestyle. Along with these difficulties, it creates other issues such as mental health issues and deaths. In a study by Dr. Orrin Devinsky (Devinsky, 2008), as far as medication goes, there is a reduction in the number of seizures in epileptic patients that takes medication, but not completely. Meaning that the fear of having a seizure remains. This project is to provide a way to monitor and manage this disorder through an application integrated inside a smartwatch. This application will monitor the heart rate of the caretaker, the epileptic diagnosed person, and will alert them beforehand of a possible epileptic attack. Moreover, caregivers, people that provide help to the caretaker, can register in the application and be notified also along with the GPS location of the caretaker. This project will also provide concrete information about the critical issues related to this disorder and the seriousness of these issues. To create the system, the most suitable system development methodology should be used. Therefore, this project also provides a comparative analysis on which system development methodology to use that will provide a quality system. Also, to gather information and the appropriate statistics and analysis about the necessity and efficiency of creating this system.

2. Introduction

Epilepsy is a neurological disorder that is associated with repetitive seizures that occur because of abnormalities in the brain cells, as stated by Dr. Dekker (Dekker, 2002). This is a continuous concern globally both for the individuals diagnosed with it and also the caregivers of that particular individual. According to the World Health Organisation, from the statistics they gathered from 2016 to 2018, they concluded that an estimated average of 2.4 million people is diagnosed with epilepsy (Who, 2019) from an article written by the Epilepsy Foundation of Michigan (Michigan, 2017), it states that from a survey of 2008 from both people suffering from epilepsy and people who have relatives suffering from it. They came out with the conclusion that 90% of the respondent stated that this disorder limited their quality of life. The article also states that there are many issues accompanied with this disorder. One issue includes

the fear of having a seizure. This is mainly caused by the awkwardness of social life when having a seizure. Moreover, this is the chance of SUDEP (Sudden Unexpected Death in Epilepsy). These are death caused by either breathing, heart rhythm, or other causes and mixed causes related to epilepsy. Another issue is stress and depression. This is mainly because the patients do not have good control over this disorder. This causes depression as they cannot live a quality of life and it stresses them out which in return might trigger an epileptic episode. They came up with the conclusion that these issues are mainly due to the lack of education on ways to manage this disorder and also lack of aid for the management of this disorder. This paper proposes a smartwatch system for monitoring epilepsy that is integrated inside smart watches. This system main goal is to reduce concerns and help epileptic individuals to be more alerted and educated on what to do before and during an epilepsy episode. The research will justify what are the main concerns and problems that arise because of this disorder and will also justify how effective the system will be.

3. Literature Review

3.1 Domain research

The main domain of this project is bioinformatics. According to Konstantin Okonechnikov (Okonechnikov, 2012), bioinformatics is the storage, analysis, and retrieval of biological information. It is now involved in so many fields including computer science and software development. Structural Bioinformatics was the first based field in bioinformatics. It involved attempts to study and give a prediction of protein structures. Now it has advanced to give readings and prediction of states of cells and their activities. Many devices use bioinformatics for commercial purposes nowadays. Two of the main devices are FitBit's and Smartwatches. The users of these devices are more than keen to purchase this bioinformatics product as it helps them understand and get a visualization of their internal body activities.

3.2 Similar System

In terms of similar systems that exists, only one is available. It is called the embrace watch which also monitors epilepsy.

3.2.1 The embrace watch for epilepsy

The embrace smart watch is a related work developed by Empathica, a computing company in Massachusetts, but has some limitations and weaknesses. As written in an article by Dr Heidi Maowad (Maowad, 2019), the embrace watch is a watch for epileptic individuals which is used as an aid for the to manage it.

The article continues by stating that once an epilepsy episode or a seizure occurs, the information is sent to an application in the user's phone. The app is called, Alert app for embrace watch. Moreover, the users should be within 10 meters to the user. The alert app then sends a notification message to the assigned caregiver(s). The watch detects physical movements and responses. These are fluctuations in body temperatures, breathing, and heart rate. This is done by using the EDA (electrodermal activity) sensor, which is defined in an article by Roberto Zangróniz (Zangróniz, 2017), as a sensor which measures activities in the nervous system and this is activated in the occurrence of a seizure.

Dr. Heidi Maowad (Maowad, 2019), elaborates about the watch by stating that the watch machine learning is used to detect if the movements and responses are normal or abnormal and sends the data to the Alert app.

3.2.2 Main features of the embrace watch

Its features generally include real-time data reading which uses machine learning. The main features are listed below stated by Rob Senior (Senior, 2019).

1. Live data visualisation

This watch uses an EDA (Electrodermal Activity) sensor to measure the pulse from the heart rate of the patient. These measurements are done in real-time and also displayed for visualization. These reading can be seen from a smartphone which is connected via Bluetooth with the watch.

2. Alert when an epileptic attack is occurring

The watch alerts the other users that are registered to the appropriate user when an epileptic attack is occurring. This alert is done as a notification.

3. Location

The watch gives out the location of the user main user to the other users registered to that particular user. This location is given all the time unless the user chooses to turn off their location.

3.2.4 Workflow Model

The workflow model of the embrace watch is shown below in Figure 1 below shows the workflow model for the embrace watch.

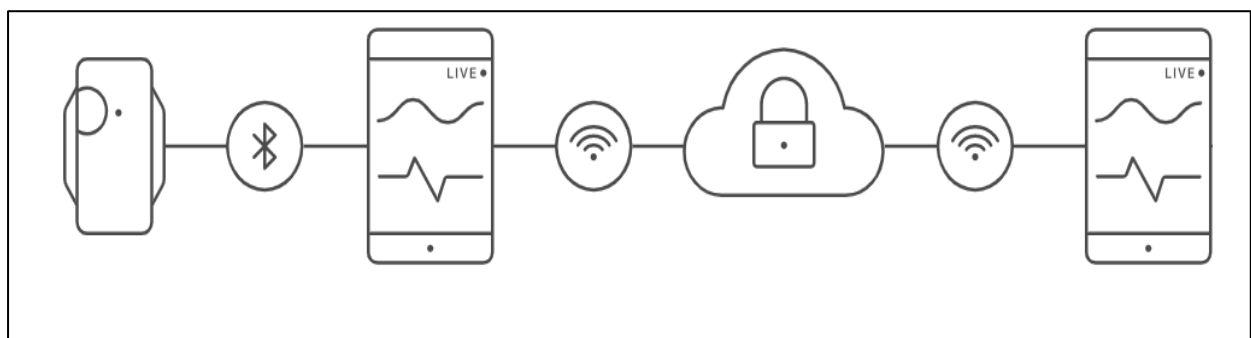


Figure 1 Embrace watch workflow model (Empatica, 2019)

The reading is taken from the watch sent to the device. This is done by using a Bluetooth connection. Afterward, the reading is sent to a cloud server and database for storage. This can

only be done if there is an available internet connection. From the cloud server and database, users that have been registered to the appropriate user can see the readings of the main user which is wearing the watch.

3.2.5 Limitations and weakness of the embrace watch.

Dr. Heidi Maowad (Maowad, 2019). states that the watch has some limitations and weaknesses such as it does not alert or notify beforehand that a seizure is might occur. The general limitations to the embrace watch stated by Dr. Heidi Maowad (Maowad, 2019) from users that purchased the watch, is listed below.

1. Notification is done only during an attack.

One downside to the watch is that it does not notify beforehand to the main user or the registered user of a possible epileptic attack. This was one of the main weaknesses mentioned by the users who purchased the watch.

2. Location privacy.

Another weakness of the watch is that the registered users can see the main user's location at any time unless the main user turns off the location from there part. The user's specified in their testimonies that one recommendation is to provide the location only during an attack.

3. Expensive.

In terms of purchasing this watch is quite expensive in comparison to the average cost of a smartwatch. The embrace watch costs \$250 with a monthly subscription fee of \$10 according to Richard N. Fogoros (Fogoros, 2019), whereas the average cost of a smartwatch is \$210 onetime payment according to Lucy Ingham (Ingham, 2019). Moreover, the watch does not tell time which kind of misleading.

4.0 Materials and Methods

4.1 Programming language chosen

There are only two main programming languages that can support wearable operating system application that can be used for this project. These are Java and Swift. Below is a comparison of Table 3.1 in relation to which programming language is suitable for this project.

Table 4.1 Comparison between Java and Swift

| Description | Java | Swift |
|------------------------|---|---|
| Resource availability. | Java is very popular and has been around for 14 years. This means there are more resources available on how to use it efficiently. ✓ | Swift is quite young, being created for 6 years now. This means that there are fewer resources on how to use it efficiently in comparison to Java. ✗ |
| Ease. | Java is easier to learn than swift. This is about its syntax rules and coding structures. ✓ | Swift is more complex to learn than java. These complexities are related to its syntax rules and coding structure. ✗ |
| Libraries. | Java can only use its libraries and SDK's in comparison to swift that can use C and C++ libraries. ✓ | Being a superset of C, Objective-C allows you to comfortably and smoothly use C and C++ libraries. ✗ |
| Programming Paradigms. | Java supports more programming paradigms than swift, which includes the imperative and declarative programming paradigm. ✓ | Swift only supports the imperative programming paradigm. ✗ |

Java seems to be more suitable for this project, as it has more advantages over Swift in terms of the descriptions mentioned in Table 4.1. Therefore, the programming language that will be used for this project is java.

According to Ken Arnold (Arnold, 2005), the java programming language is a general-purpose programming language which was developed by computer scientist from Canada called James Gosling on 23rd January 1996. Java is also class and object oriented based with implementations of dependencies. Which means it can use the reference technique for the relations between components by using classes and abstract classes.

4.1.1 Why use Java?

Many programming languages have been developed nowadays. However, java is the most suitable programming language to be used for this particular project. The main reasons for this are provided below.

1. *Cross functionality and portability.*

As stated by Ken Arnold (Arnold, 2005), java is able to offer higher cross-functionality and portability in comparison to other programming language. This is because, programs using this language can be written in only one platform and can run across desktops, mobiles and embedded systems.

This shows that it is suitable for this project as the application needs to interact with two different interface and devices, which is the smartwatch along with the smartphone. Moreover, having this advantage, makes it easier for real time data to be recorded and visualized on the various connected and registered devices.

2. *Programming paradigms.*

As stated by Dr Drigas (Drigas, 2006), Programming paradigms are known as methods of solving a problem by using tools and techniques available by following a specific approach. These paradigms are used for solving problems in the most efficient way possible. Therefore, as java supports both these programming paradigms, the coding will be able to run smoothly

and produce a quality end product. These programming paradigms is shown in Figure 3.1.1 below.

I. Imperative Programming Paradigm.

Imperative Programming Paradigm is known to be one of the oldest programming paradigms. It includes step by step tasks being done and change of states. There are three main approaches approach are included in imperative programming paradigms.

- **Procedural programming approach:** Executes statements sequentially and stores the result. Moreover, it has the ability to reuse the code such as iteration and recursion.
- **Object Oriented programming approach:** This is written as a set of classes and objects. These are meant for communication.
- **Parallel processing approach:** This is processing of program statements by dividing them amongst available processors efficiently.

II. Declarative programming paradigm.

Declarative programming paradigm is known as a programming paradigm for complex programs using short lines and simplified codes. This increases the speed of the overall end product since there only short lines of codes. There are three main approaches approach are included in imperative programming paradigms.

- **Logic programming approach:** This approach uses a knowledge base along with questions given in the machine to produce a result. This is suitable for intelligent systems and this project, as the knowledge base needs to know what to do with the real-time data recorded.
- **Functional programming approach:** This approach basically executes a series of mathematical functions, without changing their meaning in the program. This makes the coding compilation much faster.
- **Database/data driven programming approach:** This approach mainly focuses on data and its movement. Meaning that the statements in the program is defined by data than hard coding. This is an advantage for programs that needs to use a database such as this project.

3. Uses *Interpreter*.

Interpreter is a program execution technique whereby instead of executing the whole program instantly like a compiler, it uses intermediate representations such as binary trees. This makes it easier to identify errors in the early coding stage.

4.2 IDE (Interactive Development Environment) chosen.

The 3 main IDE's that supports wearable device applications which will be suitable for this project are Android Studio, Xamarin and Xcode.

However, in order to access wearable application development for Xcode, such as smartwatch, it needs to be on a premium package with continuous monthly payments and additional payment to access the real-time database regularly. Moreover, Xcode can only run on a MacOS operating system or a virtual machine. In terms of the Operating system used for this project, which is Windows OS, only a virtual machine can run Xcode, but it will lag and cause a major delay in the development process. Due to these constraints, Xcode is excluded for this project.

This means that Android Studio and Xamarin is the two suitable IDE's for this project. Table 4.2 below shows the comparisons between these IDE's.

Table 4.2 Comparison table Android studio and Xamarin

| Description | Android Studio | Xamarin |
|-------------|---|--|
| Deployment. | <i>Fast deployment, no need to reinstall.</i> Only the updated assemblies are re-synchronized to the target device. ✓ | <i>Fast deployment, no need to reinstall. Only</i> the updated assemblies are re-synchronized to the target device. ✓ |
| Emulators. | Emulators runs and deploys faster in comparison to Xamarin emulators. ✓ | Emulators runs and deploys slower in comparison to Android Studio emulators. ✗ |

| | | |
|-------------|--|--|
| Platforms. | Android studio can develop codes for android devices only. | Xamarin can develop codes for both android and IOS devices. ✓ |
| Pricing. | In terms of commercialising the end product, for Android studio it is free, unless there is a need to hire a third party to market the product. ✓ | In terms of commercialising the end product for Xamarin it has a yearly fee of \$800. ✗ |
| Wearable OS | Android studio does support wearable OS development. ✓ | Xamarin does support wearable OS development. ✗ |

Android studio seems to be more suitable for this project, as it has more advantage over Xamarin in terms of the descriptions mentioned in Table 4.2.

Therefore, the IDE chosen for this project is Android studio. This is because it makes mobile app development easy because of its open source platform. Moreover, in terms of wearable OS app development, even though Xamarin is crossed platform, in order to develop or run the project for IOS platform it needs to use a virtual machine and a premium account with monthly payment fee to access the database.

According to Jeffrey DiMarizio (DiMarizio, 2012) , other reasons of using android studio as an IDE for this project is listed below.

1. Availability of Drag-and-Drop

Android Studio provides a GUI (Graphical User Interface) development. However, the main advantage to this is the availability of Drag-and-Drop. This allows developers to drag such widgets as buttons, text box and labels into the GUI container without the hassle of coding for the positioning of these widgets.

This will be beneficial for the development of this project as it will reduce time consumption in terms of positioning and adding constraint to widgets used.

2. Firebase real-time database integration

Android studio allows an integration with Firebase, which is a BaaS (Backend as a Service), to allow the use of a real database. This allows storage, instant update and synchronisation of data in the NoSQL cloud database.

This will be beneficial for this project as there is a need for real-time reading, storage and visualisation of body readings, such as heart rate and blood pressure.

3. Wearable OS

Android studio has plugins, SDK's (Software Development Kit that supports) and libraries that support application development for Wearable OS. This means that Android studio can develop applications for smartwatches.

This will be beneficial for this project as this project is an application that integrates with both smartwatch and mobile phone. Moreover, the plugins, SDK's and libraries will be needed to check the users heart rate and blood pressure.

4.3 Database Management System chosen

According to Neil Smyth (Smyth, 2017), the two of the most suitable database management systems that can be used for this project is Firebase and SQLite. A comparison table is given below to differentiate between the two database management systems.

Table 4.3 Comparison table for Firebase and SQLite.

| Description | Firebase | SQLite |
|--------------|---|---|
| Portability. | Since Firebase is cloud hosted, therefore it is compatible with all operating systems. ✓ | SQLite is compatible and portable for all 32-bit and 64-bit operating systems. ✓ |

| | | |
|--------------------------------|---|---|
| Reliability. | Since Firebase is cloud hosted, data loss due to circumstances such as power failure or crash is not an issue. ✓ | Data is automatically updated continuously. However, little work can be lost in the case of power failure or crash ✗ |
| Sever. | As firebase also helps with hosting by using Googles cloud services. ✓ | SQLite need to be integrated with an external server for application hosting purposes. ✗ |
| BaaS (Backend as a Service) | Firebase is its own BaaS. Therefore, it does not need any integrated or external BaaS. ✓ | SQLite needs an integrated BaaS to take care of cloud storage and hosting. ✗ |

Firebase seems to be more suitable for this project, as it has more advantages over SQLite in terms of the descriptions mentioned in Table 4.3.

Therefore, the database management system to be used for this project Firebase. According to Neil Smyth (Smyth, 2017), firebase is a BaaS which was created by Google in 2014. Meaning that it allows developers to only concentrate on the frontend of the application. Firebase takes care of cloud storage, hosting and other backend services.

The main reasons for using Firebase as a database management system for this project is listed below is listed below.

1. **Web Server.**

This one of the main benefits of using Firebase. It is both your database management system and your host. It uses Googles cloud services, since it was created by Google, in order to host the application.

This will be beneficial for this project as there is a need for a server to send and request data over a network with good quality.

2. Realtime database.

Firebase provides a Realtime database which means that data is synced with the clients in Realtime. Moreover, with Firebase, data stays available offline.

As stated by Neil Smyth (Smyth, 2017), while other database uses typical HTTP requests, Firebase makes use of data synchronization. Meaning that with Firebase, every time changes occur within the database, the devices which are connected receives the update.

3. Authentication.

Firebase provides authentication services. This means that it helps to validate and verify user information. This will be very helpful as to who has access to what in the database.

This will be very beneficial for the project in terms of the Caregivers having access to what of the caretakers in the database.

4. Free.

Firebase is giving all these services completely free. This becomes beneficial for any project, especially this one as gets access to all these services completely free of charge.

4.4 Operating System chosen

The operating system used for this project is Windows 10. Windows 10 is a well-known and used operating developed and produced by Microsoft. It was released for retail sale on 29th July. Windows 10 gets updates on an ongoing basis, which is also free of charge for users. Moreover, there are test updates which is available to Windows Insiders.

The main reasons for choosing Windows 10 for this project is listed below.

1. *Support for all hardware.*

Windows OS (Operating System) is known to be used currently by 77% of users in comparison to other operating systems as stated by Alexandru-Catalin Petrini (Petrini, 2016), This means that hardware sellers makes drivers mostly for windows OS. Therefore, if there is any hardware issue, fixing it will be fast and there is a high possibility that the needed hardware will be available.

2. *Ease of use.*

According to Alexandru-Catalin Petrini (Petrini, 2016), The windows OS's user interface is known to be the easiest to use in comparison to other operating systems. Moreover, amongst all the versions of windows OS, Windows 10 is known to be the most user friendly, as the features was recommended by users from the previous versions. These features such as, advanced start menu and hotkey navigations makes the Operating system much easier and faster to use. Therefore, it will help make the project much easier to complete due to this benefit.

3. *Software support:*

As concluded by Alexandru-Catalin Petrini (Petrini, 2016), windows OS is known to be best suited for game and software development. This is because windows OS has a large number of audiences, therefore they make and give frequent updates to the windows OS in terms of utilities, gaming and software development. This gives assurance that the operating systems keeps running smoothly and efficiently. Therefore, it will help make the project much more efficient to complete due to this benefit.

4. *Plug and play feature.*

According to Alexandru-Catalin Petrini (Petrini, 2016), windows OS has plug and play feature. Meaning that, most hardware automatically detected by the plug and play feature. Meaning that there is no need to manually install the hardware such as mobile devices, keyboard, mouse and webcam. This helps reduce installation time and process time. Therefore, it will help to consume less time for this project completion.

4.5 Comparison of system development methodologies.

The two most suitable SDM's (Software Development Methodology) to use for this project is the Waterfall Model and Spiral SDM. According to Mike McCormick (McCormick, 2012), Waterfall Model is a SDM methodology which follows a sequential process. Meaning that the previous stage needs to be finished to start the next one. Whereas Spiral, as stated by Mike McCormick (McCormick, 2012), this a SDM follows an iterative process. Meaning that the phases is done continuously and also sometimes simultaneously. A comparison table is given below to differentiate between the Waterfall model and Spiral SDM.

Table 4.5 Comparison table for Waterfall model and Spiral

| Description | Waterfall Model | Spiral |
|--------------|--|---|
| Ease. | Easy to use, understand and implement. This is due to its sequential structure and phases being completed one at a time. | Complex to use, understand and implement. This is due to the high amount of risk analysis and documentation in each intermediate stage. |
| When to use? | When the quality of the end product is of higher importance than the cost or schedule. | When significant changes are expected in the end product. |
| Cost. | Using the Waterfall methodology is usually done at a low cost. | Using the Spiral methodology is usually done at an expensive cost. |

| | | |
|--------------|--|---|
| Flexibility. | It is difficult to make changes in the waterfall methodology as all requirements is declared at the requirements gathering stage. Moreover, because it has a sequential structure. | Changes can be made any time in the spiral methodology. |
|--------------|--|---|

Therefore, the most suitable SDM to use is the Waterfall model. This is because in this project, as soon as the requirements is gathered the project can continue sequentially. When data is gathered, there is not a high probability for change in the end product.

4.5.1 Waterfall Model.

The waterfall model is a suitable development methodology for the development of this system. This is because this methodology is simple and easy to understand and use. More-over, according to Mike McCormick (McCormick, 2012), It is easy to manage due to the rigidity of the model – each phase has specific deliverables and a review process. Also, the design does not really matter as long as the software does what it supposed to do. So, developers and customers agree on what will be delivered early in the development lifecycle.

As shown in Figure 4.2 below, even-though the waterfall model is sequential there are times that developers has to go back to a stage to make small changes. This makes the waterfall model more hybrid.



Requirements Specification.

At this stage the needed requirements which include functional and non-functional requirements is gathered from stakeholders. These include both the design and functionality of the system.

In order to gather all the requirement in order to develop the *Smart Watch System for Monitoring Epilepsy*, fact finding techniques must be done in order to have a good decision on

the requirements necessary. For example, for a Functional requirement, it may include that the system should be able to provide an interface that is user friendly and easy to use.

Questionnaires can be used to get a more structured understanding on how the current process works since questionnaires is open book. Which means that detailed answers can be given. Moreover, surveys can be used to get short direct answers for simple questions. Such as Yes/No questions. Another fact-finding technique is interviews. This will be helpful in terms of getting a detailed and in-depth answer from the stakeholders.

System Design

System Design facilitates identification of hardware and system requirements and helps in defining overall system architecture. In the design stage it comprises of three main design types. This includes Conceptual, Logical and Physical Design.

Conceptual design is basically used to understand the concept of the product and its usually presented to customers and users. A context diagram is suitable for it. This is because for the road tax application, has various data being processed and stored, context diagram does a good job in showing what happens to each data. For example, Details for one customer might include Customers personal information, Name, Age and Email. Moreover, body readings has to be done and has to go through a calculation algorithm. Therefore, many processes must be made on different types of data, which a context diagram can easily show what happens to each data.

The next one is Logical design. Logical design, basically means, an abstract of the system. This is more in detail compared to conceptual design and it is intended for the developers. Data Flow Diagram (DFD) is used at this stage. Since waterfall model is following a sequential principle, a DFD is more appropriate to be used because a Context Diagram can be expanded into a DFD. In terms of the *Smart Watch System for Monitoring Epilepsy* a DFD is more appropriate to help the developers understand what happens to each data. For example, when a user enters their login details in the system, the system should be able to identify if the user exists in the database and if the details is valid. The DFD will represent the user as an external entity and their email and password as the data flow for verification.

The last one is physical design. This is a working model of software with some limited functionality. In other words, prototyping. This model is appropriate for the *Smart Watch System for Monitoring Epilepsy* because prototyping allows the involvement of the user which enables them to see and interact with a working model of their project.

Implementation

With inputs from system design, the system is first developed in small programs called units, which are integrated in the next phase.

For example, first the sign-up interface can be created then once it is done the login interface can be created. This makes it easier to get a final product and easier to test for errors since it is created by units.

Testing

In relation to the road tax mobile application, the two most appropriate testing methods includes:

➤ Unit Testing

Unit testing has many benefits in terms of software development. The main benefit is that it identifies every defect that may have come up before code is sent further for deployment. This is crucial for the road tax mobile application because if the wrong data is entered into the database it will be very expensive to re-configure the database.

Therefore, Unit testing also reduces cost. According to Ekaterina Novoseltseva (Novoseltseva, 2017) since the bugs are found early, unit testing helps reduce the cost of bug fixes. Just imagine the cost of a bug found during the later stages of development. Of course, bugs detected earlier are easier to fix because bugs detected later are usually the result of many changes, and you don't really know which one caused the bug.

➤ Black Box Testing

Black box testing basically means only the input and output is seen. Whereas the process, meaning the source code are hidden. This testing method is intended for users that has no idea about the source code of the system and the user inputs data and the output is prompted.

This is appropriate for the *Smart Watch System for Monitoring Epilepsy*. This can be done whereby the user can sign up for the first time. Therefore, that user's information will be stored in the database. So, the user will have to enter appropriate details and the developers can see if the system does what it is supposed to do.

Deployment of system

Once all the testing is done, the product is deployed in the customer environment or released into the market. Testing meaning that it includes pre-deployment testing, which is testing done on the production site and post-deployment testing, which is testing done on site and it includes Technical tests, Connection tests, Security test and user acceptance test. Once the department has viewed the pre-testing and post testing results and are satisfied. This means that the road tax mobile application can finally be deployed.

Maintenance

If there are some issues that comes up in the client environment. To fix those issues, updates and upgrades are released. For example, if there is a lag when in the system. A new update can be released where the lag has been removed. Two main Maintenance method that is appropriate is:

➤ Adaptive Maintenance.

This maintenance method basically means additions of enhancement to the system is made. For example, if a new type feature or technology comes out that can make the system work faster, this can be added into the system.

➤ **Perfective Maintenance**

Involves changing an operational system to make it more efficient, reliable and maintainable. For example, if from the feedbacks gained if the user is not satisfied with the navigation of the system, therefore this can be changed for it to be more efficient.

4.6 Research Method

The research methods involve the data gathering and analysis that will with the quality of the project deliverables. This will also help identify the true necessity of this project or if there is any change needed for the project. In terms of the research methods used, it includes questionnaires and interviews. Questionnaires will be used to get a poll of answers. Two batch of questionnaires, one for the caretakers and one for the caregivers. This will help better understand why epilepsy is difficult to both manage and monitor. Questionnaires is suitable for this purpose as there will be poll of subjective answers. Another method will be interview. One interview will be conducted with a neurologist. This is for the purpose of better understanding the cause and technicalities of epilepsy. Another interview will be conducted with a caretaker (someone diagnosed with epilepsy). This is for the purpose of better understanding what do they have to do to try to manage this disorder. Moreover, to get a perspective on if there is a necessity of the *Smart Watch System for Monitoring Epilepsy*. One last interview will be conducted with a caregiver (someone that provides help to the caretakers). This is to understand how they help the caretakers manage this disorder. Also, to understand the necessity of the *Smart Watch System for Monitoring Epilepsy*.

4.6.1 Questionnaires

One research method that will be used for this project is questionnaires. Surveys proves a way to gather a poll of answers. Meaning that a generalized of answers from different demographics and cohorts of participants. Moreover, it shows the pattern of answers and which makes it easier to see the direction the project will go. Which means that it will be easy to see if the highest percentage of participants finds this system to be beneficial or not.

Two surveys will be carried out. One questionnaire will be for the caregivers. This is for the reason of getting their perspective and opinion.

4.6.1.1 Consent Form

In figure 2 below shows the consent form for the participants before starting to do the survey. This consent form is ensuring them that their participation is volunteer and that their information given will be treated with discretion. Also, to by agreeing to the consent form they will be agreeing to fill out the questions in an utmost honest, truthful and faithful manner. A much clearer document of the survey consent form is attached in the appendix.



Dear Participant,

My name is Kevin Samuel Marie. I am a student in Asia pacific university of technology and innovation. I am doing a research for my final year project for the fulfilment of a degree of Software Engineering. You are kindly invited to participate in this research entitled "Smartwatch system for monitoring epilepsy". Epilepsy is a neurological disorder which causes seizures to people which are diagnosed with it. The purpose of this research is to understand how to make this disorder more manageable through a smart watch system that can alert the user and registered caregiver when the epileptic attack is about to happen and when it is happening. Moreover, sending out the GPS location of the user to the registered care giver(s).

Your corporation to fill out the questions in an utmost honesty, truthfully and faithfully will be highly appreciated. The questionnaires will only take around 5-10 minutes of your time to be completed. Please be informed that there are no consequences or known risk in participating in this survey. Your participation is voluntary, and this research is only conducted for academic purpose and that your response will be strictly confidential. If you have problems or concerns regarding this research, please feel free to contact the researcher through the number or send an email as provided below.

Thank you for your corporation.

Sincerely,

Kevin Samuel Marie, TP046942@mail.apu.edu.my, TP046942

Figure 2 Questionnaire Consent Form

4.6.1.2 Information Sheet

In figure 3 below shows the information sheet for the survey. This is given before the participants start the survey. It is given in order for the participants understand the purpose of this system and this questionnaire. Moreover, for them to understand where they stand as a participant in this project. A clearer document of the information sheet is given in the appendix.



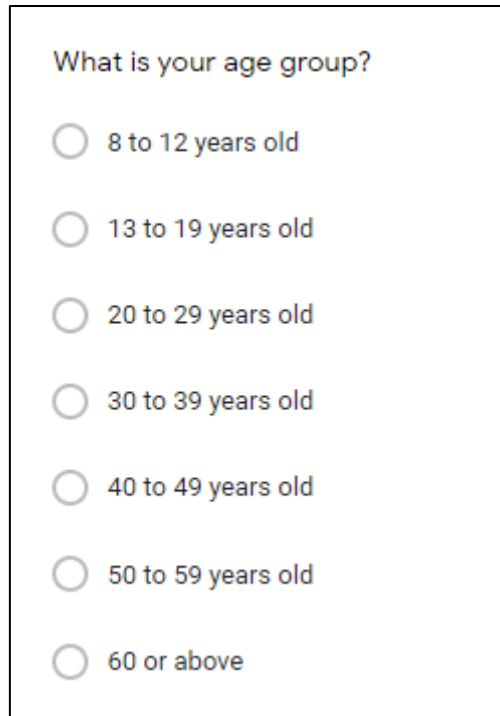
This project is titled *smartwatch system for monitoring epilepsy*. It is basically an application integrated between mobile devices and smartwatches in order to identify and give an alert notification when a caretaker (user that is diagnosed with epilepsy) is having an epileptic attack. This application will monitor the heartrate of the caretaker, the epileptic diagnosed person, and will alert them beforehand of a possible epileptic attack. Moreover, caregivers, people that provides help to the caretaker, can register in the application and be notified also along with the GPS location of the caretaker. This is being developed in order to make the neurological disorder known as epilepsy more manageable and to know the causes of epileptic attacks.

Figure 3 Information Sheet

4.6.1.3 Questionnaire questions for caregivers.

The following are the questions asked to the caregivers. Moreover, the justification and reason for asking the particular questions.

Question 1: What is your age group?



What is your age group?

- ☐ 8 to 12 years old
- ☐ 13 to 19 years old
- ☐ 20 to 29 years old
- ☐ 30 to 39 years old
- ☐ 40 to 49 years old
- ☐ 50 to 59 years old
- ☐ 60 or above

Figure 4 Question 1

The question in figure 5.2.1.3.1 is asked in order to know difference patterns in answers in terms of age. These age are listed by Child/Adolescent (8 to 12 years old), Teenagers (13 to 19 years old), vicenarians (20 to 29 years old), tricenarians (30 to 39 years old), quadragenarian (40 to 49 years old), quinquagenarian (50 to 59 years old) and the elderly (60 years and above). The labelling for the different was not given as it is different for some nationalities. Therefore, the ages were only given numerically.

Question 2: What is your gender?



What is your gender?

☐ Male

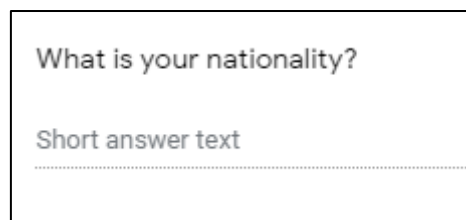
☐ Female

☐ Other

Figure 5 Question 2

The question in figure 5 will be asked in order to see the difference patterns in answers in terms of gender. The gender is categorized as male, female and other for there are some countries that has more than two genders.

Question 3: What is your nationality?



What is your nationality?

Short answer text

Figure 6 Question 3

The question in figure 6 will be asked in order to see the difference patterns in answers in terms of nationality.

Question 4: What relation do you have with the epileptic person?

What relation do you have with the epileptic person?

- ☐ My Mother
- ☐ My Father
- ☐ My Grandfather
- ☐ My Grandmother
- ☐ My Son
- ☐ My Daughter
- ☐ My Partner
- ☐ My Friend
- ☐ Other...

Figure 7 Question 4

The question in figure 7 is asked in order to know how the different caregivers react with the caretakers in terms of an epileptic attack. This question is given as checkboxes as the participant might be related to more than one person with diagnosed with epilepsy.

Question 5: How helpful are you to the epileptic person?

How helpful are you to the epileptic person?

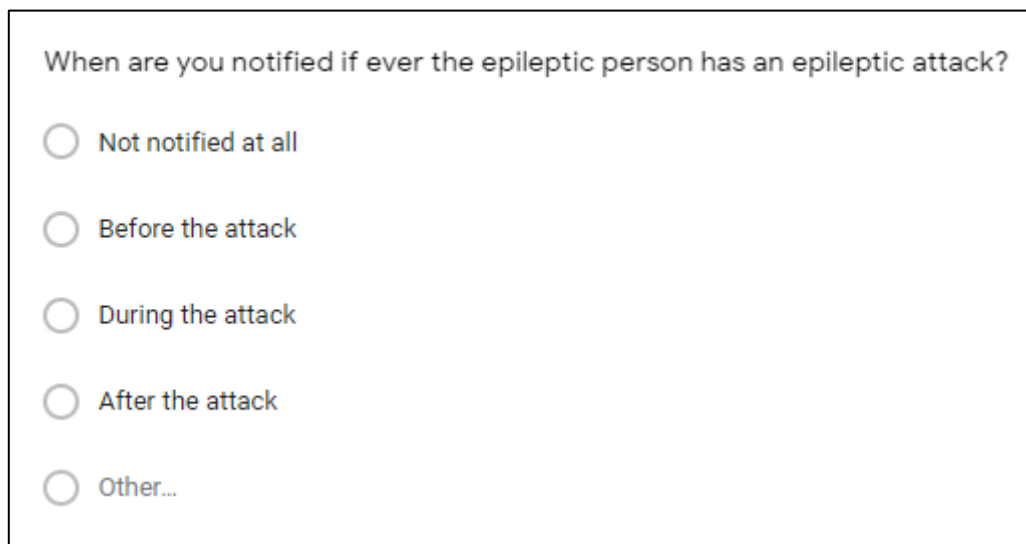
0 1 2 3 4 5 6 7 8 9 10

Not helpful ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ Very helpful

Figure 8 Question 5

The question asked in figure 8 is to know if currently the caregivers are of good help to the caretakers. This is asked in order to know to the level of necessity of the epilepsy smartwatch system.

Question 6: When are you notified if ever the epileptic person has an epileptic attack?



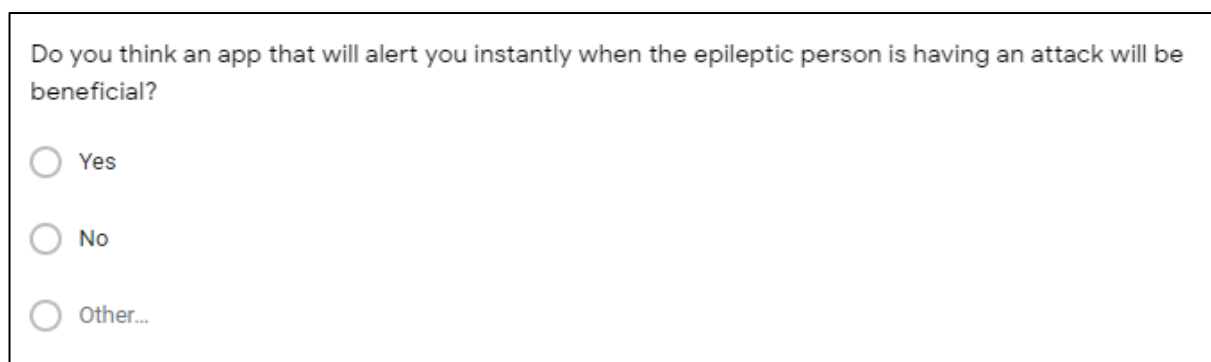
When are you notified if ever the epileptic person has an epileptic attack?

- ☐ Not notified at all
- ☐ Before the attack
- ☐ During the attack
- ☐ After the attack
- ☐ Other...

Figure 9 Question 6

The question asked in figure 9 is to know in general when caregivers are notified about an epileptic attack. This is also asked in order to know to the level of necessity of the epilepsy smartwatch system.

Question 7: Do you think an app that will alert you instantly when the epileptic person is having an attack will be beneficial?



Do you think an app that will alert you instantly when the epileptic person is having an attack will be beneficial?

- ☐ Yes
- ☐ No
- ☐ Other...

Figure 10 Question 7

The question asked in figure 5.2.1.3.7 is asked in order to identify the true necessity of the smart watch system from the perspective of the caregivers.

Question 8: If you chose "No", state the reason for your answer.

If you chose "No", state the reason for your answer.

Long answer text

Figure 11 Question 8

The question asked in figure 11 is asked to know the reason why caregivers will not find this system beneficial.

5. Results and Discussions

5.1 Analysis of data collected through Questionnaire

Below are the feedbacks from the questionnaires that was done. There were 32 responses overall.

Question 1.

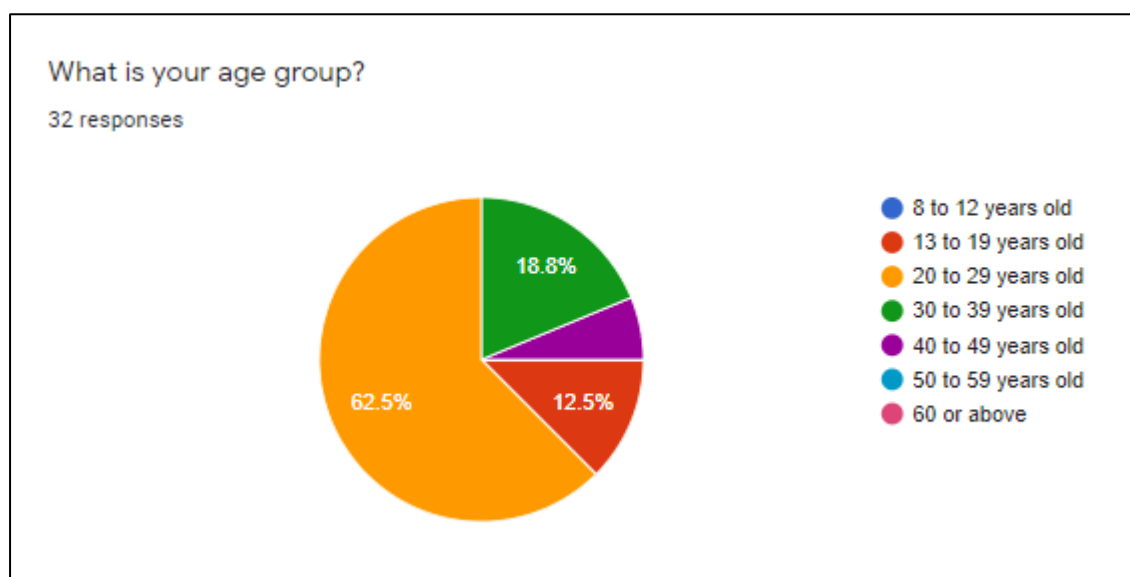


Figure 12 Question 1

Figure 12 shows the age group of the participants. Most of the participants comes from the vicenarians (20 to 29 years old) age group. However, there other variations in age groups such as Teenagers (13 to 19 years old), (40 to 49 years old) and quinquagenarian (50 to 59 years old).

Question 2.

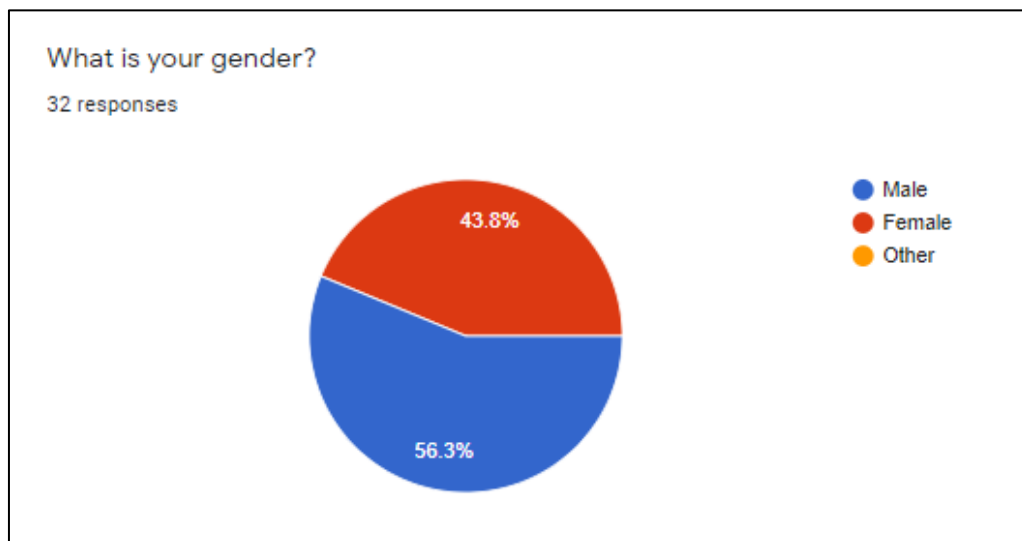


Figure 13 Question 2

In terms of gender of the participants, most of the participants was male, as shown in Figure 13 above.

Question 3.

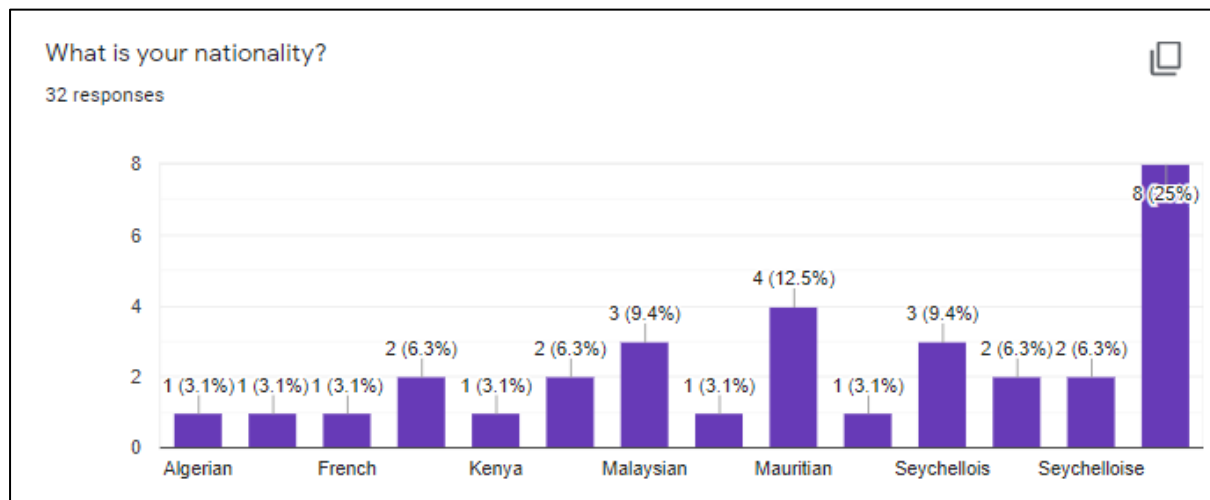


Figure 14 Question 3

The participants are of diverse nationalities. Meaning that response was from various nationalities. However, most of the participants was from Seychelles as shown in Figure 15 above.

Question 4.

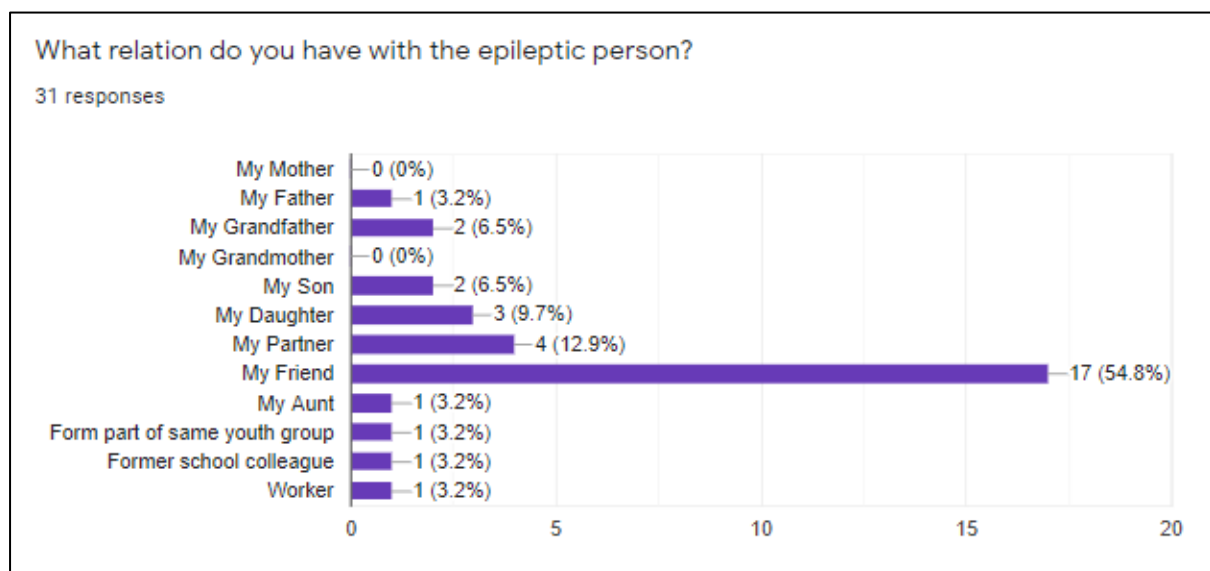


Figure 15 Question 4

The highest percentage of relation that the participants had with an epileptic person was “My Friend”. This is shown in figure 15 above.

Question 5.

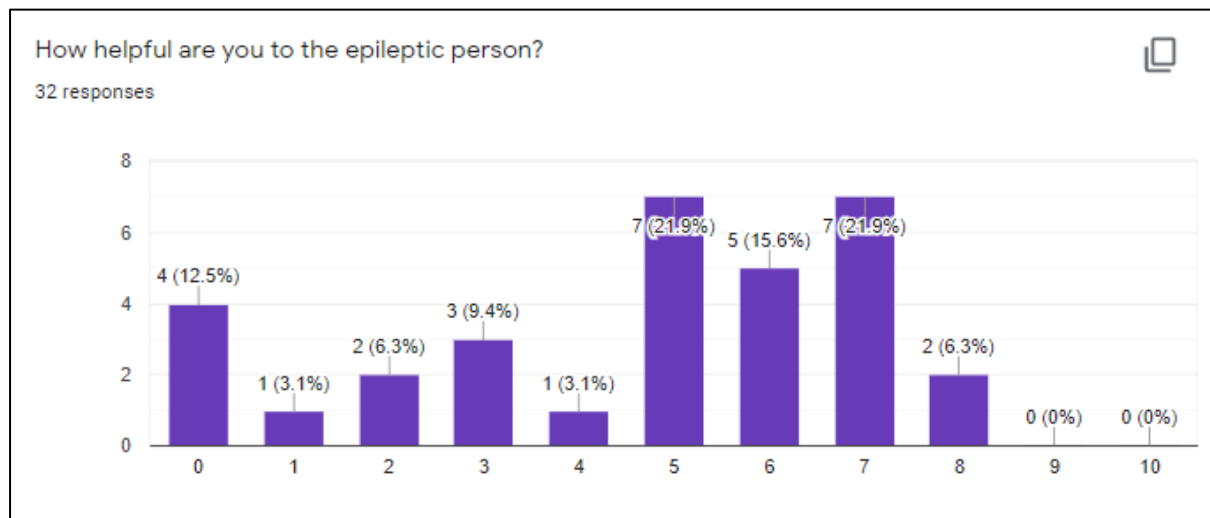


Figure 16 Question 5

In terms of being of help to the caretakers, the caregivers help is on average 5 to 7. This scale is 0 is not helpful at all and 10 is most helpful.

Question 6.

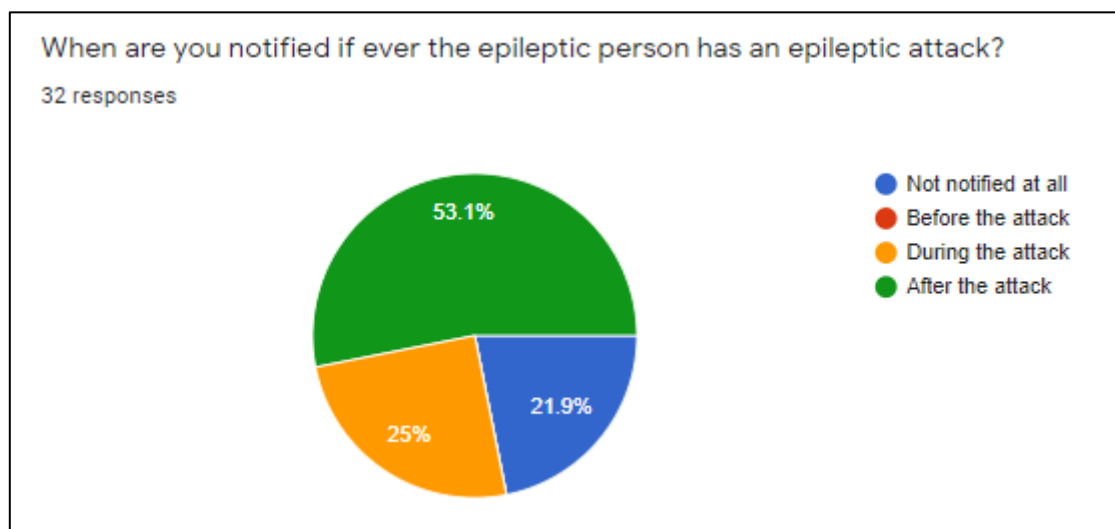


Figure 17 Question 6

In terms of when the caregivers are notified, the highest percentage shows that most of the caregivers are notified after the attack as shown in figure 17.

Question 7.

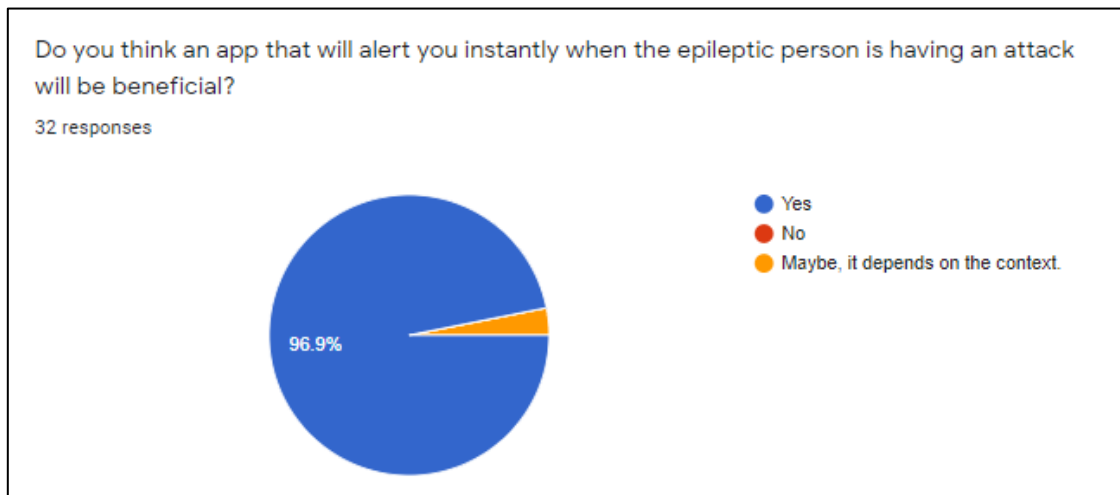


Figure 18 Question 7

In terms of the caregiver's perspective on the necessity of the app to alert them when there is an epileptic attack, the highest percentage of answers was yes as shown in figure 18.

5.2 Analysis of data collected through Interview

Interview 1: Dr Aleksander Jesic (Neurologist).

Interview 1 was conducted with Dr Aleksander Jesic, a neurologist based in Seychelles. The interview was conducted with him in order to get an expertise point of view about the project. Dr Aleksander Jesic agreed to do a face to face interview, to sign and to give an organisational stamp. The contract is in appendix.

He explained that epilepsy is short circuit in the brain cells and its symptoms includes repetitive seizures. He also elaborated that it is amongst the most neurological disorder. Along with that, he specified that epilepsy is incurable, but there are medications that can help reduce the amount of seizures occurring. In terms of my project, he said that it will be beneficial for people diagnosed with epilepsy, however, do add a reminder feature that can help the users know when to take their medications.

Interview 2: Danielle Mancienne (Caretaker)

Interview 2 was conducted with Danielle Mancienne, an epileptic diagnosed person. This is in order to get a caretaker's perspective about the project and to understand how the caretaker is coping with this neurological disorder. Danielle agreed to do a face to face interview and voice recording. The contract is in appendix.

Danielle explained that he was diagnosed with epilepsy and he was photo sensitive epilepsy meaning that he gets a reaction towards flashing lights. He goes on by saying that his biggest fear living with this neurological disorder is having an epilepsy attack when no one is around. He gave the example that he was scared that if he gets one during his sleep and no one knows, and it becomes very critical. Also, Danielle stated that this project will be of benefit to him if it is developed.

Interview 3: Linda Mancienne (Caregiver).

Interview 3 was conducted with Danielle's mother, Linda Mancienne. This was conducted to get the perspective of a caregiver. This interview was conducted via phone call, however, Mrs Mancienne did not give consent for recording.

Mrs Mancienne stated that she throughout Danielle's childhood all the seizures was due to light sensitivity. Moreover, most of the seizures, she was not around and was notified few moments after. She agreed that it was a major challenge to help his son manage this neurological disorder. She also stated that her biggest fear related to this disorder is if Danielle gets an epileptic attack in a dangerous place and she is not notified, and she will not be able to do anything about it. After I explained to her my project, she said that the project will be of huge benefit to both her and Danielle.

6. Conclusion

In conclusion, from all the research and analysis done, this project shows that there is a necessity. Moreover, it proves that all its functionalities will be able to solve the problems mentioned in the problem statement.

Also, in terms of the benefits that it will bring such as decrease of SUDEP and decrease in mental issues related to people diagnosed with epilepsy, it shows that this project can have a major change in the epileptic world. However, after the interview with Dr Aleksander Jesic, I have decided to add a new feature in the system which is a medication reminder. As he stated that medication proves to reduce the amount of seizures, but It does not specifically cure the patient.

7. References

- Arnold, K., 2005. The Java Programming language. *Sun*, 17 August , Volume 4, pp. 25-30.
- Dekker, P., 2002. *Epilepsy, A manual for medical officers in Africa*. Geneva: World Health Organization.
- Devinsky, O., 2008. Epilepsy. *Demos Medical*, pp. 109-133.
- DiMarizio, J., 2012. Android Programming with Android Studio.. In: s.l.:s.n., pp. 44-56.
- Drigas, 2006. Development of asynchronous e-learning systems with the use of Java technology,. In: *Development of asynchronous e-learning systems with the use of Java technology*,. s.l.:s.n., pp. 36-41.
- Empatica, 2019. *Empatica*. [Online]
Available at: <https://www.empatica.com/research/e4/>
[Accessed 20 January 2019].
- Kukreja, R., 2020. *Conserve Energy Future*. [Online]
Available at: <https://www.conserve-energy-future.com/biotechnology-types-examples-applications.php>
[Accessed 7 February 2020].
- Landers, D. C., 2017. *Seizure Triggers*. [Online]
Available at: <https://www.epilepsyqueensland.com.au/seizure-triggers-1>
- McCormick, M., 2012. Waterfall vs Agile Methodology. *MPCS*, Volume 1, pp. 3-10.
- Nashef, L., 1997. Sudden Unexpected Death in epilepsy: Terminology and Definitions. *Epilepsia*, 38(11), pp. 6-8.
- Okonechnikov, K., 2012. Bioinformatics. In: *Bioinformatics*. s.l.:s.n., pp. 1166-1167.
- Petrini, A.-C., 2016. Implementation of the huffman coding algorithm in windows 10 IoT core. *International Conference on Electronics, Computers and Artificial Intelligence (ECAI)*, Volume 8, pp. 1-6.
- Senior, R., 2019. *Elite Healthcare*. [Online]
Available at: <https://www.elitecme.com/resource-center/nursing/smartwatch-cleared-for-seizure-tracking-in-children/>
[Accessed 20 January 2020].
- Smyth, N., 2017. Firebase Essentials. *Android Edition*, 1(1), pp. 2-10.