AFTERCOVID: TOWARDS PRODUCING A WEB-BASED APPLICATION FOR MONITORING LONG COVID SYNDROME PATIENT

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ABSTRACT

The long-term consequences of COVID-19 or Long COVID syndrome is a normal illness, both physical and emotional affected the ex-COVID-19 patients. Some people with this syndrome still not getting a proper treatment and support, especially mentally support. Thus, AfterCOVID web application been built as a platform to help Long COVID Syndrome patient in their recovery process. This web-based application is developed based on Waterfall model to make sure that process can be synchronized with all the requirements and can be completed in time. Based on this model, there are five phases as guideline, which are Requirement, Design, Implementation, Verification and Maintenance. In general, this AfterCOVID web application allows user to view how many people register to the application so that they know that they are not alone. User also can record their daily health condition such as blood pressure, oxygen

saturation and new symptoms. Besides, they can view useful information such as exercises, breathing techniques and any programs that runs by an organization for Long COVID patients. Usability testing has been held for this first AfterCOVID prototype system and it managed to get grade B (78%) from the test result, which is based on System Usability Scale (SUS). Hopefully, this application can help Long COVID Syndrome patients stay stronger and give community knowledge about the effects of COVID-19.

Keywords: Healthcare, COVID syndrome, self-monitoring, long COVID application.

INTRODUCTION

Long COVID is a general term for a syndrome where a person who have recovered from Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infection and are still experiencing its symptoms (Raveendran et al., 2021). This syndrome not only affect patient's health physically but also mentally. Patient still can experience new symptoms even though they already recovered from SARS-CoV-2 many months ago.

Therefore, AfterCOVID web application is a project that focused on giving a digital support to ex-COVID patient that diagnosed with a Long COVID Syndrome. Hopefully, it will become a web application that can motivate and support patient with Long COVID Syndrome digitally. The aim for this project is to help user with the syndrome keep motivated to fight the disease. This application contains health log, recommended exercises, breathing technique, upcoming programs related to Long COVID Syndrome and mental support hotline number.

With relevance to the Long COVID Syndrome issue, this paper aims to focus on three research questions, which are; 1) What are the symptoms and the needs of Long COVID patient? 2) What solution can we suggest to assist the Long COVID patient to face the symptoms and try to fulfil the needs? 3) How far do the solution can assist the Long COVID patient?. Based on the research questions, this paper presents processes and findings towards achieving them, which are related to the main objectives of Long COVID Syndrome project, 1) to present the symptoms and the needs of the Long COVID patient, 2) to develop a prototype system as suitable digital support for Long COVID Syndrome patients name AfterCOVID web application

system and 3) to test basic usability capabilities of the first prototype system based on System Usability Scale (SUS).

The following is a breakdown of this paper structure: Related Works will discuss, firstly about healthcare, which then specifically into symptoms and needs of Long COVID Syndrome patients. Thirdly, the discussion will go further on self-monitoring activities for Long COVID patients and lastly, on other COVID-19 computer-based application that focusing on Long COVID issues. The approach, Waterfall model, that had been employed to produce the prototype system for this project will be discussed in Methodology section. Findings for this project, specifically the screenshot of AfterCOVID prototype system that had been developed and findings from evaluation phase, are discussed in Results section. The Discussion section will go further on the basic evaluation results based on comparison with current application and lesson learned from the researchers' Point of View. Finally, the Conclusion section concludes the overall achievement of this project with suggestion for future enhancement.

RELATED WORKS

Research done in Thailand by Intawong et al (2021) concluded that control and mitigation of COVID-19 requires participation of users, academics and service organizations enhanced success of any technologies to support learning about COVID-19, to encourage social responsibility of all and to integrate applications for real time monitoring of suspect and confirmed cases of disease. Similar efforts are required on dealing with Long COVID issues.

Healthcare and Long COVID Syndrome

Based on a systematic review about experience of Long COVID patient in UK and the condition of healthcare services offered to them, it basically concluded that the healthcare services are evolving and getting much better, since this COVID-19 pandemic gave a great unprecedented implication towards the globe and stress on healthcare services (Macpherson et al, 2022).

Mahase (2020) described "Long COVID" as "illness in people who have either recovered from COVID-19 but are still report lasting effects of the infection or have had the usual symptoms for far longer than would be expected". Some patients with Long COVID Syndrome especially those who experienced SARS-CoV-2 stage 1 to 3 still not

get a proper treatment especially mentally. During the pandemic, some government hospitals need to refuse entry of patients with other illness because limitations of bed and service in the hospital. The COVID-19 pandemic has continuously overburdened health-care systems, resulting in high deaths and significant disruption to daily life (Beasley et al., 2021). People that are sick but not critical are recommended to get a treatment at a private health care but, not many people can afford it. Besides, SARS-CoV-2 is a new virus so, it is still not much research about the after effect and the symptoms of Long COVID Syndrome might have similar symptoms with other disease that can cause misdiagnosed.

Some people think that after someone infected with SARS-CoV-2 done their 10- or 14-days quarantine, that person still have the same health quality before they infected with the virus. But it is wrong. Person that has infected can get a Long COVID Syndrome. The syndrome can cause someone have a fatigue, brain fog, anxiety attack, panic attack, dizziness and many more, as stated in the following Figure 1. Figure 1 revealed the percentage rate of the symptoms split by hospitalized versus home treated patients in Italy (Harari et al, 2022). In addition, according to a survey by Tenforde et al in 2020 as cited in Raveendran et al (2021), 35% of participants failed to return to work 14-21 days after reporting COVID positive. Lack of knowledge about this syndrome can cause issue such as people around the patient assume that he pretending to be sick.

Figure 1

Percentage Rate of Post-COVID Symptoms
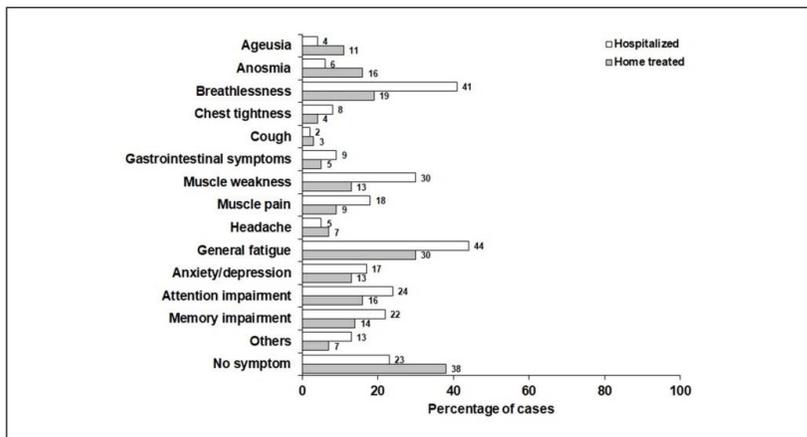
Symptoms and Needs of Long COVID Syndrome Patients

Anxiety and Panic Attack

Anxiety and panic attack are the symptoms of Long COVID Syndrome. Patients with COVID-19 experienced fatigue or muscle weakness, sleep problems, anxiety, or sadness six months after initial infection (Huang et al., 2021). Meditation training was found to be useful in lowering symptoms of depression and anxiety (Carpena et al., 2019). With relevance to this symptoms, AfterCOVID contains two guided meditation videos to help manage anxiety and panic attack. The application also has silent meditation audio such as wave, fire, crickets, bird, and rain sound.

Exercise for Long COVID SyndromePatients

According to the American Association for Cardiovascular and Pulmonary Rehabilitation guidelines, the most difficult aspect of exercise prescription for pulmonary patients is estimating the appropriate intensity for each person to ensure that exercise is not too intense to cause adverse physiological effects but is sufficient to promote beneficial effects (American Association of Cardiovascular & Pulmonary Rehabilitation, 2020, as cited in Wittmer et al., 2021). Some of Long COVID Syndrome patients experienced shortness of breath, chest tightness, muscle weakness and joints pain. They cannot be active or do hard work like before. Thus, three videos been included in the AfterCOVID web application to help patients in their recovery process. The videos are about exercise that suitable for Long COVID Syndrome patients and techniques to improve their breathing. Furthermore, the videos are created by a certified therapist and instructors.

Health Log as Self-Monitoring tool

Figure 2

Long COVID Management – based on Three Different Pathways (Resource: Staffolani et al, 2022)
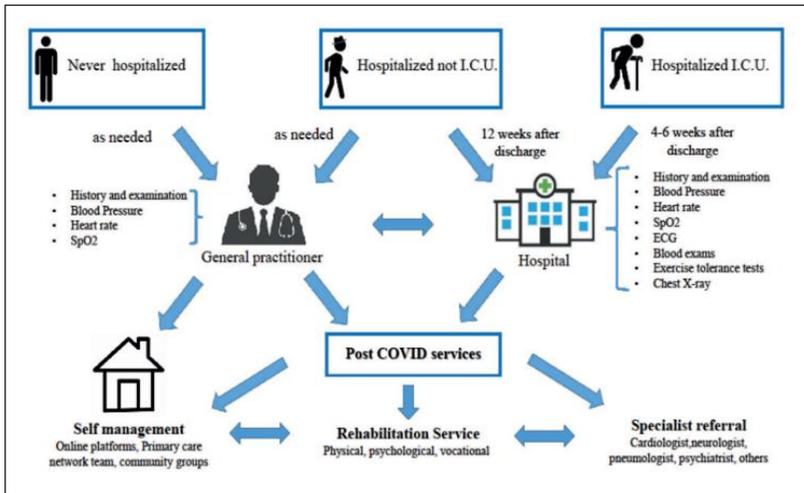
As presented in Figure 2, Staffolani et al (2022) summarized an overall Long COVID Management which basically depend on three different pathways on how the patients get treatments. They also highlighted three Post COVID services, which include self-management services such like AfterCOVID web application as an online platform. The important message that they cited is that self-monitoring of the signs/ symptoms and mood using a diary is highly recommended in all steps (Salman et al, 2021, as cited in Staffolani et al, 2022).

A diary or health log is an important feature in the AfterCOVID web application. It helps user to record their health condition daily and help them in tracking their health improvement. Miyagawa, Oguma, and Ohgi (2016) found that a group that used the online diet record system, their self-rated sense of achievement in terms of nutritional comprehension and dietary sense of control increased significantly. They suggested, continuous record will rise the self-rated sense of understanding.

Current Long COVID Application

COVID Recovery *(National Health Service (NHS) Wales, 2021).*

COVID Recovery is aimed to assist any adult recovering from COVID-19, where it has been developed with NHS Experts and version 2.0 has exciting updates in collaboration with Long COVID Wales. The following Figure 3 are descriptions of COVID Recovery's features.

Figure 3

Overall COVID Recovery Features

Health Log *(AR Production Inc.,2020).*

Although it may not specifically developed for Long COVID cases, Health Log is another suitable app that make it easier to personally track health-related information. The above figure 4 is one of the screen shot of this app. With this information, it may assist any patients to find the causes, most effective treatment and provide better understanding of the patient's health condition.

Figure 4

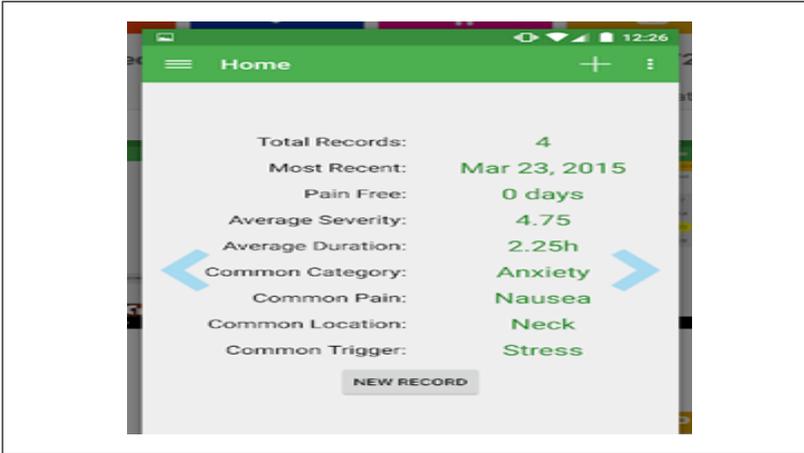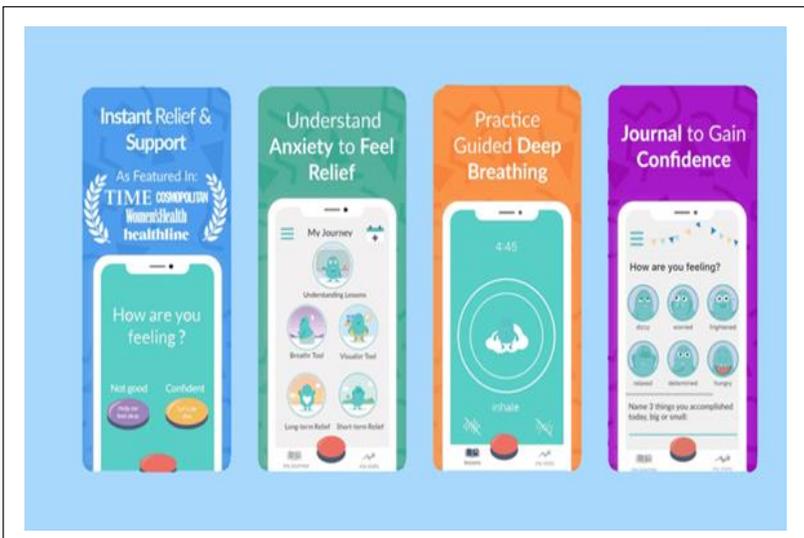*Health Log's Screen Capture Rootd (Echosec System Ltd., 2022)*

Figure 5

Rootd's Screen Captures

Rootd is a leading anxiety and panic attack mobile app that may also assist any Long COVID patients to overcome their mental health. According to its founder, Ania Wysocka, she mentioned that Rootd

is meant to be symbiotic with other things like talking to a therapist (Echosec System Ltd., 2022).

Comparison between COVID Recovery, Health Log and Rootd

The following Table 1 is a comparison between three Long COVID apps with AfterCOVID.

Table 1

Comparison between three Long COVID apps with After COVID

Features	Application			
	COVID Recovery	Health Log	Rootd	AfterCOVID
Target User	Ex-covid patientthat diagnosed with Long Covid Syndrome	People that diagnosed with a disease	People experience panic attack and anxiety	Ex-covid patient that diagnosed with Long Covid Syndrome
Contains Ads		/		
Health Log	/	/		/
Anxiety andpanic management	/		/	/
Exercise	/			/
Uncoming event				/
Contact of mental support			/	/

Comparisons are made between After COVID web application and other three application which is related to Long COVID or Anxiety. The application are named as COVID Recovery (National Health Service (NHS) Wales, 2021), Health Log (AR Production Inc., 2020) and Rootd (Echosec System Ltd., 2022). AfterCOVID web application have features that can help in recovery of Long COVID Syndrome patients such as anxiety and panic management, health log, upcoming events and exercise that suitable for them to practice. AfterCOVID web application contains meditation audio and video to help reduce symptoms of anxiety and depression. Besides, in the application also

included exercise that is not too intense for patients and techniques to improve their breathing. Lastly, health log feature can help patient to track their health improvement and ease the process of getting treatment when they have their past health record.

METHODOLOGY

Framework for planning, executing, and managing the process of developing software systemsare provided by software development methodologies.Waterfall, Prototyping, Iterative, Rapid,Structured, Object and Agile approaches are some examples of software development model
(Vijayasarathy, L. R. et. al., 2016). Three model that compatible for the AfterCOVID project were compared and one model from that was chosen for the development process.

Waterfall Model for AfterCOVID Project (Profit.co, 2022)

AfterCOVID web application is a small project that targeted users from one district which is Lembah Klang. Besides, AfterCOVID is a medium-size project and can fit with a long schedule. The requirements are well defined and well understood. Comparison of suitable Model in Table 2 was to find which one is the most suitable for the project development. Based on the comparison table, Waterfall model is perfectly suited to be implement for the development of AfterCOVID. AfterCOVID is considered as a small project because it contains a smaller number of function and more to displaying information. The duration for the development and implementation is around 1 year, which is enough to follow the Waterfall model development schedule. Lastly, expert skill is not a must when incremental model is been implemented for the development.

Table 2

Comparison between three suitable model for AfterCOVID Prototype Development

	Rapid	Waterfall	Agile
Project size	Small, Medium	Medium, Large	Large and medium
Schedule	Short	Long	Short

	Rapid	Waterfall	Agile
User Requirement	Clear and understood	Dependson the requirement	Clear and understood
Flexible	Yes	No	Yes
Cost	Intermediate	High	Medium
Easy error detection	Yes	No	Yes
Software team skill	Expert	Intermediate	Expert

Requirement Phase

The product analysis experts identified the product needs, which contain both functional and non-functional requirements and ensured that the requirements are compatible for this phase. When implement incremental models to software design, this phase is the most crucial. This AfterCOVID project is produced based on Software Engineering principles and guidelines. Therefore, details of findings from this requirement phase is documented in the attached Appendix A: System Requirement Specification (SRS) for AfterCOVID.

Figure 6

Waterfall Model (Resource: Profit.co, 2022)
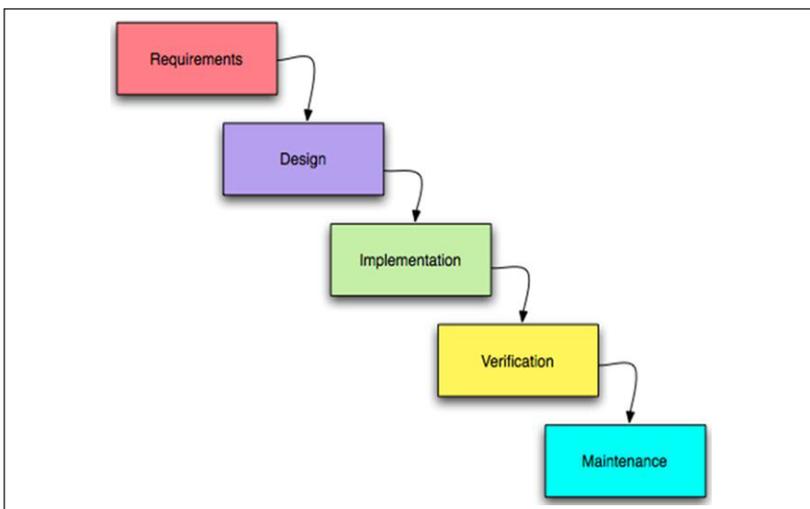
Design Phase

The design for archiving and implementing requirement were proposed. The waterfall model used the development phase and style when software creates additional practicality. Details of processes involved in the design phase are reported within the attached Appendix B: Software Design Document (SDD) for AfterCOVID.

Implementation Phase

Coding process were accomplished in this phase according to the requirement and the findings from the design phase. The coding standards need to be fulfilled without any unwanted hard codes or defaults. This phase also allows for the execution of the designs on a practical level. The product's quality can be improved and updated by completing this step

System Component Installation & Configuration

In the development of AfterCOVID prototype system, installation of software needs to be done before project implementation. Software that been used to write the project's code are Visual Studio Code and Notepad++.

Visual Studio Code

Visual Studio Code is a source-code editor for windows that made by Microsoft. Visual Studio Code supports hundreds of programming language. Some features in Visual Studio Code are support for debugging, code refactoring, syntax highlighting, snippets, intelligent code completion and embedded Git.

Notepad ++

Notepad++ is a text editor and source code editor that can be used in Windows. It supports tab editing that allow user to work with many files in one window. Notepad++ is free to be installed. It also supports many programming languages, easy to use and light.

Database Design

For the database design, software that had been used for AfterCOVID database are XAMPP and phpMyAdmin.

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XAMPP

XAMPP built by Apache Friends is a free and open-source cross-platform web server solution stack bundle which consists mostly of the MariaDB, Apache HTTP Server, database, and interpreters for Perl scripts and PHP. To view AfterCOVID from localhost, only Apache module and MySQL module are required to be start in the XAMPP.

phpMyAdmin

phpMyAdmin is a PHP-based free application for managing MySQL and MariaDB databases. Most administration activities, including as creating a database, performing queries, and adding user accounts, may be done with phpMyAdmin. There is three table in AfterCOVID database named lcm that can be seen in phpMyAdmin which is info, event and log.

Verification Phase

At this phase, completed prototype sent to the targeted respondents for the Functionality Test. They reviewed the prototype and gave feedback about how far it met the requirements. For this preliminary project for Long COVID issue, it will only involve five respondents, two male and three female respondents that have Long COVID Syndrome. The project had faced main constraint to perform wide geographical coverage and involved more respondents since the project took place during pandemic period which also involved one of the developer team as Long COVID patient. Therefore, the evaluation process is limited to five respondents and only involved in Klang Valley. The findings for this phase is presented in the next sub section in Findings Section, which is User Evaluation Result.

Maintenance Phase

Development team will do maintenance when client reported that the product has bug or other technical issue. The issue will be solved until client satisfied with the result. Since this is the first prototype for this AfterCOVID project, this phase only involves minor modifications when it is requested to be presented in any research project competition or any Research Grant Proposal. Other than that, the team will focus on other routine maintenance tasks and other plan on upgrading into AfterCOVID Second Version.

FINDINGS

AfterCOVID Prototype System

Interface Design

Menu, button, table, image and colour in interface plays as an important role to display the AfterCOVID web application. Simple interface, user-friendly and easy-to-use need are the main aspects in the development of project interface.

Web Application Arrangement

Some qualities need to be achieved to get a good arrangement of web application. Every design should easea user's task and fulfill user's requirements.The differences between a good web application and a bad web application are based on User Experience (UX). The following are qualities that had been considered in designing and developing the AfterCOVID web application:

Simplicity

Language,flow, hierarchy ,and metaphors for visual elements help to avoid ambiguity in the AfterCOVID web application interface. Manuals are not necessary with simple interfaces. They also make it less likely for people to make mistakes when using them.

Compactness

It's easy to make the interface more understandable by over-clarifying and labelling everything, but this can make interface looks mess where there's simply too much information on the screen at once. When there are too many objects on the screen, it's difficult to find what user searching for, and the interface becomes not enjoyable to use. The key problem in creating a great interface is keeping it both concise and clear.

Cost-effectiveness

Because time is money, a good interface should help the user be more productive. AfterCOVID web application providing shortcuts and good design. It allows user to complete task in less time and effort.

Interface Interaction

Figure 7 shows user interaction with the system when they want to register their account. The user needs to click the sign-up button at navigation bar. Then, the web application will redirect user to sign up page where user need to enter their information to create the account.

Figure 8 shows user interaction with the system when the user wants to log in into the web application. User needs to click the log in button at navigation bar. Then the web application will redirect user to sign in page where user needs to enter their email and password. Error dialog box will appear if the user enters wrong email or password.

Figure 7

User Sign Up
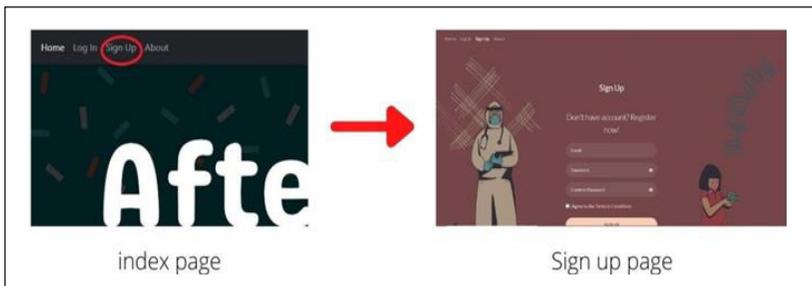
Figure 8

User Sign In

Figure 9 shows user interaction with the system when user wants to go to Anxious and Panic page or Need Someone to Talk page. User needs to click button Anxious & Panic or Need Someone to Talk when

the user is not mentally well. The web application will redirect user to ther equested page. Anxious and Panic page will display meditation videos and audios while Need Someone to Talk page will display organization that offered mental health support.
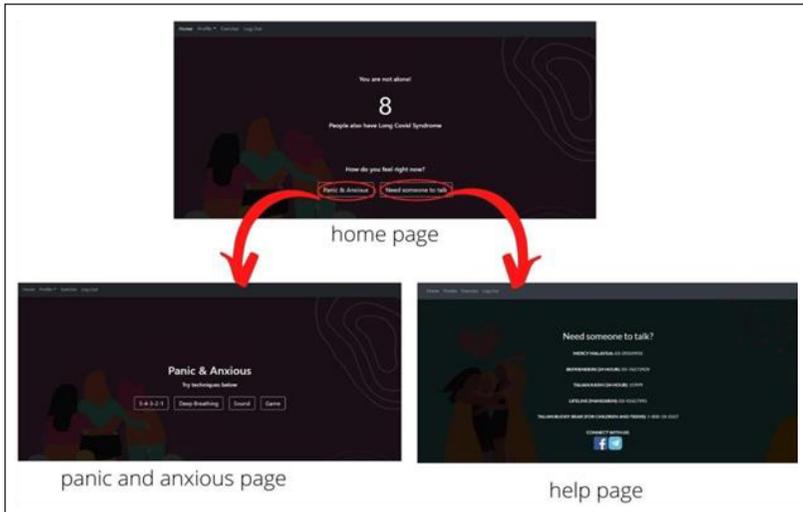
Figure 9

Panic and Anxious Page and Help Page

Figure 10 shows user interaction with the system when the user wants to view or update their profile. User simply needs to click profile button at navigation bar and select view profile. The web application will display profile page and user can update their profile. The new profile will be updated in the database by the system.

Figure 10

User View or Update Profile

home page   profile page
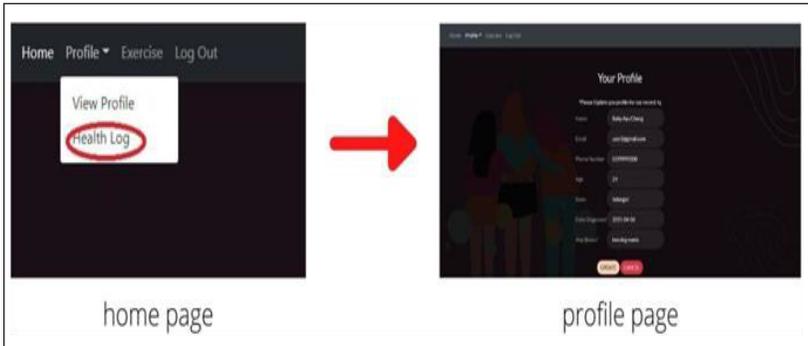
Figure 11 shows user interaction with the system when user wants to view health log record, add new record and modify record. User needs to click profile at navigation bar and click health log. The web application will display health log page that contain list of health condition that useralready recorded before. User can choose to edit or delete existing record. Beside, to add new record, user can click at new button at the right table and the web application will display page that allow user to add a new record.

Figure 11

User View or Update Profile User View and Update Delete Log

home page   health log page

add log page
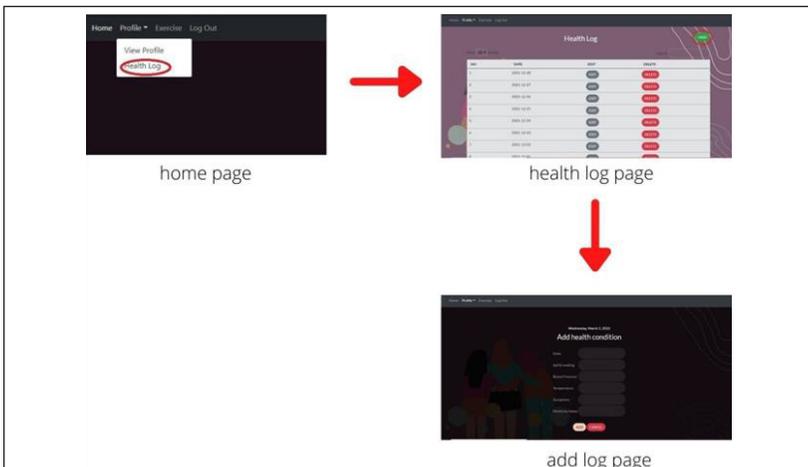
Figure 12 shows user interaction with the system when user wants to view recommended exercise video for Long COVID Syndrome recovery. User simply needs to click exercise button at navigation bar then, the web application will display the exercise page.
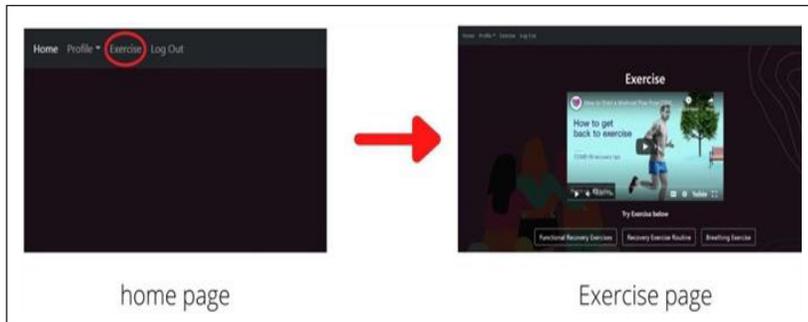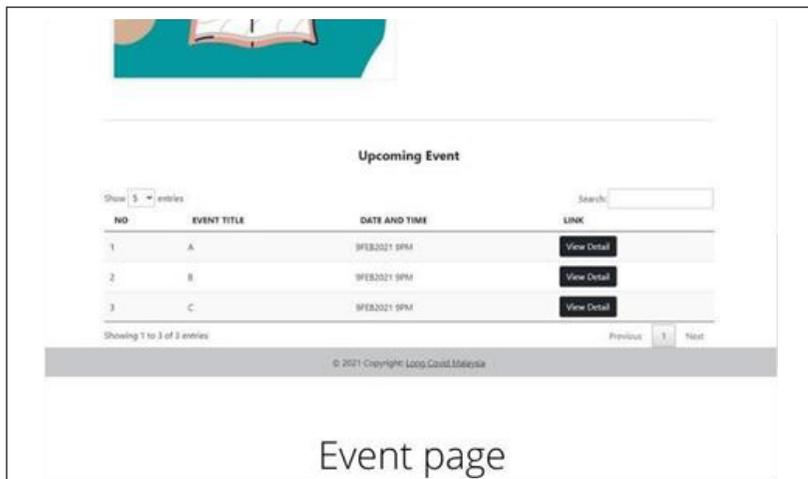
Figure 12

Log Exercise Page

Figure 13 showed the section in Home Page where user can view list of upcoming events related to Long COVID Syndrome. User can click view detail button if they want to know more about the event.

Figure 13

Event Section

User Evaluation Results

During the evaluation process, respondents tested and evaluated AfterCOVID prototype system. Respondents were given evaluation form that contains question related to usability of the web application. The evaluation procedure using System Usability Scale (SUS) that consists of ten questions with five response options for respondents from strongly agree to strongly disagree. Five respondents that have Long COVID Syndrome and live in Klang Valley has been selected to participate in the evaluation process.

Data Analysis and Discussion

Figure 14 showed that 2 respondent (40%) strongly agree that they would like to use AfterCOVID frequently while 3 respondent (60%) answered agree.
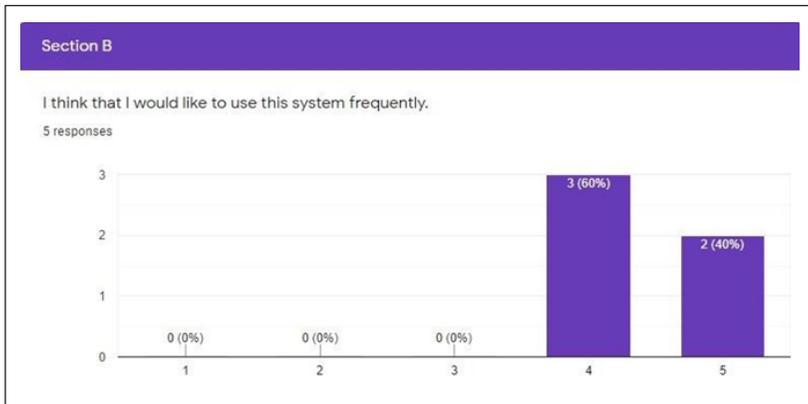
Figure 14

Question 1

Figure 15 showed that 2 respondent (40%) strongly agree that AfterCOVID unnecessarily complex while 1 respondent (20%) answered agree, 1 respondent (20%) answered neutral and the other 1 respondent (20%) answered disagree.
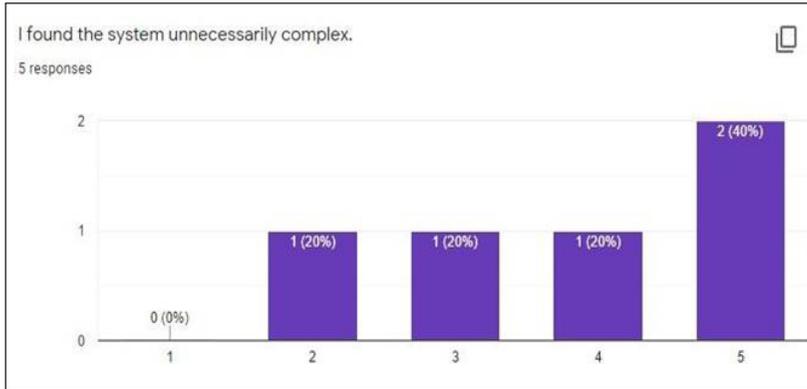
Figure 15

Question 2

Figure 16 showed that 4 respondent (80%) srongly agree that AfterCOVID was easy to use while 1 respondent (20%) answered agree.
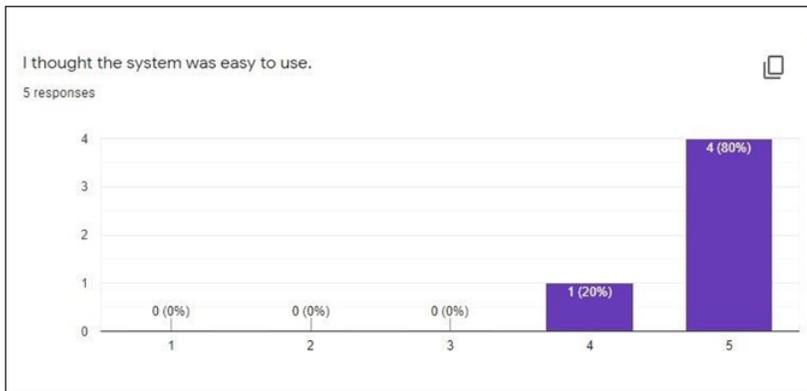
Figure 16

Question 3

Figure 17 showed that 2 responden t(40%) strongly disagree they would need technical support to use AfterCOVID while 2 respondent (40%) answered disagree and 1 respondent (20%) answered agreet hat they need tehnical support.
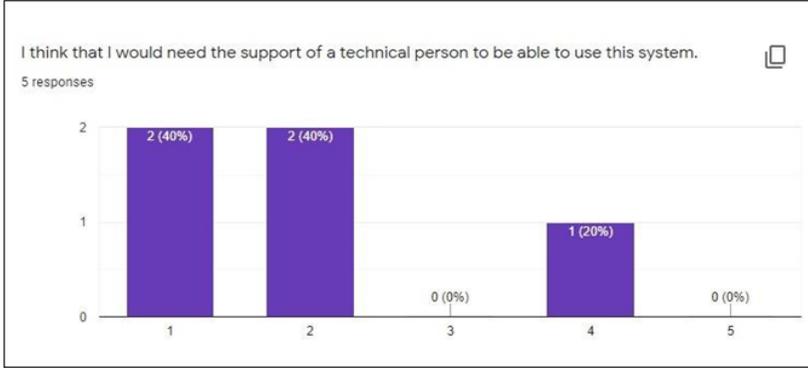
194

Figure 17

Question 4

Figure 18 showed that 3 respondent (60%) srongly agree that functions in AfterCOVID were well integrated while 2 respondent (40%) answered agree.
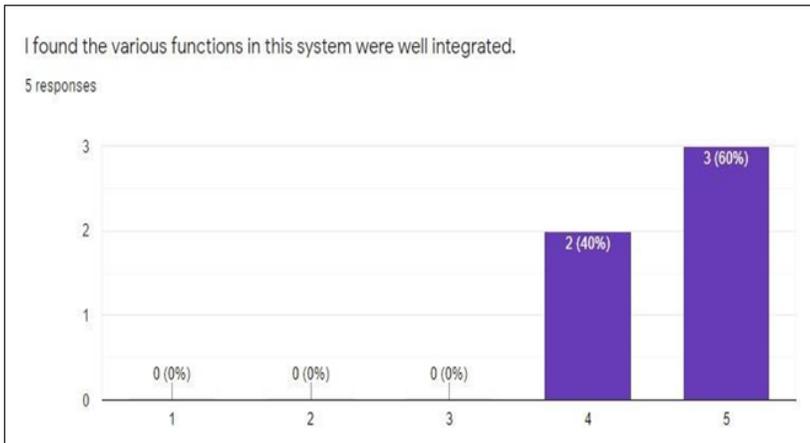
Figure 18

Question 5

Figure 19 showed that 2 respondent (40%) strongly disagree that AfterCOVID have too much inconsistency while 2 respondent (40%) answered disagree and 1 respondent (20%) answered neutral.
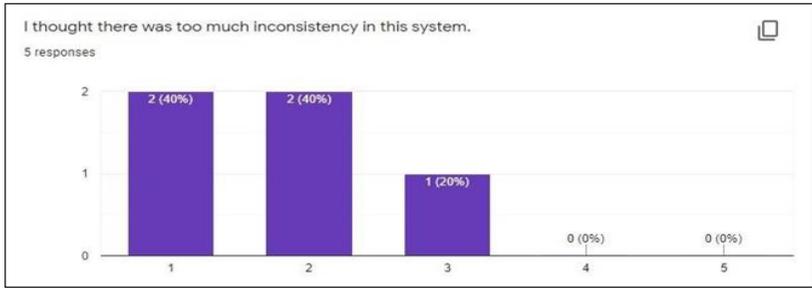
Figure 19

Question 6

Figure 20 showed that 3 respondent (60%) strongly agree that people would learn to use AfterCOVID very quickly while 2 respondent (40%) answered agree.
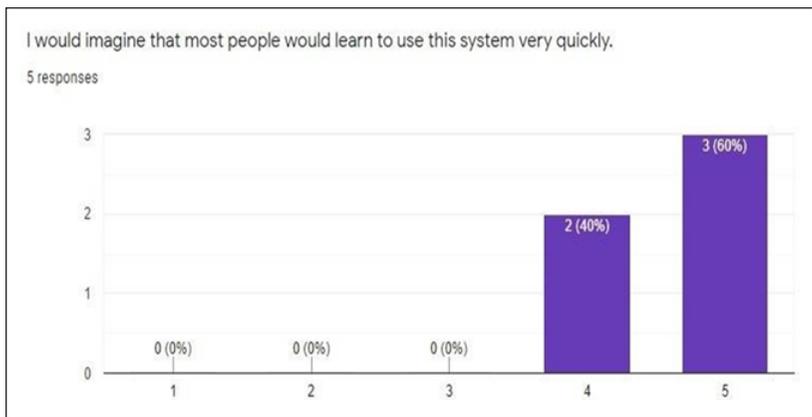
Figure 20

Question 7

Figure 21 showed that 2 respondent (40%) strongly disagree that AfterCOVID is very cumbersome to use while 2 respondent (40%) answered disagree and 1 respondent (20%) answered neutral.

Figure 21

Question 8

I found the system very cumbersome to use.

5 responses

2 (40%)   2 (40%)   1 (20%)   0 (0%)   0 (0%)
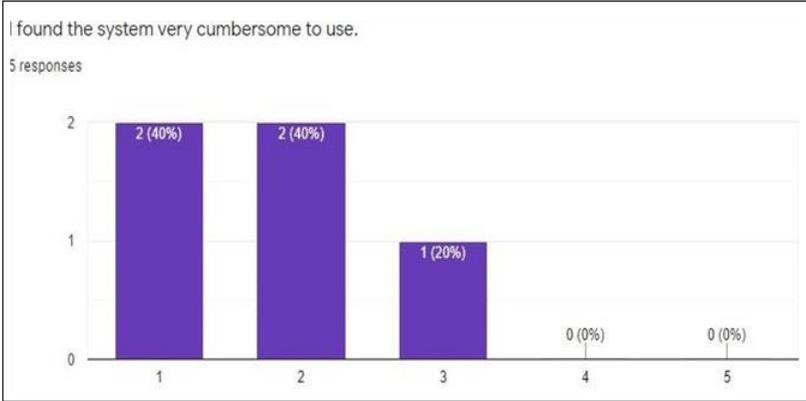
1   2   3   4   5

Figure 22 showed that 3 respondent (60%) strongly agree that they are very confident to use AfterCOVID while 2 respondent (40%) answered agree.

Figure 22

Question 9

I felt very confident using the system.

5 responses

0 (0%)   0 (0%)   0 (0%)   2 (40%)   3 (60%)
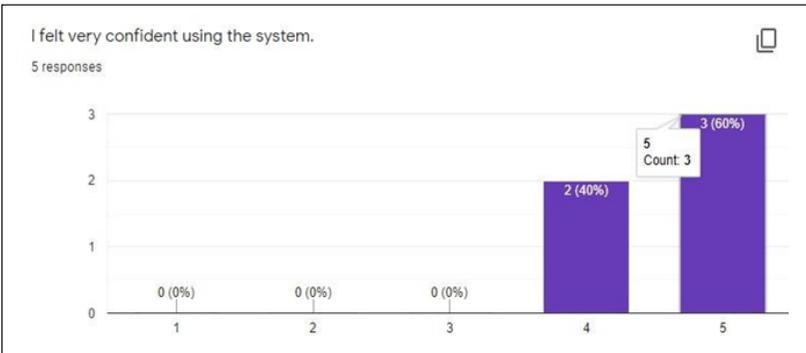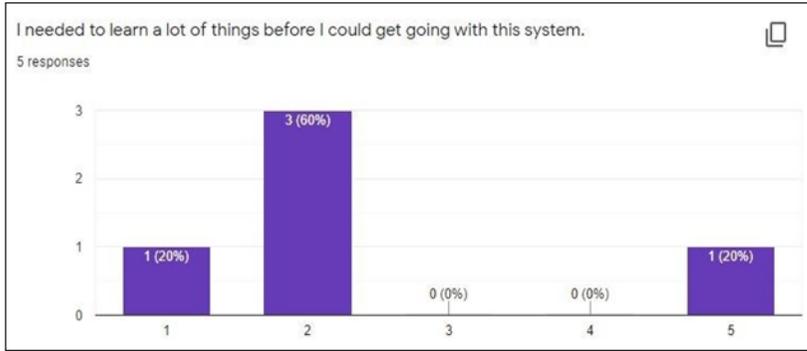
5
Count: 3

1   2   3   4   5

Figure 23 showed that 1 respondent (20%) strongly disagree that they need to learn a lot of things before they could get going with AfterCOVID while 3 respondent (60%) answered disagree and 1 respondent (20%) answered agree.

Figure 23

Question 10

As summary, Table 3 showed overall evaluation of AfterCOVID web application. AfterCOVID web application got 78% marks (Grade B) based on System Usability Scale (SUS).

Table 3

Overall Evaluation of AfterCOVID Web Application

Scale	1 (Strongly Disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Strongly Agree)	Total 17
Question 1	0	0	0	9	8	6
Question 2	0	3	2	1	0	19
Question 3	0	0	0	3	16	15
Question 4	8	6	0	1	0	18
Question 5	0	0	0	6	12	16
Question 6	8	6	2	0	0	18
Question 7	0	0	0	6	12	16
Question 8	8	6	2	0	0	18
Question 9	0	0	0	6	12	13
Question 10	4	9	0	0	0	156
Total						390
156 x 2.5						78%
390/5 respondent						

DISCUSSION AND CONCLUSION

AfterCOVID prototype system had been developed based on objectives stated in the earlier section of this paper. Table 4 below showed achievement of this project.

Table 4

Objectives Achievement

Objectives	Achievement
to present the symptoms and the needs of the Long COVID patient	As presented in Related Works section, there are list of symptoms and needs summarized based on past literature search.
To develop a prototype system of suitable digital support for Long COVID Syndrome patients named AfterCOVID web application system.	AfterCOVID web application successfully been developed and have features to help solve the main problem.
To test basic usability capabilities of the prototype system based on System Usability Scale (SUS).	Usability testing already been done and AfterCOVID got 78% marks (Grade B) Based on System Usability Scale (SUS).

Future Enhancement

New features will be added as a suggestions and improvement for future planning. Features that are planned to be added in AfterCOVID version 2.0 are as follow:

AI Chatbot

Artificial Intelligence (AI) is a current technology trend that can attract user to use a system. People that experience anxiety need someone to talk when they feel anxious. AI chatbot is a right feature to be implement in the future because it is constantly available 24/7 to answer AfterCOVID user when they in an anxious or panic situation.

Customise Exercises

Customization exercises based on gender, age and health condition is important for an individual because not all people are same. Right

choice of exercise is helpful to fasten the recovery process of Long COVID Syndrome Patient. Besides, exercise that recommended also can be start with beginner level and lastly, expert level when user feel more confident to do a heavy exercise.

ACKNOWLEDGMENT

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