

Systematic Review and Usability Evaluation Covid-19 Mobile Applications in a Developing Nation

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Abstract: Mobile phone technology made tremendous progress today. In this current ongoing Coronavirus disease (COVID-19) pandemic situation worldwide, mobile phones have an essential role due to its number of applications. To save lives through proper guidelines and information, it is necessary to retain the people up to date. That's why well-needed applications are required that aim to decline the rampant increase of COVID-19 cases country-wide. Today with the increasing pandemic Covid-19, several applications have been developed to inform people about safety measures and keep them updated with the public health measures. COVID-19 applications relate to large public, hence, usability of these applications has far larger impact than any other type of applications which generally have a specific user group. Therefore, in this article, a systematic review is taken by considering their range of functions, target user groups, name, languages, size, user ratings, available interfaces, response time, release date, up-dating date and up to date cases. There exist several methods for evaluating usability. In this work, we use user-based usability evaluation methods to explore usability issues in COVID-19 apps. By performing analysis on the extracted data, we examine some facts like the impact of gender on usability, impact of age, usability dimensions, and the effect of app functions on usability to see whether they affect usability positively or negatively.

Keywords: Usability Evaluation, Usability, Usability Models, HCI, Covid-19, Pandemic, Android, IOS, mobile phone applications

I. INTRODUCTION

Mobile phone technology made marvelous progress today due to its robust processor, high-speed memory, sensors, GPS, high-resolution screen, quick data access through Wi-Fi, and so on [1] [2]. Their services are consecutive start from 0G and now reach the 4G generation, which is currently upgrading, and the Internet makes mobile devices more prevalent [3]. According to the survey, it is demonstrated that an individual has more than one mobile phone due to its uninterrupted services. Human-computer interaction (HCI) [4] has a significant role in interacting with these technical devices [5].

Cloud computing played an essential role in worldwide increasing broadcasting applications and has an excellent benefit for the people [2]. According to the current situation in worldwide broadcasting, apps are the blessing for the

people to give the people awareness regarding Covid-19, which started spreading from Wuhan city of China from late 2019 [6]. Now it keeps spreading day by day in most of the countries and takes the lives of millions of people worldwide. About two international conveyances and 210 countries are there, which are affecting by the Coronavirus, and this number is kept spreading day by day.

It's imperative to ensure the people up to date towards the number of spreading cases and aware of them about the essential SOPs point of entries, self-quarantine areas for the patients, isolation hospitals, and alert them to apply the safety measure and controls. A report published on 24 January 2020 [7] conveys that the patient who is infected with Coronavirus indicates the signs of cough, fever, and fatigue [6]. There is nothing which provides any assistance to prevent this virus, but some safety measure supports the people to stay safe.

Many applications keep on coming into the market to accomplish user demands and serve the people by giving them awareness about the Covid-19. In this paper, we take a systematic literature review on Covid-19 applications and perform usability testing [8]. The main aim of the usability is to ensure whether that application is accurate, safe, sufficient, and easy to use. Previous studies on quality attributes used to evaluate mobile application usability were reviewed and tested on the applications being assessed to find their issues. Therefore to evaluate the usability following points are covered in this work:

- We carried out a systematic review on currently available Covid-19 applications for the operating systems IOS and Android
- Conduct usability evaluation on Covid-19 Apps
- Take a review on all the quality attributes of Usability
- Analyze the influence of usability attributes on Covid-19 apps
- Identify the usability issues

The rest of the essay is structured as follows. Section 2 examines pertinent literature and presents the fundamentals of usability regarding a mobile app's attributes. Section 3 details our review of Covid-19 mobile apps selection and their salient details. Section 4 provides the user-based study of select apps that are found to be important for usability testing and results. Section 5 concludes the paper.

II. REVIEW FROM LITERATURE

A. Search Strategy

We perform a systematic literature review for achieving a careful study by using some identified keywords, comparative categories, and their specifications, subsequently, by analyzing and collecting the previous researches, which exposes the significant dimension and measurement used in evaluating mobile application usability. To find the content of high-quality data for the usability measurement, we perform the search, which involved two types like primary search and secondary search.

While performing a primary search, we use a famous database like Google's Scholar, Science Direct, Scopus, and IEEE Xplore to search scientific articles, journals and conference papers and secondary search involves the reference and citations which are obtained through the primary search.

Data Base	Found Articles	Selected Articles
Google Scholar	50	15
IEEE Explore	25	3
Sci hub	28	11

Reports	10	2
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Table 1 Total number of collected articles from the literature.

Besides, a systematic review of applications is done based on the information given in the app themselves, Google Play Store, and the Apple App Store.

Here is presented some related study facilitating usability evaluation to ensure the quality of the app. Similar techniques have been extracted through primary search and secondary search by considering the scope of the usability evaluation of the applications and highlight the concepts that are related to our studies.

B. What is Usability?

Different models have been developed to define usability in various aspects. Usability is the "achievement of user-specific goal" from the software product. Neilson (1993) [9] illustrates the usability in terms of five attributes: efficiency, satisfaction, learnability, memorability, and errors for accessing the usability of any software product. The description of these attributes as:

Efficiency: Efficiency is defined in terms of accuracy and completeness from which specific goals are achieved.

Satisfaction: Satisfaction is defined in terms of freedom from discomfort.

Learnability: Learnability is defined as a more fundamental understanding of the product.

Memorability: Memorability is defined according to Neilson as more straightforward to remember everything if used again and again.

Error: An error is defined in terms of a system having a low error rate, like if any error occurs in order, it should be easier to recover.

ISO provides an internationally accepted definition of usability in terms of its attributes and functionality. International Standard of Organization (ISO 9241-11) (1998) [10] Usability is "the degree to which a product may be used by the defined user to achieve the specified goals with efficiency, effectiveness, and contentment in the context of use," according to the definition.

Effectiveness: Effectiveness measured in provides, how well the user achieves their goals from the product.

Efficiency: Efficiency measure in terms of the number of resources consumes to achieve the user-specified goals.

Satisfaction: Satisfaction means the comfort of the user from the product.

This model is then extended to give the advanced definition of usability (ISO 9126) (2000) "as the capability of the software product to be understood, learned, used, and attractive to the user when used under the specified condition." The software product can be used in a particular context and fulfill the user requirements with ease of use. There are several terms which are related to usability, but from this definition, three factors are considered essential for evaluating the usability:

1. **User:** The end-user of the application is necessary to review while developing a product designer's product to look as an alternative input.
2. **Goal:** Task or purpose of the user that has to be accomplished.
3. **Context:** The designer designs the application by considering the environment of the user under which this product is used.

C. Usability Attributes for evaluations of Usability of mobile apps

Hoehle et al. [11] conceptualized the mobile application usability and developed an associated survey instrument to validate these constructs. This study analyzes the Microsoft usability guidelines and defines ten constructs to evaluate the usability of applications by considering the outcomes: continued intention usage and brand loyalty. Lacka and Chong [12] investigated the perception of social media applications and their adoption. They suggested the adoption of these applications in the B2B market due to the learnability and memorability attributes of usability.

Matraf and Hussain [13] evaluates a usability model by considering five attributes of usability, which contains the remarkable effect on the user satisfaction for mobile application. They develop their model by considering the characteristics: Readability, Effectiveness, Accessibility, Efficiency, and Navigation. Ardito et al. [14] conducted a e-learning applications usability evaluation. Costabile et al. [15] apply the evaluated usability dimensions on e-learning applications and perform usability testing. Squires and Preece [16] evaluate usability dimensions on potential educational software. Mkpojiogu et al. [17] find the quality attributes for applications like learning applications for children. Chua and Dyson [18] apply the ISO model to evaluate the learning applications' usability.

Abubakar et al [19] uses a heuristic evaluation approach to evaluate the usability model for real-world mobile banking applications which consists of three usability measures, namely: Gain Satisfaction, Interface Satisfaction, and Task Support Satisfaction. Brade et al [20] evaluates the usability of applications and shows that the virtual world can be used as a real-world environment and improves the realism of virtual models. Nathan et al [21] gives an evaluation model to addresses the needs of deaf people requirement for better user experience in any application. The model consists of six (6) usability dimensions to be measured, which relates to the conditions of the deaf people.

D. Approaches for the evaluation of usability of mobile application

Heuristic evaluation was firstly purposed by Nielsen [9] and Møller [22], who evaluate their usability heuristics by using expert's base method (3-5 participants). Each expert judges the product and gives their suggestions and, in the end, generates a list of usability issues. Hands-on measurement, laboratory experiments, and field study are used by Nayeibi

et al [23]. Evaluate the usability of mobile apps by using the user-based testing method. Several authors use the Nielsen method to find the usability of their products. Kaya et al [24] used system usability scale SUS with an adjective rating to find the usability of the mobile applications, which he applied to 222 participants who use apps on their mobile phones. His results give satisfactory and above standard results. Holl et al [25] reviews the IOS applications by understanding their implementations and design using the automated testing technique of usability. The author does not involve human experts; instead, usage of the automatic usability analysis is employed.

E. Usability testing methods

Usability testing methods are used to evaluate the usability of the products. Usability testing procedures are different for applications used at different platforms like the desktop app and mobile app. We consider various factors while performing usability testing for obtaining user feedback. These approaches are:

1. Survey method

The survey method is best suited to get higher satisfaction for the customer regarding their personal experience with apps. Getting feedback through questionnaires is also the best method. We can achieve the user suggestions for apps by emphasizing how a user is converted into a customer.

2. A/B Testing

For comparison, this testing is used to find significant differences to see which one of them engage and attract the customer more to a greater extent. A/B testing is done to check which one is more appreciated. After gaining particular information from A/B testing, it is decided which app is more functional?

3. Expert-Based Evaluation

Automatic testing is always the first choice for performing testing, but usability testing, expert base testing is best. Usability experts people test the software and check all its regarding details. In the end, they give suggestions after reviewing all features of apps.

4. Participant base usability testing

In this testing, real users judge the application and could be recruited to evaluate the usability by using different functionalities of the application. To obtain the full features of apps, this method of testing is excellent.

F. Review on mobile application statistics

In the revenue of 2020, expected \$189 billion mobile apps generate. According to the survey, 2.2 million apps are available on the Apple play store, and 2.8 million apps are there on Google Play store. According to the survey from 2017 to expected 2022, the downloaded ratio of mobile apps will globally reach to 258.2 million.

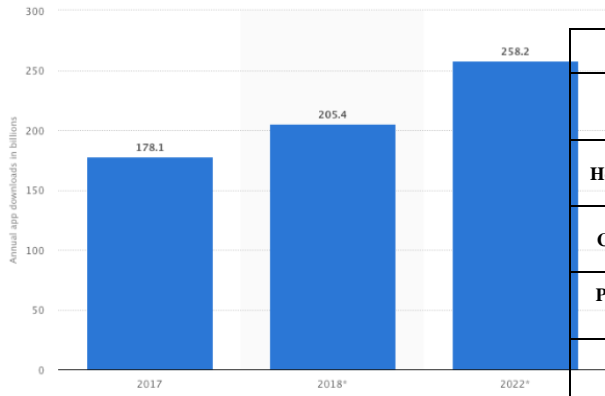


Figure 1. Usage of mobile phones across years in terms of the annual app downloads (in billions).

III. SYSTEMATIC REVIEW OF COVID-19 APPLICATIONS OVERVIEW

A. Searching Strategy

Data collected for usability analysis is done by following fundamental steps. For collecting data, we mainly focus on Android and iOS operating systems. The Apple play store is used to collect the iOS platform's based apps, and Google play store is used to collect the android platform based apps. To start searching for apps, we used the following keywords on both platforms.

Keywords used for searching: “Covid-19”, “Corona Virus”, “Pandemic update”, “Covid-19 updates”, “Covid-19 scanner”

Several apps are collected, which gives information regarding the pandemic. The first step that is performed is comparative analysis. All kinds of information are collected, whether provided in iOS or Android. All the things are critically analyzed, like date of release, date of update, range of functions, target user groups, languages, user ratings, available interfaces, response time, and up to date cases.

B. Application Selection criteria

There are not any specific criteria for selecting only particular applications. Covid-19 apps are mobile software applications that use digital tracking in response to the Covid-19 pandemic. Only a few applications have been developed, having government support serving the people's needs and providing knowledge of worldwide spreading disease Covid-19. Therefore we select all the available apps for analysis. Data for performing analysis are collected on 15 December 2021.

1) Android collected apps

By using the keywords mentioned above, all the applications on Covid-19 are collected from the android play store phone. Five applications are available on the android platform working for all Pakistani districts; therefore, all apps for the screening process are selected.

Table 2 represents all information obtained from Google store.

App name	Language	Acquisition Cost	Popularity	Size	Last update	Release date
WHO Info	English	Free	4.3	7.6MB	1-30-2021	13-4-2020
Health Assessment PDMA	English	Free	3.9	13MB	16-05-2021	24-3-2020
Covid 19 Care for media	English	Free	4.5	4.2MB	30-10-2021	24-3-2020
Pakistan National Action Plan for COVID-19	English	Free	3.9	16 MB	25-02-2021	18-2-2020
Covid-19 Gov PK	English	Free	4.3	5.1MB	1-11-2021	27-5-2020

Table 2 App names with their corresponding specifications.

2) IOS collected Apps

For searching Covid-19 apps on the IOS, iPhone is used. Several applications are available on the IOS Store. Those applications are selected, which also gives information of Pakistan regarding COVID-19 cases. Only one application is found, which is used in both Android and IOS platforms. Table 3 shows the specification of the app.

App name	Language	Acquisition Cost	Popularity	Size	Last update	Release date
Covid-19 Gov PK	English	Free	3.9	18 MB	1 December 2020	27 May 2020

Table 3 iOS apps.

C. Results

1) Screening

Five applications are collected from the search. Five applications are available on the android store, and one app is available, which use in both IOS and android platform.

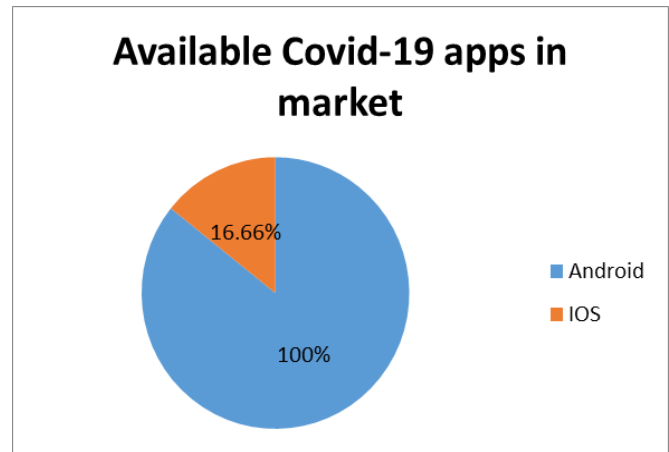


Figure 2. Comparison Android vs. IOS

2) Market Contribution

The figure shows that Android plays a crucial role in the market contribution regarding giving services to people. In serving the people, IOS has a 16.66 percent role as compared to Android.

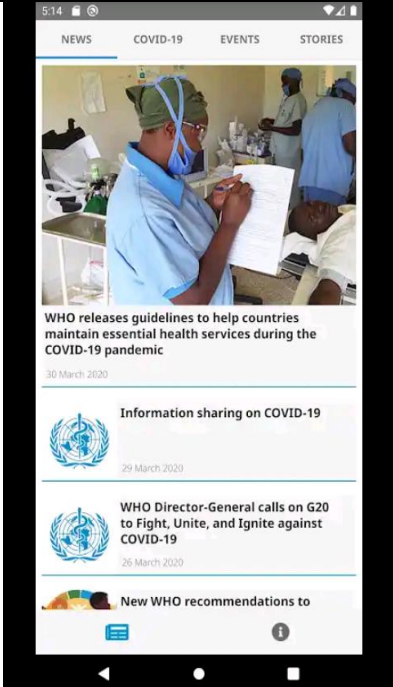
3) *Development of the app*


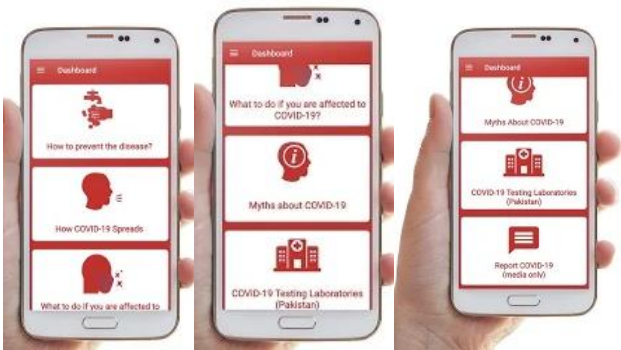
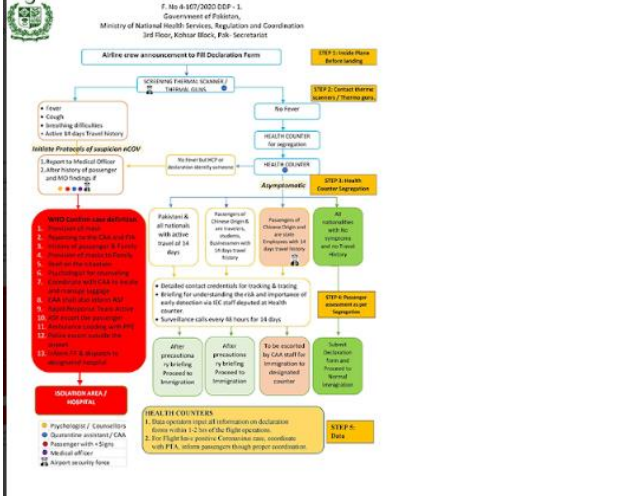
By collecting applications from the Android and IOS, we see that the Android platform have more number of applications as compared to IOS. There are only five applications of Covid-19 that are available on Android, and one app is available on the IOS platform.

4) *Range of Functionalities in apps*

It is observed that giving awareness and up-dating functions are available in all applications by examining the app specifications and results. All forms are giving knowledge and guidelines to the people and giving them up to date information. There is only one app that is observed serving the people by providing facilities like provision vise cases, chatbot facility, radius alert facility, and giving guidelines to people through videos.

Another unique feature observed in Covid-19 care for media which is giving the laboratory information to the people and also giving global information. In the table 4 type of function and their specifications with screenshots are listed.

App	Function name	Function/specification	Screen Shot
WHO Info	<ul style="list-style-type: none"> • News • Events • Stories • Info of Covid-19 	<p>Who info app gives the information at fingertips with official health care organization and display the news, features and events updates of outbreak.</p>	 <p>The screenshot shows the WHO Info app interface. At the top, there are navigation tabs for NEWS, COVID-19, EVENTS, and STORIES. The main content area displays several news items: <ul style="list-style-type: none"> A top article with a photo of a healthcare worker in a blue uniform and mask, titled "WHO releases guidelines to help countries maintain essential health services during the COVID-19 pandemic" dated 30 March 2020. A second article titled "Information sharing on COVID-19" dated 29 March 2020. A third article titled "WHO Director-General calls on G20 to Fight, Unite, and Ignite against COVID-19" dated 26 March 2020. A fourth article titled "New WHO recommendations to" is partially visible at the bottom. </p>

<p>Health Assessment plan for PDMA</p>	<ul style="list-style-type: none"> • Awareness • Self-assessment • Previous assessment • (Sindh) 	<p>An app Health Assessment PDMA enables the people to get at home and provide them with local and public health officials with real time information. This app find the health status of people of Sindh. This app enable the people on how they feel and where they have been in about a minute ago</p>	
<p>Covid 19 care for media</p>	<ul style="list-style-type: none"> • Latest updates • Awareness • Testing labs • Reports on covid-19 • Preventive measure • Myths 	<p>Another app Covid-19 care for media is developed to facilitate Pakistanis to stay updated with corona pandemic. This app gives latest updates globally and in Pakistan.</p>	
<p>Pakistan National Action Plan for COVID-19</p>	<ul style="list-style-type: none"> • awareness 	<p>An App Pakistan National Action Plan for Covid-19 consists of set of SOPs for the prevention and control of corona which are published by the government of Pakistan and national health institute.</p>	

<p>Covid-19 Gov PK</p>	<ul style="list-style-type: none"> • Updates • Provisional cases • Self-assessment • Radius alert • Awareness through videos • Notification • Chatbot 	<p>Ministry of National IT board and Government of Pakistan health and fitness develop an application Covid-19 GovPK, an app to saves the life of people through knowledge and information. This app gives the update of affected persons by province and also display self-assessment feature, radius alert, notifications and also provide awareness videos and chatbot. Their app gives some guidelines that help the people to remain quarantined and untouched with virus.</p>	
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Table 4 Covid-19 apps specifications

5) *User rating*

It is extracted from the collected information that among the available applications, the highest rating observed is for Covid-19 care for media, which is 4.5 out of 5. After Covid-19 care for media, Covid-19 Gov.pk has the highest rating used in both platforms has 4.3 ratings given in the table.

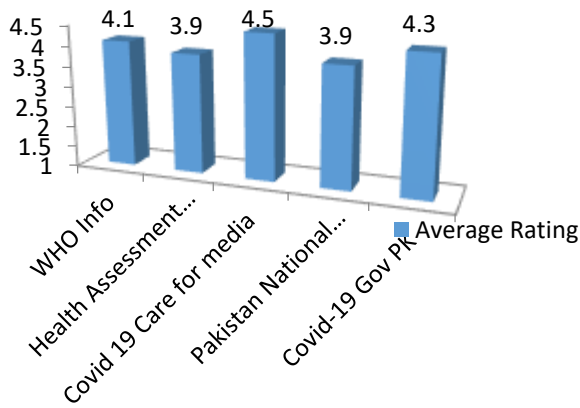


Figure 3. Ratings of apps

6) *Range of specifications*

By seeing the number of functionalities, it is observed that some applications have more services for the people, and some applications are there, which only giving awareness and guidelines. So by considering their functions, the following graph is obtained to see which app plays a huge role in serving people. Here Covid-19 Gov PK and Covid-19 care for media are highly recommended by the people.

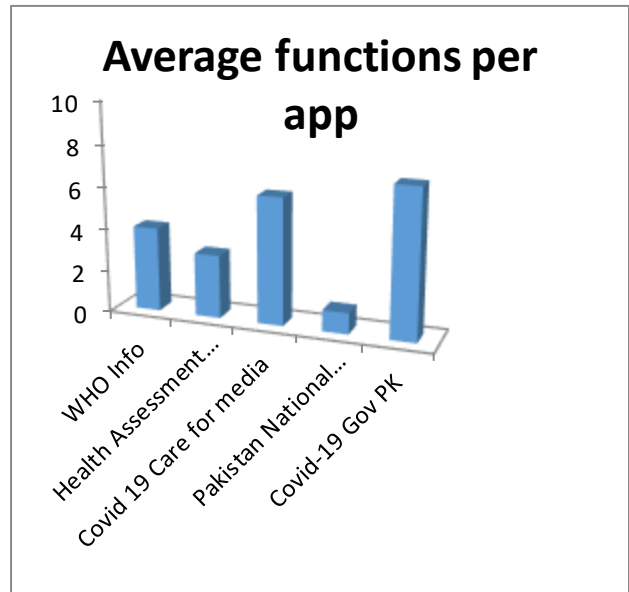


Figure 4. Functions per App

WHO Info	Health Assessment PDMA	Covid 19 Care for media	Pakistan National Action Plan for COVID-19	Covid-19 Gov PK
<ul style="list-style-type: none"> • Events 	<ul style="list-style-type: none"> • Self-assessment 	<ul style="list-style-type: none"> • Awareness 	<ul style="list-style-type: none"> • Awareness 	<ul style="list-style-type: none"> • Provisional cases
<ul style="list-style-type: none"> • Stories 	<ul style="list-style-type: none"> • Previous assessment 	<ul style="list-style-type: none"> • Testing labs 	<ul style="list-style-type: none"> • Myths 	<ul style="list-style-type: none"> • Self-assessment
				<ul style="list-style-type: none"> • Chatbot
				<ul style="list-style-type: none"> • Radius alert
<ul style="list-style-type: none"> • Info of Covid-19 		<ul style="list-style-type: none"> • Preventive measure 		<ul style="list-style-type: none"> • Notification
		<ul style="list-style-type: none"> • Reports on covid-19 		<ul style="list-style-type: none"> • Awareness through videos

Table 5 Number of functions for each app considered here

7) *Up-to-data info interval between apps*

Almost all apps give up to date information and awareness to the people to aware of them from everyday cases according to the information given on them. By taking a systematic review of the applications, check which app has a more time break to update its data. We collected the data on 15 December 2021 and see that Pakistan national action plan app has more time left not to bring its app up-to-date information. This app last updated its information on 25 March 2020. Covid-19 Gov PK and WHO info app is giving information with minimum time left to upgrade but not consistently updating the info.

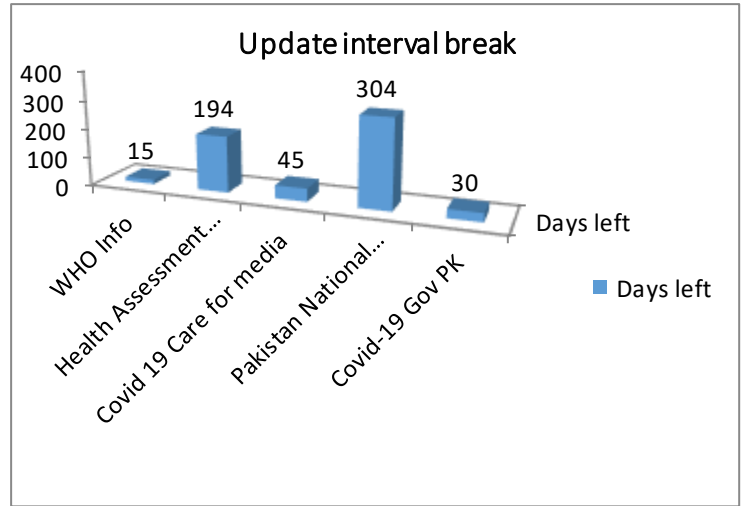


Figure 5. Breaks in the update intervals of each of the considered apps.

IV. USER BASED USABILITY TESTING

Involving real-time users in performing usability testing is called the participant base usability testing technique. Several factors are there which are taken into consideration while performing usability testing. We conduct user base usability testing because of the number of benefits. Using user-based usability testing, it's easy to check whether the participant successfully performs their task or not according to the application user. Time can be measured to spend on achieving a particular mission. Our focus on delivering User-based usability testing on the Covid-19 mobile application is to find their usability level.

A. *App Selection*

From the literature, we see that 10% of apps are enough for providing evidence of performing usability testing. Still, by performing a search on the Apple Play Store and Google Play, we see that only rarer numbers of apps are available there so we perform usability testing on all apps to find clear evidence regarding Covid-19 apps. We see the apps by putting several keywords like Covid-19, Coronavirus, Corona update, and Covid-19 update.

No.	App name	Platform
1	WHO Info	Android
2	Health Assessment PDMA	Android
3	Covid 19 Care for media	Android
4	Pakistan National Action Plan for COVID-19	Android
5	Covid-19 Gov PK	Android/IOS

Table 6 Apps with their corresponding platforms.

B. Materials used for Testing

Due to the Covid-19 pandemic, we perform usability testing by distributing Google forms. Google forms consist of pre-test and post-test questionnaires.

1) Pre-questionnaire

The first section of the questionnaire consists of personal questions in which we ask the participants their name, age, mail, and gender and experience of using mobile applications. It also contains a set of some tasks which user have to check before giving answers to given questions.

2) Post-questionnaire

The second section consists of the usability criteria of objective and subjective questions, which is set on the usability dimension basis extracted from literature. It contains several questions given in the table 7. In the end, we ask from the participants their feedback and some suggestions for the application.

In the table, we give the usability dimension, its description, and questions.

Usability Dimension	Description of Dimension	Questions
Efficiency	Efficiency means the expanded recourses to achieve the completeness and accuracy of the application.	1. Does all the functions are working properly? 2. Does the application have fault tolerance capability? 3. How much efforts need to run the app?
Effectiveness	When users use a product to accomplish their intended objectives, it is said to be effective if it is accurate and comprehensive.	4. Does the application give accurate information? 5. Does the application gives the information is up to date? 6. Does the application contain all the function? 7. Interaction with app is easy?
Learnability	For every type of user, the application should be easy to understand	8. Does learning the application is easy? 9. Understanding the application features is easy understandable? 10. Language used in the application is understandable?
Satisfaction	Being comfortable and having a favorable mindset towards using the application are both definitions of satisfaction.	11. The response time of the user is reasonable? 12. The application do not gives any discomfort? 13. Do you have a positive attitude towards the application? 14. Does interface of the app is satisfactory?
Covid-19 feature	Application gives all feature of Covid-19 that are necessary for the user.	15. Does the app give all required guidelines? 16. Does the app properly giving awareness to the people? 17. Does the app give up to date information consistently? 18. Does the app give all required information regarding Covid-19?

Table 7 Questions extracted from usability dimensions

The questionnaire consists of only specific and related questions because we do not want to burden the participants. To test each participant, we prepared a set of the task which consists of each possible feature required for the Covid-19 applications. The primary purpose of making a list of tasks is to check every conceivable function of the Covid-19.

List of Tasks	
Availability	<ol style="list-style-type: none"> 1. Check the reported cases 2. Check the death cases 3. Check the recovered cases 4. Check provisional wise cases 5. Check total cases 6. Check total recovered cases 7. Check total death cases
Functions	<ol style="list-style-type: none"> 8. Check proper guidelines 9. Awareness assessment 10. Corona awareness 11. Other assessment 12. Check weather user can find quarantine areas 13. Check weather user can find Covid-19 infected areas 14. Check weather required cases are up to date
Interaction	<ol style="list-style-type: none"> 15. Time required checking the features 16. Time required accessing the particular function 17. Check the feature where user can interact with other 18. Check weather user can interact with doctor 19. Check the user interface

Table 8 List of Tasks.

4.3 Participant selection

From the research it is suggested that five to fifty participants are enough for getting valid results and five to ten participants are considered to be the baseline. Getting more number of participants can create complexity in calculation especially for the critical projects [26] [27]. Taking all these perspectives into account or for getting more reliable and accurate results we select 30 numbers of participants. To make the results in a balanced state, we choose fifteen females and fifteen males from age 20 to 40 having experience of at least 5 years smart phones usage.

C. Usability Evaluation

For evaluating the usability following process is done.

1. Before distributing the forms, we give some briefing to the participants.
2. We ask them about their age, qualification and their native language.
3. We ask the participants about their mobile phones they are using.
4. One day is not enough for checking all applications accurately and entirely; therefore, two full days are given to them to check and test the app properly to reduce the fatigue.
5. We are going to test 5 applications with thirty selected contributors. At the end of the test, we get the feedback and suggestions of the contributors to those applications.

D. Usability Analysis

1) Age Impact on usability

Our participants consist of different age groups. After analyzing their results, we see that the participant's age impacts the usability of apps but at a very little extent. By classifying the age into the group, we know the difference. We take the average of their ratings, which is shown in the graph. The age group from 20 to 30 groups have a more positive usability evaluation as compared to the age group from 30 to 40. So we see the difference of age towards experiencing the Covid-19 applications. It is demonstrated that Age impact the usability of Covid-19 apps but at a very little extent. When we talk in terms of the platform, we see that we have only one resulted form for the IOS and five resulted forms for the android; therefore, we ignore to consider the platform differences and conclude our results based as an average.

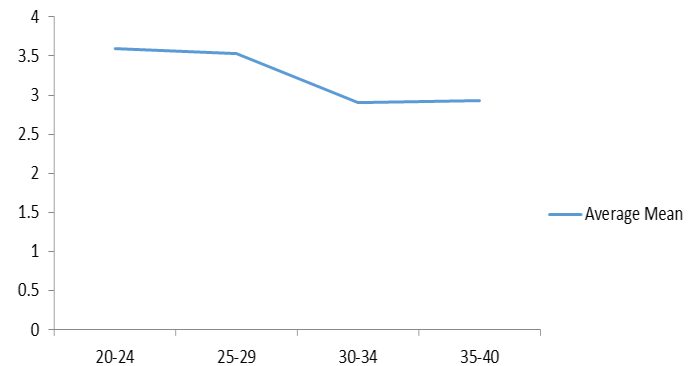


Figure 6 Impact of user's age on usability

2) Gender Impact on Usability

By taking the average mean of assessments of participants for every app, we see that there is no significant difference in gender when experiencing the usability of applications. So it's concluded that gender does not have a specific gap in evaluating the usability of applications.

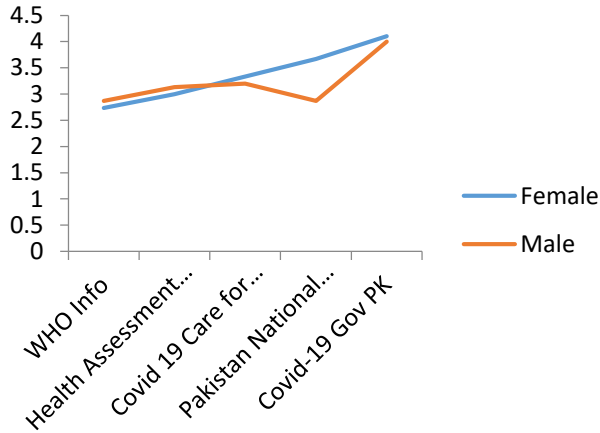


Figure 7 Impact of gender on usability

To confirm this, we take the question wise Assessment of all applications gender-wise. There is not any significant difference appear among the man and women.

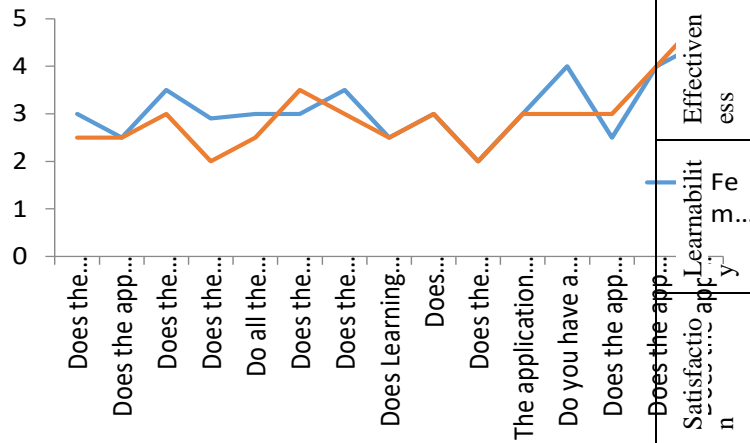


Figure 8 Gender impact in terms of question-wise assessments

There are some questions where males rate the app more than the females for some features and there are some questions where females rate the app features more than the males there for we cannot say with surety that gender impact the app usability. The apparent reason behind this is we see that all the participants use the applications equally without considering their gender differences. There is not any precedence lies whether men and women use the app more.

3) Dimension wise impact on usability

When we observe the dimension wise Assessment of participants for apps, we see that learnability and effectiveness have fewer ratings, according to participants.

From the literature, we see that an app is effective if it is complete and accurate. So from the table 9, we demonstrate that effectiveness is directly related to the average rating of the application. As the effectiveness of the app increase, the usability of the app increase. Features of Covid-19 and learnability of the app are also directly proportional to the app's average rating. From this observation, we see that the usability dimension has a strong direct relationship with the usability of the app.

Usability Dimension	Covid-19 feature	Satisfaction	Learnability	Effectiveness	Efficiency	Average ratings
WHO Info	3.5	3	2.5	2	3	2.97446
Health Assessment	2	3	2.5	2	3	2.658
Covid-19 Care for media	4	4	3	4	3	3.28574
Pakistan National Action Plan	4	2.5	2.5	2	3	2.82274
Covid-19 Gov PK	4	3.5	4	4	4	3.71522
Mean of ratings	3.54	2.9888	2.777	2.6444	2.9166	

Table 9 Usability dimension wise ratings.

By taking a correlation between usability dimension and average assessment of applications, we see that all usability dimensions have positive relation on the overall usability of the app.

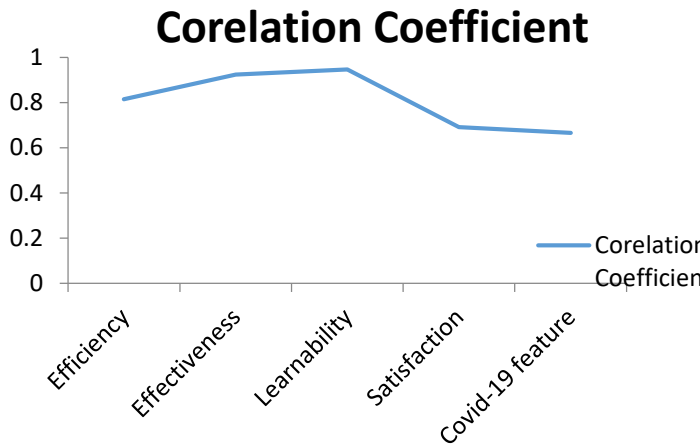


Figure 9 Correlation Coefficient between usability dimension and average assessment of applications.

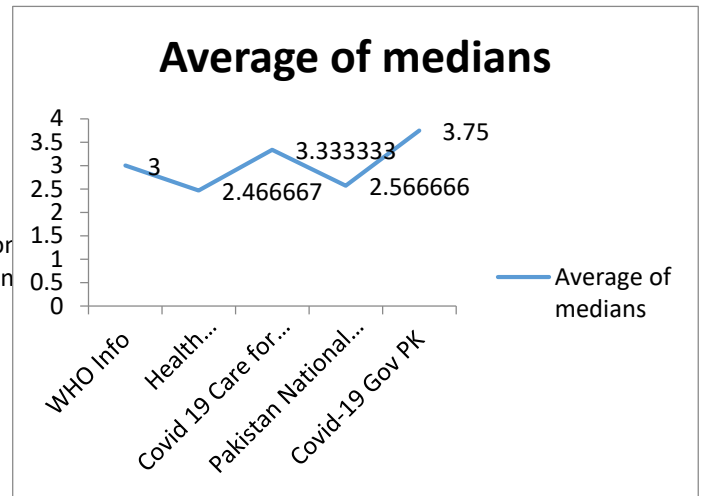


Figure 10 Average of medians for each apps considered here.

4) *Best rated App*

Figure 10 determines the evaluations of all participants. From the applications, we see that Covid-19 GovPk has a more positive assessment than other apps. Health Assessment PDMA and Pakistan national action plan got the lowest evaluation among the applications. By taking the average of all medians, if we set the threshold value 3.08 and considered it had good usability dimensional app containing, then we see that two apps pass this value, which is COVID-19 govpk and COVID-19 care for media.

5) *Usability regarding their functions*

By taking a look at the assessment of overall apps according to their functionalities, it is interesting to see that neither any of application is there which give full functionalities at a time nor their rating goes to five. In table 10 you will see the average of the median of scores of all apps and the functions that an app holds.

	WHO Info	Health Assessment PDMA	Covid-19 Care for media	Pakistan National Action Plan for COVID-19	Covid-19 Gov PK
Functions	<ol style="list-style-type: none"> 1. News 2. Events 3. Stories 4. Info of Covid-19 	<ol style="list-style-type: none"> 1. Awareness 2. Self-assessment 3. Previous assessment 4. (only for Sindh) 	<ol style="list-style-type: none"> 1. Latest updates 2. Awareness 3. Testing labourties 4. Reports on covid-19 5. Preventive measure 6. Myths 	<ol style="list-style-type: none"> 1. Awareness 	<ol style="list-style-type: none"> 1. Updates 2. Provisional cases 3. Self-assessment 4. Radius alert 5. Awareness through videos 6. Notification 7. Chatbot
No. of Fun	4	3	6	1	7
Ratings	3	2.666	3.333	2.666	3.75

Table 10 Ratings regarding their functions

It's concluded by taking the Pearson correlation coefficient that there is a strong positive relationship between the usability of the app and its functions.

E. Usability issues

We perform a usability analysis of the participants' assessment to identify the usability issues in the interface of Covid-19 apps. We conduct usability review on the Likert-scale and take an average threshold value 3.08, which show

We find the Pearson correlation coefficient of the average of the median of ratings of apps with their function.

Pearson Correlation Coefficient = 0.940366

excellent and poor ratings. According to the score, the following apps appear mediocre and attractive.

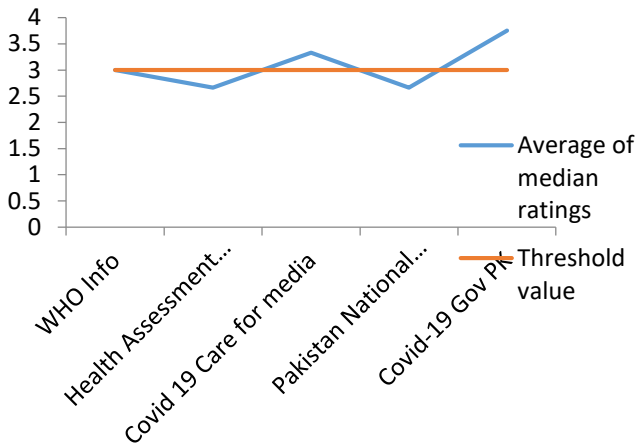


Figure 11 Average regarding their threshold value for each of the apps considered here

The Figure 11 shows that two apps like Covid-19 Gov PK and Covid-19 care for media pass the threshold value and are considered excellent. Two apps, Health Assessment PDMA and Pakistan National Action Plan have a shallow value from the threshold; one app WHO info has rating equals threshold value; therefore, we named it an average-rated app.

1) *Positive features*

By performing a usability analysis, we observe some positive features. From the Table 10, we see that functions used in-app have a strong relationship with the app's usability.

- ✓ All app providing proper awareness to the people regarding COVID-199
- ✓ All apps give suitable guidelines to people according to situation
- ✓ All app is offering total cases, reported death cases and recovered cases
- ✓ All apps are giving correct information.

2) *Negative features*

By seeing the positive features, as well as some negative features, are observed in apps after performing usability analysis which are as follows:

- ✓ Learnability in the usability dimension is the most observed feature which has the lowest contribution in apps.
- ✓ Languages used in-app are challenging to understand by everyone
- ✓ Understanding some features of the app are complicated for some people

- ✓ App is giving the Covid-19 cases but not updated consistently
- ✓ Not enough information regarding Covid-19 is provided to people
- ✓ Fault tolerance capacity is deficient

V. CONCLUSION

In this survey, we perform a comprehensive review of all available Covid-19 Apps serving the people in a developing nation, namely Pakistan. We collected apps from both android and IOS platforms, however there was only one app that is available on both an 5 apps available on android store. We perform analysis on the user ratings, functions used in Covid-19 apps, target user groups, size, name, languages, user ratings, available interfaces, response time, and up-to-date cases through our systematic review. Also, we perform user-based usability testing on COVID-19 apps to evaluate its usability. After completing testing, we analyze the results by investigating the age impact on usability, gender impact on usability, the function used in-app on usability, and usability dimension effect on the overall usability of mobile applications. In the end, we found several positive and negative features in the Covid-19 apps and these can provide better insights in deploying the time critical information about Covid-19 in developing countries context.

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