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Infectious Disease-Related Applications
A Descriptive Review

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Abstract— This study aims to identify and analyse the existing mobile applications for infectious diseases currently available for stakeholders in two major application stores: Google Play Store and Apps Store. The Google Play and Apps Store were searched between 15th June 2022 and 21st June 2022. The keywords used to search related applications on the infectious disease were "infectious disease," "dengue," "ebola," "h1n1", "influenza," "Japanese encephalitis," "MERSCOV," "SARS," "tuberculosis," and "Covid-19". The selection of the applications is based on the predefined inclusion criteria. Initially, two hundred eighty-three applications were identified, and 262 met the inclusion criteria. A total of 125 applications were sampled. The codes and themes were extracted from the description available in the application store. Information was recorded in Microsoft Excel. Finally, the existing application and its purpose were summarized and presented with descriptive statistics. The study discovered that the application was first released in 2011 for general infectious and significantly increased in 2020.Most applications were developed for multiple functions, mainly for general information, close contact notifications, self-reporting cases, and symptom tracking. This study provides an overview of infectious disease applications currently available regarding their purpose and the trend of the application released. It significantly contributes to mobile application research by providing the developers with an informed decision while designing infectious-related disease applications to suit the stakeholders' needs.

Keywords— mobile applications, infectious diseases, Covid-19, Ebola, Tuberculosis, Dengue, H1N1, Influenza.

I. Introduction

Infectious diseases have been a persistent hazard to human health and global welfare. It had a lasting impact on human well-being and prosperity, resulting in significant and adverse effects on populations worldwide. For example, from the Black Death to the Covid19 pandemic, infectious disease outbreaks have devastated populations worldwide. Fear of infection can lead to social distancing [1], stigmatization and discrimination against affected individuals and communities [2], which disrupt social life. On the other hand, economists estimated that the pandemic could cost the global economy over $6 trillion in the 21st century [3]. It disrupts the economy in terms of supply and demand [2] and labour productivity [3] due to morbidity and mortality caused by the diseases.

Mobile application is one of the recent information technology solutions adopted by various countries in managing infectious disease emergencies. Mobile applications have become an essential tool in the fight against infectious diseases. With the increasing prevalence of smartphones and mobile devices, mobile applications have become an effective tool for disseminating health information, tracking disease outbreaks, and monitoring the spread of infectious diseases.

To date, 83.72% of people worldwide use smartphone [4]. With the high penetration of smartphones in developing and developed countries, there are growing opportunities for the local government to take adequate measures in managing infectious disease crises and improving patients' access to treatment and advice. Outbreak identification, diagnosis, treatment and patient management, disease control and elimination are among the potential of mobile applications [5]. There were numerous studies focused on m-health-related applications. However, the concentration was more on non-Communicable diseases (NCD), for example, cardiovascular disorder [6], depression [7] cancer ([8] schizophrenia [9] monitoring physical activity [10] and managing bipolar disorder [11].

Additionally, previous work by Almaliki focused on Covid-19 only. Since the threats of infectious diseases to public health is not only Covid-19, the study should expand to other available applications developed for infectious diseases, such as Ebola, Tuberculosis and Dengue virus. If the transmission is not adequately controlled and the community cannot access the information about the disease, like identifying the symptoms and how to react if they or their family members were infected, the spread can rapidly increase in incidence or geographic range.

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Therefore, it is necessary to identify, analyze and categorize health related to infectious disease applications currently available for consumers in application stores to provide a better understanding of the available resources on infectious disease. Therefore, it could help in public health monitoring, disease prevention and control, user education and empowerment.

Thus, this article identifies, categorize and discuss the various functions of mobile applications for infectious diseases applications currently available for mobile application users.

II. METHODOLOGY

A systematic application review was conducted in this study to explore the existing applications developed for infectious diseases. The study was performed following the steps explained in the following subsections.

A. *Identification of relevant applications*

The review was based on existing applications across two major mobile application stores: Google Play and Apple Store. The keywords used to search related applications on the infectious disease were "infectious disease," "dengue," "Ebola," "h1n1", "influenza," "Japanese encephalitis," "MERSCOV," "SARS," "tuberculosis," and "Covid-19". Each of the keywords was searched in both application stores.

Application titles and application descriptions were considered for the initial screening. The relevant application was recorded in Microsoft Excel regarding the disease type, application's name, star rating, first release, version, platform, privacy policy, descriptions and country context.

B. *Screening and Eligibility of Assessment*

The second round of exclusion criteria focused on removing the duplicated apps found in both the application store and none English Language application. In this round, the applications which did not meet the criteria were removed from Microsoft Excel. The process flow is depicted in Figure 1. Finally,125 applications from each key term were randomly selected for review.

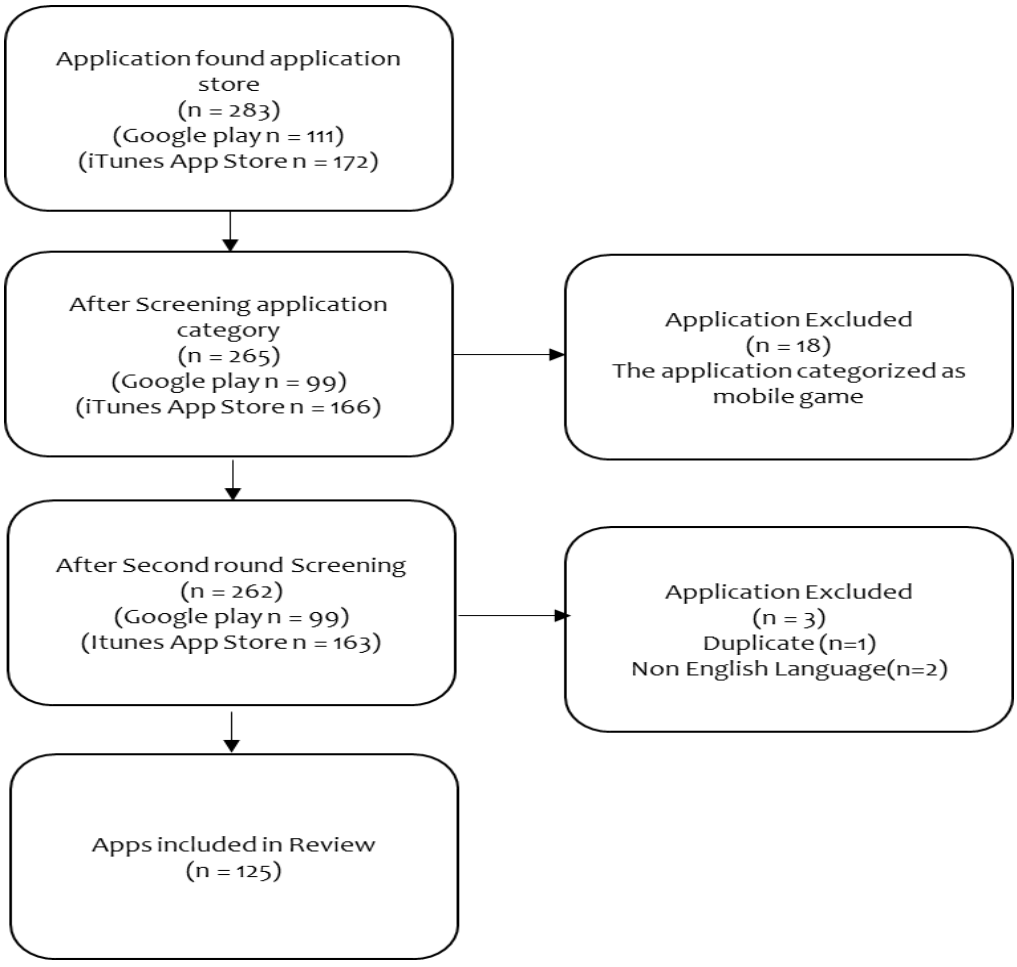

Fig. 1 Process Flow of Screening and Eligibility Assessment

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C. *Data Analysis*

To achieve the objectives of this study, the initial coding was given. The coding was given based on the application descriptions, screenshots, and the application only downloaded and examined websites of those applications that have unclear descriptions or did not provide screenshots.

The codes were recorded in a table in Excel to manage the coding process easier. The extracted keyword from the application description was added as the table's header name. If any code is identified, it will mark as 1. 1 was used because later, the total of the identified code will count to classify the purpose of applications. After completion, the same process was repeated to ensure no further codes emerged. The assigned code was then categorized to represent the common themes. Finally, available applications, the purpose and the type of the applications were summarised and presented with descriptive statistics

III. PRESENTATION OF THE RESULTS

This section presents the result of the selected applications.

A. *The existing infectious Applications*

Based on the searched keywords,283 mobile applications were found on Android and IOS platforms. After the screening based on the exclusion criteria, 262 existing applications were developed for infectious diseases. Figure 2 shows the percentage of mobile applications available in both Google Play and Apple Store for the most infectious disease declared by the World Health Organization (WHO).

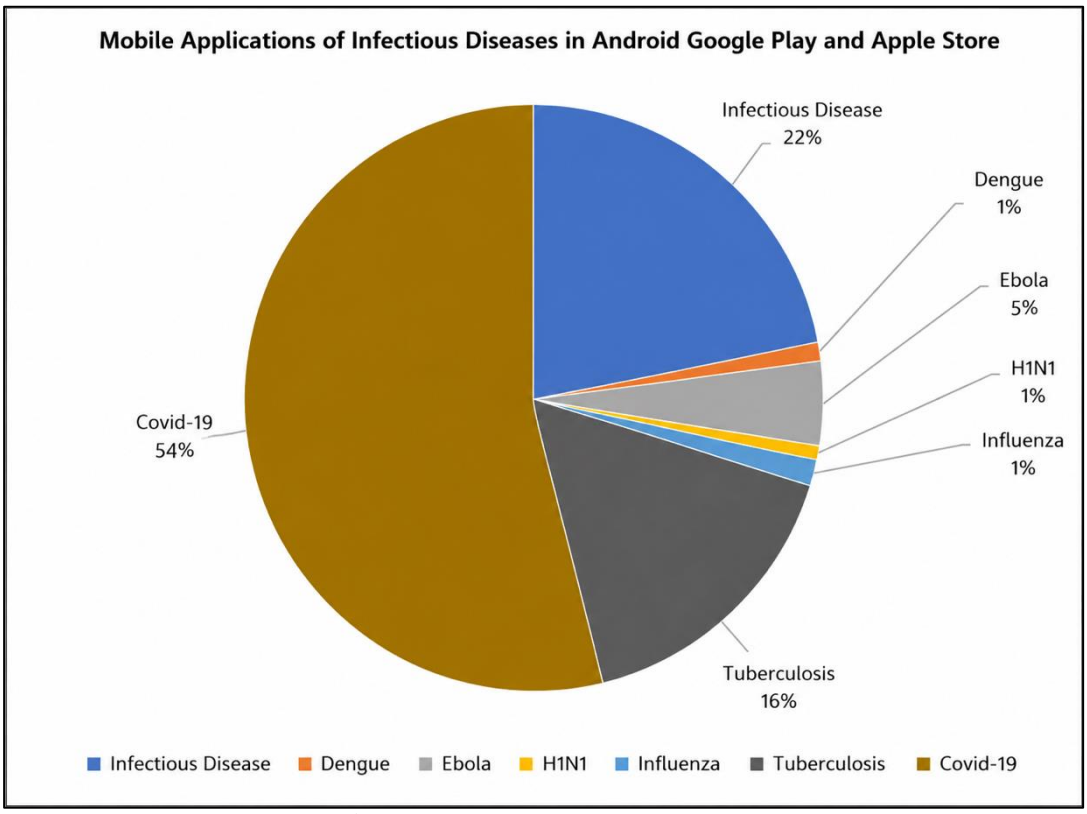

Fig. 2 Percentage of Mobile Applications Available in Google Play and Apple Store

The application was mainly developed for Covid-19, with 50% of the related infectious disease available in the application store, followed by general infectious disease at 22% and Tuberculosis at 16%. Whereby applications developed for Ebola, dengue, H1N1 and Influenza related were 5 to 1 %, respectively. However, none of the applications were found to be developed for Japanese Encephalitis, MERS-COV and SARS.

In terms of the trend of the availability of the application on the market, the availability of the application tremendously increases in the year 2019 to the year 2020. Most of the applications were focused on Covid-19 related applications. Figure 3 depicts the trend of the applications release in the application stores.

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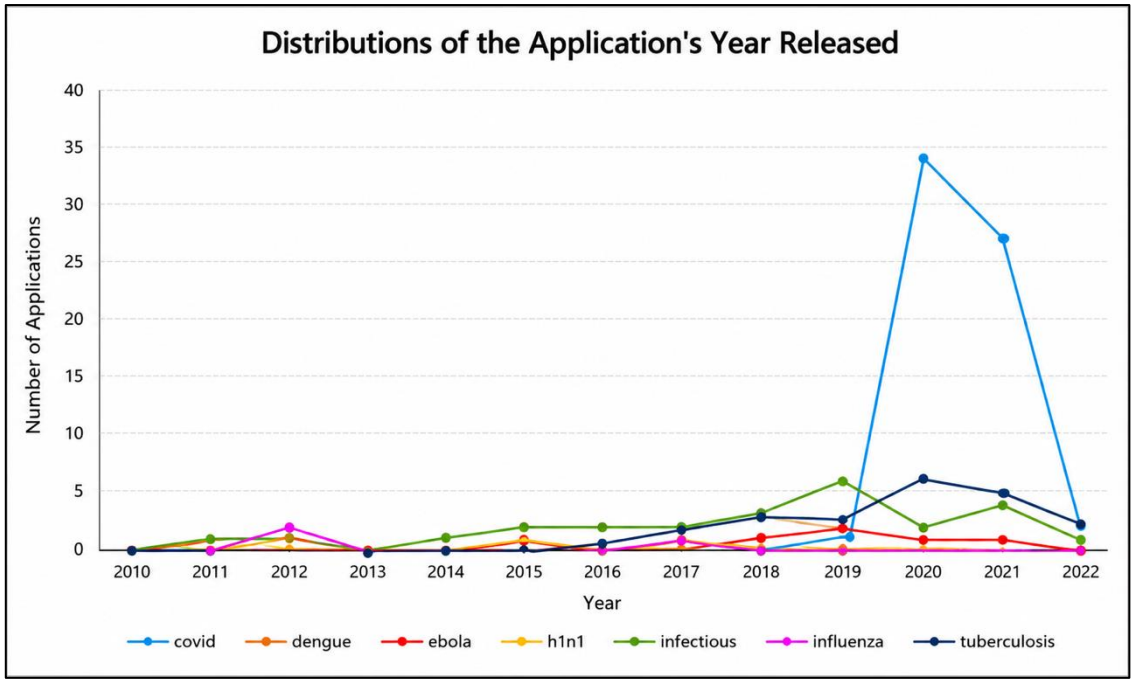

Fig. 3 Distribution of the Application's Year Released

B. The purpose of the available applications

Based on the 125 selected applications, the study extracted a total of 15 functionalities. The number of applications that offered a specified function is shown in Figure 4. The result shows that most applications were developed for multiple functions. The extracted functionalities of the infectious disease application in the application stores are briefly discussed below.

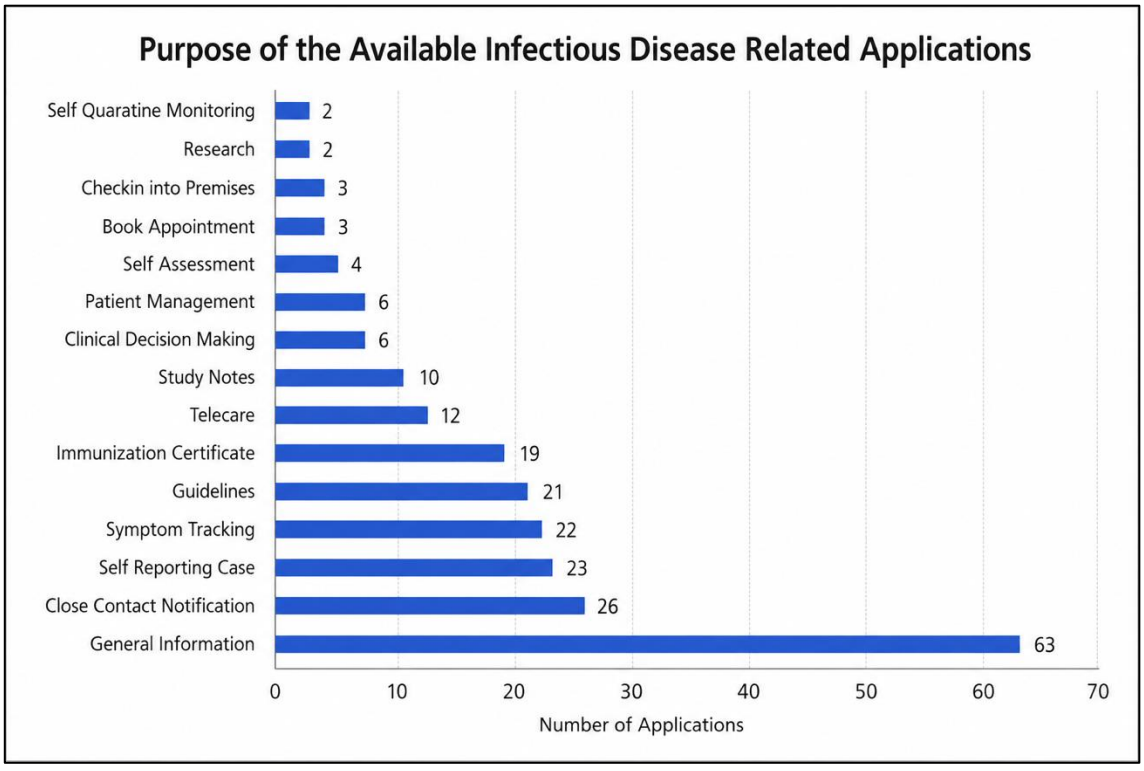

Fig. 4 Purpose of the Available Infectious Disease Related Application

1) General Information – 50.40% (63 out of 125 applications) of the application provide general information about infectious diseases, such as their causes and symptoms. Some of the applications also provide the latest news and update on the current situation of the diseases. 40 out of 63 applications shared information about covid-19, nine shared general information on the various infectious diseases, followed by Tuberculosis, eight applications, two shared information specifically on Ebola and dengue, respectively, and one on influenza, H1N1.

2) Close Contact Notification – 20.8 % (26 out of 125) of the applications offer close contact notification. All of them were used in managing and controlling Covid-19 cases. Notification of exposure was given primarily using push notification technology voluntarily. The users need to turn on the Bluetooth signal in their smartphone to receive the notification of close contact if they were exposed to a tested positive Covid-19 patient within 6 feet in 15 minutes or more. However, this can only happen if the positive Covid-19 case consents to share their anonymized data through the application. Whereby few applications used QR Code check-in data to track, trace and notify close contact to tested positive Covid-19 patients.

3) Self-Reporting Case - 18.4% or 23 out of 125 applications has a self-reporting case function. The self-reporting cases are also available for Covid-19 application only. Most available applications are based on the patients' voluntary sharing of test results. However, names of users and locations of possible exposure are never tracked and shared. The self-reported case will ensure the effectiveness of close contact notification. The more people willing report positive cases, the more people will get exposure notifications.

4) Symptom Tracking – 17.6% of applications have a symptom-tracking function. The function is also for Covid-19 applications only. The users need to answer a set of predetermined questions available in the application to monitor their health condition. The application prompts the users for medical assistance if a positive symptom is detected.

5) Guidelines – 16.8% of the reviewed applications provide guidelines functionalities. The functions focused on two types of users. Most applications were dedicated to healthcare personnel for the public users' guidelines. Nine applications provide guidelines on general infectious diseases. For example, the latest definitions, risk factors, primary and ambulatory care and aid in diagnosing common infectious diseases. One application is served for health personnel to assist them in managing Ebola at the point of care. On the other hand, guideline functions are available in 5 Tuberculosis related applications. Most of them provide Tuberculosis management for healthcare personnel. Six applications on Covid-19 provide guidelines functionality. Most of it provides steps to use a home test kit for public users correctly.

6) Immunization Certificate -15.2 % (19 out of 125) applications have immunization certificate-related functions. All of them are available in the Covid-19 application. Various countries used the function to store the immunization information of the users and verify the Covid-19 vaccination certificate among their local citizens and abroad travellers enter to their countries like European Countries and the Kingdom of Saudi Arabia.

Telecare – 9.6% of the reviewed application equipped with telecare functionalities. One is for Tuberculosis and 11 for Covid-19 application. The patients were monitored remotely through the information provided by the patients. The patients need to update their vital signs like blood pressure, oxygen level, and condition through the application. Further treatment will be evaluated based on the information provided through the application.

7) Study Notes – 8% of the applications have study notes functionality. This feature provides a handy note of infectious diseases. The function is designed for medical students to access common infectious disease notes easily.

8) Patient Management – 4.8% or 6 out of 125 applications provide patient management options. The function is to help the health professional monitor their patient's health condition and plan the treatment. The majority of the application is to serve tuberculosis and covid patient management.

9) Clinical Decision Making – 4.8% of the reviewed application offer clinical decision-making function. Most of the application is developed to assist healthcare professionals in determining the prescription and calculating the exposure window. The function was available for general infectious diseases and Ebola. premises.

10) Self-Assessment - 3.2 % of the applications served as self-assessment tools. The functionalities only available in Covid-19- related application. the applications mainly allow the users to assess themselves and their family members, monitor their health progress throughout the COVID-19 outbreak.

11) Check-in into Premises – 2.4% of the application offer function to trace and track the users' mobility based on the premises they are entering. The users must check in using a unique QR Code provided by the premises before entering. A close contact or exposure notification will be sent to the users if positive report cases are entered into the same premises.

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12) Book Appointment – 2.4% of the applications have a book appointment function. The menu is only available for Covid-19 applications. The application allows users to make an appointment at the nearest facilities to perform Covid testing and book for vaccination appointment.

13) Self-Quarantine Monitoring – 1.6% of the application allow the authorities to monitor self-quarantine patient. The quarantine patient must update their current location and health condition during their quarantine period.

14) Research – 1.6% or 2 out of 125 applications is developed for research purposes. General information shared by users, such as age, health conditions and disease symptoms, is captured through the application. The data will be used for the research.

C. *Distribution of Application's Purpose based on Diseases*

Based on the identified application above, this study narrowed down the analysis based on the distribution of the application's purpose based on the diseases. Figure 5 depicts the distribution of application's purpose based on diseases. The following subsection explains the findings of the purpose of the application for four major applications available in the applications store, mainly Covid-19, general infectious disease, Tuberculosis and Ebola-related applications.

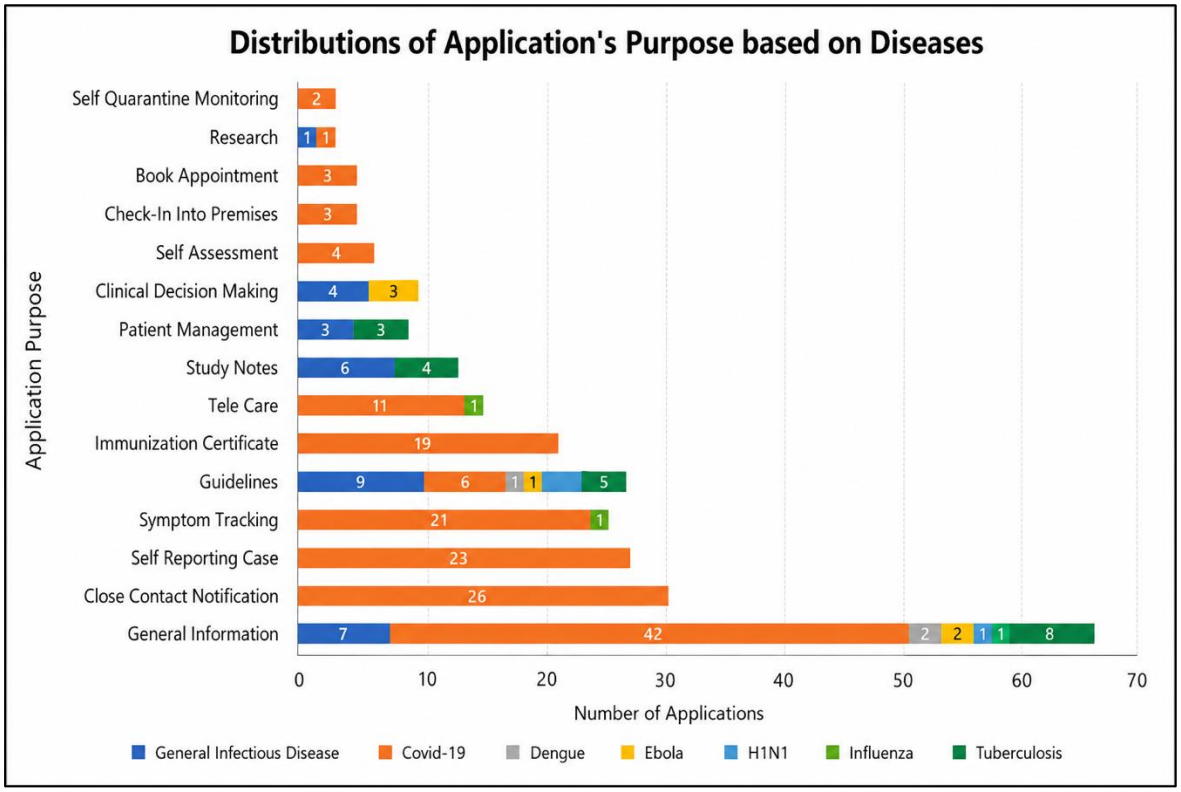

Fig. 5 Distribution of Application's Purpose based on Diseases

1) *Covid-19 related applications*

As depicted in Figure 2, Covid-19-related applications were found to have the highest number of infectious disease-related applications available in the application store compared to other infectious illnesses. The result from the analysis shows that the application offers various purposes. Forty-two applications provide general information about the disease, twenty-six serve as close contact notifications, twenty-three provide self-reporting case function, twenty-one applications allow symptom tracking, and six provide a guideline. Some applications serve as Covid-19 immunization certificates, eleven provide telecare functions, followed by self-assessment, and four offer Self-assessment, whereby three applications include check-in into premises and book appointment purposes in their application. One application served for the research, and two were developed for self-quarantine monitoring.

2) General infectious disease application

The result shows that the application on general infectious disease applications provides general information about the disease, guidelines, study notes, clinical decision-making, and patient management and serves for the research. The Figure 5 depicts seven general infectious diseases providing general information, nine applications providing guidelines, six applications serving as the study notes, four providing clinical decision-making, three functions as patient management and one application for research.

3) Tuberculosis-related Application

The finding exhibits that Tuberculosis-related applications were offered general information, guidelines, study notes and patient management. The available applications mainly serve as general information about the disease, which were eight applications, followed by five guidelines applications. Four applications provide study notes, and three applications serve as patient management.

4) Ebola-related Application

The findings indicated that Ebola-related applications were developed to provide general information, guidelines and clinical decision-making. Three applications offer clinical decision-making, two provide general information, and one provides guidelines.

IV. DISCUSSION

The highest number of applications were Covid-19, 54% of the available infectious disease-related application, followed by general infectious disease 22% and Ebola-related applications 5%. Whereby dengue, H1N1, and Influenza related application are 1% only. COVID-19 was declared a pandemic on March 11, 2020, by World Health Organization (WHO), affecting many people worldwide. As of June 28, 2023, there have been 767,518,723 confirmed cases of COVID-19, including 6,947,192 deaths, reported to WHO [12] The finding indicates that the urgency of the Covid-19 situation between 2019 and 2020 has stimulated innovation and development of the application to control disease transmission. Thus, there is a need for immediate solutions to control the spread of the disease and mitigate its impact through the use of mobile applications. Therefore, the authorities took the initiative to develop the application to assist them in controlling the crisis efficiently.

Conversely, the finding exhibits no Japanese Encephalitis (JE), MersCov and SARS-related disease applications available in the applications stores even though these three diseases are the threats.

JE is Asia's most important cause viral Encephalitis [13]. It was estimated to be nearly 68000. According to WHO, the primary outbreak occurs every two to fifteen years and intensifies during the rainy seasons when mosquito populations increase. Furthermore, it is estimated that the mortality rate for this disease ranges from 13,600 to 20,400 deaths per year.

Similar to MersCov, a disease caused by the Middle East respiratory syndrome coronavirus (MERS-CoV). It can be highly pathogenic in humans. Individuals infected with MERS-CoV may experience no mild or severe respiratory illnesses or even death. As of May 30, 2020, 27 countries in the Middle East, North Africa, Europe, Northeast Asia, and North America have reported 2562 laboratory-confirmed MERS cases and 881 associated deaths, according to the World Health Organization (WHO) MERS-CoV has significantly impacted respiratory health, mortality, healthcare settings, pregnancy and perinatal outcome, comorbid conditions, and transmission.: Most people infected with MERS-CoV develop severe acute respiratory illness, with symptoms of fever, cough, and shortness of breath[14]. Furthermore, MERS-CoV has a mortality rate of over 35%, and approximately 35% of patients with MERS-CoV have died[15]. It is essential to take appropriate measures to decrease the virus's transmission risk and better understand its risks, including the source, how it spreads, and how to prevent infections.

Generally, mobile application use to manage TB, Ebola and dengue is minimal. TB was declared the five deadliest infectious diseases in the world [16]. Whereby Ebola was declared the largest outbreak in 2014-2016 in West Africa since the virus was first discovered in 1976 [17]. The disease threatened public health safety due to its contiguous nature.

Tuberculosis-related applications mainly provide general information, guidelines, study notes, patient management and telecare. The purpose of the application is not diverse, thus limiting the use of mobile applications in disease surveillance and management. The first application was only released in 2017, even though the disease emerged a million years ago[18].

Similarly, with Ebola-related applications, the available Ebola-related application was mainly developed to provide general information. Additionally, it was not widely used by the affected community. For instance, even though many districts have been spread with viruses in Africa, the use of mobile applications is not extensive. The first application was released in 2014 to provide healthcare personnel with guidelines at the point of care. The second application was released in 2018 with the same purpose and state holders. It can be seen that no application was released to educate the users, even during the major outbreak from 2014 to 2016.

Contrary with Covid-19 crisis. Covid-19 is also contagious and was declared a global pandemic on March 11, 2020. The use of mobile applications to respond to this crisis has increased exponentially compared to Ebola and

Tuberculosis (TB). Various countries have taken responsibility for reaching out to their community by deploying mobile applications as one of their innovative strategies to manage the crisis. Compared to the application developed to fight Ebola and TB, the functionalities have been extended. Based on the finding, the purpose of the application ranged from providing general information, self-reporting case, symptom tracking, guidelines, immunization certificate, telecare, self-assessment, check-in into premises, book appointments, research and self-quarantine monitoring observed from the available application. Further, [19] in their review outlined nine functionalities of Covid-19 available in the Google Play Store, iTunes and Microsoft Store for remote assistance, monitoring patients, current status, communication support and more.

In terms of the development of the application on infectious disease-related applications, it is shown that the development shown tremendously increased in the year 2019 to the year 2020 during Covid-19 hits worldwide. The application development before the COVID-19 pandemic was insignificant compared to during the pandemic. It may be due to the need for efficient transmission control and increased mobile phone penetration globally. In the early years of infectious disease application, they focused on influenza, dengue and general infectious illnesses. In 2017, the application related to Tuberculosis was released. However, in 2022, the newly released application significantly dropped compared to 2021. It may be due to the Covid-19 Pandemic declared by various countries. Therefore, this no urgencies urged to release new application.

In terms of the purpose of the application available, it can be seen that the applications developed before the COVID-19 pandemic serve global users by providing information to educate the public about infectious diseases, like symptoms and causes and effects. However, the application developed to manage and control Covid-19 has much improved using mobile applications compared to other infectious diseases. Most of the applications developed for Covid-19 help local authorities manage and control the outbreak within the local community by having exposure notification of close contact. This feature helps the community to self-alert once they are identified as having close contact with Covid-19 patients. Therefore, they may isolate themselves from the community and family members. Thus, the transmission could be minimized and contained.

Based on the application developed in responding to contiguous health crises like Ebola and TB. It can be synthesized that the purpose of the application should be extended to what was developed mainly to help the people to prepare, response affected population, for example, to educate them on the transmission and help them to prepare and respond to recover from the event. It is in line with the emergency management cycle discussed earlier, which comprises mitigation, preparedness, response and recovery. Mobile application use may educate and alert people through the information shared. However, the functionalities of other infectious diseases shall be diversified; therefore, the potential use of mobile applications as one of the mediums controls and manage the disease can be an effective initiative.

A. Implications

Overall, the outcome of this study provides a summary of the currently released application on the infectious disease-related application in two central application platforms, mainly Google Play Store and Apps Store, about their purpose. The findings can provide a necessary initiative in designing and developing a new application or updating the existing one to manage the emergence and re-emergence of infectious diseases efficiently.

The review study also can be considered a requirement-gathering study. The application developers may consider the revealed functionalities as user requirements, especially for Ebola, TB and dengue-related applications. More functionalities shall be considered for this disease, especially for screening, detecting, and monitoring the disease as they have been developed for Covid-19 applications. It is because epidemiology shows the disease's significant impacts on public health. Dengue is the most prevalent vector-borne disease worldwide[20], while TB is a significant public health problem, particularly in low- and middle-income countries[21]. Whereby Ebola is highly contagious and often fatal[22].

B. Limitations

This study has a few limitations that are important to acknowledge. Firstly, the keyword chosen for selecting the relevant applications for this study may not cover all the infectious disease-related applications.

Secondly, the study does not include the relevant applications released after June 21, 2022. Thirdly, this study only explored the purpose of the available application but did not explore how the stakeholders perceived the applications.

Thus, a future study may explore more infectious disease-related applications with the extended year of released compared to this study. Further, it is interesting to assess how users perceived the application they used, especially during an infectious disease crisis. So that the usability issues of the available application can be explored. Therefore, the issue can be addressed based on the user-centred approach. Thus, it will improve the stakeholder user experience of using the application.
guidelines.

V. CONCLUSIONS

This study provides an overview of mobile applications on infectious diseases available in two major application stores, Google Play and Apps Store, based on the years when the application was released, the trend of the development, and the purpose served by the applications. The analysis of the available application showed that the application released tremendously increase during the Covid-19 crisis hit the world even though other threats of infectious disease emerged before it. The analysis observed that the existing applications provide 15 primary purposes. Most of the applications were developed for multiple functions. Mainly the application serves as general information to the end users, close contact notification, self-reporting case, symptom tracking and guidelines.

The finding significantly contributes to mobile application research and gives the developers an informed decision while designing a new and updating infectious-related disease applications.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of Interest

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