Systematic Literature Review on Mobile Applications on Covid-19 Crisis

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Abstract

The COVID-19 pandemic caused a worldwide crisis and has affected many fields, most notably technology and medicine. As a technological endeavor to understand and deal with this crisis, many smartphone applications were developed. In this article we review the accomplishment made by the mobile applications indealing COVID-19 risk assessment. The study examines the literature found in bibliographic databases on COVID-19 such as PubMed, IEEE Xplore, MDPI and Scopus on mobile apps that have real-time usability and description on the design and performance. Mobile apps have been implemented for training, information sharing, risk assessment, self-management of symptoms, contact tracing, home monitoring and decision making, rapidly offering effective and usable tools against COVID-19. In this review, 1487 studies were processed and the studies about mobile application on risk assessment were very few, while the maximum of studies were focused on contact tracing and self-symptom assessment and 50% of the studies were experimental. The studies with the theme of symptom assessment were cited over 1000 articles. The focus of most of studies was to have prevention as objective but there were very few focusing on assessing the risk. Mobile apps play a crucial role in creating awareness and acting as liaisons between government and health care professionals and the public. Using a mobile app, decision makers can create a system to face critical challenges imposed by the pandemic and discover new predictors.

Keywords

Mobile apps, systematic survey, COVID-19, mobile health, eHealth, mobile applications

1. Introduction

The outbreak of coronavirus disease (COVID -19), which first appeared in China, has spread around the world.On 11 March 2020, the World Health Organization (WHO) declared COVID -19 a pandemic [42]. The diseasehas disrupted global trade, employment, and travel, while many governments have taken stringent measures to control the spread of the virus and reduce the disease burden and death to keep systems functioning properly[1]. In many countries around the world, people are advised to stay at home and keep social distance, if possible, to prevent the spread of COVID-19.

While mobile apps have been used successfully for chronic disease management [2,3], the current COVID- 19 pandemic has posed a need for app solutions for mobile devices to reduce the risk of cross-contaminationin close contact [4,5,6]. Mobile technology has been used in several ways to prevent the spread of COVID -19. Mobile apps are accessible, acceptable, easy to use, and can support social distancing efforts. As such, theyhave been widely developed and deployed in recent months to "flatten the curve of the rising number of COVID -19 cases, empowering civilians with knowledge and information while trying to. Despite the growing reliance on mHealth solutions as part of the COVID -19 response plan, there are significant knowledge gaps related to their usefulness and effectiveness during the current pandemic, both for health care professionals butnot for the general population, regarding the use and evaluation of mobile applications for prevention, management, and treat, treat, or monitor COVID-19.

Other recent studies have only focused on testing COVID-19 mobile apps in general app stores [7] or have limited themselves to apps available in countries specific countries such as the United States, United Kingdom, and India [8]. Although there have been general information and communications technology (ICT) related COVID -19 investigations [9,10], they focus on specific topics such as contact tracing [11,12] , specific medical fields such as child health care [13], mental health [14], epilepsy [15], palliative care [16] or countries such as India [42] , China [17] and the United Kingdom [18]. To our knowledge, limited work has addresseda systematic literature review of pragmatic studies that have demonstrated real-world use and evaluation of the COVID-19 mobile app- 19. Since the advent of pandemic, many mobile applications have been developed

across the globe and the list of the applications is provided in the following list, most of the applications are not involved in this study due to lack of any research work supporting these applications [43].

A systematic literature review that addresses COVID-19 research in the context of mobile applications and identifies research gaps. Our research provides further guidance for future work involving big data for COVID-19 through deep learning. We analysed articles from leading journals and conferences conducted between 2020and 2022. The remainder of this review paper is arranged as follows. The research methods used in our study, including research strategy, research objectives and research questions, quality assessment methods and data extraction for each assessment topic are discussed. in Section 2. Section 3 details the results and discussion about various features. Section 4 includes the final comments and a conclusion.

2.   Methods

2.1.   Search Strategy

The main purpose of systematic mapping research is to determine the search area and the number and types ofsearches and discoveries within it. A researcher can examine the frequency of posts over time to identify trends. Identifying published research on this issue may be an additional goal. This section includes research of related articles, design, and mapping of publications. Mapping studies summarize current knowledge and identify key themes through in-depth literature reviews. The qualities and merits of technical systems literature reviews for specific research contexts are discussed in this section. This is not the goal of systematic map search as thearticles are not subjected to in-depth examination.

2.1.1. Research Questions

A research question is a specific topic that research will address. It is the foundation of systematic research and helps develop a well-defined research pathway. Choosing a research topic is the first step in any research work. A compelling research question is needed to begin a research paper or thesis. It defines exactly what you want to learn and directs your efforts in the right direction. Objectives are used to create research questions.In SLR, the importance of selecting study participants cannot be stressed enough. These make it easier for searchers to stay on track. The research questions and motivations are outlined in Table 1. Research topics influence how a research plan is developed. Accordingly, the research questions for SLR were carefully planned. This section includes a set of research questions along with their rationale.

2.1.2   Research Resources and Search String

Articles were searched using the IEEE Xplore Digital Library, Scopus, MDPI and PubMed databases. Google Scholar was also used to find gray literature on the subject, including white papers and technical studies. Google Scholar has proven to be a useful tool for conducting bibliographic searches. Table 2 shows the research databases used to search the literature for the research project. The next step in SLR is finding suitable research studies. A search string was set to collect published studies on the research topic. It was decided to use specific search engines and digital libraries based on their relevanceto the academic content and research objectives. As a result of the analysis Scopus, MDPI, IEEE Xplore and PubMed were used. Finally, technical, and scientific documents using our search engine and digital library. The next step is to decide which strategies and search phrases to use. A set of words from the training questionswas selected to define the search string.

Table 1
Research Questions and Their Motivations

S.No	Research Questions	Main Motivation
1	What is the role of mobile applications for fighting COVID-19 pandemic?	The main motivations for writing this question are to identify COVID-19 outbreaks and determine where considerable data research may be discovered as well as finding appropriate targets for future study.
2	How are mobile application used for risk assessment and prevention?	The aim is to examine the available data channels and determine thepatterns in publishing data over time
3	What are the most usedand popular mobileapplications during pandemic?	The reason for writing this question is to identify what large-scale data efforts are being utilized to encourage the extension, validation, and cooperation of work in the global pandemic battle.

Table 2
Research Resources and Search String

Resources	Search String	Context
IEEE Xplore and MDPI	"((mobile health) OR (mhealth) OR (ehealth)) AND (smartphone) OR (mobile application) OR (mobile app))) AND ((COVID-19) OR (SARSCoV-2)) AND (risk assessment)"	Mobile applications an dCOVID-19
Scopus an dPubMed	"((mobile health) OR (mhealth) OR (smartphone) OR (mobile phone) OR (mobile application) OR (mobile app) OR (app)) AND (COVID-19) AND (risk assessment)"	

an

2.1.2. Eligibility Criteria

2.1.2.1.   Inclusion Criteria

- features of the COVID-19 mobile app should be described,
- the study should show evidence of the implementation of the COVID-19 mobile app inreal-life and provide quantitative outcomes,
- the paper describing the study, must have been written in English.
- Studies that were subjected to peer review.
- All published research papers that can answer the research questions.

2.1.2.2.   Exclusion Criteria

- Duplicate papers
- Literature works that are do not give a clear idea of the research objective.
- Papers that were published before 2020.

- Case reports, letters to editors, pre-print papers, reviews, simulation studies, and studiesdescribing protocols, were excluded from the review.
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2.1.3. Study Selection

The selection process aimed to identify the articles most relevant to the objectives of the cartographic study. When there is a document in several places, we only review it once, following our search sequence. We followed the recommendation of Priority Reporting Items for Systematic Review and Meta-analysis (PRISMA) [19]. A total of 1487 studies were reported from the years 2020, 2021, and through August 2022.

We took each article, which was then evaluated by two other authors to see the title, summary, and keywordsto include. The two authors who reviewed the articles discussed the articles that received different scores untilan agreement was reached. Other authors have considered the final options. Once the articles have been found,the first step is to remove the obvious duplicates. We performed extensive searches to filter out publications unrelated to our research topic through the research selection process. Figure 1 depicts the study selection stages and the activities that took place during each research phase, showing the number of records included and excluded at each selection step. The focus of research is COVID-19, which is rapidly gaining the interestof government officials, researchers, and scientists.

2.1.4. Data Extraction

Different ways of solving the research questions were proposed for data extraction. In fact, the type of data collected is largely determined by the original research topic. Important details include how the research was designed and methodology, how qualitative and quantitative results were obtained, and when, where,and by whom the primary research was conducted. Relevant information from each relevant study in the sample was collected, extracted, and selected in the next step. The following extraction technique is available for the extracted data from each study topic.
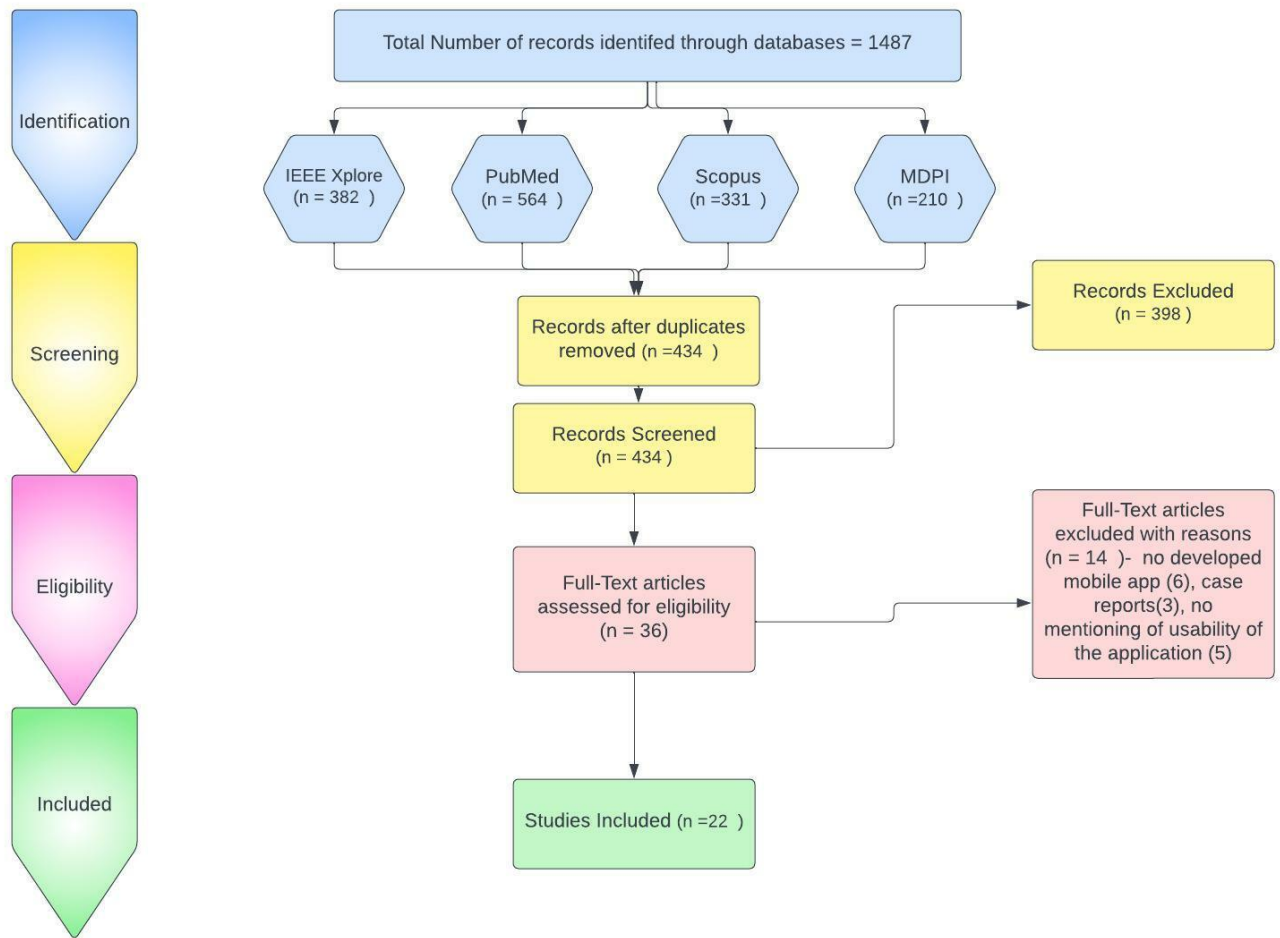
Figure 1: Prisma Flow Diagram

## 2.2.	Results And Findings

2.2.1. Comparison On Year, Number, Study Design And Location

YEAR WISE DISTRIBUTION

Number of Studies

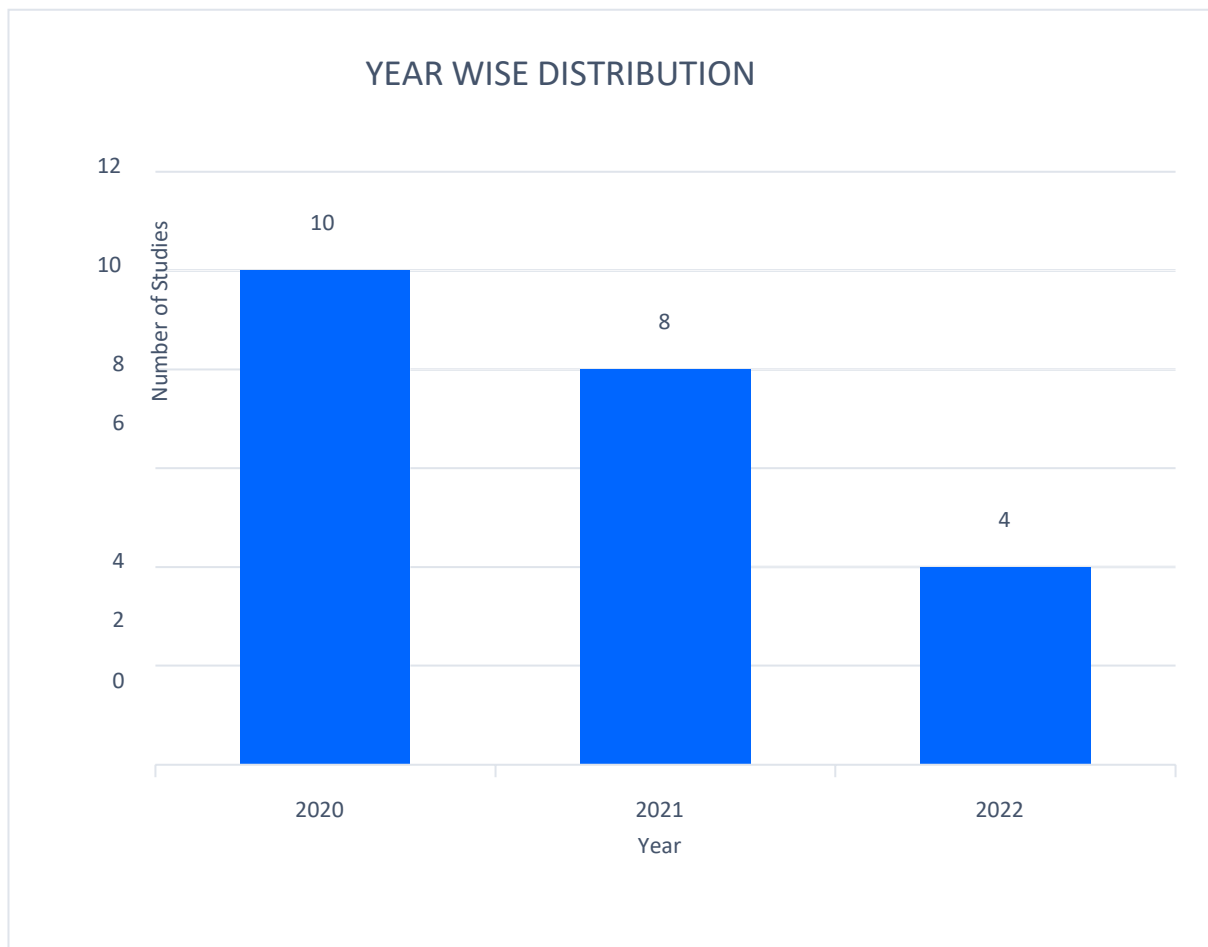| Year	Number of Studies
2020	10
2021	8
2022	4

Figure 2 Year Wise Distribution of The Studies

In Figure 2, the depiction illustrates the emergence of COVID-19 in the year 2020. During this period, a substantial number of studies were conducted to better understand the virus and its impact. One notable observation is that PubMed, a well-known publisher of scientific literature, had the highest number of articles published compared to Scopus. Conversely, there were no significant articles published in IEEE and MDPI during this time. Furthermore, it is worth mentioning that, except for MDPI, the remaining three research sources (PubMed, Scopus, and IEEE) showcased articles that focused on the development and utilization of mobile applications in their respective studies. This indicates the growing interest and importance of leveraging mobile technology in combating the effects of COVID-19. Lastly, it is noteworthy that the highest number of articles across all databases was published in 2022. This suggests that the research community's efforts to study and address the challenges posed by COVID-19 intensified during that particular year.
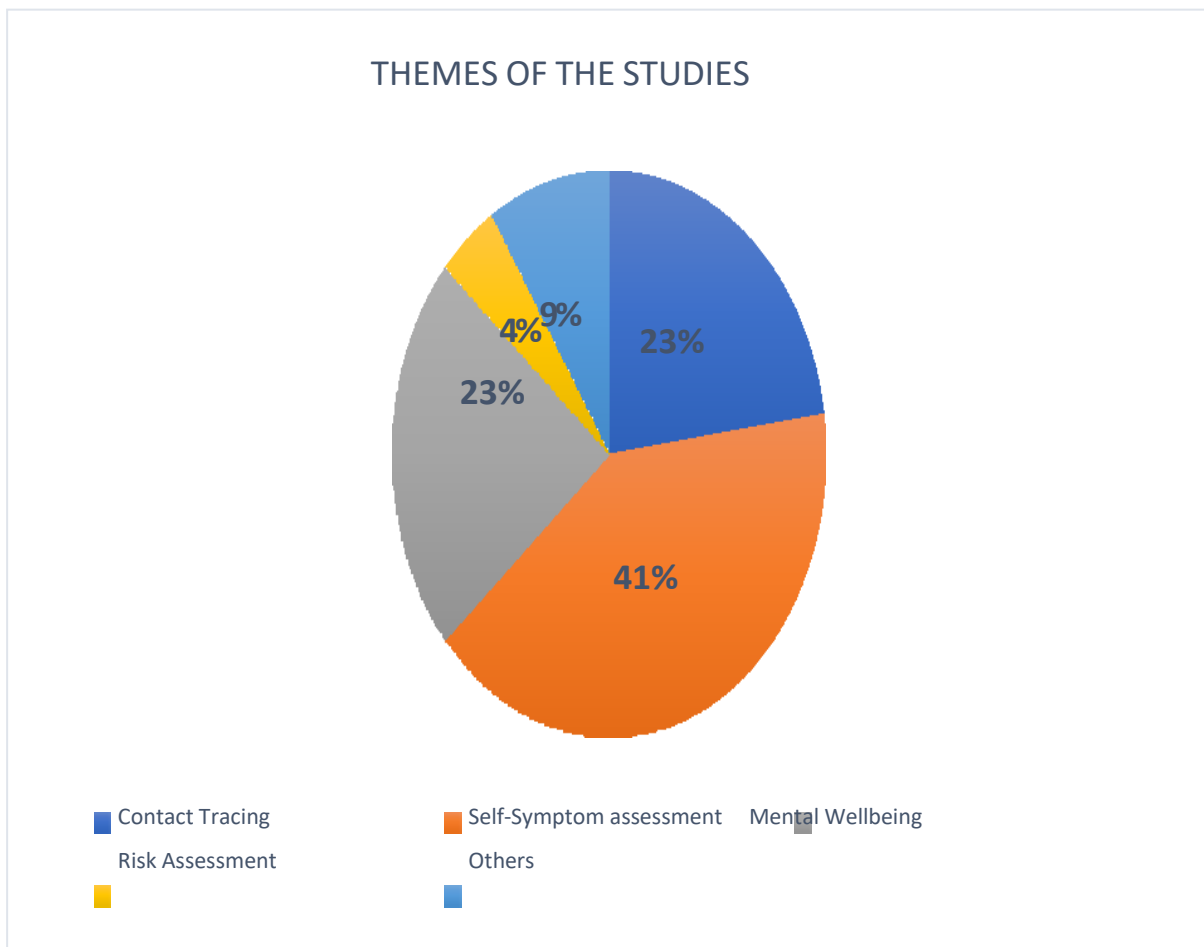
Figure 3 Types of Themes of The Studies

Figure 3 provides a pie chart that illustrates the distribution of themes or aims of mobile applications developed over a period of two years. The analysis of the chart reveals the following key insights:

The largest portion of the work, accounting for 41% of the total, was dedicated to the theme of Self-Symptom Assessment. This indicates that a significant amount of effort and focus was placed on creating mobile applications that allow users to assess and monitor their own symptoms related to various health conditions. This could be attributed to the increased demand for self-diagnosis and health monitoring tools, especially during the COVID-19 pandemic. In terms of equal yet slightly lower contributions, both Mental Well-being and Contact Tracing themes accounted for 23% of the mobile applications developed. This suggests that considerable attention was given to the development of mobile applications that promote mental health and well-being, as well as those that facilitate contact tracing for disease control and prevention. These themes highlight the growing importance of mental health awareness and the need for effective contact tracing measures during the given period. Only a small percentage, 5%, of the mobile applications were aimed at Risk Assessment. This indicates that a relatively smaller number of applications were developed with the purpose of evaluating and analyzing potential risks associated with specific situations or activities. However, it is worth noting that risk assessment plays a vital role in various domains, such as healthcare, finance, and security. Lastly, the theme of Digital Proximity and Face Recognition had the lowest contribution, accounting for only 4% of the mobile applications. This suggests that a relatively limited number of applications focused on utilizing digital proximity and face recognition technologies.
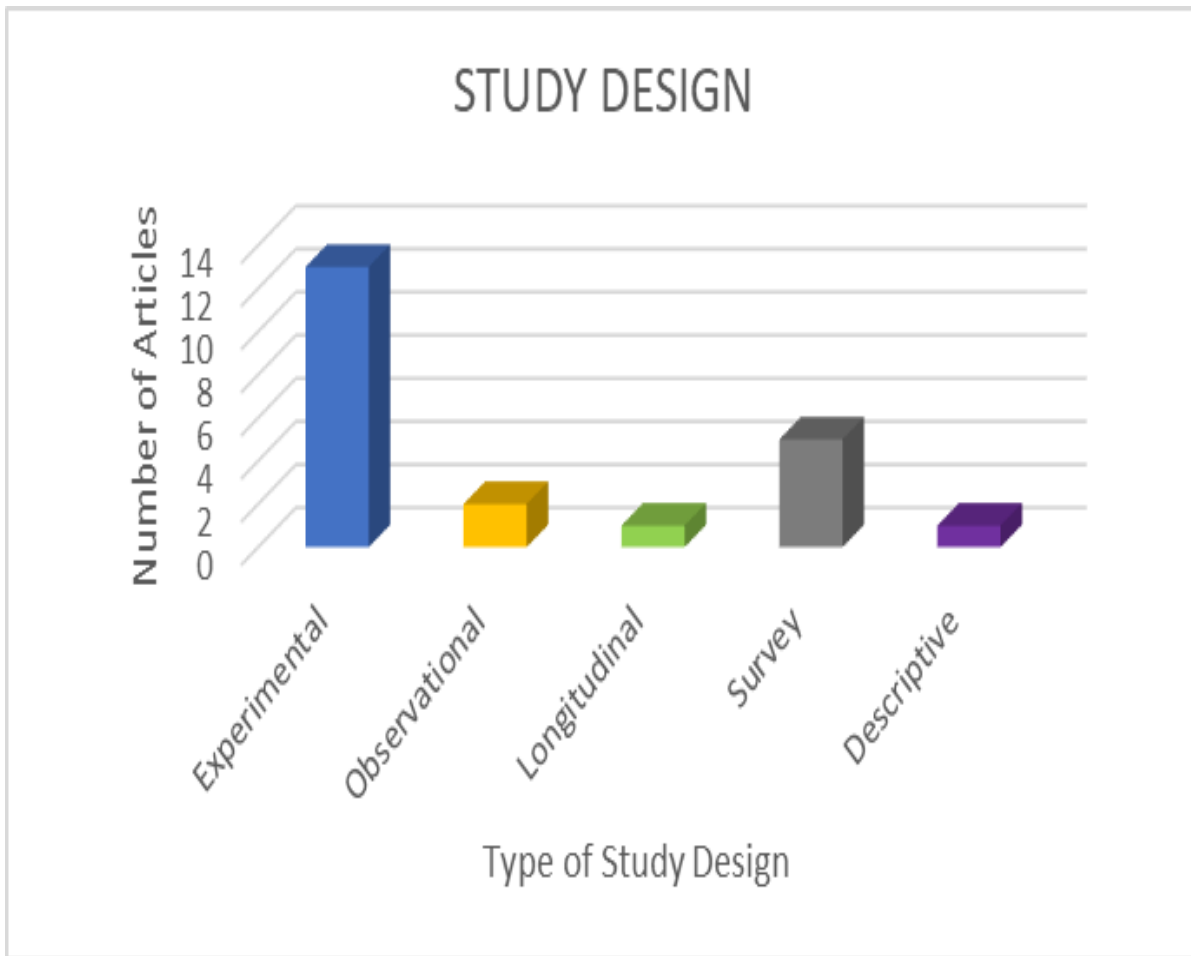
Figure 4 Types of Study Designs

Figure 4 presents the distribution of study design types adopted in the articles selected for this particular study. The analysis of the chart reveals the following observations:

The most prevalent study design, constituting half of all the studies, is the Experimental study design. This indicates that a significant number of articles included in this study employed experimental approaches to investigate and test hypotheses. Experimental studies are commonly used to establish cause-and-effect relationships and assess the effectiveness of interventions or treatments. Following Experimental studies, Survey studies accounted for 6 studies. Surveys are a widely used research method for collecting data from a sample population to gain insights into attitudes, opinions, and behaviors. The inclusion of a notable number of survey-based studies suggests the importance of gathering self-reported data and understanding perceptions or experiences related to the research topic. Observational studies, on the other hand, were relatively fewer, with only 2 articles adopting this study design. Observational studies involve observing and analyzing existing data or phenomena without intervening or manipulating variables. These studies are valuable for exploring relationships, patterns, or trends in real-world settings. Descriptive and Longitudinal study designs were the least represented in the selected articles. Descriptive studies aim to describe characteristics, behaviors, or phenomena without making causal inferences. Longitudinal studies, on the other hand, involve collecting data from the same subjects over an extended period to examine changes or patterns over time. The relatively lower representation of these study designs suggests that they were less commonly utilized in the articles included in this study.
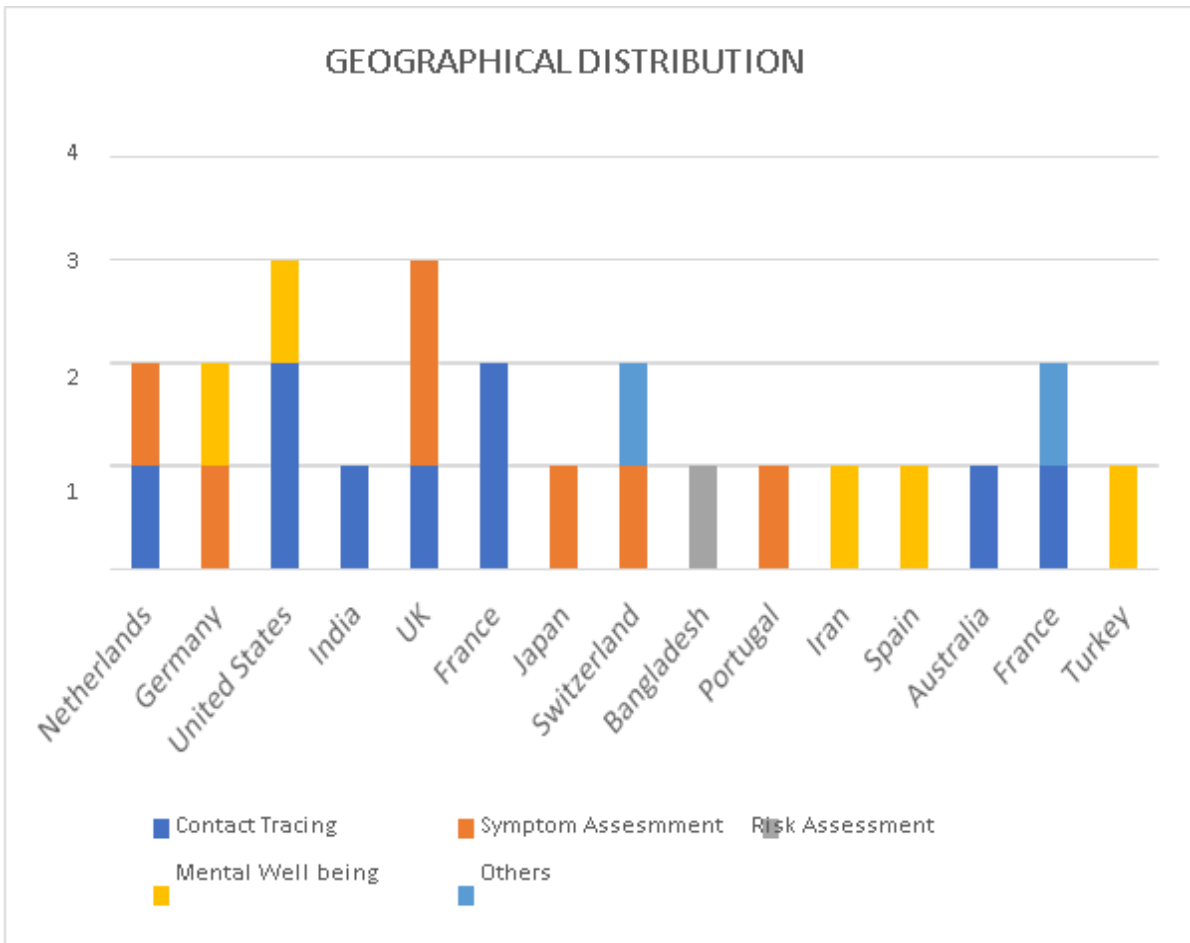
Figure 5 Geographical Distribution of Studies with Themes

Figure 5 provides a visual representation of the countries where the studies included in this analysis were conducted. Upon observing the chart, it becomes evident that most of the studies originated from the European region and the United States, while there were fewer studies conducted in other parts of the world. Additionally, a common theme observed across the European countries was contact tracing. The concentration of studies in Europe and the United States suggests that these regions were actively engaged in research related to the topic under investigation. This may be attributed to factors such as the availability of resources, research infrastructure, and the prominence of academic institutions and research organizations in these areas. The prevalence of contact tracing as a common theme across the European countries indicates that a significant portion of the studies conducted in these regions focused on developing and evaluating contact tracing methodologies. Contact tracing has been recognized as a crucial tool in managing and containing the spread of infectious diseases, including COVID-19. Therefore, it is likely that the European countries recognized the importance of contact tracing and invested in research efforts to better understand and improve this aspect of disease control. It is important to note that the relatively lower representation of studies from other parts of the world in Figure 5 does not necessarily imply a lack of research activity or interest in the topic. The distribution of studies across different countries can be influenced by various factors, including research funding, collaborations, and regional priorities.

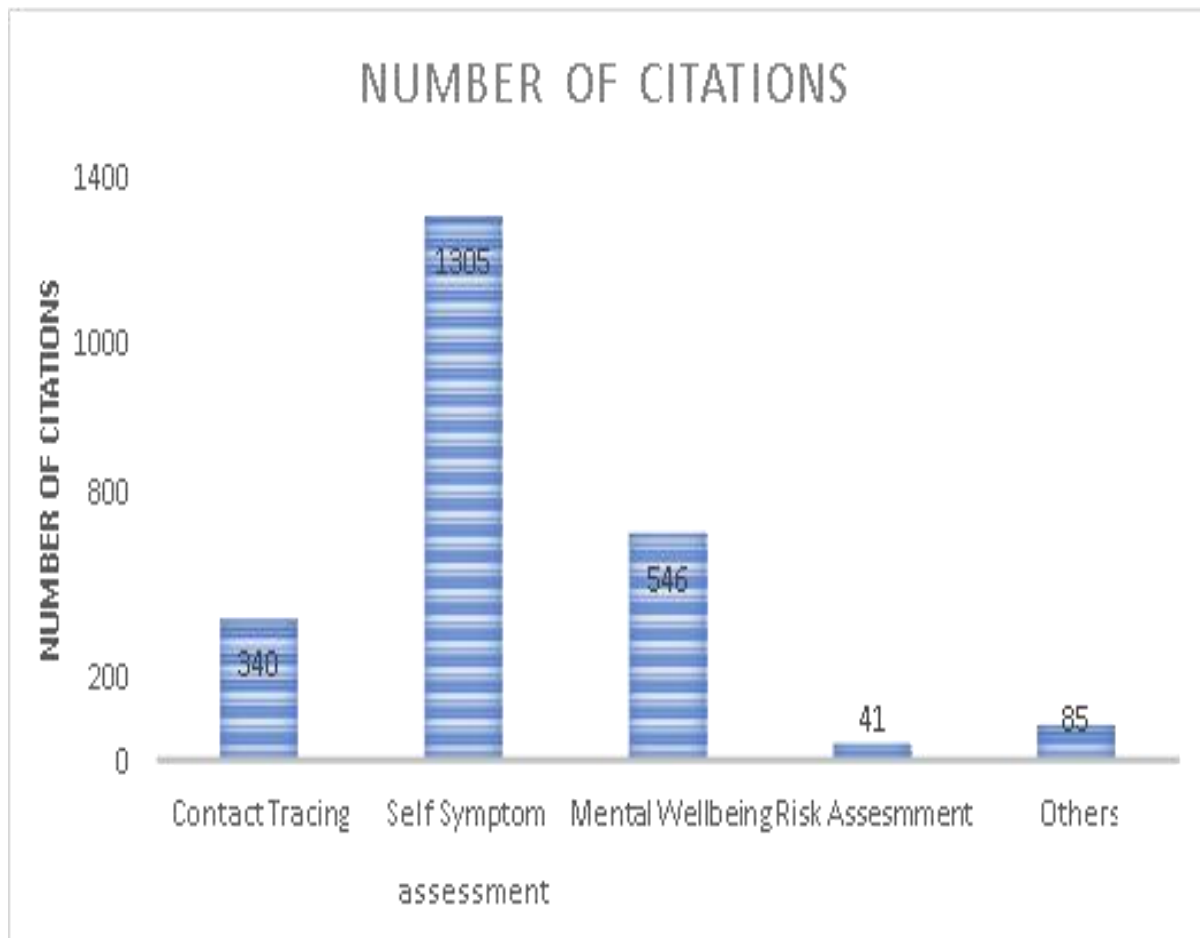## 2.2.2. Comparison On Co-Authors and Keyword Co Occurrence

Figure 6 Number of Citations

Figure 6 presents the citation index of various themes within the studies analyzed. The analysis reveals that Self-Symptom Assessment studies have garnered the highest popularity and citation count in the context of mobile applications. Following closely, studies focusing on Mental Well-being as the theme have also received significant citations and popularity. The prominence of Self-Symptom Assessment studies suggests that these types of mobile applications, which enable individuals to assess their own symptoms, have garnered considerable attention and interest within the research community. This could be attributed to the increasing demand for self-monitoring tools, especially in the context of healthcare and well-being. Additionally, the theme of Mental Well-being emerges as the second most cited and popular theme in Figure 6. This highlights the significance of mobile applications aimed at promoting mental health and well-being. The recognition of mental health as an important aspect of overall wellness and the increasing awareness of its significance could explain the popularity and citation count of studies within this theme. Contact Tracing, as the third most cited theme, indicates that mobile applications designed to facilitate contact tracing have also attracted considerable attention and interest within the research community. Contact tracing apps gained significant relevance during the COVID-19 pandemic to track and manage the spread of the virus. The citation count within this theme underscores the importance of such applications in public health and disease control efforts. Furthermore, Risk Assessment and other themes such as Face Recognition and Digital Proximity also received citations, albeit to a lesser extent compared to the themes. This suggests that studies focusing on these themes have also contributed valuable insights to the field of mobile applications but may not have received as much widespread attention or popularity as the top three themes.
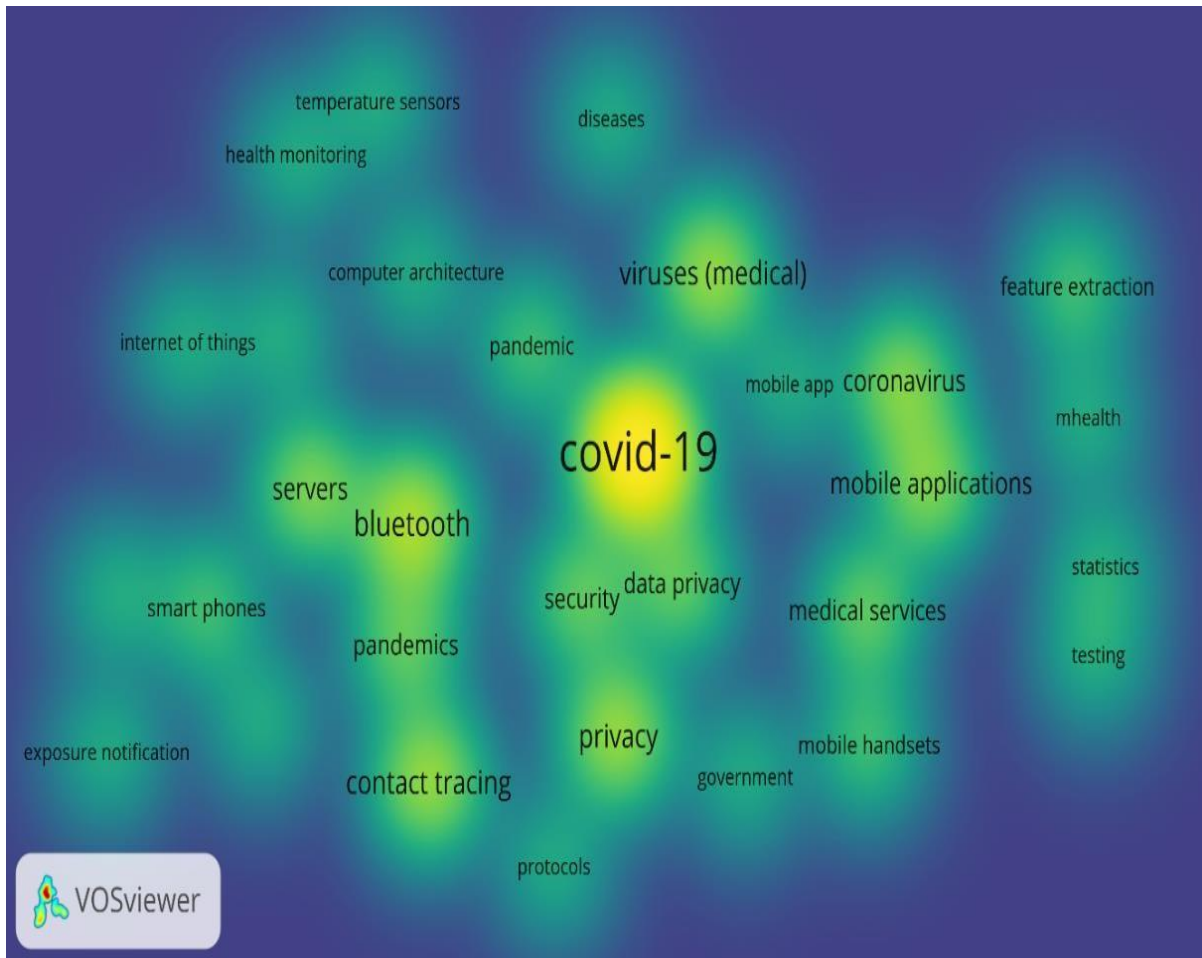
Figure 7 Density Visualization of Co-Occurrence of Keywords

Figure 7 presents a density visualization obtained from the Co-occurrence of Keywords in the VOS Viewer software. The visualization reveals that keywords such as COVID-19, SARS CoV2, mobile applications, and humans exhibit a high density, represented by bright yellow areas. This indicates that these keywords have strong relationships with other keywords in the analyzed dataset. The high density of these keywords suggests that there is a significant body of research and literature focusing on the relationship between COVID-19, SARS CoV2, mobile applications, and humans. The density implies that these topics have been extensively studied, and there is a mature and well-developed body of knowledge surrounding them. Researchers have likely explored various aspects of these keywords, such as the impact of COVID-19 on mobile applications, the role of mobile applications in disease control, and the effects of the virus on human health. However, it is important to note that the visualization also reveals that the yellow area, representing high-density keywords, is relatively smaller compared to the green area. The green area suggests a lower density of keywords, indicating that there are several research fields or topics that are less mature or less well-developed. This information suggests that while there is a substantial amount of research on the core topics represented by the yellow area, there are numerous other research fields that are still in their early stages or less explored. The green area highlights areas where further research and development are needed to expand the understanding and knowledge base. To gain further insights into the methodologies, outcomes, and limitations of the studies, Table 3 provides a clear depiction for comparison. This table likely presents a comprehensive overview of different research methodologies employed, the resulting outcomes, and any identified limitations or challenges. Analyzing this table can provide a deeper understanding of the research landscape and help identify gaps or areas for improvement.

3. Discussion & Conclusion

A systematic review of COVID-19 mobile apps used and evaluated in published research studies in the scientific literature. Our literature search revealed a significant period of time (December2019 to June 2022), demonstrating great scientific interest in the research on Mobile app for COVID-19. Our main finding is that even though current research is based on the studies of applications which has proven to contribute inCOVID-19 risk assessment are still needed to be developed.

The studies are more prominent in the advent of the pandemic crisis which are more focused on the contact tracing than that of early diagnosis or risk assessment [30]. Some studies were more inclined in the direction of prevention such as face recognition and digital proximity [21,22]. The frequency of experimental design in the study was found more prominently in understanding the applications where the symptom assessment was the main feature. More Rigorous Methodology Shows Mobile Apps Are Beneficial to Citizens and Health Professionals and Decision makers dealing with the COVID-19 pandemic. Especially mobile apps help with this solving multiple challenges related to COVID-19 by broadening the range of information that can be trusted by both parties. Citizens and health professionals to reduce misinformation and confusion, track symptoms, civic mental health, home surveillance and isolation, discovery of new predictors, optimization, allocating medical resources and reducing the burden on hospitals.

The studies are more focused on the symptom assessment and remote health care, followed by contact tracing and mental health and finally risk assessment. The studies implied lot survey-based research to check the functionality and the usability of the application, risk assessment was not very predominantly found in these studies. The co-author matrix among the studies is low and there few significant clusters found working on the development and testing the contact tracing, symptom assessment and menta wellbeing applications. The co-occurrence of the keywords is more focused on COVID-19 and contact tracing than the other keywords on density visualization. The global distribution of the studies in quite sparse and the high number of studies were found in Europe than the other parts of world. The studies that have answered the first research question aboutthe role of mobile application in the COVID-19 are [22,24,26,32,33,38,39] where the different roles of mobilephone application were studied for diagnosis and contact tracing the roles played are for collection of epidemiological, biographical, and real time symptomatic data. The studies that have supported the second research question about risk assessment [30] and prevention [27,28,29,31,36,41] are focused on developing application for assessing the user's health status to find the percentage of risk and for remote surveillance of users' health status for early recognition and prevention. The final question about most used and popular applications were studied [20,21,23,25,34,35,37,38,40] based on the number of users and the complications that have been associated with it and the surveys conducted on the trust of the application use.

Some the studies health professionals to understand the diagnosis and symptom-based assessment along with the patients especially in remote health care while the mental health applications where more focused on the younger generation and students. Our review contrasts with others that have not investigated COVID-19 reviews. A mobile app in practical research [8] found that the majority of included studies are not expensive.

Methodical quality, mainly due to its observational nature that may be the reason for this. The fact that the COVID-19 pandemic crisis has generated an international call for rapid response and development of digital health tools by the research community. Our literature search was performed on a limited number of bibliographic databases (Pubmed, Scopus, MDPI and IEEE databases), but these were widely used worldwide. Therefore, useful, and effective apps may not be included in this review study due to the limited quality of relevant studies. The systematic review includes the studies from the advent of pandemic until now and provides an overview of the development of the applications especially for risk assessment which is not prominently worked on and needs further evidence and research for development.

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