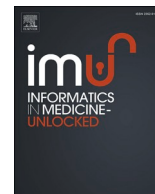




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Applications, features and key indicators for the development of Covid-19 dashboards: A systematic review study

Akram Vahedi^a, Hamid Moghaddasi^a, Farkhondeh Asadi^{a,*}, Azam Sadat Hosseini^a, Eslam Nazemi^b

^a Department of Health Information Technology and Management, Faculty of Paramedical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran

^b Computer Engineering Faculty, Shahid Beheshti University, Tehran, Iran

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ABSTRACT

Introduction: Interactive dashboards can collect data from various information sources and be used nationally and internationally. These information systems have played an important role in managing and controlling epidemic diseases, especially Covid-19. This study aimed to identify the applications, features, and key indicators of advanced dashboards in Covid-19.

Method: The present article is a systematic review study that searched the PubMed, Scopus, and ISI web of sciences databases in 2021 by combining the relevant keywords. After applying the inclusion and exclusion criteria and selecting articles, data collection was prepared using a data collection form. Data analysis was performed using the content analysis method.

Results: Out of 171 articles retrieved, 19 were included in the study for review by applying inclusion and exclusion criteria in the first stage. The most important data sources for the studied dashboards included general online, national, and hospital databases. Monitoring and tracking in the target community and resource management (hospital and public) are the most important issues in Covid-19 dashboards. The study showed that KPIs in 5 main categories of indicators related to hospital beds, clinical data in the hospital, diagnostic and therapeutic measures of hospitals, epidemiological data at the level community, and follow-up indicators of Covid-19 studies were worldwide.

Conclusion: Considering the technological advances at the world level and the large amount of data produced, one of the effective solutions for managing and controlling epidemic and pandemic conditions and diseases is the rapid development of interactive dashboards; Therefore, it is suggested that health officials and policymakers, in addition to developing and updating the existing dashboards in the field of Covid-19, developing the dashboard immediately in case of similar conditions.

1. Introduction

Covid-19 was declared an epidemic disease by the World Health Organization (WHO) on March 11, 2020 [1]. The management of this crisis requires policy-making, coordination, and coherence in implementation, centralized information, organization, continuous monitoring, and management of crisis medicine [2]. Crisis management in this area requires reliable information for appropriate decision-making. Providing accurate and reliable information is one of the most important policy strategies for control and preventive measures concerning the disease [3].

Due to the impact of Covid-19 disease worldwide, different countries

have implemented various programs and policies in various dimensions such as health, policy, and management to deal with it. One of the most effective and widely used solutions for managing Covid-19 is information technology [4,5]. Covid-19 data management using information technology can be made available to managers and policymakers by providing online information to help make evidence-based decisions, effectively manage the disease, reduce its effects and consequences at the community level, and ultimately reduce mortality and eradicate it to play an effective role [6–9]. Dashboards are one of the most widely used information technologies in Covid-19 management [10,11].

Dashboard is an intelligent and analytical tool that collects data from various information systems and presents them in a concise,

* Corresponding author. Shahid Beheshti University of Medical Sciences and Health Services, Faculty of Paramedical Sciences, Tehran.

E-mail address: asadifar@sbmu.ac.ir (F. Asadi).

comprehensive, meaningful, and intelligent way using visual features in the form of key performance indicators for faster decision making so that managers to be able to take a brief look at the current situation in terms of whether the evaluation performance is desirable or undesirable, identify existing problems and analyze their root causes, and finally, improve their performance [12,13]. For this reason, various dashboards have been designed and used in the world to deal with this disease in a limited period. Dashboards effectively integrate and properly disseminate information as part of decision support systems [14].

Dashboards, by providing up-to-date, accurate, and concise information through data mining technologies, can provide management reports to stakeholders in the shortest possible time, thus reducing decision costs and increasing managers' decision-making power, and reducing medical errors by providing a better relationship between the decision-making process and quality improvement in the field of health [15–17]. Therefore, the development and maintenance of dashboards are essential to measuring performance, improving decisions, evaluating and managing a comprehensive range of health care provided to patients, and providing management services [15]. Due to the need to use dashboards in the last two years, many studies have been conducted on the design and use of dashboards in the face and control of the Covid-19 pandemic. In the study by Ivanković et al., 158 designed dashboards during the outbreak of Covid-19 were identified and examined to control and manage the disease worldwide (in 53 countries). Government organizations developed 63% of dashboards, and 58.9% are operated nationally. Although all the dashboards studied included epidemiological indicators, a limited number of them stated their main purpose and intended users. Only 7 of the dashboards addressed the social and economic indicators of individuals. Almost a quarter of the dashboards studied did not report their data sources [18]. In a study by Dixit et al., a regional dashboard was designed in the United States in 2020 to rapidly design a dashboard to raise awareness of the use of telehealth in covid-19 in a multi-hospital health care system [19]. Florez et al. designed and implemented a dashboard to assess the incidence and mortality of Covid-19 internationally and noted the positive impact of its use in the control of Covid-19 [20]. In another study, Ibrahim et al. conducted a study to develop and use a clinical intelligent dashboard for frontline physicians to optimize important resources along covid-19, which could interact and receive information from the electronic health record (EHR) [21]. Considering that many studies have been conducted in the design and use of dashboards about Covid-19 worldwide, the present study has been conducted to identify the applications, features, and key indicators of covid-19 dashboards.

2. Methods

The present study is a systematic review conducted in 2021 based on the PRISMA Statement [22].

3. Search for source

To access electronic search resources in three scientific databases, PubMed, Scopus, and ISI Web of Sciences, was conducted from 2019 to 2020. The combination of keywords in # 1 and # 2 in Table 1 was used in various forms to find the articles related to the study.

Table 1
Resource search strategy.

Time limitation	2020 - present
language	Full text in English
#1	"Dashboard*" OR "interactive dashboard" OR "control panel" OR "indicator panel"
#2	"COVID-19" OR "Covid" OR "SARS-COV-2" OR "corona virus"
Strategy	#1 AND #2

4. Inclusion and exclusion criteria

All conducted studies on the design and use of interactive dashboards to deal with Covid-19 were included in the study. The selected studies were original research articles in English. Articles related to other dashboards (non-interactive) and monitoring systems were excluded. Dashboards related to other diseases and epidemics were excluded from the study. All articles published in languages other than English were excluded. Review articles, letters to the editor, short articles, case reports, and other reports were excluded from the study.

5. Data collection

Data collection was performed using a data extraction form from the articles included in the study. The relevant form has three main sections: a) Bibliographic information of the articles including the title of the article, the name of the journal, the names of the authors, the year of publication of the article, and the country b) Features of dashboards in studies including dashboard subject, dashboard-type and software were used for dashboard development and c) The content of the dashboards in the studies included key performance indicators and the most important results from the use of the dashboard. Data collection was done by two researchers independently, and in case of any discrepancies, the third person was referred, all three were discussed, and the consensus was reached.

Quality assessment of studies has been done by Newcastle-Ottawa Scale (NOS) as a standard tool for assessing the quality of observational studies [23] with some modifications for health information systems quality of studies assessment [24]. Based on the assessment that was done by the authors the selected studies have the quality for including in the review.

6. Data analysis

After collecting the data, using the content analysis technique, the study data were analyzed and summarized and reported based on the objectives of the study.

7. Results

Out of 171 articles found in the first stage of the search, 19 articles were finally included in the study by applying inclusion and exclusion criteria (Fig. 1).

The information and characteristics of the articles included in the study are shown in Table 2. This table shows the year, country, type of software used for development and visualization, dashboard interactivity status, the main purpose, and the most important study findings.

According to Table 2, the findings of the study showed that 15 of the dashboards used were developed in 2020, and the rest were from 2021.

Fig. 2 shows the activity level of Covid-19 dashboards, which were mostly related to national dashboards (68%).

Other findings of the study showed that most of the studies were in the United States (4 studies), Canada (3 studies), Iran, and Spain (each with two studies).

Eleven studies (57.90%) were developmental, and eight (42.10%) were descriptive studies.

All dashboards related to data visualization have been done using graphs and geographical maps, and in many dashboards related to increasing the quality and accuracy of data presentation, a chart has been provided for each index [29].

According to Fig. 3, the data sources of Covid-19 dashboards are divided into five main categories. Hospital data sources include laboratory information [28] and electronic health records [21].

According to Fig. 3, the most important data source for the studied dashboards is public online databases (national and international) (31.58%). In one case, depending on the type of dashboard, the

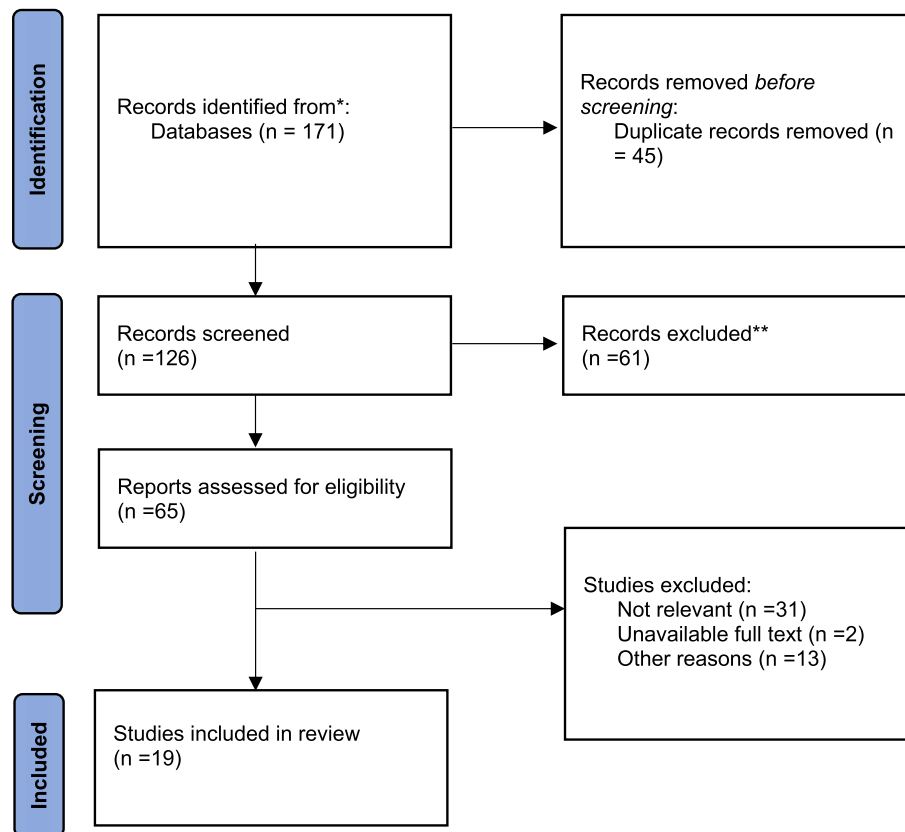


Fig. 1. The process of selecting related articles.

dashboard data source was the RCT registries of different countries [31].

Although within all dashboards, the issue of monitoring the emerging disease of Covid-19 has been considered by designers and system manufacturers, but according to Fig. 4, the main topics of dashboard development fall into five main categories.

According to Table 3, the key indicators of the studied dashboards are divided into five categories, which also show the definition of the indicators of each category and the purpose of using the indicators.

According to Table 3, each item in the indicator definition column has several indicators and calculation methods that their details are not discussed in the articles and are not included in the study objectives.

Other results of the study showed that the most used software for the development of dashboards was the use of the R language and the use of the Shiny capability, and the most important software for receiving data was Excel software.

8. Discussion

After the widespread spread of Covid-19 worldwide, various strategies were adopted to deal with it, and various sciences were used for this purpose. Undoubtedly, information technology is one of the most advanced sciences for dealing effectively with Covid-19 [5]. One of the most effective IT-based solutions that were quickly used by many countries globally was the development and use of different types of dashboards [18,20]. The present study results showed that most of the studied dashboards were created in the first months of the outbreak in the design countries. The use of information dashboards at the beginning of the outbreak plays an important role in empowering managers and officials at different levels of management to make appropriate and effective decisions and encourages managers to make evidence-based decisions. It is suggested that further studies be conducted on the design of dashboards and dashboard manufacturing tools to provide a basis for further development of these tools for possible future epidemic

and pandemic conditions.

Covid-19 dashboards updated the information during this pandemic by providing disease-related information to the general public and raising awareness of the prevalence. They were introduced as a tool to tackle Covid-19 [4–6]. Another point that can be mentioned as the role of the dashboard in the face of Covid-19 is to help track infected areas and report the disease prevalence to different level managers and policy-makers using different tables and graphs. These user-friendly tables and graphs can be used to evidence-based decide to deal effectively with Covid-19 [19–21] quickly. For this reason, it should pay attention to all the technical and content aspects of the dashboard so that these features can be fully used.

Another part of the study indicates that most of the dashboards studied are national, and the rest are local (hospital, multi-hospital, or in a specific area) or international. Due to their nature, national dashboards can be effective in managerial and health aspects [31]. Its various users can obtain their information at the national level and specific regions. International dashboards also work to monitor the status of the disease at the international level and use public databases, and provide valuable information to officials in those countries and regions where dashboard development is not possible. It seems that the development of dashboards at all three levels is regional, national, and international, and each of them has its nature and tasks.

Visualization and proper reporting of data and information in information technology tools [41] and especially dashboards are among the aspects emphasized in their design and evaluation [42]. The results of the study of Covid-19 dashboards indicate that in the design of these dashboards, special attention is paid to the visualization of data and in addition to selecting and using different graphs according to the nature of the disease from geographical maps to show disease distribution and indicators A related key is also used; In addition to meeting the needs of managers and policymakers to be responsive to the general public.

Other findings from the study show that online public databases are

Table 2
Characteristics of included studies.

Item	First author	Year of publish	Country	Software used	interactivity	Main purpose	Results
1	Obda [25]	2021	Spain	Matlab (LHM algorithm)	✓	Monitoring information about hospital beds to manage beds	Using the management dashboard improves the management of hospital beds in different disease peaks
2	Godari [26]	2020	Iran	QlikView, Excel	✓	Management dashboard design	In the diagnostic dashboard, epidemiological background, clinical signs, chest CT images, laboratory diagnosis, and the monitoring dashboard, statistics related to patients, age, gender, and time of their infection were determined as functional indicators.
3	Wissel [27]	2020	United states	–	✓	Develop a registry to deal with emergencies	Collect up-to-date data from various sources and use it in dashboards to help monitor data to predict future epidemics and pandemics
4	Dixit [19]	2020	United states	Tablea, Excel	✓	The rapid development of a dashboard to raise awareness of mobile health usage status in covid-19 in a multi-hospital healthcare system	A dashboard was designed with high visualization capabilities based on user needs. Special purpose dashboards were designed to meet the needs of users.
5	Maury [28]	2021	Swiss	R Shiny, Excel	✓	Assist in managing the performance of diagnostic laboratories	Key indicators were divided into five categories: 1) General and gender-related indicators, 2) Number of tests, 3) Cycle threshold and viral load, 4) Duration of the test, and 5) Invalid results
6	Beltrán [29]	2021	Spain	R Shiny	✓	Its main purpose was to facilitate visualization, interpretability, and comparison in different data directions with different natures according to different times and places.	Interdisciplinary dashboard, area sensitive, history sensitive, flexible, downloadable, and easy to use
7	Yie [30]	2021	Taiwan	Google map Excel	✓	The purpose of the dashboard design was to help complete the study, which was designed to analyze social networks to identify patterns of spatial-temporal dispersion during the Covid-19 outbreak.	This dashboard has been created for the geographical representation of different regions with the help of Google Map and shows the clusters created by regions.
8	Thorlund [31]	2020	Canada	–	✓	Designed to centralize and enable up-to-date and timely analysis	Uses artificial intelligence to collect clinical data of clinical trials performed in the field of Covid-19 worldwide
9	Florez [20]	2020		Download data from Excel files for development from PHP and JavaScript	✓	To assess the incidence and mortality of Covid-19	Mathematical models are proposed for predicting morbidity and mortality in different countries
10	Maghdid [32]	2020	Iraq	HTML5, PHP, JavaScript, and google Map API	✓	To provide plans to policymakers to implement quarantine to be effective in these economic conditions. The dashboard has been compiled to predict the level of quarantine areas based on location and distance data.	This dashboard was designed as a basis for the main purpose of the study, which was to monitor and track patients.
11	Arora [33]	2021	Canada	–	✓	A dashboard that systematically monitors and analyzes global findings from Covid-19 serological studies.	This dashboard provides a comparative world map of studies conducted in different study groups and regions. Furthermore, does the work in a systematic live search and searches the Medline, Embase, Web of Science, and Cochrane databases.
12	Marvel [34]	2020	United states	–	✓	Visualize key vulnerability Stimulants, historical trend data, and quantitative forecasts to support local decision making	Epidemiological modeling and machine learning predictions have been used in dashboard development.
13	Ibrahim [21]	2020	United Arabic Emirates	Microsoft Power BI and Cerner Computer Language (CCL)	✓	Development and use of clinical intelligent dashboards for front-line physicians to optimize vital resources during Covid-19	The dashboard enables physicians to effectively assess patient size and severity to prioritize clinical care and allocate scarce resources appropriately. The dashboard can be replicated by developing health care systems that continue to struggle with the epidemic. Receives 55 fields of information from the EHR

(continued on next page)

Table 2 (continued)

Item	First author	Year of publish	Country	Software used	interactivity	Main purpose	Results
14	Wimba [35]	2020	Congo	R software	✓	Monitoring preventive measures in response to the outbreak of COVID-19 in the Democratic Republic of the Congo	The color coding pattern is used. Username and password are defined for individuals. They have real-time access to data that helps fight the epidemic. The findings of this pilot study called for rapid public awareness measures to support national media-based prevention campaigns.
15	Lin [36]	2020	Canada	Shiny	✓	Monitoring the prevalence of Covid-19 in Canada	It allows users to monitor the prevalence of the disease by looking at the data
16	Pellert [37]	2020	Austria	API, web-scraping to retrieve the data	✓	Develop a dashboard that displays processed data from three different sources to track emotions on Austrian social media during COVID-19.	Combined methods and experiences of other dashboards have been used to develop this dashboard.
17	Wise [38]	2020	England	-	✓	Provide data and information online and promptly to researchers and other stakeholders	Tasks This dashboard detects, tests, tracks, isolates, and supports - and identifies areas that need more data. This dashboard provides key metrics using charts and bar charts and is constantly updated, and allows users to access regional data.
18	Salehi [39]	2020	Iran	R Shiny	✓	It introduces a useful online interactive dashboard that visualizes and tracks Covid-19 verifications in real-time.	Provides an online statistical program, which aims to make reasoning a large amount of data collected during the COVID-19 epidemic for academic and general consumers.
19	Al-Jazairi [40]	2020	Saudi Arabia	For web publishing, common standards such as HTML, CSS, and JavaScript (Oracle Corporation), JSON, Bootstrap, JQuery, Chart.js, and Data Tables	✓	Determining the performance of the Pulmonary Drug Care Dashboard during the Covid-19 era in a complex healthcare environment	Reasoning large amounts of data. Creating a dynamic and semi-realistic pharmacy dashboard in unstable conditions such as those that arose during the COVID-19 epidemic can be very helpful in managing the outpatient pharmacy workload.

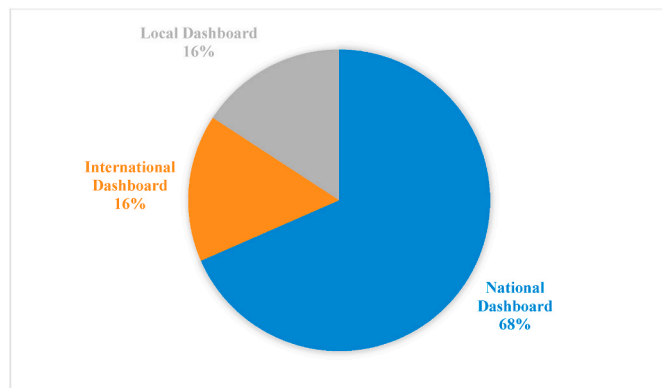


Fig. 2. Activity level of Covid-19 dashboards.

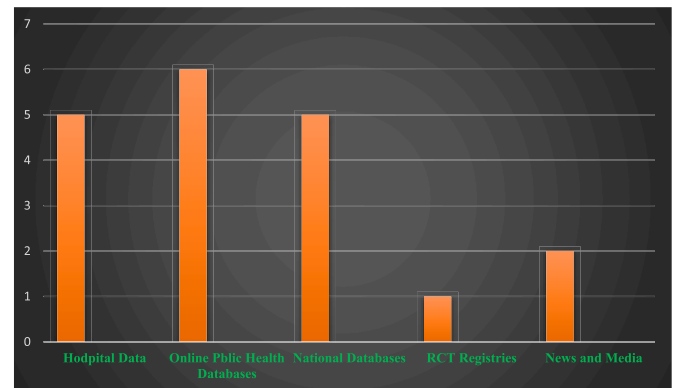


Fig. 3. Data sources for COVID-19 dashboards.

the most important data source for Covid-19 dashboards. Due to the large amount of data generated and easy access to these data sources, many national and international dashboards were developed to help control the epidemic. One of the data sources used in two dashboards is news and media data. It is suggested that these reliable, free and available data sources be used more to develop dashboards in the field of pandemics and epidemics. Possible future, because it will provide more accurate information about the state of society at the time of the outbreak of the disease.

Although disease monitoring is a major issue and the main goal of the development of Covid-19 dashboards, other issues that were considered in the development of dashboards were diagnosis and monitoring, resource management at the hospital level and other higher levels of service, monitoring studies conducted in the field of Covid-19 nationally

and internationally and public and private information. Paying attention to the subject of studies conducted and ongoing by covid-19 in research dashboards can provide relevant and practical information to researchers and policymakers.

The most important part of the development of dashboards is identifying and selecting performance key indicators [41]. Findings of the study showed that the performance key indicators of Covid-19 dashboards include indicators related to hospital beds, epidemiological data in the hospital (information of patients referred to the hospital due to Covid-19), diagnostic and therapeutic measures of hospitals, general epidemiological data (statistics beyond a hospital or diagnostic and treatment center) and indicators of studies conducted in the field of Covid-19 worldwide. Appropriate management can be applied to hospital beds in different wards using the indicators related to hospital beds.

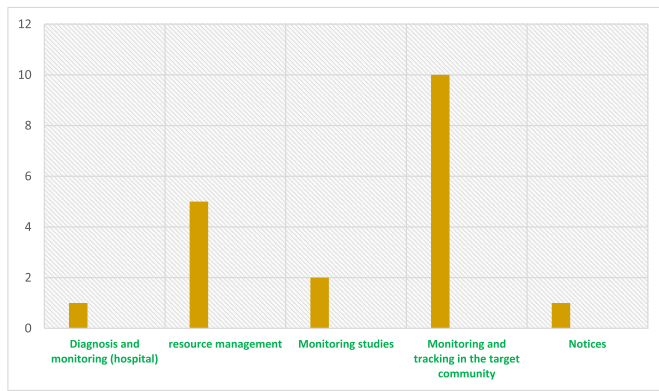


Fig. 4. The main topic in the design of dashboards.

Table 3

Indicators used in Covid-19 dashboards.

Item	The main category of indicators	Definition	Purpose of indicators
1	Indicators related to hospital beds	Hospital beds based on peaks (as an amount and percentage), bed occupancy status in normal and special wards	Management of hospital beds at the hospital and district level
2	Indicators of epidemiological data in the hospital	Incidence and mortality Indicators (based on the identity information of the recovered in the hospital and by wards) (as a percentage)	Monitoring the disease status in hospitals for hospital management and reporting to higher authorities
3	Indicators related to diagnostic and therapeutic measures of hospitals	Indicators such as diagnostic measures (including laboratory measures, number of tests, test results (positive, negative, suspicious, etc.), results of measures, treatment measures (such as telehealth)	Status of measures taken in hospitals to combat Covid-19
4	Indicators of general epidemiological data	Indicators such as morbidity and mortality at the community level, recoveries, disease trends, demographic indicators, population concentration, infection rate, health, and environmental vulnerabilities, travel history, time trend, care information provided	Monitoring the disease status at the community level
5	Indicators of studies conducted in the field of Covid-19 worldwide	Indicators related to the subject of studies, the spatial distribution of studies	Monitoring Covid-19 studies worldwide

Patients in need of hospitalization should be directed to hospitals with empty capacity to finally avoid the crowding of waiting patients and thus reduce the waiting time. The report of indicators related to epidemiological data and indicators related to diagnostic and therapeutic measures can indicate the performance of hospitals and other service centers in the face of the disease, whether at the level of one hospital or several hospitals (provincial, regional, and country) to be used [21,26]. The study results showed that in the hospital dashboards of Covid-19, the mentioned indicators could be effective in the appropriate management and allocation of resources. It is recommended to develop

dashboards despite the data generated in hospitals and other care centers such as laboratories.

Our study showed that the general epidemiological indicators are the widest category of indicators of Covid-19 dashboards. One of the notable findings of the study is the presentation of indicators in the field of studies conducted or ongoing in the field of Covid-19 worldwide, which focus on RCT and serological studies [31]. The use of these indicators provides valuable information to researchers.

The choice of health software development technology will be one of the success factors of these systems [42]; in the present study, the most important software for the development and visualization of Covid-19 is R-language and Shiny dashboard design software. However, Python, MATLAB, QlikView, and Tableau software were also used. Due to the nature of the R programming language in visualizing data and the high capabilities of Shiny, the use of these tools to design dashboards is recommended.

9. Conclusion

The results of the study showed that the most important applications of Covid-19 dashboards are their use for managing hospital beds to allocate them to patients in priority and need of hospitalization, monitoring the community based on epidemiological data for macro decisions at the national level and regional, review of the performance of hospitals and the number of services provided to allocate resources commensurate with their performance and monitoring of recent scientific studies and findings in this field. One of the most important features of the studied dashboards was focusing on the national level and interacting with information resources and other similar dashboards. The main topics of interest for the designers of Covid-19 dashboards included diagnosis and monitoring, resource management, monitoring studies, disease monitoring in the community, and information at various specialized and general levels.

Considering the study results and the role of dashboards in tracking the prevalence of the disease in different communities and regions, it is suggested to use this program more widely in the field of tracking the disease and similar epidemic and pandemic situations. Given that the present study has examined all the important aspects of Covid-19 dashboards over a year of its prevalence, the results of the study can be used to upgrade existing Covid-19 dashboards and develop new dashboards in the field of epidemics and possible future pandemics to be used by policymakers and designers of Covid-19 dashboards.

Ethical approval

IR.SBMU.RETECH.REC.1399.1162.

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This study was extracted from a Ph.D. thesis approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences.

Guarantor

Farkhondeh Asadi.

Author contributions

A.V and F.A conception and design of the study, A.V and A.H acquisition of data, A.V and H.M analysis and interpretation of data, A.V, A.N and F.A drafting the article and revising it critically for important intellectual content, A.H, H.M and F.A final approval of the submitted version.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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This study was extracted from a Ph.D. thesis approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.RETECH.REC.1399.1162).

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