# Epidemiologic surveillance for controlling Covid-19 pandemic: types, Challenges and implications

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## ARTICLE INFO

## ABSTRACT

The objectives of the study was to determine the types, challenges and implications of surveillance methods for controlling Covid-19 pandemic. An integrative article review was done. The source of data were documents from WHO, Euro-surveillance, CDC, Saudi CDC, MOH, and journals from PubMed, Medline, etc. The inclusion searching criteria were surveillance, Covid-19, types, benefits and challenges, during the period 2005−2020. Published studies, reviews and guidelines that determined these criteria were collected. Data extraction and analysis were completed for all included articles. A critical appraisal was done based on the University of Michigan Practice Guideline's levels of evidence. The final sample for the integrative review comprised 30 studies. Results revealed that types of Covid-9 surveillance includes routine surveillance (comprehensive, case-based, and aggregated weakly methods), active, wildlife, syndromic, sentinel and sentinel-syndromic methods. Laboratory and hospital-based surveillance are another important types. Help-lines, surveys, participatory electronic, digital and event-based surveillance are relatively new cost-effective methods. Many surveillance indicators can be calculated. Timely and accurate of surveillance data is an essential element for effective Covid-19 interventions. Regarding challenges, the quality of surveillance in developing countries is constrained by resources and training. The main limitations of surveillance are under-ascertainment/under-reporting, lack of timeliness and completeness of surveillance data. In conclusion, surveillance is a cornerstones for controlling Covid-19 pandemic. Enhancing Covid-19 surveillance is vital for rapid cases detection, containing spread & ending pandemic.

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## Introduction

Currently, the whole world is straggling and facing the era of eco-epidemiology. There is emerging and re-emerging of numerous devastating infectious agents. The emerging viral zoonotic diseases outbreaks are growing in number. Severe Acute Respiratory Syndrome (SARS), H5N1, influenza A / H1N1 pandemic, and Middle East Respiratory Syndrome Coronavirus (MERS-CoV) are among such infections. All of these infections and others had serious public health implications [1].

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) causing Covid-19 is one of the most important devastating emerging infectious diseases, nowadays. Covid-19 was classified as a public health emergency of international concern (PHEIC) on 30 January 2020 [2]. Then, it was characterized as pandemic by the WHO on March 11, 2020. SARS-CoV-2 was also classified as "Risk Group 3" pathogens as it carries a very big risk to the community due to its effect on health and the global economy [3,4]. Covid-19 pandemic leaves huge devastating burdens on health, lives, economy, with restriction of the whole populations' societal activities worldwide [5,6]. It causes a global health and economic crisis; with countries shutting their borders and issuing travel bans, closing schools and businesses, imposing strict quarantines, and more [3].

Several factors participated in occurrence of Covid-19 pandemic. Firstly, the global spread of the new SARS-CoV-2 (without previous human exposure or immunity). Secondly, SARS-CoV-2 as an RNA virus exhibits high mutation rates that allow rapid diversification at the cost of generating non-viable descendants [3]. In addition, the virus transmission rate or its basic reproduction number ($R_0$) is high [4]. Furthermore, up to date, no effective treatment nor vaccine exists for Covid-19 [3].

The cornerstone of any prevention and control measures is the epidemiological surveillance. Surveillance is "the ongoing systematic collection, analysis, interpretation and dissemination of data regarding a health-related event; for doing actions". Surveillance is a critical part of public health practice [7]. Real-time analyses of epidemiological data are urgently required for increasing the awareness about the problem and for prompt interventions [8]. Identification of the newly suspected or confirmed Covid-19 cases is an essential element for effective public health interventions, and for prevention of future pandemic [9].

Covid-19 surveillance involves monitoring the spread of the disease in order to identify the patterns of progression, and for application of preventive and control measures [10]. In spite of the efforts for enhancing epidemiological surveillance, developing nations still have difficulty in accurate identification, diagnose, and reporting such communicable diseases [11].

A study conducted using a susceptible-exposed-infectious-removed (SEIR) model to estimate Covid-19 epidemiological parameters before the implementation of preventive measures in Wuhan, China. Results revealed that if the measures had been started 1, 2, or 3 weeks earlier, the cases could had been reduced by 66%, 86%, and 95%, respectively [12], These findings magnify the importance of surveillance in controlling Covid-19.

There are many benefits for applications of sensitive surveillance system for controlling and ending Covid-19 pandemic. However, there are challenges for its application, especially in the developing countries. Limited number of state of arts were conducted about Covid-19 surveillance. So, such review is urgently required.

**The objectives of the study was to** determine the types, challenges and implications of surveillance methods used for controlling Covid-19 pandemic.

## Methods

An integrative review was conducted. The method of the current integrative review included articulation of the problem regarding surveillance of Covid-19, completion of a well-defined literature search, evaluation of the quality of data, analysing data, and presentation of conclusions. The first step is a clear identification of the problem epidemiological surveillance and Covid-19. Literature search was clearly addressed subjects such as search terms, the sources used, and the inclusion and exclusion criteria. The sources of information were documents from WHO, Euro-surveillance, CDC, Saudi CDC, MOH and journals through search on PubMed & Medline. The search included surveillance, Covid-19, magnitude, indicators, challenges, and benefits (implications). Regarding the inclusion criteria, published guidelines, reviews, studies that assessed surveillance system and surveillance in Covid-19 during the period from 2005 throughout 2020 were selected. Other articles were excluded. For evaluating, grading quality of the included articles, the University of Michigan Practice Guideline's levels of evidence Evidence-Levelling Hierarchy was used for grading of evidence. In the data analysis process, data are ordered, catego-

**Table 1**
A summary of reviewed surveillance articles.

| Author, year | Objectives | Methods | Level of evidence |
|---|---|---|---|
| 2. Rodriguez-Morales AJ, et al, 2020. [2] | To summarize the clinical, laboratory, and image features, outcome of, risk factors, and comorbidities of COVID-19 confirmed case (from current available observational studies). | A systematic review and meta-analysis | A |
| 1. Helmy YA, et al. 2020L. [1] | To provide the most recent information about SARS-CoV-2. | Review | D |
| 3. Schröder I. COVID-19: 2020. [3] | To explore why COVID-19 is able to progress to a global pandemic that affects our daily lives to an extent not known in recent history. | Review | D |
| 4. Sohrabi C, et al. 2020[4] | To summarize the current state of knowledge surrounding Covid-19 | WHO review | D |
| 5. Kummitha RKR. 2020[5] | To determine how governments in China and Western democracies differ in their technological response to control the transmission of the pandemic. | Review | D |
| 6. Bong C–L, et al. 2020. [6] | To outline the problems facing all countries in response to Covid-19, especially those with serious economic and health resource challenges, and possible ways to address them. | Review | D |
| 7. Ibrahim NK, Al Bar HM. 2009[7] | To assess health facilities' performance and health workers' knowledge of surveillance activities for childhood vaccine-preventable diseases. | Quantitative, cross-sectional analytical study | C |
| 8. Sun K, et al. 2020. [8] | To describe efforts to compile and disseminate epidemiological information on COVID-19 from news media and social networks. | Quantitative, Population-level observational study, | C |
| 9. Fan C, et al. 2020[9] | To estimate the distribution and scale of the migrants residing in Wuhan after they returned to their hometown communities in Hubei Province or other provinces after the 2019-nCoV outbreak. | Quantitative, Quasi-experimental analysis | B |
| 10. WHO. 2020. [10] | To update Covid-19 case definition, define transmission pattern, revise the definition of a contact and update on global surveillance with aggregated data reporting | Guideline | D |
| 11. Prieto JT, et al. 2017[11] | To evaluate the quality and characteristics of electronically collected data, the user acceptability of the symptom reporting platform, and the costs of running the system and of identifying ILI cases, and to use the collected data to characterize cases of reported ILI. | Quantitative, Follow-up study | B |
| 12. Ricoca Peixoto V, et al. 2020[12] | To present and discuss early evidence on under-ascertainment of COVID-19 and its motifs, options for surveillance, and reflections around their importance to tailor public health measures. | Review | D |
| 13. ECDC; 2020.[23,13] | To purpose an updated strategy for COVID-19 surveillance at national and EU/EEA level that specifically aims to reconcile the data needs for effective pandemic response with what is still feasible in countries and within healthcare systems under siege, while taking into account guidance issued by the World Health Organization | Report from Euro-surveillance | D |
| 14. WHO. 2020. [14] | To provide an overview of surveillance strategies that Member States should consider as part of comprehensive national surveillance for COVID-19. | WHO's report | D |
| 15. Spiteri G, et al. 2020 [15] | To give details about the epidemiology of the first European cases of Covid-19. | Quantitative, Retrospective study | C |
| 16. Pung R, et al. 2020 [16] | To report data for the first three clusters of COVID-19 cases in Singapore, the epidemiological and clinical investigations done to ascertain disease characteristics and exposure types. | Quantitative, Prospective cohort | C |
| 17. CDC. 2020 [1,17] | To monitor the spread and intensity of the pandemic, to enable contact tracing to slow transmission, and to identify disease clusters, to understand severity and spectrum of disease, identify risk factors and methods of preventing infection. | CDC's report | D |
| 18. Pal M, et al. 2020 [18] | To update the history, genetics, epidemiology, modes of transmission, pathogenicity, clinical features, laboratory diagnosis, public health implications, economic impact, treatment, control, and prevention of SARS-CoV-2. | Report | D |
| 19. Udugama B. [19,2]. | To summarize the current known biological properties of SARS-CoV-2, diagnostic tools and clinical results for detecting SARS-CoV-2, emerging diagnostics, and surveillance technology to curb the spread. | Report | D |
| 20. CDC. 2020. [20] | To highlights guidance and recommendations for evaluating and identifying patients who should be tested for COVID-19 | CDC report. | D |
| 21. Zwald ML, et al. 2020 [21] | To conduct rapid Sentinel Surveillance for COVID-19 — Santa Clara County, California, March 2020 | Quantitative, Follow up, Experimental study | B |
| 22. de Lusignan S, et al. 2020 [22] | To identify whether there is undetected community transmission of COVID-19, estimate population susceptibility, and monitor the temporal and geographical distribution of COVID-19 infection in the community. | Quantitative,Experimental study | B |
| 23. Eurosurveillance 2020. [23] | To provide regularly updated information on coronavirus disease-2019 (COVID-19) | Guideline from Eurosurveillance | D |
| 24. Ng Y, et al. 2020. [24] | To analyse the first 100 COVID-19 patients in Singapore to determine the effectiveness of the surveillance and containment measures. | Quantitative,Follow-up study (retrospective) | C |
| 15. Saudi MOH, SCDC, 2020. [25] | To provide guidance on COVID-19 surveillance in healthcare and community settings and enhance rapid detection of confirmed COVID-19. | Guidelines of Saudi CDC and MOH | D |
| 26. Domeika M, et al. 2009 [26] | To present the introduction process of the electronic surveillance system for communicable diseases ULISAS in Lithuania. | Quantitative, Intervention study | B |
| 27. CDC. 2020 (4). [17] | To improve public health surveillance builds on prior progress inside and outside CDC. | CDC Review. Booklets series | D |
| 28. Mahmood S, et al. 2020 [28] | To provide several cases for infection control, home-based diagnosis and screening, empowerment through information, public health surveillance and epidemiology, and leveraging crowd-sourced data. | Review | D |
| 29. WHO. 2020. | To provide an overview of surveillance strategies that member States should consider as part of comprehensive national surveillance for COVID-19. | Guidance document by WHO | D |
| 30. Louis MS. 2012. [30] | To propose a vision for improving access to and sharing of data useful for public health surveillance, identify challenges and opportunities, and suggest approaches to attain the vision. | Report arise from MMWR. CDC | D |

rized, and summarized into a combined and integrated conclusion. Finally, conclusions of reviews was reported in a table. Analysis of different sources was done & presented in three main themes: The first one summarizes the aims and types of surveillance, the second one is about the indicators and implications, and the third part is about challenges and limitation of Covid-19 surveillance. Table 1 demonstrates a summary of the reviewed surveillance articles. It summarize the 30 most suitable articles on surveillance.

## Results

### I Aims and types of global Covid-19 surveillance

a. Aims of Covid-9 global surveillance (according to WHO & CDC) are to [13,14]:

1 Monitor trends of the Covid-19 where human to human transmission occurs.
2 Rapid detection of new cases in countries where the virus is not circulating;
3 Provide epidemiological information to conduct risk assessments at the national, regional and global level.
4 Provide epidemiological information to guide preparedness and response measures.
5 Monitor viral changes to inform drug and vaccine development, and to identify markers of severe infection".

### Additional aims at the national levels are to

1 Detect and contain nosocomial outbreaks to protect healthcare workers and patients.
2 Detect and contain outbreaks in long-term care facilities and other closed communities to protect those most at risk of severe disease and poor outcomes.

**b. Types: there are many types of surveillance can be used in Covid-19** [13]:
**Routine surveillance:** It includes 3 types (Comprehensive, case-based, aggregated routine surveillance) [13,14].

### 1- Comprehensive routine surveillance

This type of surveillance deals with complete testing of all suspected cases. It uses the rate of the number of newly confirmed cases / 100,000 inhabitants. The advantage of this type is that it gives the most accurate indicator of Covid-19 intensity. Furthermore, such type can measure the geographic spread, and severity of COVID-19. This surveillance method can be also monitors trends by time and compare between intra-country data [13]. The challenge facing the application of comprehensive surveillance is the huge cost of testing all suspected cases, considering both the testing capacity, prices, manpower and safety [12]. So, it is impossible to be applied low income, or developing countries.

### 2- Case-based routine surveillance (reporting)

The WHO requests national authorities to report probable and confirmed cases of Covid-19 infection within 48 h of identification. An update of the line-listing needs to be provided immediately as the outcome data being available, within 30 days of the 1st report [13,14]. This surveillance type can be applied by most of the countries. Very low-income countries can apply such type with the assistance of the international organization as WHO or Non-Governmental Organization (NGOs); for providing of laboratory kits, other facilities. The drawback of such type, if applied alone,

is losing opportunity of early diagnosis of many Covid-19 cases, and no measures will be applied for them or for their contacts. This can lead to more spread.

### 3- Aggregated routine surveillance (reporting) (10, 13, 14)

For understanding the epidemiology and trends of Covid-19, all countries are required to provide the following minimum set of aggregate counts once weekly.

*At the national level*

*Weekly number of each of the followings*
a- newly confirmed cases, b- newly case-deaths from Covid-19, c- new cases hospitalised due to Covid-19, d- newly confirmed cases discharged, e- newly confirmed cases tested for Covid-19 by age-group in years, f- newly confirmed deaths by age-group in years [13].

This type of surveillance can be easily applied in most of the countries, even the poor, either by its own or by the help of other agencies. Again, the drawback of such type, if applied alone, is the loss of diagnosis of many cases.

For the 3 routine types, countries should report on a case-by-case basis as far as possible, but in case of limited resources, aggregate weekly reporting is also possible [10,13].

### 4- Active surveillance

It deals with active search for the disease in a certain population. WHO recommends such type of surveillance for case finding, testing, and contact tracing in all transmission cases. All countries need to quickly strengthen Covid-19 active surveillance for fast recognition of the infected persons, and to allow prompt isolation and quarantine [5]. The overall aim of surveillance after the first case of Covid-19 was to support the global strategy of containment measures with rapid identification, follow-up of cases, minimizing transmission [15] and prevent clusters from spreading [16]. Contact and co-exposure identification is done for all recognized possible cases [15]. It is expected to monitor epidemiological trends, rapid detection of the new cases, conduction of risk assessment, and guiding for disease preparedness [10]. It supports the affected individuals and warning their contacts in order to stop Covid-19 cycle of transmission. This surveillance type can be done by training public health workers and volunteers. Through training, the contact tracers identified how to quickly locate and talk with the affected individuals, assist with isolation issues, and identify close contacts and help those who need self-isolation [17]. Such type of surveillance is significant for nations which actively find the cases among contact [16]. In France, for example, contacts are traced from the date of onset of clinical symptoms in the index case [15].

### 5-Syndromic (clinical) surveillance

It means surveillance of health data about the clinical manifestations that has an important impact on health.
As of March 2020, the WHO recommends Covid-19 Case definitions as:
- A suspected case:
A. Patient with acute respiratory illness (fever & at least one sign / symptom of respiratory disease as cough, shortness of breath), AND a history of travel to or residence in a location reporting community transmission of Covid-19 disease during the 14 days prior to symptom onset;
OR

B. Ä patient with any acute respiratory illness AND having been in contact with a confirmed or probable Covid-19 case in the last 14 days prior to symptom onset";

**OR**

C. "A patient with severe acute respiratory illness (fever and at least one sign/symptom of respiratory disease, e.g., cough, shortness of breath; AND requiring hospitalization) AND in the absence of an alternative diagnosis that fully explains the clinical presentation"

*- A probable case*

A. "A suspect case for whom testing for the Covid -19 virus is inconclusive".
OR
B. A suspect case for whom testing could not be performed for any reason.
- A confirmed case:
"A person with laboratory confirmation of Covid-19 infection, irrespective of clinical signs and symptoms".
Laboratory confirmation is done using two samples of real-time polymerase chain reaction (RT-PCR) through various clinical specimens; mainly nasopharyngeal or oropharyngeal swabs. [18,19].
The information taken from this surveillance is utilized for making decisions about health policy and health education [13]. It helps in rapid case detection by using the working case definitions. On the other hand, the confirmation of the cases need a big costs, and laboratories with high bio-safety levels.

## 6- Sentinel surveillance

A network of healthcare providers or hospitals are recruited to regularly report data about a disease [13,20]. Reporting units with a high possibility of seeing the cases, having good laboratory facilities, and a qualified staff were selected. Such type of surveillance is used for promptly understanding the magnitude of Covid-19 in a certain population. Detection of such transmission is essential for notifying response actions, including testing criteria, quarantine guide, investigation protocols, and community mitigation actions [21]. The drawback is that it is based only on the cases in sentinel health care facilities.

## 7- Sentinel syndromic surveillance

Nations which not testing mild suspected cases for Covid-19, but still encouraging such cases to consult their primary healthcare providers (PHCP), including telephone consultations, must integrate Covid-19 surveillance with sentinel surveillance of influenza-like illness (ILI) or acute respiratory infection (ARI). Swabs obtained by sentinel physicians from a systematic sampling of cases presented with ILI/ARI need also be tested also for SARS-CoV-2. In nations where sentinel physicians can't swab the cases, self-swabbing and shipment of specimens through devoted channels can be utilized. The intensity of Covid-19 can be known from the weekly number of positive results over all tested specimens, and / or the weekly number of confirmed cases over the number of ILI/ARI consultations [10,13]. The drawback is that it based only on the health care facilities.

*Laboratory based surveillance: it contains 3 types*

**8- Virological (serologic) surveillance:** It is done by using molecular tests for Covid-19. Laboratory confirmed cases of Covid-

19 are usually reported within 24 h of recognition. SARS-CoV-2 rapid antigen detection and antibody detection tests are also available [13]. Such methods are less costly, but less accurate, can be used the developing countries.

**The testing priorities in case of limited resources**, while the number of suspected cases exceeds the available testing capacity, needs to be available for certain groups. These groups are healthcare workers visiting patients, elderly people, those with underlying chronic medical conditions who show signs of acute respiratory illness, hospitalised patients with SARI in order to appropriate clinical management and all cases, even mild, who developing ARI in hospitals, long-term care facilities or other vulnerable communities [13].

**9- Virological sentinel surveillance** of Covid-19: Such surveillance is based on using the clinical specimens that obtained through national sentinel surveillance of ILI/ARI/SARI using RT-PCR [13].

Both virological and virological sentinel methods are very important for confirmation of the case by RT-PCR. The drawbacks of these types is mainly related to cost of testing. Furthermore, both non-propagative and propagative virological testing for Covid-19 must be conducted at laboratories using procedures equivalent to bio-safety level 2 (BSL-2), and BSL-3, respectively [13]. Such levels of safety may be not available in low-income nations.

## 10- population serological surveillance

In UK, for example, the health care practices contributing in virology surveillance collect blood samples from persons coming for a routine blood testing. They are asked to give an extra sample for Covid-19 serology [22]. It is a very important type for the intensity and distribution of the virus in the population. However, such surveillance type needs a huge cost, and usually can not applicable in the low or moderate income nations.

**Hospital-based types:** It is needed to identify risk groups for severe disease, measure impact and inform decisions on mitigation measures [23].
It includes 5 types

## 11- Hospital-based surveillance for SARI

Nations which is no longer testing the mild cases of suspected Covid-19, must at least test all SARI patients admitted to hospital and Intensive Care Unit (ICU) / High dependency Unit. These countries need to monitor the percentage of confirmed Covid-19 from all SARI. Sentinel hospitals need to be chosen if the catchment population is well recognized and stable. Another appropriate method is selection of all hospitals in a given area/region and use the inhabitants of this area as denominator [10,13]. Such surveillance method can be applied for most of the countries. However, it has a drawback of late case detection, were it is primarily based on the symptomatic patients.

## 12- Routine surveillance of nosocomial outbreaks and outbreaks in long-term care facilities

Infections can cause many outbreaks in hospitals. Covid-19 nosocomial outbreaks must be notified within 24 h of detection (class I reporting). This surveillance leads to quickly manage such events, enhancing infection prevention and control measures. It leads to contact tracing for protecting healthcare workers, patients and residents (who are at high risk of severe disease and poor outcome). In addition, such approach leads to preserving the essential health-care infrastructure. At national level, the number of such Covid-19 outbreaks and the proportion of affected facilities may be used as supplementary indicators of intensity, geographic spread

and its impact on the healthcare system [10,13]. On the other hand, the limitations of such type may be related to lack of timeliness or completeness of the report.

### 13- Enhanced surveillance of hospitalized cases

In such type, the risk groups can to be recognized and followed-up through Covid-19 enhanced comprehensive or sentinel surveillance of the hospitalized patients [13]. For example, in Singapore an enhanced Covid-19 surveillance was applied early by testing all patients with pneumonia, patients in ICUs, people who died of unknown cause, and individuals with ILI in sentinel PHC clinics. Suspected patients are also tested according to clinical or epidemiological reasons [16,24]. Such surveillance is a very important type to detect new cases. However, the case detection methods were primarily based on the symptomatic patients [28].

### 14- Mortality surveillance

The surveillance is done for death among hospitalised confirmed Covid-19, and elderly who die outside hospitals in long-term care facilities. This type of surveillance remains a vital tool for measuring the disease severity. The surveillance data is also easy to collect, available and frequently updated. However, such mortality data can't mirror the correct Covid-19-related mortalities in the whole population. [10,13].

### 15- Health care surveillance

Such type notifies the effect of Covid-19 on the capability of the healthcare system (acute and long-term care facilities). It gives information concerning the availability or lacks of essential resources as hospital beds, ICU beds, ventilators, personal protective equipment (PPE), and healthcare personnel shortages. It can provide data that are timely, easy to interpret, and readily accessible [17]. WHO, other organizations, NGOs and rich countries can help low-income nations, according to their deficiencies, and based on such surveillance reports. On the other hand, the limitations of such type may be related to lack of timeliness or completeness of the report.

### 16- Surveillance of wildlife

It was needed at China for the identification and characterization of possible reservoir and source of infection. Surveillance among people who are in contact with wildlife is important to recognize behavioural risk factors [1]. Surveillance of wildlife can prevent further pandemic if there banning of some food habits like eating bats and others [25]. Dealing with wildlife may carry a high risks of transmission of Covid-19, and many other infections. This type needs the applications of high levels of bio-security. Improvement of biosecurity regarding wildlife trade and closing wet markets in China is important. (1)

*Media, electronic and digital types: (it includes 4 types)*

17- Help-lines, surveys, participatory surveillance:
Nations which is also not routinely tested the majority of suspected cases, and minimize the access to PHC need to use another methods. Among these methods are consultations' calls with sentinel doctors, calls to health care telephone help-lines (at regional or national levels), consultations of online health care apps or self-assessment tools for advice on Covid-19 testing [13]. This type can be applicable for the low-income countries due to low cost. It helps in decreasing the rate of hospital-acquired infection by iso-

lation & follow-up of the contact and mild cases at home. It gives reassurance of the isolated cases as they are under supervision of consultants. However, many cases can be lost by this method.

### 18- Electronic reporting systems

It used web-based tools for reporting disease & epidemics [13]. Such surveillance can improve the quality and timeliness of the surveillance. Electronic record dashboards, and other electronic tools are needed to assist surveillance system [26]. American CDC utilizes interactive Germ data dashboard, bio-informatics in the cloud, application programming interfaces (APIs), Fast Healthcare Interoperability Resources (FHIR), and SMART (Substitutable Medical Apps, Reusable Technology) on Fast Healthcare Interoperability Resources (FHIR) apps to enhance the surveillance system [27]. In KSA, the Health Electronic Surveillance Network (HESN), established in 2014, is utilized nowadays for rapid reporting, updating and giving feedback about Covid-19 cases [25].

### 19- Digital surveillance

Many countries utilizes digital surveillance including apps, location data and electronic tags in Covid-19 pandemic. In the USA, an ankle bracelet technology was used to enforce quarantine among Covid-19 patients (avoid violation). Tracking wristbands can takes the place of Smartphone apps. In South Korea, a GPS apparatus was used to track the locations of isolated individuals for sending alerts to authorities if people leave the chosen areas. Hong Kong authorities requires a bracelet and an app for all travellers. In Singapore, individuals have to report their locations with photographic proof. Furthermore, Thailand is using an app and SIM cards for all travellers to enforce their quarantine. India is planning to manufacture location and temperature-monitoring bands. Social media search indexes (SMSI) was used in China as an effective early predictor of Covid-19 outbreak. Such work can allow the health departments to locate possible and high-risk outbreak places [9]. Furthermore, the crowd sourcing artificial intelligence tasks for a database of Covid-19 was done in China. Research outputs compiles thousands of research articles on SARS-CoV-2 & other coronaviruses [9,28]

Regarding the cost-effectiveness, electronic and digital surveillance may require a big budget at the start. Such budget is needed for the running a telemedicine and for extensive training. [27–30] However, the operational cost of running a telemedicine center can be low compared to running primary care facilities or specialized hospitals (reduced hospital-acquired infections), and can reduce the economic burden on strained health care facilities and systems [28]. On the other hand, digital surveillance may be supposed to break the confidentiality, and human rights. Furthermore, it is important for stakeholders to determine how to tackle the problem of fake news and misinformation (infodemic) [28].

### 20- Event-based surveillance (29)

The capacity to rapidly detect any changes in the overall COVID-19 situation can be further strengthened through robust event-based surveillance (EBS) mechanisms. EBS captures unstructured information from formal and informal channels such as online content, radio broadcasts and print media across all relevant sectors, to complement conventional public health surveillance efforts. Successful EBS implementation requires dedicated human resources and clear processes to sift through large volumes of information to filter, triage, verify, compare, assess and communicate relevant content. Numerous web-based systems have

**Table 2**
Summary of types and characteristics of Covid-19 surveillance.

| Types of surveillance | Description |
| --- | --- |
| **Routine surveillance (3 types)** | |
| 1- Comprehensive (mass) routine surveillance | Complete testing of all suspected cases |
| 2- Case-based routine surveillance | Reporting cases of Covid-19 infection within 48 h of identification |
| 3- Aggregated routine surveillance | Weekly numbers of newly Covid-19 cases, deaths, etc. |
| 4- Active surveillance | Active search & contact tracing |
| 5-Syndromic (clinical) surveillance | Surveillance of health data about the clinical manifestations |
| 6- Sentinel surveillance | Healthcare providers or hospitals are recruited to regularly report Covid-19 data |
| 7- Sentinel syndromic surveillance: | Intergradation of Covid-19 surveillance with sentinel surveillance of ILI or ARI. |
| 8- Virological surveillance | Molecular testing of Covid-19 by PCR. |
| 9- Virological sentinel surveillance | Using clinical specimens obtained through national sentinel surveillance of ILI/ARI/SARI using RT-PCR |
| 10- Population Serological Surveillance | Collecting blood samples from persons coming for a routine blood testing |
| **Hospital based types (5 types)** | Used to identify risk groups for severe disease, clinical spectrum, measure impact and inform decisions on mitigation measure |
| 11- Hospital-based surveillance for SARI | |
| 12- Routine surveillance of nosocomial outbreaks and outbreaks in long-term care facilities | |
| 13- Enhanced surveillance of hospitalized cases | |
| 14- Mortality surveillance | |
| 15- Health care surveillance | |
| 16- Surveillance of wildlife | Identification of possible reservoir & human behavioural risk factors |
| **Media, electronic and digital types (4 types)** | Cost- effective new types depending on using media |
| 17- Help-lines, surveys, participatory surveillance | |
| 18- Electronic reporting systems | |
| 19- Digital surveillance | |
| 20- Event-based surveillance | |

been developed over the years to support EBS activities, many of which converge through the WHO-led Epidemic Intelligence from Open Sources (EIOS) initiative. It is equally important to monitor for other potential events that may emerge in parallel, further impacting lives and compromising COVID-19 response efforts. Table 2 Summarizes the different types and description of Covid-19 surveillance.

### II- Surveillance indicators and implications in controlling Covid-19

a- Surveillance indicators for monitoring Covid-19:
Indicators of transmissibility, seriousness and impact of Covid-19 are vital. Such indicators can help in informing about the measures that need to be taken as social distancing and quarantine [13,23].

The evaluation of the outcome on hospitals must depend on bed occupancy in wards and ICUs, and the capability for ventilation. These indicators can inform decision makers about health-care supply requirements and guide towards shifting or enhancing capabilities [13,23]. Further indicators to assess effectiveness of containment measures need to be calculated [28]. The usual surveillance indicators as the sensitivity, specificity of surveillance, timeliness and completeness of the surveillance reports can be also calculated [7].

b- Implications of surveillance (How can effective surveillance help in Covid-19 containment)?
Nowadays, efficient surveillance is highly needed for collecting information, doing action, and hence controlling Covid-19 pandemic. Surveillance data gives us pictures of reality, and informs policy and decision makers about the situation [24]. It is useful for early detection of Covid-19 cases, application of case management protocol, and containment measures. Such early detection is successful for treatment and prevention of further transmission [1]. Exploring and using the open source, web-based tools to modernize mortality data reporting can provide newer, faster insights on how to prevent further lives losses [24,27].

Surveillance can influence the timeliness of policy application, public risk perception and decision making [12]. All levels of government and healthcare system need detailed and timely infor-

mation about the availability and shortages of the key resources [7,12]. This can slow Covid-19 growth, or even ending the pandemic [24]. Incorporation of epidemiologic and virologic surveillance can play an important role in the future; once vaccines and antiviral drugs will be available. Such methods can be used to monitor virus / vaccine match, and the possible emergence of anti-viral resistance [13]. Finally, surveillance among people who have contact with wildlife, with improvement of biosecurity regarding wildlife trade, can prevent the next pandemic outbreak [1].

### III- Challenges & limitations facing Covid-19 surveillance

a- Challenges for application of Covid-19 surveillance:
Public health surveillance in low-resource countries differs from surveillance in developed nations. There are many challenges for application of an efficient surveillance in developing countries. The first one is that more must be done with less. The second challenge is that strengthening surveillance system in these countries is more complicated due to deficiency of resources and lack of adequate training. The third one is that sustainability of the surveillance is more challenging [30].

### B- Limitations of Covid-19 surveillance

There is major under-ascertainment / under-reporting of total Covid-19 cases from different countries. There is still uncertainty due lack of big longitudinal studies and clinical trial (due to short duration). Covid-19 surveillance is also limited as the mild and subclinical cases are usually not seeking treatment. Furthermore, mild cases usually avoid hospital unless it is necessary. The testing capacity may be also limited for only severe cases. The clinically detected cases represent only the tip of ice-berg of the actual infected Covid-19 cases [12]. Furthermore, the generalized under-detection of the imported cases is another limitation. In high-quality surveillance locations (based on the Global Health Security index) the overall ability to detect imported cases is only 40%. In addition, lack of timeliness and completeness of reports are other problems [7]. Additionally, the quality of surveillance data in many developing

countries is limited by several factors including resources and training [30].

## Conclusion

Surveillance is one of the cornerstones for controlling Covid-19 pandemic. There are many types of surveillance can be used. Routine surveillance (comprehensive, case-based and aggregated surveillance), active, syndromic, sentinel and sentinel-syndromic are some types. Laboratory and hospital-based are another types. Help-lines, surveys & participatory surveillance, electronic, digital surveillance and event-based are other cost-benefit types depending on media. Surveillance of wildlife was needed in China at the start of pandemic and for detection of behavioral risk factors.

Surveillance is needed as any missed Covid-19 case can lead to new chains of transmission, which may be more difficult for containment.

Many surveillance indicators can be calculated as transmissibility, seriousness and the impact of Covid-19. Other important indicators based on evaluation of the Covid-19 outcome on hospitals. Sensitivity, timeliness and completeness of reports can be also calculated.

There are many challenges facing the application of Covid-19 surveillance. These challenges are mostly related to the cost, training and sustainability, especially in developing nations. Other limitation of surveillance is mainly related to Covid-19 under-ascertainment/under-reporting, lack of timeliness and completeness of reports.

### Recommendations

Enhancing epidemiologic surveillance of Covid-19 is a crucial tool for rapid cases detection, containment of spread, enabling public health authorities to manage the risk of COVID-19, allowing economic and social activity and monitoring the longer-term trends and changing in the virus.

Adoption of multiple and complementary surveillance systems can ensure broad coverage. Furthermore, regular evaluation of surveillance system ensures that Covid-19 is monitored efficiently and effectively. Health authorities should designate laboratories to implement tests for rapid, accurate diagnosis and early detection (with high levels of bio-safety). Enhancing the accountability, resource use, workforce, and innovation for surveillance is also important. Accelerating the use of emerging tools and approaches to improve the availability of quality and timely surveillance data need to be done. Covid-19 surveillance system should be dynamic. It must be sensitive enough to detect any Covid-19 new case. It should be specific to identify problems and focus resources. It must be flexible and connected to protect people locally, nationally, and globally. Improving availability, timeliness and completeness of Covid-19 data are needed. Adopting new technologies to improve surveillance accuracy and speeding reporting of disease are required. More training is needed for public health surveillance officers and volunteers to implement the most promising practices and uses of technology. Applying active surveillance, use of more innovative methods for data collection, and crowdsourced tasks will add important values in controlling the pandemic. The design of surveillance systems needs to be appropriate for each country. Furthermore, there is a need to control coronaviruses based on biosecurity regarding animals as well as on shifts in food habits with banning wet market places. Finally, we are at the beginning of a new era for new digital and electronic surveillance. We must be prepared to handle Covid-19 challenges of today and, at the same time, to make real the potential of the new innovative technology of tomorrow.

## Limitation of the review

There is still a big un-certainty regarding Covid-19, the characteristics of its causative agent (SARS- CoV2) and its surveillance. Furthermore, there is lack of enough data about the types of surveillance used from different countries, especially from the developing countries. As there is very limited number of meta-analysis, systematic review, clinical trials, follow-up studies about Covid-19 surveillance, there is still uncertainty about the evidence.

## The strengths and weaknesses of sources of the article

All sources were critically appraised. Many articles were from WHO, CDC, ECDC & Euro-surveillance. PubMed critically appraised articles were included. Most of the sources are recent. The weakness is the lack of adequate articles from the developing countries and the level of evidence is still low.

## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jiph.2020.07.019.

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