COVID-19 Surveillance: Not Everything That Counts Can be Counted, and not Everything That Can be Counted Counts[a]

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Infectious disease surveillance is one of the most valuable tools in monitoring the COVID-19 pandemic. Here we examine the components of an ideal surveillance system and assess the effectiveness of COVID-19 surveillance in North Carolina and around the world.

Introduction

Infectious disease surveillance is one of the most valuable tools to health care epidemiologists. With the COVID-19 pandemic, we have seemingly used all our existing surveillance resources to measure and track this infectious disease in more ways than we have ever had to use before. But how useful are all these systems and metrics? Where has surveillance succeeded, where are the shortcomings, and where should we be headed to make these tools as effective and efficient as possible?

Surveillance is defined as "the ongoing systematic *collection*, *analysis*, and *interpretation* of health data essential to the planning, implementation, and evaluation of public health practice, as well as the timely *dissemination* of these data to those who need to know" [1]. Surveillance systems can be designed to detect individual confirmed cases (i.e., maximize specificity) or to monitor overall trends (i.e., maximize sensitivity). Maximizing specificity for case detection can be most useful for detecting new cases for intervention or doing outbreak case finding by contact tracing, exposure evaluations, and linking new cases to an identified cluster. On the contrary, sometimes it is more effective to monitor the overall data trends for outliers or patterns. Monitoring disease activity can be useful for outbreak detection (e.g., tracking progress of an outbreak on a college campus), identifying groups that are disproportionately impacted in order to target messaging to higher-risk groups, evaluating effectiveness of prevention and control measures (e.g., universal masking), allocating public health resources (e.g., personal protective equipment), and understanding the epidemiology of new or emerging pathogens (e.g., role of children in COVID-19 transmission).

Ideal surveillance systems are simple, sensitive and specific, flexible, acceptable to both the public and health care providers, timely, representative, and cost-effective [2]. The two main types of data that can be harnessed for surveillance are diagnostic surveillance data (e.g., laboratory diagnoses) and syndromic surveillance data (e.g., constellation of symptoms presenting at the emergency department). Some systems are designed to be a form of sentinel surveillance in which a select number of locations are chosen and actively engaged to collect high-quality, detailed data.

For COVID-19, the most well-known and referenced metrics are based on the diagnostic surveillance that summarizes the case counts of individuals with positive COVID-19 tests. Early in the outbreak, the case definitions were based on signs and symptoms consistent with COVID-19 disease and an epidemiologic link either by travel or exposure to a known case. Over time, as diagnostic capabilities improved, the case definition could be refined to capture laboratory-confirmed cases. Now with the advent of different testing types, such as antibody tests and rapid antigen tests, case definitions must be further adapted to classify these cases (e.g., positive rapid antigen tests initially were defined as probable cases) [3]. It is important to appreciate that changing diagnostic capabilities and case definition changes impact the diagnostic surveillance system. In China, early in the outbreak, cases were diagnosed with radiologic findings when microbiologic testing was not readily available for the case volumes [4]. This change from microbiologic to radiologic identification of disease caused a large influx of new cases in China that appeared in the surveillance system merely as an artifact of this detection method. While these types of changes are expected within the course of the outbreak, without trained epidemiologists and public health officials to help with data interpretation, these sudden shifts can cause public mistrust in the data.

[a]Quote attributed to Albert Einstein

Electronically published January 4, 2021.

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N C Med J. 2021;82(1):71-74.
0029-2559/2021/82116

In North Carolina, testing was initially only available on a limited basis—in fact, a provider needed State Epidemiologist approval to have a patient tested under very strict criteria; only patients with symptoms (fever usually required), known epidemiologic link (at time, travel history), and negative for other respiratory viruses were approved for COVID-19 testing. As more labs were able to test and more information was garnered about the disease epidemiology, testing criteria shifted to testing symptomatic patients (fever no longer required) with negative respiratory virus results who fell into higher-risk categories, such as hospitalized patients, health care personnel, patients living in congregate settings, and patients at higher risk of severe illness. Ultimately, the case definition was expanded to testing asymptomatic patients (e.g., patients with known exposures, patients admitted to hospitals, patients in congregate living facilities, etc.). Importantly, the percent positivity in asymptomatic population is much lower, and this greatly impacts the overall percent positivity that is reported out, rendering the percent positivity metric difficult to interpret.

North Carolina COVID-19/Diagnostic Surveillance

The diagnostic surveillance system in North Carolina worked well in that the North Carolina Division of Public Health (NCDPH) was able to relatively quickly add a COVID-19 module for case counts, testing data, and deaths to an existing reportable disease surveillance system that was already very familiar to the local health departments [5]. The potential for increased electronic lab reporting (ELR) capacity increased timeliness and accuracy of reporting. However, the volume of data quickly became unfeasible to provide and many reports were missing key demographic data (e.g., complete addresses, race, ethnicity), which ultimately caused delays in case follow-up and contact tracing. The surveillance system is set up for local health departments to only view cases in their county and hospital staff do not have access to these data, limiting the ability to share timely information about cases. Despite an electronic module for the health department, necessary data are submitted in various formats (ELR, paper labs, faxed reports, mailed reports, phone calls, physician reporting) and integration is cumbersome. Ultimately, the existing system was overloaded as it was not built to handle the volume of cases reported and NCDPH had to build a new system, NC COVID, to house only COVID-19 data. If our surveillance goal is detection of every case so that action can take place, health departments lacked resources to meet this goal. Due to lack of funding and necessary resources, the public health infrastructure was not robust enough to efficiently handle receipt of data reports and there were often delays in reporting to the appropriate health department, as well as inability to follow-up with each case in the time window during which meaningful interventions (e.g., isolation guidance, assessment of contacts) could take place.

Hospital-based Public Health Epidemiologists/ Sentinel Surveillance

Since 2003, North Carolina has invested in a sentinel surveillance system network of trained epidemiologists who are based in hospitals and serve as liaisons between hospitals and local and state health departments [6]. Through this network, there were weekly submissions of key COVID-19 metrics using syndromic data from the North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT), which helped the state understand hospitalization, intensive care unit utilization, and death trends [7]. Having dedicated point people to whom health departments could reach out enhanced timeliness of reporting key information. However, the metrics from this sentinel surveillance system that used both diagnostic measures and syndromic measures at each of the seven large North Carolina hospitals may not be representative of other hospital experiences or statewide trends.

NC DETECT/Syndromic Surveillance

Public health epidemiologists were able to harness existing infrastructure utilized to report other respiratory viral activity through NC DETECT's syndromic surveillance, which also helped with reporting key COVID-19 metrics to the state health department [7]. These data were timely, complete, and historically available for trending data. However, the syndromic data did not detect that COVID-19 had arrived in North Carolina through this system, nor did it successfully detect any subsequent clusters/outbreaks, which is not surprising given the high number of false positive alerts triggered by highly sensitive syndromic surveillance systems. In addition, the changes in health-seeking behavior impacted trends of the syndromic data. Many patients with respiratory symptoms were routed to outlying respiratory diagnostic centers rather than emergency departments in larger hospital systems, so emergency department chief complaint and triage data were not completely representative of disease activity in the state.

NHSN/Hospital-based Surveillance

The National Healthcare Safety Network (NHSN) is a system familiar to infection prevention staff who are closely connected to COVID-19-related data in their hospitals and have a foundational understanding of the metrics [8]. The system provided an established, secure mechanism for hospitals to share their data with state health departments and the Centers for Disease Control and Prevention. However, as metrics were added to the initial requests, it became quite time- and resource-intensive to continue to complete the reporting requirements. Additionally, there was an overall lack of transparency on how these data were being utilized. In the midst of the pandemic, the reporting through NHSN was disbanded and data submission was moved to a United

States Department of Health and Human Services daily tele-tracking tool, causing even further public mistrust of the metrics [9].

Summary

How do we evaluate the current state of our COVID-19 surveillance and how could it be improved? Table 1 provides an overview of the current status and recommendations for each surveillance element and characteristic. The current goal of surveillance is still detection of every individual case, but it may be time to rethink the strategy to choose metrics that are helpful for trending but not focused on counting each individual case, except for some focused efforts on case findings for identified outbreaks. For example, it may no longer be necessary to count each case, considering health departments are so overwhelmed they can hardly keep up with contact-tracing each one [10]. There are not enough resources to effectively de-duplicate those data, making the actual count relatively meaningless since many positive patients are tested multiple times, and the percent positivity metrics have been overwhelmed by the large volume of routine asymptomatic testing. Surveillance data are currently being collected electronically and on paper and are being submitted by phone, fax, mail, and electronic submissions. Moving toward streamlined open-access electronic submission would be a tremendous improvement in the process. The analysis that is currently being conducted on these data is fairly rigorous, but with numerous metrics being reported out regularly, there is not consistent reporting of stratified data on race/ethnicity burden of disease to better characterize the health disparities that exist. In addition, there is a need for more interpretation by trained epidemiologists in order to better reconcile the various metrics (e.g., increased hospitalization lags behind increased new cases). With various modes for disseminating data—news media, social media, state press conferences and websites—the data are widely disseminated, but could benefit from fine-tuning the metrics and interpretation for various audiences. In totality, the surveillance system is not simple and is made up of many components and metrics. The surveillance system is extremely sensitive but not necessarily specific, as the data are often not de-duplicated and the metrics on percent positivity can be easily dominated in areas where large groups of low-risk asymptomatic individuals are tested. The surveillance system is not particularly flexible, as evidenced by the necessity of building a new NC COVID system to capture all those data and also the inability of syndromic surveillance based in emergency departments to capture data when new diagnostic centers were created for patients with respiratory illness.

The public and health care providers do not have high acceptability of these systems as there are questions about the transparency of these data, and frequent changes that are not well-explained lead to mistrust. The diagnostic surveillance data are only as timely as laboratories' turnaround times for test results, which have varied over the pandemic. The surveillance system may not be representative, as these data are all based on patients who have access to care, laboratory testing, and hospitals. Targeted diagnostic testing in underserved populations has demonstrated double and triple the positivity rates compared to those who are measured overall at a large academic hospital. The cost-effectiveness of these systems remains to be quantified, but will be substantial when accounting for the labor and technology that are the bedrock of a surveillance system.

Use of existing and established surveillance systems (i.e., NHSN) has allowed for a tremendous amount of data collection since the COVID-19 pandemic began. However, the data collection demand has had a tremendous impact on the hospital and public health infrastructure and more data are being collected than can be appropriately organized, analyzed, interpreted, and disseminated. Changing requirements of the data collection process and of the reporting entities have impacted the quality, accuracy, and timeliness of COVID-19 data collection. Without trained epidemiologists and public health officials to guide the interpretation of

TABLE 1.
Assessment of COVID-19 Surveillance

Surveillance Element	Current Status/Recommended Future State	Effectiveness (+ to +++)
Goal of surveillance	Detection -> Monitoring with detection for outbreaks	++
Collection	Electronic/paper -> Electronic	+
Analysis/Interpretation	Rigorous analytics, not stratified, more interpretation needed	++
Dissemination	Wide dissemination, but consider audience and needs	++
Simple	Not simple, many metrics	+
Sensitive & specific	Test duplication, asymptomatic/symptomatic patients, no test gold standard	++
Flexible	Not adaptable to changes	+
Acceptable to public, health care providers	Public and provider mistrust of changes to the system	+
Timely	Bottleneck primarily with lab turnaround time	++
Representative	Not reaching underserved populations, most affected	+
Cost-effective	To be determined: labor, technology	+

these data, there have been instances of public mistrust of the data presented (e.g., changes to case definition, attribution of COVID-19-related death, noted lack of stratification by race/ethnicity). It is necessary to reassess the goals for surveillance periodically throughout the pandemic in order to hone the collection, analysis, and dissemination of meaningful data that leads to public health and infection prevention action. NCMJ

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Acknowledgments

Potential conflicts of interest. The authors report no conflicts of interest.

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