Contact Tracing during COVID-19 - A Systemic Public Health Failure

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ABSTRACT

Coronavirus-19 (COVID-19) created many challenges for public health agencies and healthcare services. As a virus that created immense fear of the unknown, researchers and scientists scrambled to come up with solutions to prevent the spread and rate of infection. As previously used in combating infectious diseases, contact tracing was introduced to help decrease the rapidly increasing cases. Although contact tracing is a relatively old idea, it is still a critical part of the non-pharmaceutical interventions needed to fight such an infectious virus. However, it had to be tailored to fit this new rapidly increasing virus. This paper examines the disparities, insufficient infrastructure, and lack of proper testing and reporting during the pandemic, all of which are systemic failures of public health. These systemic failures have an impact on the effectiveness of contact tracing. All barriers will be presented with potential solutions for not only this pandemic, but for any future situations as well.

KEY WORDS


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**BACKGROUND**

Within months, COVID-19 swept across the world leading to a modern-day pandemic. In the 20th century, the world was hit by the 1918 influenza pandemic. According to the Center for Disease Control (CDC), the 1918 influenza pandemic infected an estimated 500 million individuals globally and led to an estimated 50 million deaths.[1] Countries were restricted to isolation, personal hygiene practices, social distancing, and quarantines to control influenza.[2-2] 100 years later, in the 21st century, many countries were forced to resort back to these non-pharmaceutical interventions to attempt to control COVID-19. The COVID-19 pandemic is not the first time the coronavirus has instilled fear within individuals; coronaviruses have been around for nearly 2 decades as severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS).[3] However, it is COVID-19, also referred to as SARS-CoV-2 that created a major global public health crisis in late 2019. Healthcare workers, government officials, and public health agencies across the world scrambled to contain the virus that is still creating concern, even 2 years later. To date, according to the World Health Organization (WHO) COVID-19 dashboard, over 214 million cases have been reported worldwide.[4] Over 38 million cases have been reported to the CDC in the United States of America (USA) alone.[5] COVID-19, like SARS and MERS amongst many other respiratory viruses, is spread through respiratory droplets and a positive case could transmit the virus to at least 2 to 4 other individuals.[6-7] An estimated 3,000 droplets are produced and spread by a single cough.[4] With the rapid spread of the virus, case counts continue to climb. To control the high case counts, intervention, such as quarantining is critical alongside contact tracing.[3] The inability to contain such a pandemic proves to have extremely grave consequences. It has been estimated that 1.1 to 1.2 million lives may be lost if efforts to flatten the curve fail.[8] Large-scale contact tracing, testing, and quarantines are needed to limit the spread of COVID-19 instead of relying solely on lockdowns.[3] Studies have shown the negative impacts of containment policies that allow for lockdowns due to their deteriorating effects on economic systems.[3] The socio-economic effects of lockdowns can incline physiological impacts on individuals, profit losses in businesses, individuals being forced to quarantine and isolate, and having no method to support themselves during these trying times.[9] As a result, relying solely on lockdowns is not feasible and the focus should be on contact tracing efforts, testing, and quarantine to limit the spread.[3]

The efficiency of contact tracing can be determined by how the disease is spread before an individual has symptoms or if he/she remains asymptomatic, altogether.[10] Due to the ability of COVID-19 to spread while a person is pre-symptomatic or asymptomatic, the number of people needed to be traced grows exponentially.[9-10] In research models, it is estimated that 75-95% of individuals need to participate in contact tracing through automated applications to be deemed effective.[10]

Whether by traditional means of being contacted by health officials or responding to automated applications, efficiency is also dependent on the voluntary participation of the population.[8,10] While research on the effectiveness of contact tracing is ongoing, mathematical models have also been used to deduce the outcomes. Research models have shown the effectiveness of contact tracing which is dependent on the number of cases, delays in tracing and symptom onset, and the number of symptomatic cases being traced.[11-12] With the increase in cases each day, only a fraction of the positive cases can be reached, and contacts to be solicited. Through the Gardner and Kilpatrick model, they found that of the 20-40% of asymptomatic cases being contacted, tracing could reduce the spread of cases by no more than 20%.[11] As a result, the benefits of contact tracing are decreased. The need to expand contact tracing is required for it to be efficient. Overall, the efficacy of contact tracing is dependent on appropriate testing following symptom onset, quick result turnaround, and sufficient capacity for tracing.[10-11] Similar studies also stress the importance of tracing a certain fraction of positive cases and tracing immediate contacts versus long chains of transmission.[12]

Many countries went into overdrive to contain the virus by introducing contact tracing measures to combat the number of rapidly increasing COVID-19 cases. Contact tracing is a proven public health method used to disrupt the transmission of infectious diseases in the community. It involves multiple steps which include rapid notification, interview, quarantine, isolation instructions, assessing support needs, medical monitoring, and investigation closeout.[13]

Close contact notifications can be done through phone, email, in-person, or through mobile applications by any public health agency.[8,13] Interviews are then conducted to assess the risk of contraction, symptoms, and social factors to ensure adequate quarantine.[13-14] Proper quarantine instructions are then given depending on symptom status, pre-existing health conditions, and continuous exposure to persons already infected with COVID-19.[13] Next, offering support needs is a critical part of contact tracing. It connects individuals in need and those impacted by COVID-19 to social support (food, supplies, medications, testing), telemedicine, health insurance navigation (mental health services), and economic support (unemployment assistance, landlord negotiations, paid time off).[14]

In addition to assessing support needs, self-quarantine needs are also evaluated. Close contacts are coached on proper quarantine, daily monitoring of symptoms, and proper cleaning techniques for those unable to fully isolate themselves from their households.[13-14] The last step in contact tracing involves medical monitoring. This is a continuous step throughout the individual’s quarantine time to monitor symptoms and watch out for any warning symptoms that require immediate medical attention.[7,13] At the end of the contact’s quarantine period, individuals are provided general COVID-19 education and released from monitoring.[13] An overview of these steps along with challenges can be seen below in figure 1.
A recent Pew study surveyed 10,211 adults in the USA between July 13 and 19, 2020.[15] The study examined a wide range of topics which included the effects of COVID-19 on health, politics, and economics. 77% of participants reported that they would be somewhat comfortable sharing contact tracing information for tracing purposes and only 49% said they were comfortable sharing their cell phone location.[8,15] The Pew study found that 58% of adults in the USA would be very likely or somewhat likely to speak to public officials regarding COVID-19.[15] Furthermore, 93% of participants from the study stated that they would definitely/probably follow the advice of health officials when told to quarantine.[9,15] The survey also examined the willingness of participants to answer unknown calls. Only 19% of participants stated that they would answer unknown phone numbers and 67% said they would not answer unknown numbers due to scamming concerns, but they would check their voicemails.[15] Furthermore, the study examined how difficult quarantine and isolation would be. 32% said it would be somewhat difficult and of those, 40% stated it was due to too many other obligations and 39% stated they were unable to miss work.[11,15] Overall, half of the participants said they were not confident about the government keeping their information safe.[15] This new-age pandemic presented its challenges. To determine the potential challenges, a review of the current literature was conducted. Through the review, main challenges were discussed; disparities in contact tracing insufficient infrastructure, and lack of reporting have all contributed to the ineffectiveness of non-pharmaceutical interventions like contact tracing efforts.

**Disparities in Contact-Tracing**

The community’s acceptance of guidance has been one of the greatest challenges, whether mobile applications are being utilized or not. Many people across the country struggled with the idea of wearing masks, adhering to social distancing guidelines, and trusting contact tracers. The most affected by COVID-19, disproportionately, are the minority groups and the underserved.[16-17] Marginalization occurs when there's an unbalanced relationship between social groups.[17-18] These groups can be singled out due to their race, sexual orientation, gender, or immigration status. The impacts of COVID-19 affected everyone. However, some groups of individuals experienced the effects of COVID-19 greater than others, such as the homeless.[10] Studies have reported ethnic and racial differences in care, and risk of infection during the pandemic as well. Racial groups, excluding Caucasians, had an increased risk of contracting COVID-19.[19] These marginalized groups, such as African Americans, and Hispanics, also have a long history of distrust in the government and health institutions.[16] The willingness of these groups to accept quarantine or isolation efforts is dependent on their age, social norms, socioeconomic status, and even health literacy.[16,20] These effects can be seen throughout the contact tracing process in interviewing, isolation and quarantine, medical monitoring, and investigation closure.
Contact tracing challenges begin with economics and the lack of compliance which make testing and isolation difficult in many marginalized communities.\textsuperscript{[23]} In addition, the stigma of a COVID-19 diagnosis presents a barrier in the process. As seen in figure 1, stigma can be present in the interviewing process and during quarantine instructions. These social and economic insecurities prevent the general population from participating in contact tracing efforts.\textsuperscript{[9,21]} Stigmatization is much more common when it comes to controllable diseases that pose risks to others, and those with uncertain outcomes related to diagnosis which leads to fear.\textsuperscript{[10,21]} This fear and humiliation of being labeled as COVID positive are what drive the population to refuse participation in tracing efforts.\textsuperscript{[21]} This stigma is worse in marginalized communities, such as African Americans and Hispanics. This is similar across immigrants, and those of different racial and ethnic backgrounds, revealed by a recent survey. 30% of recent immigrants are four times more likely than non-immigrants to say that people should be fearful of speaking up about being positive.\textsuperscript{[11,21]} Immigrants (55%) were also more likely to say that being positive makes you an outcast in your community and 41% said speaking up would lead you to lose friends.\textsuperscript{[21]} Economics has a great impact on contact tracing efforts in these marginalized groups. Individuals are more likely to agree that the inability to work is more of a barrier if they have higher levels of uncertainty during the pandemic.\textsuperscript{[9,21]} 89% of marginalized groups, such as Hispanic immigrants, say that calling out of work is a barrier;\textsuperscript{[11,15,21]} To these marginalized groups, working for personal needs outweighs social obligations. These economic impacts create barriers for individuals that should be quarantined.

Disparities are not only seen in those communities but are also seen in information dissemination. During a public health crisis, it is critical to disseminate information quickly to stop the spread of misinformation and decrease fear, skepticism, and lobbying.\textsuperscript{[22]} According to a Pew study, 70% of Americans said that they had at least heard or seen information regarding contact tracing.\textsuperscript{[15]} While examining disparities, only 30% of African Americans had heard about contact tracing compared to 35% of Hispanics, 39% of Asians, and 44% of Caucasian individuals.\textsuperscript{[15-16,21]} Those with lower education status had heard less about contact tracing when compared to those with some college education, or higher than college.\textsuperscript{[15]} Due to the lack of technology literacy, some may not have the skills to properly participate in contact tracing efforts.\textsuperscript{[18]} Efforts included text messaging follow-ups during medical monitoring, symptom updates, and positive status. Because of these barriers, widespread messaging and communications with the public are important steps in combating this pandemic. Communication is left to local health departments to disseminate critical information despite proper resources and support.\textsuperscript{[23]} For health communication to be effective, it requires taking complex information and tailoring it to a diverse audience.\textsuperscript{[22]} As a result, the communication gaps in disseminating COVID-19 related information to these minorities increase their risk of transmission.\textsuperscript{[16]} To build trust with your community, transparency is important. It fosters a relationship of trust and allows for greater adoption of measures.\textsuperscript{[17]} Despite the training provided to contact tracers, they are faced with the challenge of building rapport with cases and close contacts in a short amount of time to gain trust. These qualities cannot be taught and the lack of ability to persuade individuals to adhere to strict guidelines is critical in preventing illness, and even death.\textsuperscript{[24]}

**Insufficient Infrastructure**

Ineffective public health measures used during the COVID-19 pandemic are greatly impacted by the lack of infrastructure. The biggest components include a lack of funding for personnel and data management and information technology capabilities. According to a survey conducted by Johns Hopkins Center for Health Security (JHCHS) and National Public Radio (NPR), over 50,000 contact tracers were hired to slow the spread of the virus.\textsuperscript{[25]} Although the number of personnel needed for contact tracing purposes is dependent on population, the prevalence of COVID-19, and adherence to guidelines, an estimated 100,000 to 300,000 additional tracers are needed for a national tracing platform.\textsuperscript{[23]} This will take the burden off local health departments to keep up with the increasing number of cases. Many of the efforts have been politically driven and the lack of a national strategy has left the states to come up with solutions themselves.\textsuperscript{[26]} Insufficient infrastructure stems from the lack of federal funding being provided for public health preparedness. A report released by Johns Hopkins and the Association of State and Territorial Health Officials (ASTHO) developed a national plan for contact tracing efforts. Over the years, funding for public health preparedness has been reduced by 15%,\textsuperscript{[27]} Organizations are struggling to provide basic social services.\textsuperscript{[28]} As per the Nonprofit Finance Fund, 60% of social service organizations are confronted with long-lasting financial challenges.\textsuperscript{[9,28]} As their demands increased by 25% in March 2020, 56% of them reported staffing shortages.\textsuperscript{[28]} As seen in Figure 1, the lack of social support impacts interviewing, isolation and quarantines, and social support steps in contact tracing.

Similarly, these findings are consistent with technology gaps across the nation. A study conducted by Holmgren, Apathy, and Adler-Milstein found impacts of the lack of funding, accounting for differences in states being able to receive critical data for surveillance.\textsuperscript{[29]} According to this study, 41.2% of hospitals stated that public health agencies cannot receive data and 31.9% stated cost-related issues.\textsuperscript{[28,29]} These numbers dramatically differ across states as well; 83.3% of hospitals in Hawaii and Rhode Island said their agencies could not receive data, and only 40% of the hospitals in New Jersey and Virginia commented on the lack of capacity.\textsuperscript{[29]} The lack of structure leaves a gap in surveillance that creates further challenges in the efforts of contact tracing on the back end. The report by Johns Hopkins and ASTHO points to the importance of having strong capabilities to hand over diagnostic information to public health agencies.\textsuperscript{[27]} These studies have not considered the causes of the inability to receive data from hospitals, and the political and economic implications of creating sufficient infrastructure to combat this pandemic and any future one.

On the front end, technological interventions such as mobile applications can be utilized to alleviate some of the strain on government agencies to trace their populations. However, these technological interventions come with their challenges as well. Contact tracing apps present technical, privacy, and participation challenges.\textsuperscript{[30]} These challenges are
also the result of technology literacy which can impact medical monitoring. Potential solutions as presented by Dar et al., in a 5-step framework to evaluate contact tracing measures which may include Bluetooth technologies to detect proximity to other potential cases.[31] The framework includes parameters around centralized vs. decentralized systems, proximity versus global positioning system (GPS) technologies, privacy concerns, adversarial models examining exploitation of these technologies, and lastly scalability of tracing efforts.[30-31]

For effective efforts, the public needs to trust and take part in the contact tracing process. Their acceptance at the hands of the public is crucial for cooperation, sustainability, and adherence.[23] The voluntary nature of participation in contact tracing app efforts poses the greatest challenge as it decreases the effectiveness of the approach. Many legal and ethical barriers hinder contact tracing practices. Sensitive populations, such as immigrants and minorities, may not feel comfortable.[18,23] Remaining individuals may fear that their compromised status may lead to termination of their jobs and are therefore less likely to comply with quarantine orders.[22] Some groups may even have economic challenges preventing them from participating in contact tracing efforts. These individuals may not have access to smart devices and may even have their services suspended due to their inability to pay their bills.[18]

Testing & Reporting
When considering the impacts that contact tracing has on this pandemic, it is important to also understand the challenges of mass testing efforts. Disparities are also present when it comes to testing efforts. Studies looking at health data through electronic health records (EHR) determined that regardless of the increased risk of being exposed, people of color did not have higher testing rates when compared to Caucasian counterparts.[32] However, people of color have a higher risk of testing positive and needing high-level care when positive.[20,22] As seen in health records data, minimal changes in testing rates among different racial groups like African Americans and Hispanics were still over two times more likely to test positive.[32] The disparities that exist in COVID-19 testing practices suggest increased barriers which result in reporting delays.[19,21-22,23] This sheds light on the importance of readily available testing and quick tracing. At one point during the pandemic, only 10% of the cases were identified and quarantined.[20] This is representative of the continued efforts to combat the virus. Nonetheless, due to the high number of cases and testing, laboratory results can take up to 7 days which in turn delays contact tracing by more than 3 days from the time of symptom onset or test date.[20,26] Mathematical models have also determined the impacts of delayed tracing. Hellewell et al., determined in their mathematical model that delays between isolation instructions and the start of symptoms were the greatest determining factors of controllability of mini outbreaks.[33] The longer the delay in tracing, the number of contacts solicited by positive cases decreased and the risk of transmission increased.[20,33] This, in return, aids in the continued spread of COVID-19 and makes it difficult for contact tracing personnel to catch up. Other models have pointed out these complexities of contact tracing as well. They discuss whether contact tracing alone is enough to identify potential positive cases and have them isolated before they become infectious.[34] In turn, the timing of tracing initial cases is critical and needs to be shorter than the typical incubation period of COVID-19.[9,34] If secondary cases are not caught early, they have the potential to increase COVID-19 numbers by creating tertiary cases and so forth. Testing and contact tracing require meticulous coordination and communication, along with social acceptability for effectiveness in decreasing cases. There are various types of tests used to detect COVID-19 and each has different characteristics which may impact the result to determine, whether a person is positive or negative.[5] Testing can be done for both asymptomatic and symptomatic individuals, depending on exposure and other recommendations by the CDC. It is imperative to understand that these recommendations are subject to change and are continuously being revised and reintroduced.

The continuous surge in cases has created long turnaround times for test results.[23] Cases that are not reported cannot be traced on time, as per CDC guidelines. These barriers stem from deeper systematic challenges that include lack of funding, lack of national surveillance guidance, and lack of testing supplies.[23,25-26] This leads us to a point where containment through contact tracing is difficult due to the failure of timely testing and tracking.[23] Some of these barriers can be mitigated by application systems which are known to be the most effective and fastest ways to notify close contacts.[20] However, the downside of such applications is that they rely on active participation from many people and do not account for the number of asymptomatic and undiagnosed individuals.[20,31]

Plans to fight against a pandemic require not only financial and legal backing but also appropriate technological advancements for mitigation. Countries, such as South Korea and Taiwan, used existing plans for their contact tracing efforts which included the integration of patient interview data, medical records, and travel history within the app data.[23] However, methods used in those countries would not be accepted in the USA. To be effective in contact tracing measures, it is critical for optimizing testing, tracing coverage, and decrease tracing delays.[28]

Successful contact tracing accounts for testing and tracing delays. Reducing the delays in testing and tracing can prevent up to 80% of COVID-19 transmission.[20,34] The lack of reporting capabilities and funding to trace individuals are barriers that interrupt the coordination and communication to combat this pandemic head-on.

Analysis of Systemic Failures
As the numbers begin to increase into the winter months, contact tracing no longer becomes proactive, but reactive. Contact tracing is most efficient when the community adheres to the guidance being provided to them. COVID-19 challenged the movement of people. After a certain threshold of cases, contact tracing is no longer the most effective way to decrease the spread of disease. Howard Brown Health (HBH), a Federally Qualified Health Centre (FQHC) and an early adopter of contact tracing found that 70% of close contacts are either positive or have symptoms consistent with COVID-19.[28] This leaves an opportunity to
prevent 30% of potential infections and, with a case fatality rate of 1% which equates to a potential saving of at least 18 lives from initiating tracing for 2000 individuals. Cooperation from cases is the most critical part of contact tracing and understanding the importance of adhering to guidelines for the greater good. For interventions to be effective, it is important to communicate appropriately, involve all stakeholders and evaluate at the end. Transparency is critical and any contact tracing communications need to outline the process and benefits of participating. Stakeholders need to do their research and be presented with potential privacy concerns, stigma, and mistrust in the process. Furthermore, due to the need for transparency, evaluations are an important part of contact tracing efforts. Evaluations will reinforce the thoroughness and reliability of the process for everyone involved. This provides an opportunity for the implementation of a national tracking system for the standardization of tracing practices at the national level. Potential solutions proposed by experts include increased testing, increased screenings, and developing affordable, easy-to-use screening tools. In efforts to increase funding for these methods, states have been known to combine resources to be able to provide their residents with over 500,000 rapid antigen test kits. These solutions include at-home testing kits which may impact reported cases and further impact the number of individuals traced.

There are many disparities in contact tracing that need to be addressed in the future. Disparities in socioeconomic, technology, and participation can lead to marginalized communities seeing the least benefits from contact tracing efforts. After understanding the socioeconomic disparities of COVID-19, one can begin to intervene and combat the virus through contact tracing and see the most benefit. The rapidly changing complex guidance needs to be quickly tailored for the targeted populations to account for culture, geography, and even the politics within a given community. Contact tracing efforts need to account for socioeconomic disparities, challenges in infrastructure, and outreach. Time and time again, history has demonstrated that when interventions are inaccessible or ineffective, they increase health disparities among marginalized populations. Things like socioeconomic factors, gender roles, and occupation need to be taken into consideration due to their chances of being exposed to COVID-19 at a higher rate. For example, a frontline worker may also be a caregiver and therefore their risk for contracting the virus is higher and their chances of exposing someone else are also higher. For continued research surrounding the effectiveness of contact tracing, these factors need to be considered. This adds an extra layer of analysis on quarantines around gender-based health and social effects. This disparity in services was seen occurring during Ebola outbreaks in cases where women had lost access to child and adult services such as abortions and treatment for sexually transmitted infections, such as human immunodeficiency virus (HIV). Additionally, policymakers need to continue to address these deep-rooted inequalities to increase safety nets. Contact tracing shines a light on the need for these safety nets and the lack of investments in public health infrastructure for those impacted by the pandemic. To prevent these gaps, it’s important to reallocate resources, reduce participation barriers, and involve marginalized populations. To tackle stigma, those who have been impacted by COVID-19 should be included in conversations surrounding solutions. Lived experiences of those affected can provide appropriate insights. Some examples may include experiences of women caregivers who are frontline workers with an increased risk of viral exposure. The current outcomes of COVID-19 have shown the importance of having access to testing across all racial groups. There needs to be continuous efforts to address systemic and institutional racism affecting minorities being impacted by COVID-19. By decreasing disparities, it will ensure equitable access to testing, treatment, and preventative measures like vaccines. Health care systems can step in to alleviate some of the gaps by focusing on community interventions, culturally appropriate education, public health partnerships, and continuous outreach to vulnerable populations. Some of those gaps can be filled through the contact tracing process as seen in Figure 1. Appropriate education can be given to the community at any point in the process, however, it is most critical when closing out an investigation.

Contact tracers should develop their own set of community assets so that they can provide contacts with attainable and appropriate access to social welfare, food banks, and other means of support. The lack of social support for those being traced is a critical part of mitigation. Contact tracing efforts cannot exist without concurrent delivery of social services to help mitigate the impact of transmission; funders of social service organizations need to consider awarding less restrictive funds to allow for organizations to pay employee salaries, rent, and other overhead costs so that they can keep their necessary services. The lack of infrastructure and funding can impact the social support component of contact tracing tremendously. The CDC has not clearly defined what ongoing transmission accounts for but has stated that contact tracing is not recommended for such communities. This, in return, leads back to a lack of appropriate policies that, once again, are placing high dependency on contact tracing with the return of high case counts and hospitalizations.

However, with applications that evaluate exposure risk based on Bluetooth, proximity exchange is, in essence, insufficient because apart from the human-to-human interaction, COVID-19 can also be transmitted through common environments or commonly touched surfaces. Therefore, Bluetooth technology that relies on proximity to a potential case is insufficient. Extreme surveillance measures have consequences: some technical, others ethical, and legal. Additionally, the lack of adoption of Bluetooth-based applications is low which has an impact on the effectiveness. Other setbacks of these applications include cyber-attacks, such as spoofing. Spoofing puts user data at risk of being exposed. Tracing applications may have sensitive information like symptoms, medical history, and location, and users have expressed concerns about the integrity of such systems. However, solutions may work for one country and may not work for another. Countries such as Israel and South Korea have opted for extreme surveillance measures like access to mobile data and public-facing databases of positive cases. Such extreme measures would be deemed ineffective in the USA. Nonetheless, it’s important to consider transparency regardless of the solution.
being applied to avoid technological misuse of surveillance efforts.[26,31] Including stakeholders in discussing details, proposed solutions, and security is important to create effective change. When discussing potential mobile applications, some factors to be taken into consideration may include battery consumption while in use and adoption of mobile applications which can be seen through downloaded numbers.[30,31] Other factors may include how easily it can be used and accounting for health literacy. There needs to be accessible data collection from hospitals, health care centers and clinicians during the development of new systems to make sharing data easier.[29,38] These new systems should be developed with quality measurements in mind and allowed for the automatic integration of health data.[38] Quality reporting agencies and the government can help to push these agendas forward.[37-38] Additionally, the lagging of reportable health data like test results needs to be reduced.[38] There needs to be a shift from manual data integration to EHR.[29,38] To do so, there needs to be more efficient data validation through EHR vendors to ensure automatic data integration.[38] This automatic data integration can make reporting COVID-19 test results to appropriate agencies a lot easier thus, making tracing efforts much faster. Quality measurements are a critical part of healthcare before the pandemic and are even more important during it.[29,38] In cities like New York, studies have shown the effects that socioeconomic and racial disparities on public health efforts.[39] These gaps in testing, policy, and outreach exist in the vulnerable population in New York.[19,32,39] Similarly, as many papers suggest, future research should focus on these disparities in testing in low socioeconomic areas to develop innovative solutions to these barriers.[29] This pandemic has shown the impact that insufficient data and a lack of seamless integration can have on the management of the pandemic.[29] Policymakers need to continue to invest in infrastructure, such as health information technology for monitoring COVID-19 in long-term as well as future pandemics.

CONCLUSIONS

Limited resources, lack of coordination, lack of communication, challenges in quarantine enforcement, and isolation have all magnified the COVID-19 pandemic. As a result, contact tracing efforts need to create multi-level strategies to tackle systemic barriers. Policymakers, public health agencies, and healthcare systems need to address disparities, lack of infrastructure, and gaps in testing and reporting to continue to improve contact tracing efforts to help prepare for future pandemics.

REFERENCES


