COVID-19 Spread Section
8/28/20
Turquoise Brewington

Introduction

Since its onset, COVID-19 has drastically spread throughout all global systems and altering typical ways of life. Throughout its spread, nowhere has its human and systemic toll been more pronounced than in the global healthcare system. With images of healthcare workers in makeshift personal protective equipment, overcrowded hospital rooms, and trailer morgues outside of hospitals, the healthcare system is a reminder of how valuable and intricate it is to sustain human life. In the past, the healthcare system has been overwhelmed with epidemics like HIV/AIDS and pandemics of Ebola, but COVID-19 has created a new strain that deeply threatens the foundation of the system itself. With new mutations and diseases, it is difficult to always be prepared for healthcare system shocks, but COVID-19 presents the opportunity to rethink the function and operation of global healthcare.

By exploring the relationship across social systems and specifically within the healthcare system, crucial connections can be made to assess what truly went wrong with COVID-19. For this section, a social system will refer to any integrated network part of a whole that denotes roles for various groups of individuals such as the economy and transportation network for this paper. Within this context, I will first delve into the healthcare system alone, followed by its relationship to other social systems like those mentioned previously. Then, I will transition into how COVID-19's initial spread created an unparalleled strain on the healthcare system by overwhelming its foundation marred by inequity. Finally, I will discuss how these social inequities manifest in interlinked ways such as medical supply shortages and disparate death tools that define the global perception of how to tackle the virus. In doing so, this research aims to reveal how social inequity underlies and connects all social systems, but also how the healthcare social system functions as the foundation of all social systems. Furthermore, I will explore how COVID-19 testing can be used to both quantify the virus spread and also be used as a mechanism to understand the importance of reimagining global system stakeholder collaboration to sustain long-term systemic impact.

Social Systems and their Relationship to COVID-19 Spread

To start, the healthcare system is a decentralized entity whose operation straddles global fragility and stability. According to the World Health Organization (WHO), the key stakeholders that must be engaged within any healthcare systems are organized top-down with: governments, NGOs and not-for-profits, community groups, business and private sector, political parties, local government, health insurance groups, donors and aid agencies, health worker networks, and lastly patients and health service providers (World Health Organization, n.d.). While the website does not designate hierarchical importance across these stakeholders, it is important to notice that the last group listed are the actual patients, which arguably should be listed first because anyone can be a patient at any given time. On another note, the government as the first stakeholder to be engaged aligns with the notion that the government ultimately decides which partnerships and apparatus "best" suits its country based on social obligations. For instance, global healthcare decentralization is largely driven by government perception which is why the German universal health care system operates completely differently from the US fragmented matrix of public and privately funded bodies (Ridic et al., 2012, p.120). Furthermore, the government regime type sets a precedent for country-specific stability in terms of the WHO's six healthcare building blocks of service delivery, health workforce, health information systems, access to essential medicine, financing, governance (Monitoring the Building, n.d., p.xi). From here, if one building block is compromised due to the social context of a country, this can systematically threaten the care a population receives such as fragile contexts. The Organization of Economic Cooperation and Development defines these fragile contexts as places in which attributes like "conflict, forced displacement, violent extremism, famine" are consequences and causes of instability that are conducive to the staggering inequities of healthcare access globally (Organisation for Economic Co-operation and Development, 2018, p.2). In the end, there is no model healthcare system standardization which influences the gradient of stability and fragility that defines the global healthcare system.

Although the healthcare system has a fragmented internal scope, it is deeply connected and sustained through social inequities that auxiliary social systems reinforce and create. Before delving into specific systems, it is crucial to take a step back to the 17th century when the "father of modern taxonomy", Carl Linneaus, instituted the first taxonomy to organize all biological life. In his culminating text, *Systema Naturae,* Linnaeus segmented *Homo sapiens* into a racial order that validated imperial expansion by if groups were "governed by laws, regulated by customs, governed by opinions, or governed by caprice" (Linnaeus, 1735, p.1-9). This racial taxonomy is crucial to understanding how current social systems operate because it not only corresponds to how colonial destruction mimics inequitable distribution today but also shows how the social world is contingent upon man-made, rudimentary order. Sociologist Peter M. Bleau characterized the power of organizing systems further by noting that "the structures of objective social positions among which people are distributed exert more fundamental influences on social life than do cultural values and norms" (Blau, 1977). In other words, social positions, and subsequently ordered hierarchies, are fundamental to unilateral system function. When returning to the present day social systems, this order is apparent in networks such as socioeconomic mobility, transportation, and government which all feed into the impact of globalization on the healthcare system. By nature of these systems being rooted in inequity, it makes sense that the WHO includes them as social determinants of health which are described as "avoidable inequalities in health between groups of people… these inequities arise from inequalities within and between societies" (World Health Organization, n.d.). Thus, the global healthcare system's inequities mimic inequity across society because all social systems are individual components whose sum is a whole society.

As a result of this deep-rooted connection, COVID-19's initial spread only needed to decimate the core healthcare system by using other systems as nodes to drastically alter all global systems. In the *New York Times* animated visualization "How the Virus Got Out" small circles correspond to individuals in Wuhan who contracted the first known cases of COVID-19 and illustrates their movements across China and the globe (Wu et al., 2020). This visualization provides excellent context on how the global transportation system was paramount in spreading the virus across countries and how government response influenced this regulation. Beyond transportation, economic operations continued as usual with minimal closures as person-to-person contact insidiously spread the virus. Building off of this, human interaction is a node of the technology and information social systems denoted by social media and globalization which allow for fast information dissemination across groups. According to health communication researchers, Toni G. L.A van der Meet and Yan Jin, the validity of consumed information paired with cognition guided the "perceived crisis severity, crisis emotions, and intention to take preventative action" that contributed to the extent of how far the virus could spread (van der Meer & Jin, 2019, p.560). Soon, the virus "settled" in the healthcare system where it overwhelmed pre-existing capacities to treat patients and protect others from the unknown. It is then by overwhelming the healthcare system with critical medical supply disruption and overcrowded spaces, that COVID-19 could ultimately alter all other systems through the monomer of individual persons. Put differently, COVID-19 fundamentally compromised human health and presented the threat of doing so to others which thwarts all system functions since humans are the gears operating such systems. Without humans meeting in person, traveling to different locations, and contributing to the economy at work, the global machine malfunctions. Finally, all social systems work together in a globalized society, yet healthcare sets the precedent for this functionality because, without adequate health, humans cannot participate in their man-made systems.

COVID-19 Impact on the Global Healthcare System

By focusing on the healthcare system, it becomes apparent that COVID-19 was effective in altering the system to its current state on the fronts of six functionalities. As outlined by the WHO, the key components of a well-functioning health system include accountable leadership and governance, good health information systems, sufficient health financing, well-performing human resources for health, affordable essential medical products and technologies, and effective service delivery (World Health Organization, 2010). When assessing the toll of COVID-19, it becomes clear that the virus impacted these six capabilities on various scales across the globe. Let's take the component of government which directly correlates to the financing of health systems and accessible health information for example. To assess government action, Scott L. Greer argues that the comparative politics of COVID-19 boil down to four buckets of social policies to crisis management and recovery, regime type, formal political institutions, and state capacity" (Greer et al., 2020, p.1414). Working within this framework, the government manifested very differently in places like New Zealand and Germany where political leaders have been aligned with providing the best science-backed health information compared to Brazil and the US where false information and virus minimization at early stages became commonplace. Thus, the government extends to these other crucial healthcare operating components that have been challenged by COVID-19. Meanwhile, an influx of COVID-19 patients has exacerbated fragile healthcare system capacities and service delivery by requiring rearrangement of space to accommodate social distancing to simultaneously maintain standard functioning like ER and birthing. While telehealth has become a substitute for in-person appointments, this cannot replace necessary outpatient surgeries that are a crucial revenue stream to the healthcare system (Søreide et al., 2020, p.1257). Lastly, healthcare staff has been overworked without sufficient PPE and medical supplies like ventilators, which not only endangers their lives but also increases the difficulty of effectively managing COVID-19 spread (Ranney et al., 2020, p.1). Thus, COVID-19 permeated all major components of the healthcare system to influence its current exacerbated state of disarray.

Testing Shortages and Innovation

Going deeper within the healthcare system, the current testing kit technology and supply shortage pose an added threat to not only sustained virus spread but also having accurate information on its devastation. Currently, the main testing mechanisms for diagnosing are centered around collecting specimens with a nasopharyngeal swab then conducting Reverse

Transcriptase Polymerase Chain Reaction (RT-PCR) to amplify segments of viral RNA (World Health Organization, 2020, p.2). While the Food and Drug Administration has declared that RT-PCR has the specificity of 100%, this fails to encapsulate the immense variability across testing brands that can drive false-negative results (Kucirka et al., 2020, p.1). In a perfect setting, Dr. Steven Woloshin notes that when assuming perfectly specific RT-PCR tests, the probability of feeling sick after contacting an infected person was 20%, and test sensitivity was 95% then the false-negative likelihood would be 1% (). However, the reality is that "for many available tests appears to be substantially lower: the studies cited above suggest that 70% is probably a reasonable estimate. At this sensitivity level, with a pretest probability of 50%, the post-test probability with a negative test would be 23% — far too high to safely assume someone is uninfected" (Woloshin et al., 2020, p.2). In other words, the current testing capacity has a high false-negative likelihood making it difficult to make true assessments on who is and isn't infected with the virus. Even beyond thresholds, the COVID-19 tests themselves are in short supply which poses the twofold barrier of less ability to test for the virus and delays that could indirectly worsen spread through individuals operating under the presumption of not having the virus. Dr. Lauren Kucirka speaks to the connection between testing delays and false negatives as she asserts "Over the 4 days of infection before the typical time of symptom onset (day 5), the probability of a false negative result in an infected person decreased from 100% on day 1 to 68% on day 4… The false-negative rate was minimized 8 days after exposure—that is, 3 days after the onset of symptoms on average"(Kucirka et al., 2020, p.4). From here, it appears that even the timing can influence the likelihood of receiving a false negative and compromising public safety. Moreover, testing serves as the central quantitative measurement of COVID-19's spread, yet its technology and current supply compromise the ability to accurately measure public risk to the virus.

To combat current testing shortages, various safeguards and innovations have been employed as short and medium-term fixes. First, 3D printing has been used to design new nasopharyngeal swab types that are rapidly reproducible without compromising effectiveness (Callahan et al., 2020, p.4). Aside from 3D printing addressing physical swab shortages, this is not enough to combat the overarching supply chain issue of reagents. Reagents are the molecular components like free-floating DNA nucleotides and enzymes that are crucial to the functioning of RT-PCR, and without them, testing cannot be done and subsequent global testing capacity decreases (American Society for Microbiology, 2020). A major way to work within the reagent and swab material shortage that has been employed is pooled or multi-testing. Here, multiple specimens are combined into a single testing apparatus and subsequently cycled through one of two main approaches. According to Dr. Matthias Täufer, "the distinction is made between adaptive testing, for example when all samples in a positive pool undergo a second round of testing, and non-adaptive strategies, where all tests can be run simultaneously" were "testing every sample individually can be considered as a trivial non-adaptive strategy, but there exist nonadaptive strategies which combine the benefit of pooling with the advantages of non-adaptive testing" (Täufer, 2020, p.2). In any case, pooling tests is a viable option to work around testing shortages especially when large groups or presumed asymptotic individuals need to be tested to return to work or school (Esbin et al., n.d., p.3). Although these testing techniques are sufficient concerning current testing shortages, their scope is concentrated in the short and medium-term because there is still potential for false negatives and undercounts. To move towards long-term solutions, these testing strategies must be combined with more targeted approaches that engage all nodes of the healthcare system's networks.

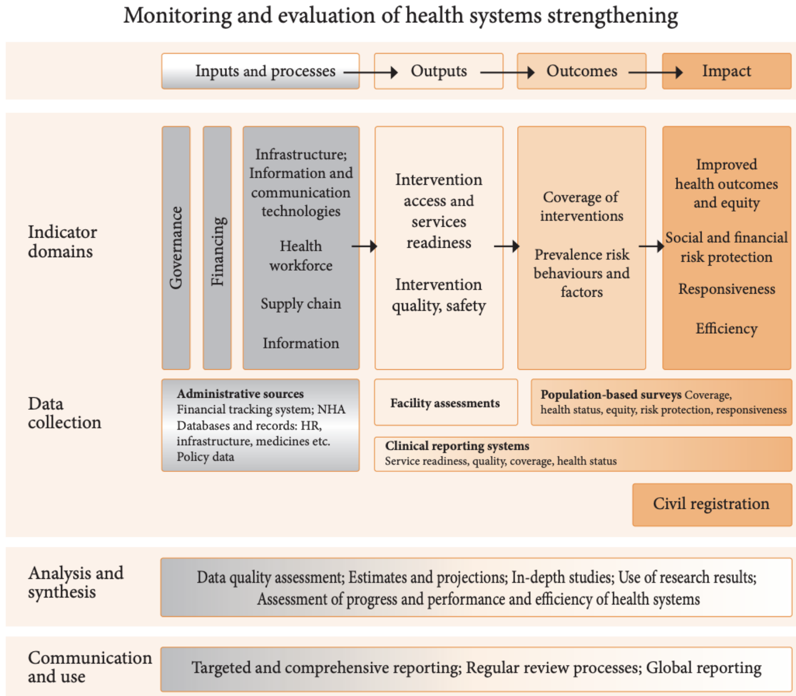
Recommendations and Conclusion

Rather than solely focusing on RT-PCR as the backbone of COVID-19 testing, its properties should be used as a manner to understand how to approach a collaborative virus response with long-term results. As previously mentioned, the process of RT-PCR entails transcribing RNA templates into respective DNA which is then amplified through the cycling of denaturation, annihilation, and extension (Thermo Fisher Scientific, n.d.). It follows that RT-PCR requires both the destruction and collaboration of its different molecules to yield the desired outcome of amplification. These steps can then be taken as guidelines to reassess the current global healthcare system and how to amplify a substantive response whose outcome can be sustained. In terms of the denaturation, current healthcare system stakeholders need to first note the blueprint of the system they operate in and how its function is facilitated on fronts such as socially propagated inequity. In doing so, the denaturation of the current healthcare system can target these specific elements that result in disparities that dictate who lives and dies during and outside of pandemics. By dismantling these elements, individual collaboration must work to anneal to the denatured system with innovative ideas divorced from previous circumstances. This annealing can be premised on the major building blocks of effective healthcare system functioning outlined by the WHO which engage across six key areas. From here, stakeholders need to extend the outreach of these new areas to encompass the entire healthcare system that will ultimately contain the effective parts of its previous templates with the new that reinforces productivity. While this process may seem difficult short term given current circumstances, it is crucial to ensure that the maximum amount of lives can be saved through proper healthcare accessibility. In this sense, RT-PCR testing would complement RT-PCR processes applied to reimagine the global healthcare system.

In conclusion, COVID-19 has drastically altered all social systems by revealing the much-needed reform of healthcare systems and human interaction. Even before COVID-19 spread, social systems were sustained through complex social interactions often premised on constructed hierarchies to maintain order. Within this need to maintain order, the healthcare system emerges as the underlying mechanism of all social systems that are both influenced by and dictated their function. Without proper healthcare, humans that operate all social systems fail to continue work as usual which causes critical malfunctions of global systems. Especially in our increasingly globalized world, a single mishap such as COVID-19 can easily spread across interlinked systems before settling and decimating the central system of healthcare. Although the healthcare system was already weakened by social conditions across systems, COVID-19's unique occurrence exacerbated these fragile foundations which have resulted in the current state of disarray. By delving deeper into the healthcare system, COVID-19 testing becomes a salient means of quantifying the virus but also the preliminary steps of reimagining the healthcare system. In using the process of RT-PCR as a means of approaching reforming the healthcare system, there is greater potential for long-term impact rather than short term fixes of a fractured system.

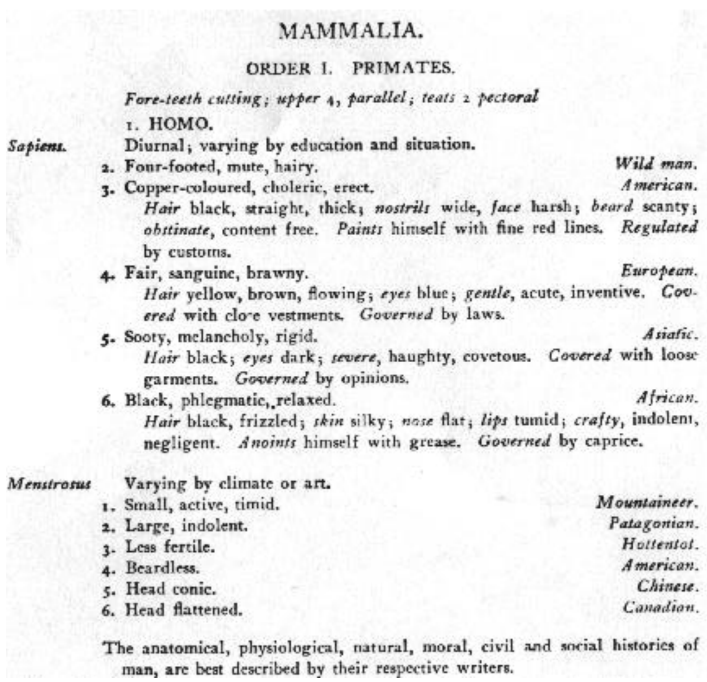
Appendix

Figure 1.



World Health Organization, "Monitoring and Evaluation of Health Systems Strengthening".

Figure 2.



MAMMALIA.

ORDER I. PRIMATES.

Fore-teeth cutting; upper 4, parallel; teats 2 pectoral

1. HOMO.

Sapiens. Diurnal; varying by education and situation.

2. Four-footed, mute, hairy. *Wild man.*

3. Copper-coloured, choleric, erect. *American.*
Hair black, straight, thick; *nostrils* wide, *face* harsh; *beard* scanty; *obstinate*, content free. *Paints* himself with fine red lines. *Regulated* by customs.

4. Fair, sanguine, brawny. *European.*
Hair yellow, brown, flowing; *eyes* blue; *gentle*, acute, inventive. *Covered* with close vestments. *Governed* by laws.

5. Sooty, melancholy, rigid. *Asiatic.*
Hair black; *eyes* dark; *severe*, haughty, covetous. *Covered* with loose garments. *Governed* by opinions.

6. Black, phlegmatic, relaxed. *African.*
Hair black, frizzled; *skin* silky; *nose* flat; *lips* tumid; *crafty*, indolent, negligent. *Anoints* himself with grease. *Governed* by caprice.

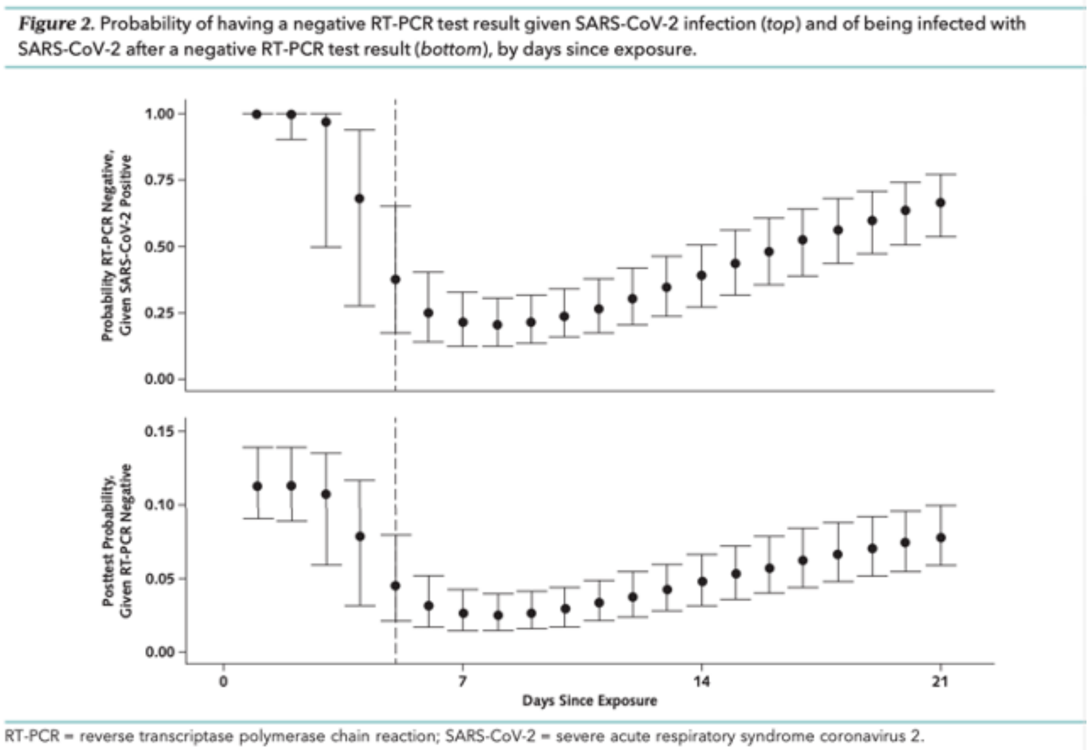
Menstrosus Varying by climate or art.

1. Small, active, timid. *Mountaineer.*
2. Large, indolent. *Patagonian.*
3. Less fertile. *Hottentot.*
4. Beardless. *American.*
5. Head conic. *Chinese.*
6. Head flattened. *Canadian.*

The anatomical, physiological, natural, moral, civil and social histories of man, are best described by their respective writers.

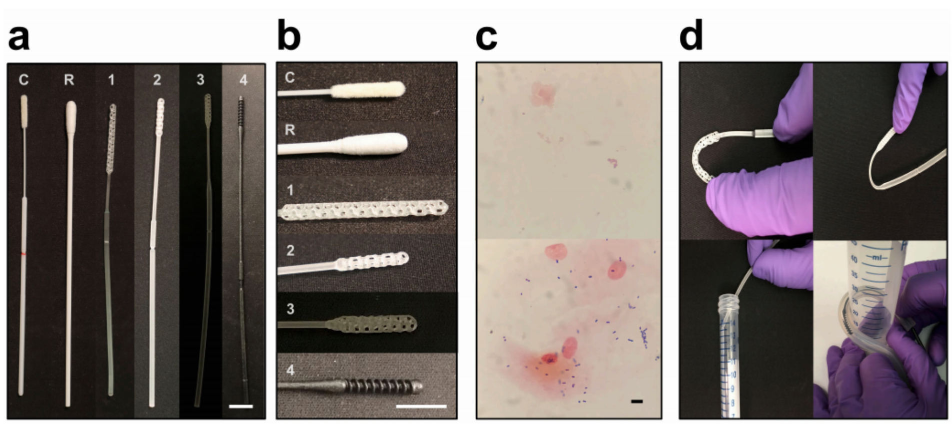
Carl Linnaeus, "Mammalia".

Figure 3.



Lauren Kucirka, "Probability of having a negative RT-PCR test result given SARS-CoV-2 infection and of being infected with SARS-CoV-2 after a negative RT-PCR test result".

Figure 4.



Cody J. Callahan, "Control and Prototype 3D Swabs".

Figure 5.

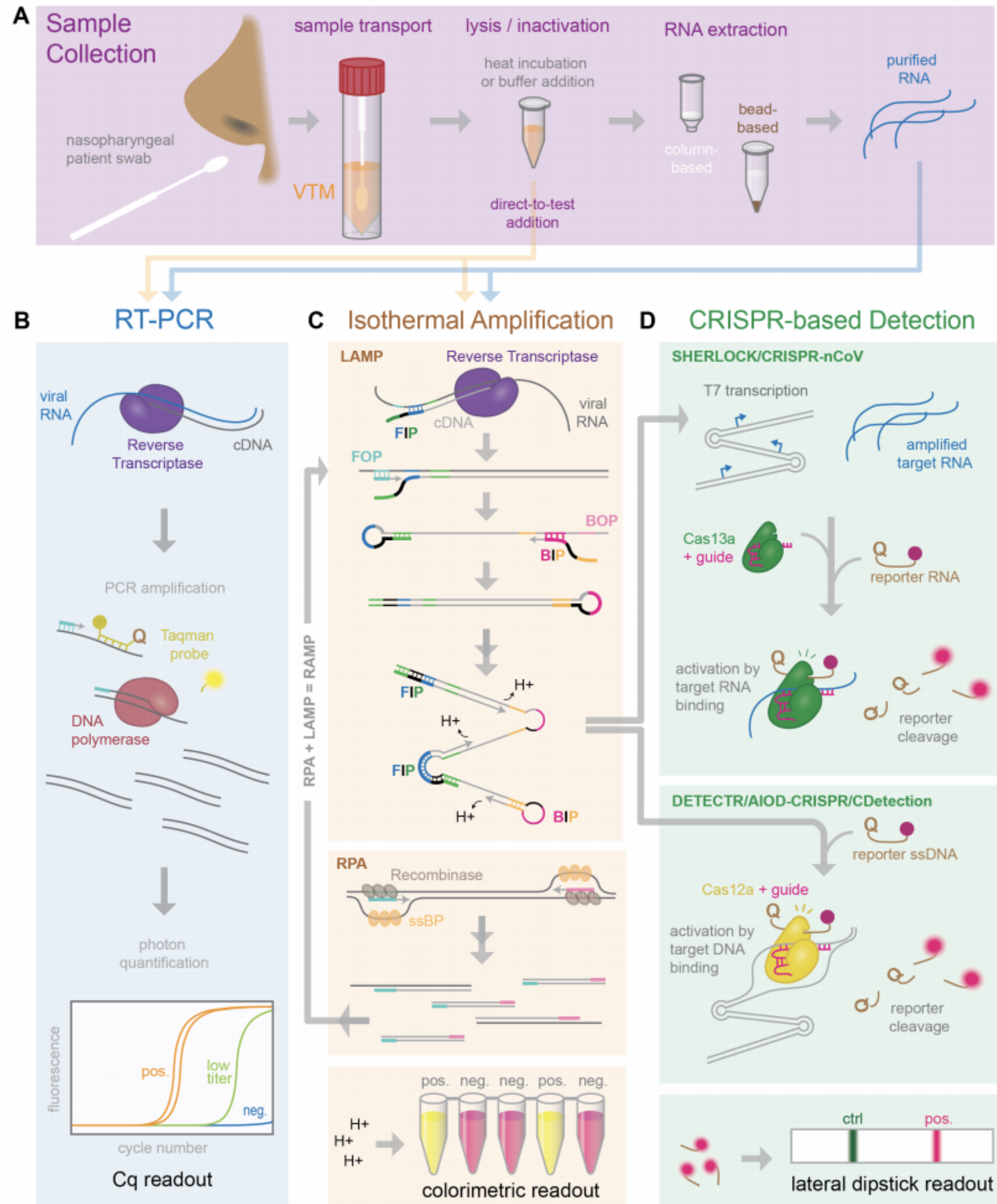


Figure 1. An overview of COVID-19 nucleic acid testing. Samples collected via nasopharyngeal swab are lysed and inactivated, and an amplification reaction is performed using either crude swab sample or purified RNA. Amplification of specific viral sequences by RT-PCR, LAMP, or RPA is detected using fluorescent or colorimetric dyes, sequence-specific CRISPR-Cas nuclease cleavage of a reporter, or separation of reaction products on a lateral flow dipstick.

Megan N. Esbin, "An Overview of COVID-19 Nucleic Acid Testing".

References

American Society for Microbiology. (2020, March 10). *ASM Expresses Concern About Coronavirus Test Reagent Shortages*. American Society for Microbiology. https://asm.org/Articles/Policy/2020/March/ASM-Expresses-Concern-about-Test-Reagent-Shortages

Blau, P. (1977). *Inequality and heterogeneity: A primitive theory of social structure*.

Blumenthal, D., Fowler, E. J., Abrams, M., & Collins, S. R. (2020). Covid-19 — Implications for the Health Care System. *New England Journal of Medicine*. https://doi.org/10.1056/NEJMsb2021088

Callahan, C. J., Lee, R., Zulauf, K. E., Tamburello, L., Smith, K. P., Previtera, J., Cheng, A., Green, A., Abdul Azim, A., Yano, A., Doraiswami, N., Kirby, J. E., & Arnaout, R. A. (2020). Open Development and Clinical Validation of Multiple 3D-Printed Nasopharyngeal Collection Swabs: Rapid Resolution of a Critical COVID-19 Testing Bottleneck. *Journal of Clinical Microbiology*, *58*(8). https://doi.org/10.1128/JCM.00876-20

Esbin, M. N., Whitney, O. N., Chong, S., Maurer, A., Darzacq, X., & Tjian, R. (n.d.). Overcoming the bottleneck to widespread testing: A rapid review of nucleic acid testing approaches for COVID-19 detection. *RNA*.

Greer, S. L., King, E. J., da Fonseca, E. M., & Peralta-Santos, A. (2020). The comparative politics of COVID-19: The need to understand government responses. *Global Public Health*, *15*(9), 1413-1416. https://doi.org/10.1080/17441692.2020.1783340

Kucirka, L. M., Lauer, S. A., Laeyendecker, O., Boon, D., & Lessler, J. (2020). Variation in False-Negative Rate of Reverse Transcriptase Polymerase Chain Reaction–Based SARS-CoV-2 Tests by Time Since Exposure. *Annals of Internal Medicine*, *173*(4), 262-267. https://doi.org/10.7326/M20-1495

Linnaeus, C. (1735). *A General System of Nature, Through the Three Grand Kingdoms of Animals, Vegetables, and Minerals, Systematically Divided Into Their Several Classes, Orders, Genera, Species, and Varieties with Their Habitations, Manners, Economy, Structure, and Peculiarities* (Vol. 1). Lackington, Allen, & Co.

Monitoring the building blocks of health systems: A handbook of indicators and their measurement strategies. (n.d.). World Health Organization.

Organisation for Economic Co-operation and Development. (2018). *States of Fragility 2018 Highlights*. http://www.oecd.org/dac/conflict-fragility-resilience/docs/OECD%20Highlights%20documents_web.pdf

Ranney, M. L., Griffeth, V., & Jha, A. K. (2020). Critical Supply Shortages — The Need for Ventilators and Personal Protective Equipment during the Covid-19 Pandemic. *New England Journal of Medicine*, *382*(18), e41. https://doi.org/10.1056/NEJMp2006141

Ridic, G., Gleason, S., & Ridic, O. (2012). Comparisons of Health Care Systems in the United States, Germany and Canada. *Materia Socio Medica*, *24*(2), 112-120. https://doi.org/10.5455/msm.2012.24.112-120

Søreide, K., Hallet, J., Matthews, J. B., Schnitzbauer, A. A., Line, P. D., Lai, P. B. S., Otero, J., Callegaro, D., Warner, S. G., Baxter, N. N., Teh, C. S. C., Ng-Kamstra, J., Meara, J. G., Hagander, L., & Lorenzon, L. (2020). Immediate and long-term impact of the COVID-19 pandemic on delivery of surgical services. *British Journal of Surgery*. https://doi.org/10.1002/bjs.11670

Täufer, M. (2020). Rapid, large-scale, and effective detection of COVID-19 via non-adaptive testing. *Journal of Theoretical Biology*. https://doi.org/10.1101/2020.04.06.028431

Thermo Fisher Scientific. (n.d.). *Basic Principles of RT-qPCR*. Thermo Fisher Scientific. https://www.thermofisher.com/us/en/home/brands/thermo-scientific/molecular-biology/molecular-biology-learning-center/molecular-biology-resource-library/spotlight-articles/basic-principles-rt-qpcr.html

van der Meer, T. G. L. A., & Jin, Y. (2019). Seeking Formula for Misinformation Treatment in Public Health Crises: The Effects of Corrective Information Type and Source. *Health Communication*, *35*(5), 560-575. https://doi.org/10.1080/10410236.2019.1573295

Woloshin, S., Patel, N., & Kesselheim, A. S. (2020). False Negative Tests for SARS-CoV-2 Infection — Challenges and Implications. *New England Journal of Medicine*, *383*(6), e38. https://doi.org/10.1056/NEJMp2015897

World Health Organization. (n.d.). *Engaging Stakeholders*. World Health Organization. https://www.who.int/nationalpolicies/processes/stakeholders/en/

World Health Organization. (n.d.). *Social Determinants of Health*. World Health Organization. https://www.who.int/social_determinants/thecommission/finalreport/key_concepts/en/

World Health Organization. (2010, May). *Key components of a well functioning health system*. https://www.who.int/healthsystems/EN_HSSkeycomponents.pdf?ua=1

World Health Organization. (2020, March 2). *Laboratory testing for coronavirus disease 2019 (COVID-19) in suspected human cases.*

Wu, J., Cai, W., Watkins, D., & Glanz, J. (2020, March 22). *How the Virus Got Out*. The New York Times. https://www.nytimes.com/interactive/2020/03/22/world/coronavirus-spread.html?smtyp=cur&smid=fb-nytimes&fbclid=IwAR3tdD6vCYfYlNLxqp60wPgtZUY-

lcGSYMp7hzANWYYTLQ9VqHe3TtgLKKY&fbclid=IwAR1ZfdmreVuRkxYNl6Wmh
2JxnQ6D5q0DxUaqCfZP5fekc1od3l-
FBUMLeNM&fbclid=IwAR2i_EXlItjJdUcYbDC29DmkkEDGmxx-Mr7Xr8aaMRULV-
CvJP2IecLo9YA&fbclid=IwAR1qcOlvkrt5P-
lkGJVBNmyKxkL28LJjJ1GI8_et6uF0S4FPm4mtg7EWC-0