4-14-2023

Using the Scientific Method to Combat the Biological and Sociological Effects of the COVID-19 Pandemic: An Aspiring Healthcare Professional's Perspective

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Honors 498-02: Honors Capstone
Professor Carmichael Peters
April 14, 2023

On March 11, 2020, the World Health Organization declared the COVID-19 virus to be a global pandemic.[1] However, the word "pandemic" does not encompass all the repercussions that this virus had on the world. According to the Dictionary of Epidemiology 5th ed., a pandemic is "an epidemic occurring worldwide, or over a very wide area, crossing international boundaries and usually affecting a large number of people."[2] Globally, however, the effects of COVID-19 are two-fold: while the virus has caused millions of infections and deaths worldwide, it has also exacerbated multiple sociological issues—many underrepresented people have faced discrimination based on race and culture, suffering from both unstable work conditions and health disparities that persist today. These sociological inequities must be addressed alongside the biological effects of COVID-19. One approach to effectively combat these consequences is to use a traditional yet reliable process that dates back to the 17th century: the scientific method.[3]

The scientific method is an organized and detailed procedure with multiple steps that ultimately allow scientists to test a hypothesis. It has allowed for the development of effective vaccines, medications, and in the case of my own research at Chapman University, a potential cure for the virus. I will, therefore, define the steps of the scientific method by applying them to my research experience at Chapman working directly with the virus itself. In Step #1 of the scientific method, a researcher discovers a "puzzling observation," in which the researcher does

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[1] Domenico Cucinotta, and Maurizio Vanelli, "WHO Declares COVID-19 a Pandemic," *Acta Biomed* 91 no.1 (March 2020): 157-160, 10.23750/abm.v91i1.9397,

[2] "Pandemic," in A Dictionary of Epidemiology 5th ed., ed. Miquel Porta (Oxford University Press, 2008) https://www.oxfordreference.com/display/10.1093/acref/9780195314496.001.0001/acref-9780195314496-e-1373;jsessionid=FFD49BFFCEC0FA6B7904DC067620C87E.

[3] Castillo, M, "The Scientific Method: A Need for Something Better?" *AJNR Am J Neuroradiol*, 34 no. 9 (September 2013). 10.3174/ajnr.A3401.

not understand a phenomenon and wants to attempt to understand it. For example, in the project, I worked on at Chapman, Step #1 involved my research team's interest in both the high mortality rate of COVID-19 and the nonspecificity of many current therapeutics. The puzzling situation we identified was that most therapeutics tend to treat diseases but target other healthy parts of the body, creating unnecessary yet severe side effects. We thought that we could apply this idea for a medication to the most current and prevalent disease, COVID-19. However, at this point in our process, we needed to develop an idea to address this issue, which is the next step. Step #2 in the scientific process is creating a hypothesis about the observation, which could be based on prior knowledge or research. My research team hypothesized that by using the endogenous mechanism that consists of argonaute proteins called RNA-induced silencing complex (RISC), we could attack the virus in the human body while preventing side effects. Then, in Step #3, the principal investigator (PI) collaborates with a team to create and execute a procedure that allows them to test their hypothesis. The team that I work with consists of multiple professors and graduate and undergraduate students who have produced and executed a procedure based on our hypothesis. In Step #4 of the scientific method, the research team discovers the shortcomings and successes of their results. In my lab, we have identified some procedural mistakes and successes with certain lab techniques. Finally, Step #5 involves preparing for the future. As a team committed to finding a solution to the direct biological effect of the virus, my research group and I have learned from our mistakes in our procedure and are currently preparing for the next steps in advancing our potential treatment for COVID-19.

Now that I have outlined the scientific method through my lab experience, I will introduce its application to address the sociological issues that the virus has created. The scientific method can help people to become what the American philosopher Martha Nussbaum

calls a world-class citizen or someone who views the world beyond themselves. Three main qualities determine this type of citizen: they can practice critical self-examination, view themselves as citizens of the world, and empathize with others. Some common methods to become globally connected include practicing open-mindedness, collaborating with others across multiple disciplines, and pursuing innovative ideas, which are all strategies closely correlated to the stages of the scientific method.[4,5] Therefore, these two concepts can be integrated to confront the social issues related to COVID-19. First, people can develop into global citizens by becoming cognizant of the inequities that the virus has amplified. They can achieve this by being open-minded to other perspectives (Step #1). This awareness can allow for the development of ideas to find ways to combat the issues (Step #2). Then, with the support of others, they can take action against unjust policies, which is Step #3. They then can discover the limitations in their approach (Step #4) and prepare for a more equitable and harmonious future (Step #5). This simple yet potent approach enables us to understand the world around us, allowing us to refine inadequate explanations and build a more just society.

Consequently, the scientific method can be used to enhance not only scientific but also sociological phenomena in light of the COVID-19 pandemic.[6] Due to the systematic nature of the scientific method, its various steps have been used to organize the following two sections below. The first section is a study of the direct biological effects, which involves the development of vaccinations, advancing technologies, medication, and my project's potential treatment for

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[4] Martha Nussbaum, *Cultivating Humanity* (London, England: Harvard Press, 1997), 65.

[5] Rebecca Chopp, "Global Citizens All," Swarthmore College Bulletin, 2011, https://www.swarthmore.edu/bulletin/archive/wp/july-2011_global-citizens-all.html.

[6] OpenAI's ChatGPT AI-Language Model, response to input from author, April 5, 2023. https://openai.com/blog/chatgpt.

COVID-19. The second section is an analysis of the indirect sociological impacts of the virus, involving systemic racism and health disparities of minorities. Both sections begin with context, and the subsequent paragraphs apply each step of the scientific method in chronological order.

Section I: Addressing the Direct, Biological Effects of COVID-19 using the Scientific Method

Context

COVID-19 has many direct global consequences. In March of 2021, it had daily death rates of as high as over 11,000 people in the Americas (July of 2021 in fig. 1).[7] Overall, it has a mortality rate of 2.4% and has killed over 6 million people to date, surpassing the deadly 1918 Spanish Flu.[8,9]

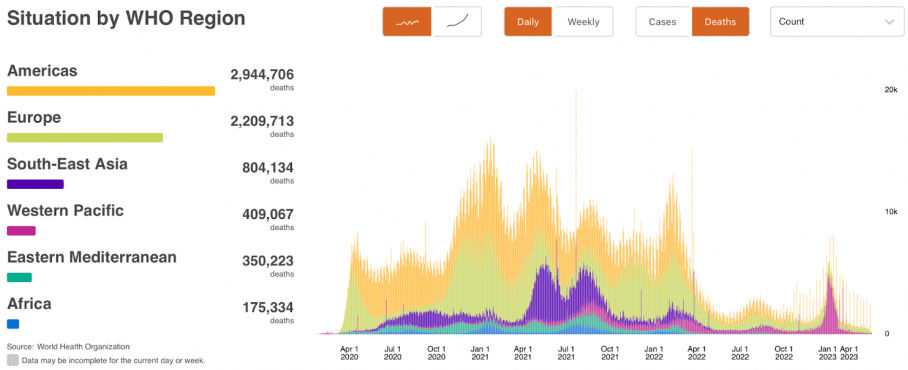

Figure 1. Daily global COVID-19 death rates from April 2020 to March 2023. Reproduced by World Health Organization, https://covid19.who.int.

[7] "WHO Coronavirus (COVID-19) Dashboard," (2023) fig. 1.

[8] Shu T. Liang, Lin T. Liang, and Joseph M. Rosen, "COVID-19: a comparison to the 1918 Influenza and how we can defeat it," *National Center for Biotechnology* 97 no. 1147 (February 2021): 273-274, https://doi.org/10.1136/postgradmedj-2020-139070.

[9] Farida B. Ahmad et al. "Provisional Mortality Data," *CDC,* 70 no. 14 (March 2021). https://www.cdc.gov/mmwr/volumes/70/wr/mm7014e1.htm.

Step #1: The Puzzling Observation Requires Awareness

The first step in the scientific process for creating vaccinations and medications requires identifying unexplained observations or patterns.[10] The high number of deaths per day, high mortality rates, and similarity to one of the deadliest diseases have influenced scientists to find ways to hinder the spread and symptoms of COVID-19 by creating vaccinations, new tracing technologies, and medication with a rapid turnaround time.

In our research project, my PI, Max Strul's idea for a potential treatment for the virus was not only influenced by the high number of COVID-19-related deaths but also the inefficiency of modern medicine. Through performing a gap analysis of scientific literature, he found that, like many other terminal diseases, there is no globally accepted therapeutic to COVID-19 despite the high number of deaths. There are only medications that can help counteract the associated symptoms of this disease. However, these medicines come at a cost— they have severe adverse side effects. Hydroxychloroquine, one of the major medications of COVID-19, has been known to cause mental health changes, eye issues, and muscle weakness, among many other severe problems.[11] My PI's awareness of the lack of treatment and the severe side effects of medications caused him to attempt to create a solution that targeted the specific disease without having side effects.

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[10] Douglas S. Fudge and Andy J. Turko, "The Best Predictions in Experimental Biology are Critical and Persuasive," Journal of Experimental Biology, 223 no. 19 (October 2020). https://doi.org/10.1242/jeb.231894

[11] "Side Effects of Hydroxychloroquine," *NHS*, June 8, 2022, https://www.nhs.uk/medicines/hydroxychloroquine/side-effects-of-hydroxychloroquine/

Step #2: Formulating a Hypothesis Requires Understanding Past Data

Publicizing scientific data as the virus was spreading was essential to create compelling ideas for vaccinations. One of the most significant contributions was from Wuhan, China; they sequenced the genome of the COVID-19 virus and shared it with the world— initiating investigations into the natural characteristics of the virus and enabling the development of diagnostic tests. Other biology companies such as BioRxiv and medRxiv posted 3000 COVID-19 studies by May 7, 2020.[12] Furthermore, prior research into messenger RNA (mRNA) vaccinations was also used. These studies have found that using mRNA could be a scientific breakthrough as it speeds up the process of drug delivery; however, it is difficult to use as it is an unstable nucleic acid and, therefore, degenerates quickly in the human body.[13] These preliminary studies allowed biotech companies to come up with an idea or hypothesis— to use the viral genome from China and create an mRNA vaccination using lipid nanoparticles that would stabilize the mRNA of the virus inside the human body. This would ultimately allow people to develop antibodies against the viral genetic material.[14]

Our research team also utilized data and prior research to understand RISC proteins before we formulated our own hypothesis. At first, we relied heavily on data about the nature of

[12] Theresa Bernardo et al. "Collaborating in the Time of COVID-19: The Scope and Scale of Innovative Responses to a Global Pandemic," *JMIR Public Health and Surveillance* 7 no.2 (February 2021), doi:10.2196/25935.

[13] Abishek Wadhwa et al. "Opportunities and Challenges in the Delivery of mRNA-based Vaccines," *National Center for Biotechnology Information* 12, no. 2 (January 2020): 102, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7076378/.

[14] "Shot of a Lifetime: How Pfizer and BioNTech Developed and Manufactured a COVID-19 Vaccine in Record Time," Pfizer, accessed March 28, 2023, https://www.pfizer.com/news/articles/shot_of_a_lifetime_how_pfizer_and_biontech_developed_and_manufactured_a_covid_19_vaccine_in_record_time.

RISC proteins to formulate our idea. We found that RISC proteins function to target and silence certain genes that might be malfunctioning or cause overexpression of certain proteins using small interfering RNAs (siRNAs).[15] We then decided to use argonaute proteins with pre-loaded siRNAs as our endogenous mechanism. This scientific data pulled from many sources was then used to form our hypothesis— argonaute proteins will target and cleave the Sars-Cov-2 genome of infected lung fibroblast cells to prevent viral proliferation.

Step #3: Methods Requires Collaboration

The idea of vaccination would not have come to fruition without international collaboration—a vital step for the methods portion of the scientific process. As mentioned earlier, COVID-19 has some similarities to the Spanish 1918 flu.[16] However, it is less severe than this flu partly due to the novel technology allowing for worldwide collaboration. One way that companies

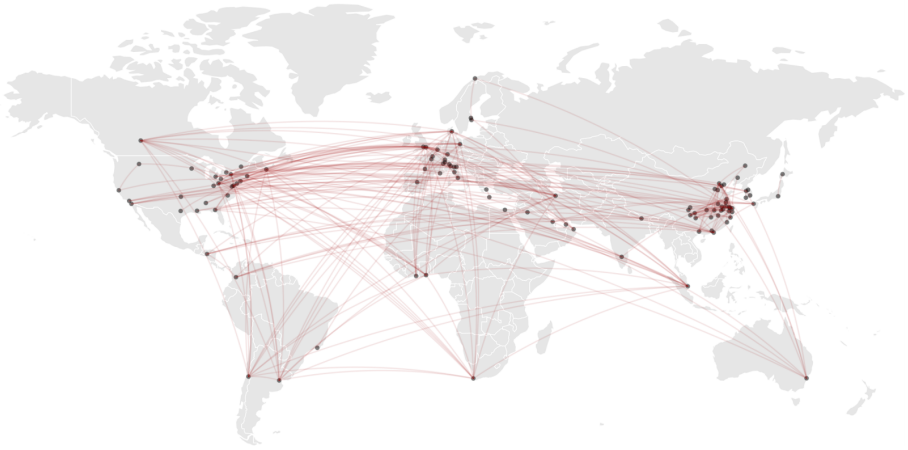

Figure 2. Map of the scientific international collaboration. Reproduced by World Economic Forum https://www.weforum.org/agenda/2020/05/global-science-collaboration-open-source-covid-19/

[15] Andrew D. Redfern et al. "RNA-induced Silencing Complex (RISC) Proteins PACT, TRBP, and Dicer are SRA Binding Nuclear Receptor Coregulators," *Proct Natl Acad SCI USA* 110, no. 16 (April 2013): 6536, doi:10.1073/pnas.1301620110.

[16] Farida B. Ahmad et al. "Provisional Mortality Data," *CDC*, 70 no. 14 (March 2021): 519-522, https://www.cdc.gov/mmwr/volumes/70/wr/mm7014e1.htm.

around the world worked together was through crowdsourcing, which helped counteract the physical effects of COVID-19.[17] Crowdsourcing involves enlisting groups of people to obtain vast amounts of data. This tactic aided in contact tracing and producing personal protective equipment. For example, in April 2020, large technology companies such as Google, Apple, and Amazon collaborated with researchers at Harvard University, Boston Children's Hospital, and the University of Toronto to develop the COVID-19 contact-tracing app, "COVID Near You." Vaccine development also largely was dependent on international scientific collaboration (see fig. 2).[18] In fact, one-third of all vaccine candidates were developed by partnerships. These partnerships required transferring knowledge and sharing materials. The former involves sharing relevant expertise and collaborating to create new technology. The companies BioNTech and Pfizer used this tactic and built a strong partnership. Each company contributed different essential components to manufacture and distribute vaccines.[19] BioNTech developed a preliminary mRNA vaccine, and Pfizer had strong global vaccine research and both manufacturing and distribution infrastructure. The alliances between these companies allowed them to share their scientific knowledge about mRNA vaccines and create an effective vaccine. Another major step in vaccine development was sharing materials.[20] This includes one group of

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[17] Theresa Bernardo et al. "Collaborating in the Time of COVID-19," *JMIR* 7 no. 2 (September 2021), doi: 10.2196/25935.

[18] Marion Maisonobe, "Map of Global Scientific Collaborations on COVID-19 Image," (2020), fig. 2.

[19] Louise C. Druedahl, Timo Minssen, and Nicholson W. Price, "Collaboration in Times of Crisis: A Study on COVID-19 Vaccine R&D Partnerships," *National Center for Biotechnology Information* 39 no. 42 (September 2021): 6293, doi: 10.1016/j.vaccine.2021.08.101.

[20] Louise C. Druedahl, Timo Minssen, and Nicholson W. Price, "Collaboration in Times of Crisis," 6294.

researchers pursuing the initial stages of a process and sharing that information with another group, which does the succeeding steps. AstraZeneca and the University of Oxford employed this strategy as Oxford came up with an mRNA vaccine candidate, and AstraZeneca aided in regulatory approvals and supply agreements.[21] Without these strong alliances, the vaccination would have taken at least four years, which is the shortest amount of time it took to manufacture and distribute a vaccine before COVID-19.[22] However, the development period for the COVID-19 vaccination was only nine months. Therefore, the collaboration of multiple countries is essential to produce efficient and effective scientific breakthroughs.

Similarly, my project manager Strul partnered with various researchers, medical students, and undergraduates, including me, at Chapman University to craft and accomplish a procedure that tested his hypothesis. First, he worked with a bioengineering researcher to help him find ways to get the argonaute proteins into human cells. He also utilized undergraduate students to help create a cohesive procedure and write a grant proposal to execute his idea. In this project, I have been working with the Co-Program director for the Faculty of the Biochemistry and Chemistry department at Chapman University, Dr. Marco Bisoffi. He has taught me various laboratory skills and the initial steps for our project. Our goal was to ensure that Strul's procedure could be successfully executed, so we have been using prostate cancer cells instead of the limited COVID-19-infected lung fibroblast cells. Currently, we are trying to analyze and identify the proteins of the cancer cells using a technique called a Dot Blot. This step is critical to ensure that the lung fibroblast cells have been infected with COVID-19 and, therefore, contain

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[21] Louise C. Druedahl, Timo Minssen, and Nicholson W. Price, "Collaboration in Times of Crisis," 6294.

[22] "Shot of a Lifetime: How Pfizer and BioNTech Developed and Manufactured a COVID-19 Vaccine"

the NSP-14 protein, which is part of the COVID-19 genome. Once we guarantee that the technique works with the cancer cells, we can proceed to the next steps of the procedure. Clearly, the help and support of a diverse community have allowed our team to execute Strul's idea— we have received a grant and a patent and have begun the initial steps of the project's procedure.

Step #4 Analysis of Results requires Detecting Successes and Shortcomings

After the procedure for the vaccine was completed, and the results were collected, the final official step of the scientific method was an analysis of the results. Though the manufacturing and distribution dates of the COVID-19 mRNA vaccines were short compared to previous vaccinations, they were highly effective. When they first were made, the Moderna vaccine was 97% effective at preventing the disease, Pfizer was 95%, and Johnson & Johnson was 86%.[23] However, there were some health risks associated with the vaccines. For example, one of the risk factors for the Johnson & Johnson vaccine included blood clots (TTS), especially in women ages 30 to

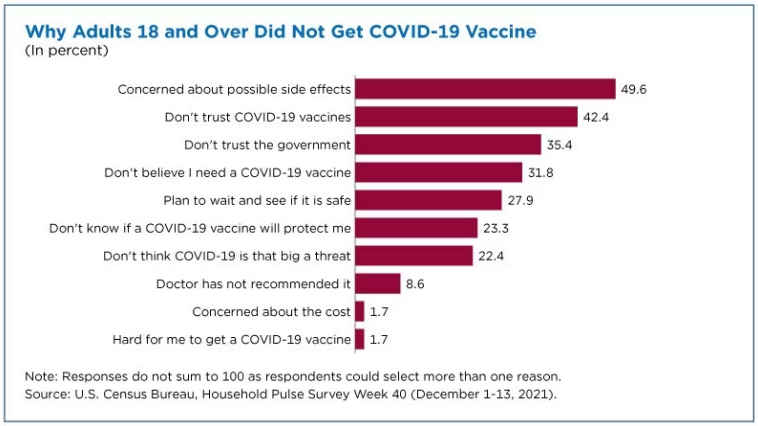

Figure 3. Bar chart representing numerous reasons why Americans will not get vaccinated against COVID-19 (December 2021). Reproduced by U.S. Census Bureau, https://www.census.gov/library/stories/2021/12/who-are-the-adults-not-vaccinated-against-covid.html.

[23] "COVID-19 Vaccine Efficacy Summary," IHME, November 18, 2022, https://www.healthdata.org/covid/covid-19-vaccine-efficacy-summary.

49 years old.[24] Furthermore, some people developed Guillain-Barre syndrome, a neurological disorder in which the immune system attacks neurons. This disorder was discovered to occur in some people around 42 days after receiving the J&J vaccine.[25] However, the risk of developing either condition was low.[26] Furthermore, vaccines produced by Moderna and Pfizer caused some people, especially young male adolescents, and adults, to develop acute myocarditis or inflammation of the heart muscle.[27] Less severe side effects of all COVID-19 vaccines immediately after receiving the vaccination included vomiting, fatigue, headaches, muscle pain, chills, and fever, which usually went away after a few days.[28] Paxlovid, the COVID-19 medication, also had promising effects as it had an "89% reduction in the risk of hospitalization and death in unvaccinated people" and has been highly effective in people who are vaccinated as

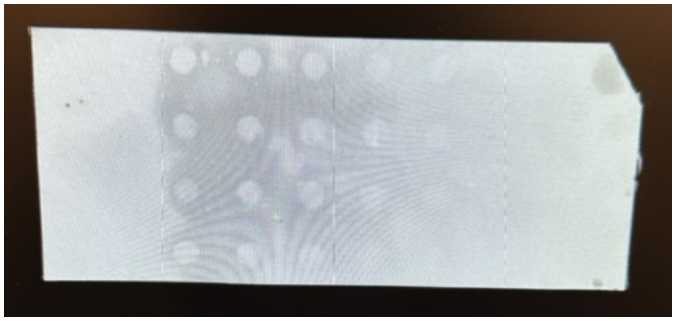

Figure 4. Dot Blot results on a Nitrocellulose membrane of LNCAP and PC3 cancer cells (Fall 2022).

[24] "COVID Vaccine Side Effects," Johns Hopkins Medicine, November 9, 2021, https://www.hopkinsmedicine.org/health/conditions-and-diseases/coronavirus/covid-vaccine-side-effects.

[25] Kathy Katella, "J&J Vaccine and Guillain-Barré Syndrome Information on the FDA Warning," Yale Medicine, December 17, 2021, https://www.yalemedicine.org/news/covid-vaccine-guillain-barre-syndrome.

[26] Mayo Clinic Staff, "What are the Vaccines' Side Effects?," Mayo Clinic, May 11, 2022, https://www.mayoclinic.org/coronavirus-covid-19/vaccine-side-effects.

[27] Mayo Clinic Staff, "What are the Vaccines' Side Effects?"

[28] Mayo Clinic Staff, "What are the Vaccines' Side Effects?"

well.[29] However, there have been reports of a rebound effect, causing COVID-19 symptoms to arise again two to eight days after taking the full dose of medication. There are also numerous side effects, which include hives, trouble swallowing, increased blood pressure, muscle aches, and abdominal pain.[30] Though the vaccines and medication are all safe and highly effective according to the Food and Drug Administration, the numerous and somewhat severe side effects have prevented people from obtaining them. In fact, around 15% of all Americans are unvaccinated due to fear of the possible side effects of the vaccine, not trusting it, and difficulty obtaining it (see fig. 3).[31] Therefore, researchers must find ways to increase vaccine and medication use.

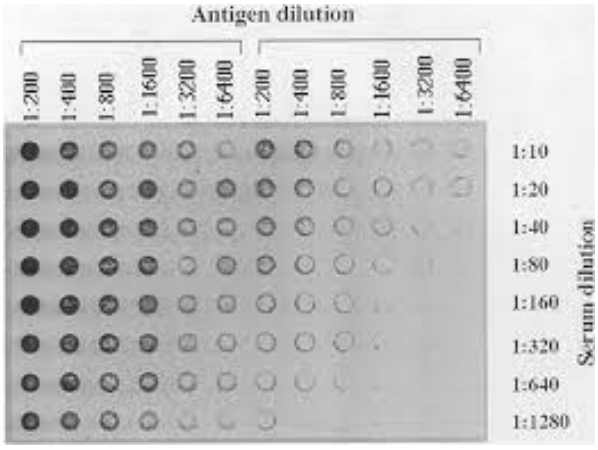

Figure 5. Sample of a Dot Blot result that is correct as the proteins remained inside the dots. Reproduced by Raphael Folitse. https://www.jstor.org/stable/1592571.

In my COVID-19 research project, analysis of results was essential to ensure that we could create an effective treatment for the virus. From the last semester, Fall 2022, until now, Spring 2023, Dr. Bisoffi and I have been working on ensuring that the Dot Blot runs smoothly. Last semester, we used prostate cancer cells on a nitrocellulose membrane to analyze the proteins. We first created an apparatus that contained filter paper and the nitrocellulose membrane that laid underneath a 3D-printed Dot Blot template. Though our

[29] Kathy Katella, "13 Things to Know About Paxlovid, the Latest COVID-19 Pill," Yale Medicine, February 3, 2023, https://www.yalemedicine.org/news/13-things-to-know-paxlovid-covid-19.

[30] Katella, Kathy, "13 Things to Know About Paxlovid."

[31] Lindsay M. Monte, "Why Adults 18 and Over Did Not Get COVID-19 Vaccine" (United States, 2021), fig. 3.

apparatus seemed to work, we found that the dot blot did not produce the correct results (see fig. 4). The proteins of varying dilutions spread around the dots. However, they were supposed to remain within the dots so that we could analyze them (see fig. 5).[32]We discussed that this dispersal of protein could have been due to a prolonged incubation time— we waited around two weeks to view the nitrocellulose membrane under a camera. It also could have been due to the nitrocellulose not working correctly. Identifying both successes and errors is an integral part of the scientific process, as it allows us to modify our methods to create more accurate results in the future.

Step #5: Future Preparations Require the Analysis of Errors

In vaccine research, the decreased vaccination rates in specific neighborhoods must be addressed. Changing the clinic and hospital setting is an essential first step— there should be a diverse healthcare environment in which there are providers of various ethnicities. Studies have revealed that people of color receive more satisfying care when they have providers who share their racial and cultural identity.[33] These providers can also improve these rates by educating people about the danger of catching the Sars-Cov-2 virus as well as the safety and efficacy of the vaccinations and Paxlovid medication despite the side effects. They should discuss the high mortality rate of COVID-19 and emphasize how the benefits of long-term immunity outweigh the costs of the minor side effects. Also, they should explain the rarity of obtaining the more

[32] Raphael Folitse, A. D. Halvorson, and V. Sivanandan, "A Dot Blot Immunoblotting Assay (Dot Blot ELISA) for Early Detection of Newcastle Disease Antibodies in Chickens" (1998), fig. 5.

[33] Pedro A. Poma, "Race/ethnicity concordance between patients and physicians," *J Natl Med Assoc* 109 no. 1 (February 2017): 6–8, doi: 10.1016/j.jnma.2016.12.002.

severe complications associated with vaccinations. For example, it has been estimated that there have been only 18 cases of acute myocarditis for every 1 million administered vaccine doses.[34] Furthermore, there were only around 100 cases of 12.8 million people who reported developing Guillain-Barre syndrome.[35] These descriptions should then be translated into multiple different languages within websites, clinics, and hospitals. COVID-19 knowledge can also be spread through information sessions to reach a vast audience all at once. These sessions can be created by partnering with local and established sources such as faith-based institutions and community organizations, as these are already trusted communities. Another opportunity to build more trust in scientific research could be sustaining Community Based Participatory Research (CBPR) to allow people of color and scientists to collaborate on all aspects of scientific research. Some of the events that CBPR could initiate may include ensuring that multiple minorities are involved in clinical trials and informing these people about the risks and benefits of the tested drug. This intervention can enhance scientific research on various communities and allow marginalized people to build trust in science.[36, 37]Another important component for increasing vaccination rates is ensuring that there is equitable access to these vaccines. Therefore, there must be increased

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[34] "Researchers Study Immune Response, Proteins in Blood of Young Adults Who Develop Rare Complication After COVID Vaccination," Mass General Brigham, January 4, 2023, https://www.massgeneralbrigham.org/en/about/newsroom/press-releases/myocarditis-after-covid-vaccination-study.

[35] Kathy Katella, "J&J Vaccine and Guillain-Barré Syndrome Information."

[36] Crista Johnson-Agbakwu et al., "Racism, COVID-19, and Health Inequity in the USA," 58. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7668281/

[37] "Community-Based Participatory Research (CBPR)," National Institute of Minority Health and Health Disparities, October 2, 2018, https://www.nimhd.nih.gov/programs/extramural/community-based-participatory.html

availability of vaccine clinics, especially in minority neighborhoods. These clinics should operate for a variety of hours, have various formats of obtaining the vaccination such as walk-in or drive-through, and be put into easily accessible locations such as schools, churches, or workplaces.[38] Building faith in science through both education and improvement of scientific research using community-based interventions and increasing accessibility to vaccinations and medications are core components to address when considering the decreased vaccination rates in underrepresented people.

Similarly, my team's analysis of the errors in our data allowed us to create new ideas for future scientists to reproduce accurate results. It allowed us to both alter minor changes, such as our procedure for the Dot Blot and also prepared us for the next steps of the project. For the Dot Blot step, we have decided to decrease the incubation time of the membrane— we will both wait a short amount of time between creating the Dot Blot and using the camera and try a different membrane called PVDF. We are currently achieving this step in Spring 2023 and are hopeful that these changes will produce the results that we need. Regarding the project as a whole, it is essential to begin learning about the drug development and approval process. This involves meeting with people acquainted with biotechnology companies to learn more about the next steps for our project once the treatment is created. They can teach us about obtaining FDA approvals, conducting safety testing, using animal models, and starting clinical trials.

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[38] Anuli Njoku, Marcelin Joseph, and Rachel Felix, "Change the Narrative: Structural Barriers and Racial and Ethnic Inequities in COVID-19 Vaccination," *Int J Environ Res Public Health* 18, no. 18 (September 2021): 9904, doi: 10.3390/ijerph18189904

Section II: Addressing the Indirect, Sociological Effects of COVID-19 using the Scientific Method

Context

When COVID-19 first hit the world, deeply-ingrained issues were brought to the surface, ultimately causing international turmoil. This disunion exacerbated engrained issues in today's society. Countries such as the US and Italy immediately set up multiple restrictions due to fear of the spread of COVID-19. As a result, a recession occurred as multiple local businesses were shut down and travel restrictions were enforced. These restrictions caused many families, especially minorities, such as African American and Latinx communities, to lose their jobs.[39] Restrictions in grocery stores also negatively affected these groups. Initially, stores allowed many wealthy families to buy groceries in bulk, depleting the resources that underrepresented people needed. Later, stores addressed this issue by both limiting the number of certain products that could be bought and raising the prices of groceries, still leaving people of low socioeconomic status at a disadvantage.[40] In a study conducted by the United States Bureau in 2020, half of the

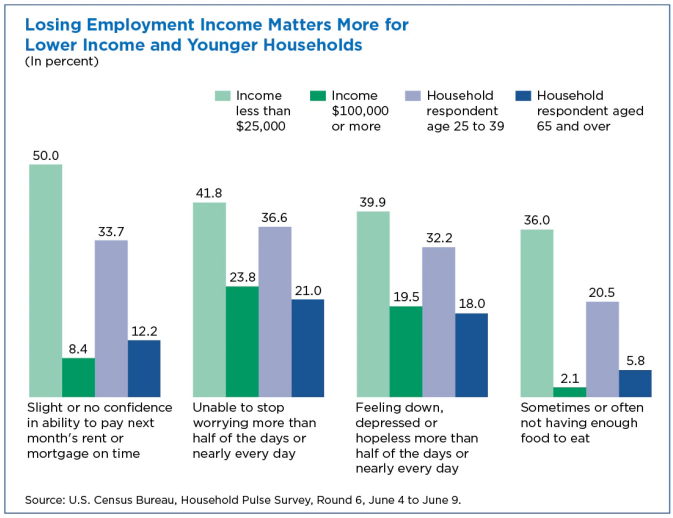

Figure 6. A Comparison of how COVID-19 has affected low SES people versus high SES people. Reproduced by the United States Census Bureau https://www.census.gov/library/stories/2020/06/low-income-and-younger-adults-hardest-hit-by-loss-of-income-during-covid-19.html.

[39] Daphne C. Hernandez and Lauren E. Holtzclaw, "Commentary: The Impact of the COVID Pandemic and the Economic Recession on Food Insecurity Short- and Long-term Recommendations to Assist Families and Communities," *The Journal of Health Promotion & Maintenance* 44, no. 2 (June 2021): 85, http://doi.org/10.1097/FCH.0000000000000291.

[40] Daphne C. Hernandez and Lauren E. Holtzclaw, "Commentary: The Impact of the COVID Pandemic," 6536.

adults with an income of $25,000 or less had no confidence or less confidence in paying their mortgage on time, whereas people making over $100,000 were fairly confident. Furthermore, these low socioeconomic groups experienced higher levels of mental health issues and had the highest food insecurity compared to those with higher incomes (see. fig. 6).[41] Clearly, COVID-19 has formed and amplified many universal economic and mental health issues, which must be addressed. One way to do so is to become aware of the issue, take action against it, and prepare for future pandemics by using the scientific method.

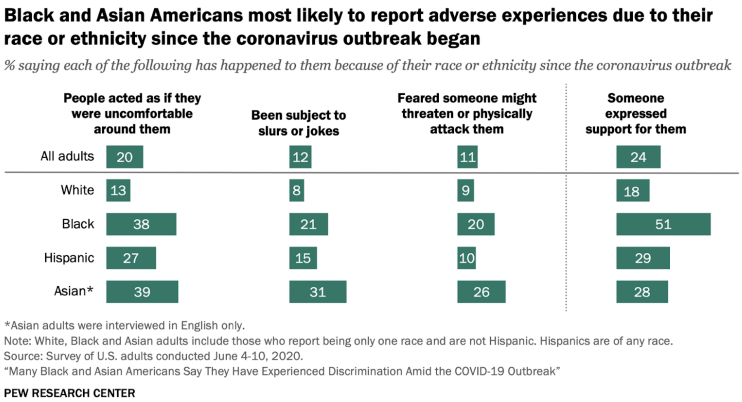

Figure 7. The discriminatory actions that various races in America have faced due to COVID-19. Reproduced by Pew Research https://www.pewsocialtrends.org/wp-content/uploads/sites/3/2020/07/PSDT_07.01.20_racism.covid_Full.Report.pdf.

Eastern Asian Americans were also disproportionately discriminated against as the virus originated in Wuhan, China. World leaders such as President Donald Trump augmented this racism by calling the virus the "Kung flu" or the "Chinese virus." As a result, an increasing number of Eastern Asians were victims of racism. In a study of 9654 Asian Americans in the year 2020, 39% of Asian Americans reported that other people were uncomfortable around them, 31% reported being subject to racial slurs, and 26% felt scared that someone would threaten or attack them (see fig. 7).[42] Some of the most common forms of

[41] Brian Mendez-Smith and Mark Lee, "Low-Income and Younger Adults Hardest Hits by Loss of Income During COVID-19" (2020), fig. 6.

[42] Neil G. Ruiz, Juliana Horowitz, and Christine Tamir, "Americans Say They Have Experienced Discrimination Amid the COVID-19 Outbreak" (2020). fig. 7.

discrimination against them included physical assaults, verbal harassment, and vandalization.[43] The repercussions and prejudice against minorities have led to increased mental health issues, including anxiety, depression, and burnout. COVID-19 created a worldwide division, causing underrepresented people to be at an economic disadvantage and discriminated against.[44] Therefore, a solution that unifies all people regardless of economic status and ethnicity is significant to counteract the adverse effects that COVID-19 has imposed.

Step #1: Puzzling Observation

Being observant and unbiased can also be used to understand the mental repercussions that this virus has created. After COVID-19 hit both my hometown of Reno, Nevada and the city where my college is in Orange, California, I witnessed the mental health effects that the virus had on various demographics. When I worked in an ophthalmology office in Reno, NV, in 2020, I saw middle-aged patients who were unable to remain calm— some were anxious about the COVID-19 policy of not allowing an acquaintance with them, and others were afraid that they could not afford to pay for in-office checkups and procedures. When I interned at the Children's Hospital of Orange County to shadow doctors of different specialties, I saw multiple kids who suffered from mental illnesses that were related to COVID-19— one kid committed suicide at his home and was rushed to the hospital, and another had an eating disorder. Doctors suspected these events most likely occurred from family stressors and the social isolation that COVID-19 had brought. Though it was an emotionally difficult time for me as I listened to these stories, I was

[43] Qin Gao and Xiofang Liu, "Stand against anti-Asian racial discrimination during COVID-19: A Call for Action," *Sage Journals* 64, no. 2 (March 2021): 261-264, https://doi.org/10.1177/0020872820970610.

[44] Wen Li et al. "Global Imperative to combat stigma associated with the coronavirus disease 2019 Pandemic," *Psychological Medicine* 51, no. 11 (August 2021): 1957-1958, https://doi.org/10.1017/S003329172000199.

grateful that I could have these experiences and begin the first step in becoming a world-class citizen. According to the American philosopher Martha Nussbaum, this initial step requires people to gain knowledge about a particular subject by acquainting themselves with multiple people's views, whether it be through first-hand experiences, watching a variety of news networks on the television, or reading various articles.[45,46]

Step #2: Hypothesis

Understanding many perspectives can then initiate the next step of the scientific process, formulating an opinion or hypothesis. Nussbaum believes that participating in Socratic discussions is critical for this step. Socratic discussions are open-ended conversations between people with diverging views. They allow people to understand other people's perspectives, reflect on their own values, and formulate their own opinions about the world around them without simply accepting other people's convictions. The critical thinking skill that results from Socratic conversations will help people become more empathetic towards others and may lead them to take action against certain policies that do not align with their own values.[47] I had multiple Socratic-style discussions with patients and doctors and thus have heard from multiple perspectives about COVID-19 and its policies. Many patients complained about the financial hardships and social alienation in the hospital, while doctors faced burnout as they had to support their patients both physically and mentally. Learning about these experiences not only made me feel an overwhelming sense of empathy for both parties but also allowed me to form my own

[45] Martha Nussbaum, *Cultivating Humanity*, 65.

[46] Nussbaum, 32.

[47] Nussbaum, 90.

judgments and feel the need to take action by volunteering my time in research for a COVID-19 treatment— the next step in the scientific process (methods) and becoming a world-class citizen.

Step #3: Methods

Correspondingly, collaboration, a primary approach to becoming a global citizen, will help execute the methods related to combat the disadvantages of certain groups due to COVID-19. Nussbaum believes that once people become aware, they can pursue actions in accordance with their perception of good deeds by cooperating with others.[48] Thus, the first step in executing action against oppressive policies is to allow underrepresented people to form trusting groups. One study conducted in Southern California used multilevel pre-intervention restorative processes to create community-based anti-racist praxis.[49] They strengthened marginalized communities that faced structural racism by creating both online and in-person restorative groups. These groups included Latinx youth, Black men, LGBTQIA+ people and allies, and transgender persons. They found that these supportive circles allowed people to build trust with each other and create praxis, which are movements that support social change. These praxis allowed underrepresented groups to share both resources and decision-making, as well as engage in knowledge co-creation.[50] As mutual trust increased within these groups, they have

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[48] Chad Keist. "Global Ethics: Capabilities Approach," *Internet Encyclopedia of Philosophy*, Accessed April 7, 2023, https://iep.utm.edu/ge-capab/.

[49] Paris Adkins-Jackson et al. "The Role of Anti-Racist Community-Partnered Praxis in Implementing Restorative Circles Within Marginalized Communities in Southern California During the COVID-19 Pandemic," National Center for Biotechnology Information 24, no. 2 (November 2022): 232, doi:10.1177/15248399221132581.

[50] Paris Adkins-Jackson et al. "The Role of Anti-Racist Community-Partnered Praxis," 232.

grown larger and stronger across all nations. As a result, they have initiated multiple social reforms. For example, in the United States, on January 26, 2021, President Joe Biden issued a Memorandum Condemning and Combating Racism, Xenophobia, and Intolerance against Asian Americans and Pacific Islanders in the United States.[51] This legal contract ensures that any COVID-related documents do not contribute to systemic racism against the AAPI community. Furthermore, he also created a national pandemic policy that would improve "data collection on high-risk groups, equitable access to vaccines, tests and personal protective equipment, and fund assistance for social services including child care and paid sick leave." [52] Furthermore, organizations, such as the United States Children's Funds (UNICEF) and Food Agriculture Organization (FAO), have responded to the major food insecurity in Asia and the Pacific by supporting family farmers and indigenous people and meeting the dietary needs of women and children.[53] Though discrimination is a major

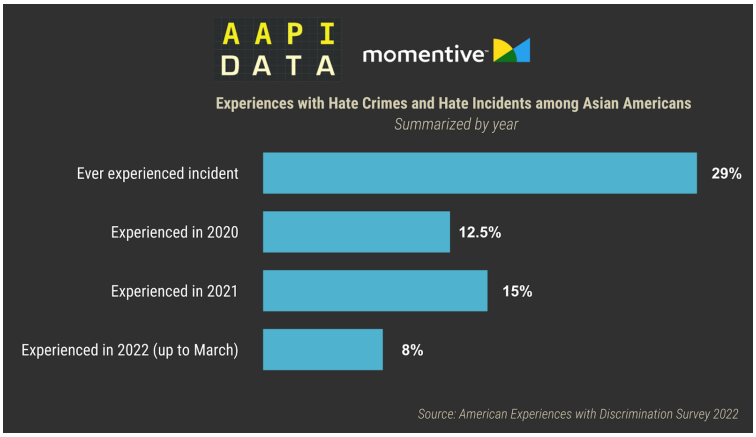

Figure 8. The increasing rates of Anti-asian crimes in America. Reproduced by AAPI Data http://aapidata.com/blog/year-after-atlanta/.

[51] "Fact Sheet: U.S. Efforts to Combat Systemic Racism," The White House, March 20, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/21/fact-sheet-u-s-efforts-to-combat-systemic-racism/.

[52] "Fact Sheet: U.S. Efforts to Combat Systemic Racism," The White House.

[53] "The United Nations & COVID-19 Global Health Emergency," United Nations Association of the United States of America, January 1, 2022, https://unausa.org/un-covid-19-response/.

persisting issue, the formation of communities has helped set forth multiple policies against COVID-19-related disparities, creating a more inclusive society.

Step #4: Analysis of Data

Despite the efficacy of these communities, global citizenship requires people to analyze the problems of certain approaches "with rigor and detail" to ensure change.[54] Therefore, it is crucial to analyze the strengths and shortcomings of anti-racism and anti-health-disparity coalitions to make progress in the future. These groups, for example, have majorly increased awareness and significant policy changes, as mentioned above. However, these issues still exist globally and should not be overlooked and ignored. One major event that marked the continued violence against Asian Americans was the Atlanta shootings in which a Caucasian man shot six Asian-American women in three Asian-owned massage parlors in Atlanta, Georgia. This incident occurred in March 2021, a year after the world entered a state of emergency. One year after this incident, in March of 2022, AAPI Data showed that around one in eight Asian Americans and Pacific Islanders reported that they had experienced at least one hate crime in 2020. This number has since increased to one in six in 2021.[55] In the first

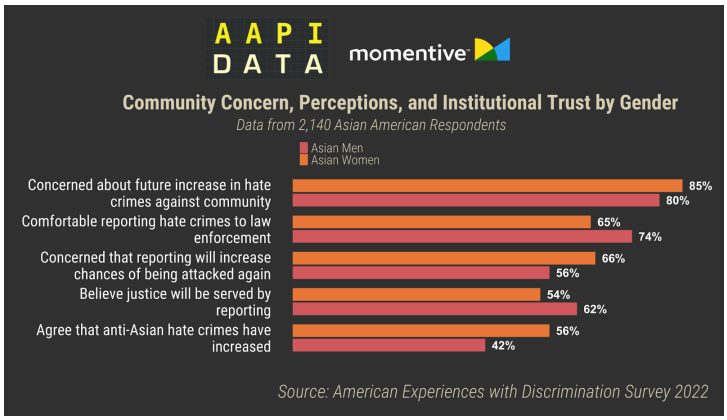

Figure 9. The mental health consequences of Asian-Americans succeeding the COVID-19 pandemic. Reproduced by AAPI Data http://aapidata.com/blog/year-after-atlanta/.

[54] Martha Nussbaum, *Cultivating Humanity*, 79.

[55] Jennifer Lee and Karthick Ramakrishnan, "Experiences with Hate Crimes and Hate Incidents among Asian Americans" (2022), fig. 8.

three months of 2022, the number was one in twelve and was projected to increase for the remainder of the year. As a result of this increase, there have been long-term mental health consequences for these minorities, which can be seen in Figure 8. Around 49% of Asian Americans agree that anti-Asian hate crimes have increased, and an average of 82.5% of Asian Americans are afraid of the further increase of crimes against their community (see fig. 9).[56]

Socioeconomic issues also persist— on August 8th of 2022, self-reported long COVID symptoms are one quarter to one third higher among adults who are female, transgender, Hispanic, and without a high-school degree (see fig. 10).[57] This trend is largely due to lower earnings of the groups and the inability to access disability benefits.

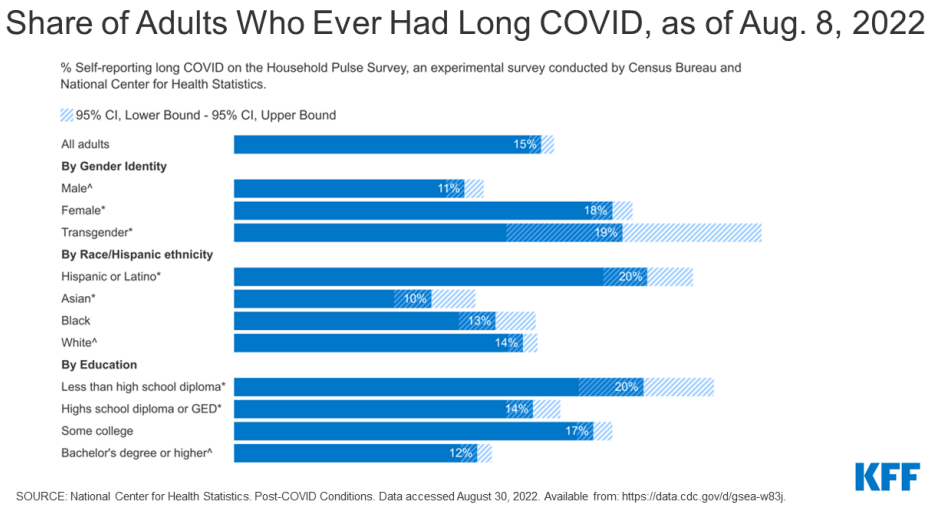

Figure 10. Demographic differences of long-term COVID-19. Reproduced by Kaiser Family Foundation. https://www.kff.org/policy-watch/will-long-covid-exacerbate-existing-disparities-in-health-and-employment/

Clearly, economic disparities and both interpersonal and structural racism persist long after COVID has struck the world. Therefore, action against these disadvantages must continue, and policies must be changed.

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[56] Jennifer Lee and Karthick Ramakrishnan, "Community, Concern, Perceptions, and Institutional Trust by Gender" (2022), fig. 9.

[57] Alice Burns, "Percent of Adults Who Ever Had Long COVID as of August 8, 2022," (2022), fig. 10.

Step #5: Future Preparations — A Call to Action

In her book "Cultivating Humanity," Nussbaum states that global citizens must "vigorously criticize" certain approaches when "criticism is due" to prepare for upcoming actions.[58,59] Therefore, the analysis of the advantages and shortcomings of our efforts to address the disparities and racism people have faced will also prepare us for future pandemics. The most important way to achieve a more equitable society is to have people of various professions actively engage in efforts. One journal conducted a meta-analysis to propose methods that can be successful in counteracting the social disadvantages that have occurred from the pandemic.[60] The first step in addressing this issue is utilizing anti-racism, implicit bias, and cultural competency training, which involves people of all professions becoming aware of institutional racism as well as internal biases. We must hold multiple mandatory training sessions for public health professionals, policy-makers, researchers, and social scientists to understand the strong links between social determinants of people's health and race to health inequity. Furthermore, workplaces should incorporate iterative self-reflection exercises so people become aware of their own internal biases. The next step is using Capacity Building or creating ethnocultural diverse environments that advocate diversity, equity, and inclusion, whether that be having a more diverse work environment, normalizing the assessment of microaggressions, or providing

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[58] Martha Nussbaum, *Cultivating Humanity*, 111.

[59] Nussbaum, 294.

[60] Crista Johnson-Agbakwu et al. "Racism, COVID-19, and Health Inequity in the USA: a Call to Action," *Nature Public Health Emergency Collection* 9, no. 1 (November 2020): 55, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7668281/.

mentorship to underrepresented groups.[61] There should also be dedicated spaces at workplaces that have resources for people to share their concerns and experiences. Finally, fostering an empowering environment by creating inclusive communities and new inclusive policies is essential. Supportive communities can allow for cultural humility and the amplification of voices to demand change. These communities should then be allowed to voice their concerns to the larger community at scheduled town halls. New policies can include supporting these groups through housing, education, criminal-reduction programs, and immigration reform. However, major institutional policies also must be created to have a larger impact in supporting these people. One major institution that must be changed is the criminal justice system, as people of color are disproportionately arrested. Furthermore, criminal convictions disqualify people from housing and many jobs.[62] Therefore, providing housing and accessible jobs after incarceration is essential. More money should also be invested in defense programs as pretrial releases require lots of money, which causes people of low SES to increasingly "accept less favorable pleas." [63,64] As the director of Collaborative in Health Equity at UMass, Crista E. Johnson-Agbaku, stated,

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[61] "Office of Equity, Diversity, and Inclusion," University of Arizona, accessed April 2, 2023, https://phoenixmed.arizona.edu/diversity.

[62] Ram Subramanian et al. "A Federal Agenda for Criminal Justice Reform," Brennan Center for Justice, December 9, 2020, https://www.brennancenter.org/our-work/policy-solutions/federal-agenda-criminal-justice-reform.

[63] Krishnan Lakshmi, Michelle S. Ogunwole, and Lisa A. Cooper, "Historical insights on coronavirus disease 2019 (COVID-19), the 1918 influenza pandemic, and racial disparities: illuminating a path forward," *Ann Intern Med* 173, no. 6 (June 2020) 173:474–481, doi:10.7326/M20-2223.

[64] "Report to the United Nations on Racial Disparities in the U.S. Criminal Justice System," The Sentencing Project, April 19, 2018, https://www.sentencingproject.org/reports/report-to-the-united-nations-on-racial-disparities-in-the-u-s-criminal-justice-system/.

"Silence and complicity are both corrosive and destructive."[65] Therefore, it is essential that institutions provide outlets for disadvantaged people to share their perspectives and change multi-sector policies to create a more equitable future that supports rather than admonishes people based on race, gender, and ethnicity.

After four years of constantly practicing the scientific method in college as a biology major, I have realized its significance— it extends beyond the basic protocols that I learned in my labs and can be applied to other prevalent issues, especially those that I will encounter when I become a healthcare professional in the near future. Through watching the interactions between doctors and patients in a clinical and hospital setting, I have realized that practicing medicine is a multifaceted skill; it requires healthcare workers to address both the direct biological effects and the indirect social effects. Many healthcare workers can efficiently diagnose their patients, help discover novel therapeutics, and provide treatments for specific diseases. However, the more difficult task is becoming global citizens to understand their patients in the context of their background, personality, and goals in life to appropriately treat them, especially in the time of a pandemic when these factors may impact patients' health and well-being on a greater scale. The scientific method can, therefore, act as a guide to healthcare workers to understand their patients on a holistic scale rather than purely a pathological one to provide optimal treatments, especially during the unprecedented times of pandemics.

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[65] Crista Johnson-Agbakwu et al. "Racism, COVID-19, and Health Inequity in the USA," 58.

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