



# Impact of COVID-19 on Physiology Research: Global Lessons Learned and Future Recommendations

Jeet Patel and Santanu De\*

Department of Biological Sciences, Halmos College of Arts and Sciences, Nova Southeastern University, 3300 South University Drive, Fort Lauderdale, FL 33328, U.S.A

\*Corresponding author's email: [sde@nova.edu](mailto:sde@nova.edu)

## ABSTRACT

The Coronavirus Infectious Disease 2019 (COVID-19) pandemic caused massive changes in not only the medical field but every aspect of the world. As the whole world moved from in-person to remote, students found themselves in a predicament where they were forced to take school online, from home. This would mean that all projects, research, tests, and meetings were conducted over Zoom or other online meeting platforms. Labs were shut down or only a limited number of people were allowed to enter to conduct the necessary research. In this paper, the field of physiological research throughout the world will be discussed, and how the COVID-19 pandemic has affected the research process of all anatomical fields and experiments themselves. An extensive literature review of many published reports has been conducted for the study. The purpose of this is to better understand the impact of COVID-19 on the vast area of physiological studies and research. Experiments that were being conducted were halted, which could change the entirety of the results. A major issue found is that volunteers were at a minimum, specifically in the ages greater than 65 years, were scarce as they refused to volunteer due to COVID-19 risk or various other reasons. As the volunteers began to drop, experiments conducted by students were forced to change to an online-only format. Medical students were forced to conduct physiological research from home as they spoke with volunteers over the phone. This not only changes the results coming in but also the learning progression for the students. This comprehensive literature review analysis summarizes how, among multifarious short- and/or long-term consequences of the pandemic in practically every sphere, the area of physiological research was drastically impacted.

**Keywords:** COVID-19; Global impact and recommendations; Physiology research

## 1 Introduction

With a growing number of cases that will soon reach a billion as well as a total of 7 million confirmed deaths, the COVID-19 pandemic has engendered one of the most pernicious challenges in modern medicine. Healthcare professionals and researchers have worked together to find treatment and vaccinations for the virus. In order to find treatment, a complex knowledge of the COVID-19 virus must be obtained. In order to do so, extensive research must

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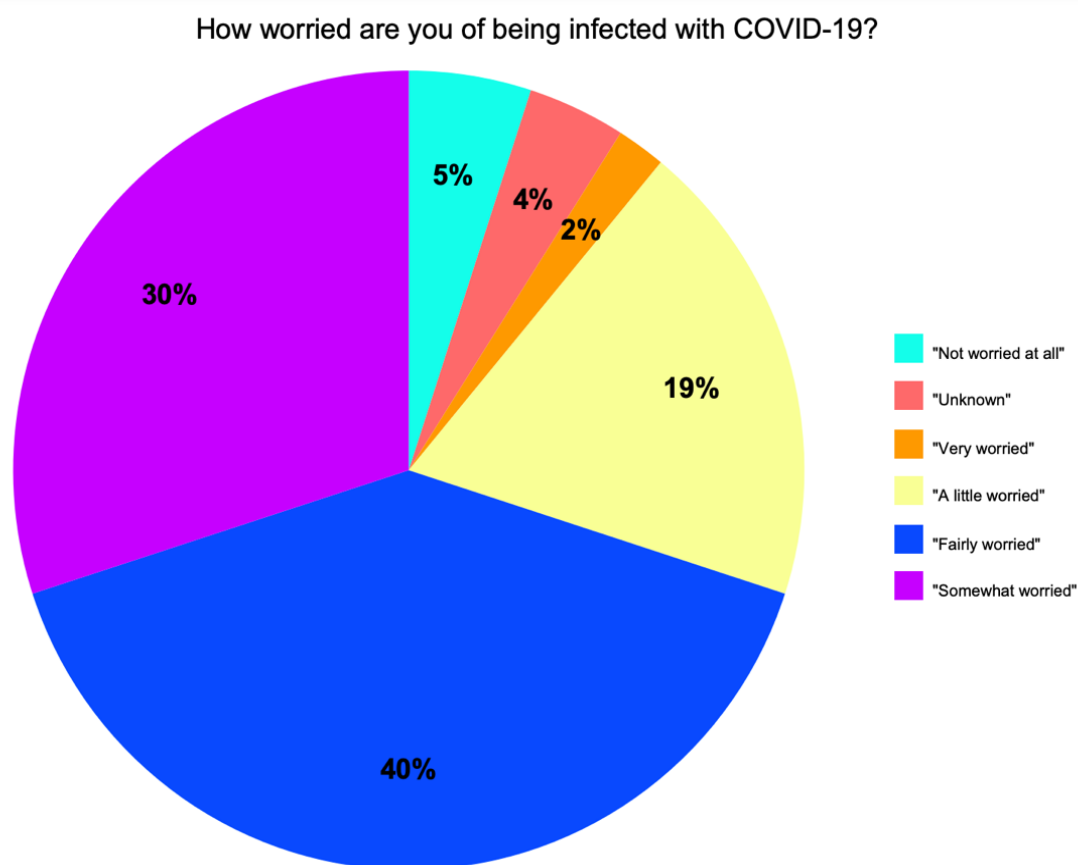
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be conducted in various areas that are impacted by the virus such as physiology, anatomy, and pharmaceuticals. However, these research studies were greatly impacted by the pandemic due to guidelines and fear of becoming infected. This led to delays and complete data changes in scientific research being conducted before and during the pandemic. This extensive study will cover the impact of the COVID-19 pandemic on research in physiology and future recommendations from lessons learned.

## 2 Impact of COVID-19 on Physiology Research: Volunteers

Physiology research is an important factor that produces intel that can assist in creating vaccines, treatment plans, and medication. Due to the pandemic, many of the research studies being conducted saw a major change in the number of volunteers readily available. There has been a major decline in the number of volunteers that would sign up for certain physiology experiments. This major disruption in human clinical trials can cause setbacks in new findings in these trials for improved advancements.

Another issue is the decline in the number of volunteers in the older population, specifically in ages older than 65, as shown in figure 1. Ethical considerations and the safety/risks to volunteers during these trials must be considered with the virus lingering around [1].



Colleen S. Deane, Amanda Gates, et. al., 2021

**Figure 1:** Percentages from a questionnaire given to elderly individuals above the age of 65 regarding their fear of being infected. A majority stated that their perception ranged from being somewhat afraid to fairly afraid of contracting the virus.

Although some participants were hesitant to participate in physiology research trials, one major theme stuck out. With the guidelines instilled by the government and CDC, volunteers were focused on whether to trust the process of the trial and its safety with researchers and volunteer interactions. A volunteer is unsure whether the trial is safe enough or risk-free from contracting COVID-19 while at the research site [2]. With such a high percentage of volunteers fearing being infected with COVID-19, there is a handful of the population that was not worried at all. In a study, altruism, and other common reasons for wanting to engage were seen, proving that the availability of an inconvenience allowance did not appear to be a determining factor in participation [3]. With the decrease in volunteers, and halt in research trials and experiments, data collected prior to the pandemic was backed up or was being lost with time. This led to lower publications of up-to-date physiology research. According to the American Physiology Society, about 45% of researchers have lost or had setbacks in their research due to the guidelines and lockdowns [4]. With all that in mind, further development of vaccinations, globally available vaccine programs, better and improved treatment plans, and proper government guidelines can help place trust in volunteers around the world [5]. These factors can bring a decrease in the number of cases around the world, which brings down the total fatalities, and volunteers see a positive view on whether participating is trustworthy [6].

According to the WHO, there has been a total of 288 vaccines against COVID-19 have been developed. However, a total of 184 are in clinical phases [7]. With further development of the vaccine and administration throughout the population, the amount of fear and death will decrease. Along with that, population immunity will arise and volunteers for trials will become more comfortable in participating. With hard evidence of positive benefits from receiving the vaccine, people became vaccinated; however, there was still fear for this constantly evolving virus.

### **3 Impact of COVID-19 on Physiology Research: Guidelines**

Due to the risk factor for patients, volunteers, and researchers, COVID-19 has somehow changed the “dogma” of how normal trials or diagnoses would be conducted [8]. The guidelines provided by the World Health Organization, WHO, had a seismic impact on the procedures and voluntary decisions made by people for certain physiological clinical trials. Guidelines placed by the CDC and WHO such as five days of quarantine with possible exposure to COVID-19, five days of quarantine as well as five days of masking with a positive COVID-19 test result [8], and retest near the end of quarantine mark, can add many steps to the research trial in need of volunteers. Researchers must follow these guidelines to not only break any healthcare or federal laws but also to gain trust among the volunteers and patients that are willing to participate. With the requirement of testing within 24-36 hours prior to any form of healthcare-related event, researchers must have volunteers present with a proper negative PCR test result for COVID-19 prior to beginning trials. In addition to the test result, volunteers are required to wear masks and maintain a 6 feet distance from a researcher [9]. With all these requirements for both volunteers and researchers, along with the fear of being infected with the virus, fewer volunteers will be readily available. An example of these safety guidelines can be seen in the disruption of exercise physiology research. In a survey distributed in this study, as many as 53% of researchers did not have access to labs and volunteers due to guidelines and 40% of researchers had less than 10 years of training experience [10]. Due to these issues, the

American Physiology Society and the Physiological Society have made major contributions to resources and additional guidelines. Advisory panels have been formed to provide up-to-date informatics on COVID-19 and how it can possibly impact ongoing research in different regions [11]. This allows researchers to expect an influx of COVID-19 patients and volunteers that may cause data inaccuracies or a decrease in volunteers. Table 1 encapsulates predominant challenges to physiology research before versus during the pandemic.

**Table 1:** Comparison of key pre-pandemic challenges to physiology research versus those during COVID-19.

Prior to COVID-19	<ul style="list-style-type: none"> <li>● Physiological volunteers were available readily at all places and all ages. Most importantly in ages <math>\geq 65</math> were able to volunteer. (7)</li> <li>● Healthier volunteers with a more even data between illnesses were found in data prior to the pandemic.</li> <li>● Studies were conducted and completed on a timely manner and data collected was processed before another major population change occurred.</li> </ul>
During COVID-19	<ul style="list-style-type: none"> <li>● Ages <math>\geq 65</math> dropped by a large percentage in volunteers for physiological studies.</li> <li>● SARS-CoV-2 virus caused major damage to both respiratory and circulatory systems, which caused major changes in data intake for ongoing physiology research, altering data drastically. (7)</li> </ul>

#### 4 Impact of COVID-19 on Physiology Research: Data

Research in physiology covers a vast number of topics from cardiovascular and respiratory to neurological and musculoskeletal areas. When trials are conducted a various amount of data during trials and surveys must be considered before the focused topic is experimented on. Data such as age, BMI, immunizations, and past medical history of participants is the most important data that is to be collected prior to focused data. A high influx of COVID-19-infected patients and volunteers who had severe infections can cause disruptions in the data that is being collected. COVID-19 targeted the cardiovascular and respiratory systems in the human body. With this information, physiology research became more focused on those systems rather than musculoskeletal, neurophysiology, and renal systems all of which are important to consider in fighting against an evolving virus. When conducting physiology research, volunteers with previous infections of COVID-19 showed a major change in respiratory breathing performance [12]. Seen most in volunteers above the age of 65, those that had severe infections of COVID-19 about 35.7% of them were placed on mechanical ventilation with about 60% mortality rate [13]. Due to the pandemic, ventilation therapy advanced and gave life-saving techniques to patients in need of it. However, with physiological research conducted, mechanical ventilation

caused altered patterns within the lungs along with the COVID-19 infection [14]. With this lung damage present, once patients are cured of the infection have difficulty breathing like asthma. Patients after treatment demonstrated a lack of response in a PEEP exam and showed a reduction in oxygenation [15]. This decrease in oxygenation from the lungs is caused by damage to the alveoli in the lungs. Upon studies, patients with COVID-19 saw diffused alveolar damage (DAD). This caused an imbalance in the ventilation between oxygen and unoxygenated cells [16]. With these issues present in volunteers, data collected is skewed from healthy individuals that have never been infected with COVID-19. With these skewed data, it is very difficult to diagnose patients and see a trend with other illnesses like COVID-19 such as Influenza or Pneumonia. Studies taken in different regions reported difficulty understanding populations with Influenza infections and COVID-19 infections, especially during flu season [17]. Without proper testing and misinterpreted data, research trials were overstimulated with COVID-19 volunteers. Conducting recent studies show patients self-reporting the impacts done by COVID-19 infections on various organs and physiological changes [18,19]. COVID-19 will have and had severe changes in human physiology that will carry on for the rest of an individual's life [20].

## **5 Impact of COVID-19 on Physiology Research: Contactless Interactions**

Many medical schools and hospitals with students face restrictions in their physiology research [21]. Along with the governmental guidelines listed above, colleges and universities placed their own guidelines along with CDC guidelines to obtain safer research, practices, and teachings. A personal example of this situation would be our own extensive literature study. Our study relied on virtual meeting platforms like Zoom in order to have bi-weekly remote, synchronous meetings. All documents and results obtained were shared via Google Docs or Microsoft Word Shared. Even though this process can be considered as an efficient way of interactive engagement, having meetings in person to talk about findings and new research pathways would give more of an advantage than Zoom. For more hands-on physiology research conducted, moving to an all-online platform can cause major problems from misunderstandings between volunteers and researchers to misinterpretation of data being collected. All of which can be missed during the conclusions of the experiment. In addition, researcher and volunteer or student-to-student lack of interaction can lead to what is called "Zoom Fatigue" [22]. Also known as videoconference fatigue, Zoom fatigue is when an individual using a computer screen for a predominant amount of time or dealing with a repetitive action creates psychological distractions and tiredness [23]. This was seen in many of the studies done with research conducted online as researchers had to deal with technological problems, questionnaires, or video conference calls for many hours in a single day for multiple days building up exhaustion [24]. With this immediate change to online platforms, researchers were required to adapt to working online. This helped with physiology trials to work along with the guidelines and remove the risk of COVID-19 spread. However, the complication of technological issues for both volunteers and researchers, improper data intake, and "Zoom fatigue" are all problems that prove conducting research studies online can be non-functional [25].

## **6 Impact of COVID-19 on Physiology Research: Funding and Publications**

Much of the funding was taken away from physiology and other health-related research. According to the American Physiology Society, a total of 82% of physiology researchers believe the pandemic closure has negatively affected their research with 28% of researchers reporting cutbacks [26]. Most of the funding was placed into COVID-19 vaccine development and research. With governments focused on the unparalleled disruption on the economy and the push for a vaccine, all funding was diverted to COVID-19 research and relief efforts [27]. This caused major health-related research that did not involve COVID-19 to become a casualty of the pandemic. Many authorized groups allowed a mass of “special issues” from publishers that fast-tracked COVID-19 research rather than allowing any other health-related research to be reviewed [28]. Additionally, many grant awarding committees placed “rapid response calls” to fund work focused on COVID-19 research and vaccination development without hesitation [29]. According to a study by James Waler *et al.*, about 40% of researchers agreed that the pandemic has lowered their confidence in applying for “non-pandemic” research grants [30]. Lower funding leads to a lower number of publications. When conducting the extensive literature review, many publications regarding COVID-19 itself were found rather than its impact on specifics such as anatomy and physiology research [31]. Publication and Grant committees focused on approving COVID-19 research. Additionally, research that had funding was removed and diverted to focused research such as vaccine development.

## **7 Future Recommendations**

With the data collected, the world has learned many lessons as we slowly move out of the COVID-19 pandemic. With the help of technology, the world was able to stay afloat rather than fall into chaos. Zoom, Google, and online interactions helped people communicate without placing themselves at risk of infection. Physiology research saw major impacts as many of the trials require in-person sessions. Evolving technology and creating advancements in online videoconferencing can lead to a safer environment for both researchers and volunteers. Improving Zoom or other platforms to allow researchers to interact more and have it easily accessible is important. Specially to overcome the roadblock with the elderly who may not fully understand the use of technology. Allowing a pathway to virtual mode can be a major step forward. Another important improvement to be made is proper collaboration between healthcare systems in different countries. This can help improve communication to understand the virus and how it spreads. It also allows us to keep up-to-date records on populations that are during a widespread infection or are slowly declining away from the infection. This can help researchers understand and prepare for an influx of data with volunteers infected. Additionally, implementing new steps before conducting trials such as pre-screenings at home and requiring masks at research centers can help limit the spreading of the virus and create trust in volunteers. There are many aspects that still need to be learned alongside developing ways to improve in order to deal with a global challenge like the COVID-19 pandemic.

## **8 Conclusion**

The COVID-19 pandemic caused major disruptions to the world and prompted the medical field to adapt and evolve. Prior to the pandemic, patients and volunteers were readily available for any trial. Guidelines were not present other than legalities and consent from the volunteers.

Most importantly, the age scale when conducting these trials were even rather than skewed with fewer elderly participants. Volunteers above the age of 65 were available to participate. Healthier population pool data was interpreted correctly and diseases such as asthma, heart disease, and diabetes were found much more clearly from physiological research. Due to the pandemic, there was a significant drop in volunteers aged above 65 as the virus was susceptible to them and those that are immunocompromised. Additionally, funding for non-COVID-related research was stopped and moved to focused research centering around vaccine development. This led to a large influx of COVID-19-related publications rather than other important health-related research. Overall, the COVID-19 pandemic was uncontrolled and unpredictable. With many factors impacting not only physiology research but many other medical research studies, lessons have been learned and new approaches will be taken if there were to be another pandemic.

## 9 Declarations

### 9.1 Study Limitations

Based on the constant and rapid evolution of the pandemic, a lot of unpublished data and ongoing or unexplored research could not be included in our literature review. Location-specific limitations in relevant, published data also prevented a more thorough picture across countries/regions across the world. Further analysis to understand the impact of the pandemic on physiology research in understudied countries across the world is recommended to acquire a wider insight.

### 9.2 Competing Interests

There are no competing interests associated with this literature review.

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