**Bad Science in the Time of COVID-19**

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**Abstract**

The COVID- 19 pandemic period continues to be a deluge of scientific research, clinical trials, controversies, and experimental implication of drugs. We have witnessed bad science creating havoc among scientists and the public and influenced the society in numerous ways. Impulsively conducted research in a short time gave fallacious results and created undesirable impacts. The arguments about the use of antimalarial drug hydroxychloroquine, BCG-vaccination in COVID-19 are just a few examples among many. Good science is built on proper scientific methods of investigation and will withstand the test of replication. Properly designed, conducted, and peer-reviewed good science should be the cornerstone to tackle the pandemic. Quality should be kept as the keyword rather than quantity in scientific research at the time of this crisis. During this historic time, clinicians, researchers, the media should team up to promote and practice good science.

**Bad Science in the Time of COVID-19**

The COVID-19 pandemic has produced a cloudburst for scientific claims and discoveries. We have seen science progress at breakneck speed. But it has come at a cost. Bad science has cracked through the fissures and created chaos among the public. There are examples galore.

BCG vaccination suddenly staked a claim for the key reason why the global south did not see much of COVID-19. Suddenly, there were graphs showing countries with high rates of BCG vaccination and the remarkably low rates of COVID-19. It was not surprising to see even doctors mistake *correlation for causation*. Ecological studies can help formulate hypothesis. But we negated the fact that these are just hypothesis and not evidence for a direct link [1].

Even brief correspondences appearing in medical journals turned into viral social media phenomenon. In a letter that was published in The Lancet Respiratory Medicine journal, it was hypothesized that patients with hypertension and diabetes who are treated with angiotensin-converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARB) and ibuprofen have a high risk of infection with COVID-19 [2]. This was on a theoretical fact that the SARS-CoV2 virus binds to their target cells through the ACE2 receptors which are expressed by the pulmonary alveolar cells, heart, kidney, blood vessels, and intestine. Chronic exposure to ACE inhibitors, ARBs, and ibuprofen has been shown to upregulate ACE2 expression in animal experiments. News media and social media amplified the message. Patients and physicians were confused and worried. Finally, after couple of months of raging debate, rigorous studies have now effectively debunked this hypothesis [3, 4].

What could have been done to avert the pandemonium? Let’s go back to the basics of scientific rigor. Good science will be built on sound principles of investigation – most importantly, that of avoiding biases, using preclinical and clinical data judiciously, and the ethical tenet of scientific integrity. Good science will withstand the test of replication. Good science will strictly adhere to scientific methods of investigation.

Of course, one can say that in the current situation of a pandemic, time is of paramount importance. But that thought presupposes on the idea that speed of scientific progress equals lives saved. Let’s not forget that bad science has hurt people since the beginning of modern scientific investigation. The best example is that of the now-debunked vaccine-autism hypothesis published in The Lancet [5]. The research study has been found faulty, and the author’s lack of integrity has been highlighted in countless articles. But the damage was already done when the first prints of the journal carrying the faulty research hit the newsstands.

Good clinical research should be properly designed, conducted, thoroughly reviewed before an eventual dissemination through peer-reviewed journal publication. The gold standard of clinical investigation, randomized clinical trials (RCTs), involves adequate randomization (to minimize risk for selection bias which is preferentially selecting people into one arm to skew the results favorably), appropriately selected control group, and blinding the interpretation from the people who can influence the conclusions (patients and investigators) [6].

The recent controversy with the use of the anti-malarial drug hydroxychloroquine in treating COVID-19 is a ripe example for bad science. A non-randomized, single-arm, clinical trial conducted by a French scientist showed that hydroxychloroquine was associated with significant viral load reduction in the SARS CoV-2 virus affected patients [7]. Even though the study was very poorly designed and conducted, it was welcomed by many powerful individuals across the World, and subsequently greater acceptance by the public. Credible scientific voices were shouted out. People overlooked the several limitations of the study - a very small sample size, lack of effective control arm, absence of blinding, unsupported conclusions, and numerous errors of omission – and campaigned for wider use for the drug. If those in power had stayed in their lane and not swayed into scientific analysis and interpretation, proper clinical investigation could have been conducted into whether the drug has any benefit in treating or preventing COVID-19.

Good science will withstand the test of effective and efficient peer review. Peer review is the scientific equivalent of a system of checks and balances seen in politics. It deconstructs the scientific validity, the clinical impact, the worthiness of the conclusions and its applications, and its contribution to the existing body of science [8]. COVID-19 science desperately missed the peer review system. Preprint servers which were meant to improve the pace and rigor of science was soon used as a source for all information. It is therefore not surprising that one of the most widely shared manuscript from a preprint server provided fodder for conspiracy theorists regarding the origin of the virus. Very few people who have read the fake news probably knows that the manuscript was discredited and removed from the server after a few days. The lay public had no understanding of peer review and what it means for scientific validity. As cliched as it sounds, the truth is that damage was already done when news reports of the spurious research hit the stands.

But peer review should not be considered infallible. The reliability of the articles that are published even after thorough peer review is currently being questioned. The journals which are considered as the epitome of scientific research: The Lancet and The New England Journal of Medicine (NEJM) have recently retracted their articles about the use of hydroxychloroquine [9], ACE inhibitors and ARB’s in COVID-19 [10] due to the skeptical research data.

Good science should be the backbone in tackling the pandemic. Speed should not be at the expense of replicability of scientific discoveries. Quality should be the buzzword in times of pandemic research rather than the quantity. Scientists, clinicians, health officials, media, and politicians should coalesce their best efforts during this exceptional time in history to conduct and promote proper scientific research. In that, there should be no conflicts of interest.

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