The Success of Pfizer and Moderna and the Failure of Merck and Co. in Developing a COVID-19 Vaccine

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Ethan Kutner

Spring 2023

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

Benjamin Laugelli, Department of Engineering and Society

Introduction

In December of 2019 the COVID-19 pandemic began in Wuhan, China, soon spreading to the rest of the world and initiating a global pandemic and the development of COVID-19 vaccine candidates by Merck and Co., one of the leaders in pharmaceutical development. At one point in 2020 there were over 169 vaccine development projects around the world in the United States, China, India, Russia, Thailand, etc. numbering 30 countries researching a means to combat COVID-19. Each organization, country, and company racing against each other and Merck for the first effective and safe vaccine (Shaheem, 2020). Various types of organizations contributed to these efforts such as universities, pharmaceutical companies, private research labs, and government labs at the time developed 133 possible vaccinations, 2 of which by Merck and Co. (Shaheem, 2020). However, on January 25, 2021 a statement was released by Merck and Co. announcing the ceasing of development of their two COVID-19 vaccine candidates, V590 and V591 due to lack of success in Phase II clinical trials (Merck, 2021).

The failure of Merck and Co. to develop a successful vaccine and release it to the general public has been faulted to the lack of immune response generated by their vaccine candidates not meeting or exceeding those of the Moderna and Pfizer vaccines released in 2020 (Thomas, 2021). The current thought is that Merck's vaccines relative to Pfizer and Moderna, had low efficacy and were developed slower (Thomas, 2021). However, the best technologies do not always win and the success of designs does not occur in isolation. By only considering the technological aspects of why Merck failed to develop a vaccine against COVID-19 future projects will not understand the priorities of the stakeholder groups that influenced the success of Pfizer and Moderna over Merck.

I will examine the failure of Merck and Co. to develop a COVID-19 vaccine through the social construction of technology (SCOT) framework. Deborah Johnson describes SCOT as a theory that broadly describes how social factors and forces shape technological development, change, and the meanings of the technology (Mitcham, 2005). It is contrasted with the theory of technological determinism in that design of technology does not inherently decide how it is used rather the relevant social groups and their interpretations also shape how technology develops (Mitcham, 2005). Specifically, I will examine the public's desire for safety and return to normalcy and the lack of strategic partnerships. I will use statements from an interview with Merck CEO Ken Fraizer and a Harvard Business School Professor, Tsedal Neeley, a press release from IAVI announcing an IAVI and Merck Collaboration, "IAVI and Merck Collaborate to Develop Vaccine Against SARS-CoV-2", emergency use authorization press releases from the FDA for Moderna and Pfizer vaccines, and a press release from Merck and Co. on the acquisition of Themis Bioscience, "Milestone Reflects Merck's Commitment to Accelerate SARS-CoV-2 Vaccine Program".

Literature Review

A lot of literature was produced over the course of the pandemic and subsequent years concerning vaccine development, clinical trials, and commentary on the vaccine development practices. In *Progress of the COVID-19 vaccine effort: viruses, vaccines and variants versus efficacy, effectiveness and escape*, by Tregoning et al. the authors discuss the various success and failures of some COVID-19 vaccine candidates including Merck and Co. (Tregoning et al., 2005). The article mentions Merck's stature as one of several "high-profile vaccine programmes" and its candiates not even entering Phase III clinical trials. In this review, the authors mention the

failure of Merck's candidate vaccines solely to poor immunogenicity, referencing a Merck press release. The authors do not investigate any non-technical reasons Merkc and Co. failed to develop a vaccine besides the lack of efficacy in clinical trials. Merck and Co. had a specific mindset to vaccine development that contributed to their candidates not succeeding that were not addressed in this review. The article states how a broad range of new technologies and platforms such as mRNA, viral vector, protein, and inactivated virus had all seen success, but those used by Merck were not listed.

In *The dawn of mRNA vaccines: The COVID-19 case,* the authors briefly compare and contrast the mRNA vaccines to other candidate vaccines developed like those developed by Merck and Co. (Verbeke et al., 2021). The article directly attributes mRNA success over competitors to higher tolerable dosages and increased immune response touting the technical benefits over other vaccines. However, while it mentions the development of mRNA it does not discuss the lack of innovation by competitors, Merck's focus on established vaccine platforms and lack of strategic partnerships that enabled competiting vaccines the diversity of thought required to win the race to develop a vaccine. The article also mentions how quickly Moderna was able to produce a vaccine in comparison in that a mere 42 days after sequencing of COVID-19 the first clinical batch of Moderna's candidate vaccine was produced.

Both of the referenced literature sources describe technical challenges with Merck and Co.'s vaccine development compared to its competitors. However, both of these journals fail to explain the social sentiments of interest parties which also contributed to Merck's discontinument. In failing to address these does the articles do not explain the significance of the social aspect of technological design in vaccine development.

Conceptual Framework

The success of the Pfizer and Moderna vaccines and Merck's failure can be analyzed with the social construction of technology (SCOT) framework. SCOT as described by Johnson refers to a theory describing how societal factors and forces determine which technologies develop and succeed or give meaning to specific technologies (Mitcham, 2005). SCOT is contra to a classic theory referred to as technological determinism, which tenets include "(1) that technology develops independently from society; and (2) that when is a technology is taken up and used, it has powerful effects on the character of society" (Mitcham, 2005). SCOT describes that technological development or success is not decided by a measure of the technology's goodness or effectiveness, it says that they are popularized or taken up due to the perception to achieve specific human purposes and meet the needs of a particular social groups or individuals (Mitcham, 2005). I will specifically use the SCOT concepts of relevant social groups, interpretive flexibility, design flexibility, and stabilization. Relevant social groups are the groups that have stake in different aspects of the technology of interest such as its design, production, use, and non-use. Interpretive flexibility is the concept that a specific piece of technologies meaning is not fixed and can change depending on the specific stakeholder and their specific priorities and concerns. Design flexibility is the technology's designer is able to respond to stakeholder concerns and priorities with changes in the design. Stabilization is the idea that technology's design stabilizes around a concept that meets the concerns of many stakeholders and is the design that wins out.

Drawing on SCOT, in the analysis that follows I begin by describing the societal forces in play that determined which vaccines won out, then I will describe the faults in Merck's vaccine development plan that led to the discontinuation of their vaccine candidates. SCOT is well suited

due to the number of interested parties involved in the success of vaccines and pharmaceuticals in general. These social groups include the general public desperate for a vaccine for safety and return to normal life, the governments of countries attempting to curb a global pandemic, and the vaccine manufacturers themselves and their interests and beliefs in the design of a successful vaccine. These groups' interests are of paramount importance to the success or failure of COVID-19 vaccine candidates.

Argument

Merck and Co. Vaccine View of Stakeholders

Merck and Co. did not properly understand the perspective of the primary stakeholders when developing their COVID-19 vaccine. In the advent of a pandemic the world entered into lockdown with only essential workers going on location, the rise of remote work, and quarantining of infected individuals. These conditions over the course of a year led to pulic desire for a return to normalcy, safety, and therefore rapid production of an effective vaccine. As one set of stakeholders the general public's interest in design of a vaccine favored both speed, safety, and efficacy in development. However, Merck and Co. did not share this same sentiment during their research and development process leading to failure of their candidates. Merck believed safety was the top priority in vaccine design as well as specific advantages such as a single dose and oral delivery should be prioritized. This misunderstanding of relevant social groups contributed to design failures.

In mid-2020 in an interview with Tsedal Neeley, a Harvard Business Professor, the CEO of Merck, Ken Frazier, made this sentiment clear with the quote, "I think when people tell the

public that there's going to be a vaccine by the end of 2020, for example, I think they do a grave disservice to the public (Neeley, 2020)." In another quote by Merck's senior vice president of clinical research, Dr. Nicholas Kartsonis, in regards to COVID-19 vaccine development he stated "We are a much larger company. We are not as beholden to having to be first (Thomas, 2021)." In the first quote Ken Frazier suggests by "that there's going to be a vaccine by the end of 2020" that Merck does not have an ambitious plan to release a vaccine by the end of the year in 2020. The quote futher suggests the company thinks it would potentially be unsafe to produce a vaccine in such a timeline with rapid development by the words "grave disservice to the public". In the second quote note that Merck did not even feel the need to be first. This highlights the belief that taking time to produce a better product than those released initially would be an acceptable and even desired outcome. Merck did not believe that releasing a vaccine first would be vital to their vaccine candidates' success and even believed that telling the public a vaccine could be produced so quickly would not be in the public's interest. On the other hand the release of the Moderna and Pfizer vaccines by the end of 2020 has been described almost as a race for release and both vaccines have seen success. The Merck sentiments and those of the public that generally did accept vaccines on such a timeline shows a disconnect between Merck's opinion and what the public, a set of stakeholders valued.

Another relevant social group in the case of vaccine development were the government institutions pushing for vaccine development and vying to curb a pandemic causing harm to their populations. The release of both the Pfizer and Moderna vaccines also shows the government willingness to authorize vaccines on such a timeline. In the below two letters to Pfizer and Moderna respectively we see letters authorizing emergency use of two COVID-19 vaccines.

December 8, 2022

Pfizer, Inc.
Attention: Gosia Mineo, M.S.
1 Pfizer Way 190/004/4405
Pearl River, NY 10965

Dear Ms. Mineo:

On February 4, 2020, pursuant to Section 564(b)(1)(C) of the Federal Food, Drug, and Cosmetic Act (the FD&C Act or the Act), the Secretary of the Department of Health and Human Services (HHS) determined that there is a public health emergency that has a significant potential to affect national security or the health and security of United States citizens living abroad, and that involves the virus that causes Coronavirus Disease 2019 (COVID-19).[1] On the basis of such determination, the Secretary of HHS on March 27, 2020, declared that circumstances exist justifying the authorization of emergency use of drugs and biological products during the COVID-19 pandemic, pursuant to Section 564 of the Act (21 U.S.C. 360bbb-3), subject to terms of any authorization issued under that section.[2]

On December 11, 2020, the Food and Drug Administration (FDA) issued an Emergency Use Authorization (EUA) for emergency use of Pfizer-BioNTech COVID-19 Vaccine for the prevention of COVID-19 for individuals 16 years of age and older pursuant to Section 564 of the Act. FDA reissued the letter of authorization on: December 23, 2020,[3] February 25, 2021,[4] May

[1] U.S. Department of Health and Human Services, Determination of a Public Health Emergency and Declaration that Circumstances Exist Justifying Authorizations Pursuant to Section 564(b) of the FD&C Act, 21 U.S.C. § 360bbb-3, February 4, 2020.

Figure 1. Pfizer Emergency Use Authorization Release

ModernaTX, Inc.
Attention: Ms. Michelle Olsen
200 Technology Square
Cambridge, MA 02139

Dear Ms. Olsen:

On February 4, 2020, pursuant to Section 564(b)(1)(C) of the Federal Food, Drug, and Cosmetic Act (the FD&C Act or the Act), the Secretary of the Department of Health and Human Services (HHS) determined that there is a public health emergency that has a significant potential to affect national security or the health and security of United States citizens living abroad, and that involves the virus that causes Coronavirus Disease 2019 (COVID-19).[1] On the basis of such determination, the Secretary of HHS on March 27, 2020, declared that circumstances exist justifying the authorization of emergency use of drugs and biological products during the COVID-19 pandemic, pursuant to Section 564 of the Act (21 U.S.C. 360bbb-3), subject to terms of any authorization issued under that section.[2]

On December 18, 2020, the Food and Drug Administration (FDA) issued an Emergency Use Authorization (EUA) for emergency use of Moderna COVID-19 Vaccine for the prevention of COVID-19 for individuals 18 years of age and older, pursuant to Section 564 of the Act.

Figure 2. Moderna Emegency Use Authorization Release

The Federal Food, Drug, and Cosmetic Act was used by the Secretary of the Department of Health and Human services in two instances at the end of 2020 for this authorization. In the case of Pfizer we can see the FDA approved the Pfizer vaccine on December 11, 2020 as seen in Figure 1 (Commisioner, 2023b). Similarly, in Figure 2, the letter Moderna's COVID-19 vaccince was granted emergency authorization on December 18, 2020 (Commisioner, 2023b). Both of these letters show the government stakeholders were willing to accept vaccines within the year of 2020 given the circumstances of a global pandemic. By the words, "there is a public health emergency that has a significant potential to affect national security or the health and security of the United States citizens living abroad…" the gravity of the situation and view by the

government that this outbreak needs to be addressed is made clear. Specifically within this statement the reference to “health and security of United States citizens” we see the concern for the people by the administration. Also, the use of the word emergency drives the belief that this is a time sensitive matter requiring an immediate remedy.

The views of the stakeholders as explained by SCOT determine what aspects of design need to be chosen, Merck and Co. had one belief for its technological design and the government and public held different ideas as to what they valued. Speed was not a value Merck held in high priority during its candidate vaccine development, but it was of great interest to the parties who receiving and approving the vaccine candidates. Alternatively, it may be argued that the Merck vaccine was discontinued solely by a lack of immune response in comparison to released vaccines as stated by a press release from Merck in 2021 at the time development stopped. However, the Johnson and Johnson vaccine showed relatively lower efficacy compared to the Pfizer and Moderna vaccines with efficacies of 71%, 88%, and 93% for the three companies (Jansen, 2021). Therefore it can be concluded that efficacy is not the sole reason for shutting down the development of Merck’s vaccine. While the Merck vaccine did fail in clinical trials, had it developed its vaccines at a faster pace and reached clinical trials earlier it could have found newer drug candidates to to develop as opposed to completely ceasing the projects. The government and the public desired an effective solution, but also a rapid one as shown by the emergency use authorizations and widespread desire for vaccination. Merck did not share this sentiment and its lack of speed and slow approach to clinical trials led to the failure of its vaccine candidates.

Reliance on Established Vaccine Development Platforms

Merck's use of established technology platforms and hesitancy to seek strategic partnerships with evolving or novel biotech companies further led to its failed vaccine candidates. The concept of design flexibility within the SCOT framework explains a designers' response to priorities and concerns. In Merck and Co.'s desire for safety it also drew on established platforms for its vaccine development, it focused on experience and prior success in an attempt to reach their end goal. However, this prevented Merck from developing partnerships that drove innovation and diversity in thought for a novel virus.

In a press release by IAVI the rVSV platform used was described as, "The recombinant vesicular stomatitis virus (rVSV) vaccine platform uses an attenuated strain of vesicular stomatitis virus, a common animal virus that has been modified to express proteins that stimulate an immune response. IAVI and Merck will leverage experience gained with this platform during the development of Merck's rVSV-based vaccine for Ebola Zaire (IAVI and Merck …, 2021)." In this section of the press release we can see Merck did believe in parterering with other companies by, "IAVI and Merck…" as IAVI is described as being nonprofit research organization dedicated to addressing global health challenges, such as HIV and tuberculosis and was described as such elsewhere in the press release (IAVI and Merck …, 2021). From "leverage experience" it suggests this partnership is focused on an established vaccine platform with experience. This focus on experience in Merck's vaccine development seems to be consistent with other thinking in how to approach the development of its vaccines in response to COVID-19. The press release quote further references "the development of Merck's rVSV-based vaccine…" which indicates Merck has already been working with IAVI on other vaccines and is taking a similar approach with COVID-19. It can be drawn that Merck did not seek to try very diverse parternships or attempt development outside of its established network in this case

Merck's desire to ensure safety of its vaccines presented the company did not want to branch out in a time where diversity of thought and novel strategies has led to successful vaccines in both efficacy and safety.

In another of Merck's press releases titled, "Merck Completes Acquisition of Themis" the same commitement to developing a vaccine using established platforms can be seen. In the release it states, "Themis developed a broad pipeline of vaccine candidates and immune-modulatory therapies using its innovative measles virus vector platform based on a vector originally developed by scientists … to develop a vaccine candidate targeting SARS-CoV-2 for the prevention of COVID-19. (Merck Completes Acquisition of Themis, 2020)." The statement "measles virus platform" indicates a basis of development on the measles vaccine originally developed in the 1960s (WHO, n.d.). This reliance on established platforms again shows a partnership between Merck and a company without the introduction of innovative strategies. The established thinking of Merck put it behind Pfizer who established a partnership with BioNTech, a German company pioneering in mRNA vaccines (Silver, n.d.). As Merck itself is a relevant social group trying to protect its own community and produce a product using with its brand and identity they as a manufacturer were less risk averse in a time where other strategies were rewarded. Merck's reliance on experience and tried and true platforms was ultimately its vaccine candidates downfall.

Conclusion

Merck and Co.'s attempt to a develop a COVID-19 vaccine and subsequent failure were due to several technical reasons however the company's difference in thought on societal concerns also contributed to its vaccine candidates failure. In not focusing on speed of development to reach markets first and deciding favorable attributes were of more importance

contributed to alternative vaccines gaining initial market share initially and preventing a successful Merck product.

The SCOT framework elucidates that these social groups have great importance on the stabilization of technologies that win out and Merck was not in alignment with the ideals valued by both the general public and the government. Additionally, Merck relied on partnerships with established platforms or for existing vaccines as opposed to acquiring or creating deals with experimental or pioneering biotechnology companies. This led to a lack of diversity in thought and experimentation, due to a belief that with its status as one the largest vaccine makers it could rely on other factors for success rather than rapid manufacturing and implementing vast changes to R&D strategies.

The COVID-19 pandemic was a time of innovation and great change in the bioligics development environment. The significance of Merck's failure to develop candidates can be an example to future mindsets in times of great need, following the relevant social groups true priorities and not assumed priorities is essential to developing both a successful design and an accepted design. Merck's actions during the pandemic provide a lesson to future pharmaceutical development in times of great need. That instead of protecting the consumer from themselves rather learning what relevant social groups desire and breaking from established technologies could provide better outcomes in the future. Also, while development is extremely technical and many vaccines fail before ever seeing clinical trials understanding the relevant social aspects that lead to positive vaccine reception and winning the vaccine arms race is vital to success.

References

Commissioner, O. of the. (2023a). Moderna COVID-19 Vaccines. *FDA*. https://www.fda.gov/emergency-preparedness-and-response/coronavirus-disease-2019-covid-19/moderna-covid-19-vaccines

Commissioner, O. of the. (2023b). Pfizer-BioNTech COVID-19 Vaccines. *FDA*. https://www.fda.gov/emergency-preparedness-and-response/coronavirus-disease-2019-covid-19/pfizer-biontech-covid-19-vaccines

IAVI and Merck Collaborate to Develop Vaccine Against SARS-CoV-2. (n.d.). IAVI. Retrieved February 27, 2023, from https://www.iavi.org/news-resources/press-releases/2020/iavi-and-merck-collaborate-to-develop-vaccine-against-sars-cov-2

Johnson & Johnson COVID-19 Vaccine Authorized by U.S. FDA For Emergency Use | Johnson & Johnson. (n.d.). Content Lab U.S. Retrieved February 27, 2023, from https://www.jnj.com/johnson-johnson-covid-19-vaccine-authorized-by-u-s-fda-for-emergency-usefirst-single-shot-vaccine-in-fight-against-global-pandemic

Merck CEO Ken Frazier Discusses a COVID Cure, Racism, and Why Leaders Need to Walk the Talk. (2020, July 13). HBS Working Knowledge. http://hbswk.hbs.edu/item/merck-ceo-ken-frazier-speaks-about-a-covid-cure-racism-and-why-leaders-need-to-walk-the-talk

Merck Discontinues Development of SARS-CoV-2/COVID-19 Vaccine Candidates; Continues Development of Two Investigational Therapeutic Candidates. (n.d.). Merck.Com. Retrieved February 26, 2023, from https://www.merck.com/news/merck-discontinues-development-of-sars-cov-2-covid-19-vaccine-candidates-continues-development-of-two-investigational-therapeutic-candidates/

Mitcham, C., & Johnson. (2005). Social Construction of Technology. In *Encyclopedia of science, technology ands ethics* (pp. 1791–1794). essay, Thomson & Gale.

Thomas, K. (2021, February 10). How Merck, a Vaccine Titan, Lost the Covid Race. *The New York Times*. https://www.nytimes.com/2021/02/10/health/merck-covid-vaccine.html

Tregoning, J. S., Flight, K. E., Higham, S. L., Wang, Z., & Pierce, B. F. (2021). Progress of the COVID-19 vaccine effort: Viruses, vaccines and variants versus efficacy, effectiveness and escape. *Nature Reviews Immunology*, *21*(10), Article 10. https://doi.org/10.1038/s41577-021-00592-1

Verbeke, R., Lentacker, I., De Smedt, S. C., & Dewitte, H. (2021). The dawn of mRNA vaccines: The COVID-19 case. *Journal of Controlled Release: Official Journal of the Controlled Release Society*, *333*, 511–520. https://doi.org/10.1016/j.jconrel.2021.03.043