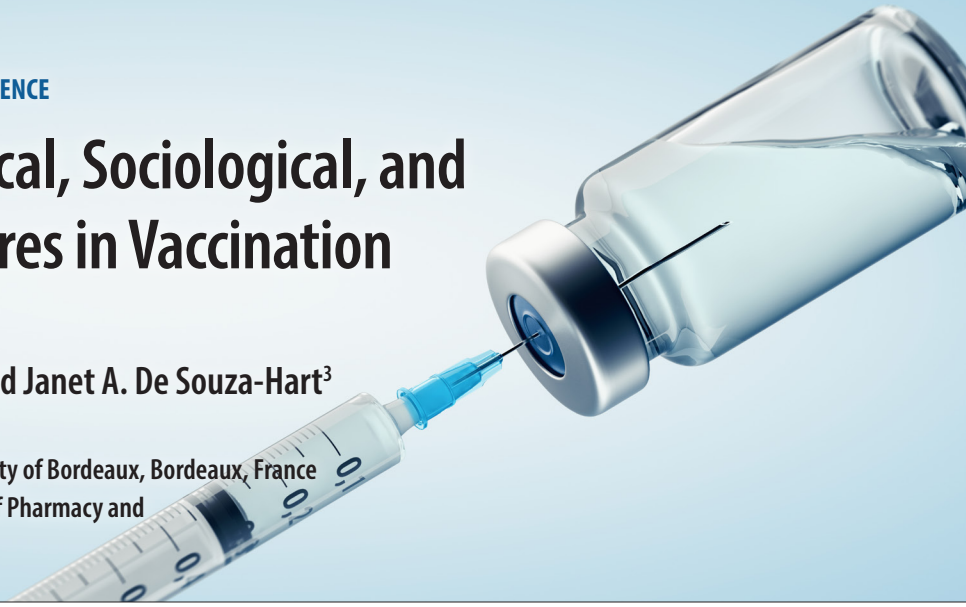
NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

# Time Travelers: Biological, Sociological, and Psychological Adventures in Vaccination



*by*

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## Introduction

Being twins, Nate and Nicola always did things together. It came as no surprise to their friends and family when they chose to go to the same university and study in the same field. Now in their final year, they both planned on focusing their senior capstone projects on the topics of vaccines and vaccine hesitancy. Despite any similar ideas and patterns of behavior they might have had as twins, they tended to be unique in their approach to this type of academic work. Nate was interested in historical and cultural insights surrounding vaccine hesitancy, while Nicola wanted to focus on the psychological and biological aspects of vaccination.

Besides getting a good grade, they had other concerns that prompted their choice of capstone project. Their older sister was pregnant for the first time. At family get-togethers, she frequently brought up various alarming social media posts regarding the effects of vaccinations, especially on pregnant women and newborns. Nate and Nicola's professors had done a great job of explaining the fundamentals of vaccines and immunizations to them in immunology and microbiology courses, but the twins still struggled to reassure their sister. Facts about biological molecules and the immune system only went so far.

One day while sitting in the campus park with their laptops open, looking for reliable peer-reviewed sources of information, a bright neon blue light appeared out of nowhere. As if by magic, a huge box that reminded them of telephone booths in old British movies appeared out of thin air. The door opened and a quirkily dressed person stepped out, unbothered and smiling at them. "Hello Nate and Nicola! Nice day!"

Having already been on some adventures in the bright blue time-traveling machine, they were used to its wise owner, Dr. Wanda Haile Ortiz, whom they affectionately called Dr. WHO.[*] [†] After explaining their capstone projects to her, the Doctor decided that a few historical stops would provide some much-needed inspiration and insight into the topic of vaccine hesitancy. So, the trio set out on their first adventure in time…

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* *Doctor Who* is a British science fiction television series broadcast by the BBC since 1963. The series, created by Sydney Newman, C. E. Webber, and Donald Wilson, depicts the adventures of an extraterrestrial being called the Doctor, part of a humanoid species called Time Lords. The Doctor travels in the universe and in time using a spaceship called the TARDIS, which externally appears as a British police box. While travelling, the Doctor works to save lives and liberate oppressed peoples by combating foes. The Doctor often travels with companions. The show was originally intended to appeal to a family audience as an educational program using time travel as a means to explore scientific ideas and famous moments in history.

† The World Health Organization (WHO) is a specialized agency of the United Nations responsible for international public health. It was established in 1948, its headquarters are in Geneva, Switzerland and has six regional offices worldwide.

## Part I – England, 1882

Even before they opened the door, the loud sound of trotting horses on a cobblestone street was apparent to Dr. Wanda and her companions. The twins were not entirely sure where and when they had landed until they stepped out onto the mud that lined the carriageways. As an intense smell of feces immediately hit them, they realized that, sadly, it wasn't really mud they were standing on. The Doctor raised an eyebrow and commented, "It's easy in your time to take sanitation and clean water for granted. You can thank public health for those types of advances!"

With a dual expression of disgust on their faces they walked across the street with the Doctor, and onto the pavement where a sign saying "The Victorian Times" hung from the eaves. Through the big front window, they could see people on typewriters and, far deeper in the room, a huge printing machine. There was a newspaper in the window display with that day's morning paper. Nicola noticed the date on the top right corner: Monday 27 March, 1882. The newspaper's masthead said in bold lettering "Immune to Balderdash!" and the author's name was J.R. Jefferies.*

They walked inside the newspaper office and the Doctor inquired if Mr. Jefferies was in. A very gaunt but smiling gentleman soon approached and after taking a thorough look at the unusual clothing of the visitors said, "Good morning! How may I be of assistance?"

"A good morning to you too, sir," the Doctor greeted. "May we inquire about your front-page article for today? It captured our attention."

Mr. Jeffries replied, "Well, this controversy I describe in my article goes way back you see. In 1840, the Vaccination Act offered free smallpox vaccines for the poor, and most did not mind because they thought only poor people could get it." He stopped and coughed into a tissue that he pulled out of his pocket. "Apologies for my cough, you see I was recently diagnosed with the consumption.† While artists may see it in a romantic light, I can assure you it is anything but.‡

"Now, where was I? Oh yes… the Vaccination Act. After that, the Act of 1853 made it mandatory for parents to vaccinate their newborns against smallpox within their first three months of life. Those who failed to comply faced penalties. Many people opposed, and riots broke out. A new law in 1867 extended the requirement for vaccination to those of 14 years and older. It was then that the Anti-Vaccination League was founded."

"I didn't know that anti-vaxxers appeared so long ago," Nate mumbled to Nicola.

"What do you mean so long ago?" asked Mr. Jefferies.

The Doctor interjected, "Please forgive the interruption. Do go on with your story, Mr. Jeffries."

Easily distracted, Mr. Jefferies cleared his throat and continued, "Last Friday, a German scientist, Heinrich Hermann Robert Koch, announced the discovery of the bacterium responsible for consumption and suggests we may be able to cure it and prevent it. I believe this is amazing progress!" He coughed a bit more. "You see, I have been struggling with this illness, without knowing what caused it and now there is hope. With the advent of the smallpox vaccine, it is my greatest wish for other illnesses like mine to be prevented with vaccination. Before I return to Brighton for rest, I decided to write articles to educate the public on the facts." He paused as if catching his breath, "Unfortunately, the Anti-Vaccination League and others started to send us letters in fear of an increase in vaccinations. Some believe that lung diseases are caused by strong emotions like melancholia and don't want to believe that vaccination can help."

The Doctor looked at Mr. Jefferies. "Could we see some of these letters please?"

"By all means. Please wait a minute," replied Mr. Jeffries as he walked behind a big counter. He returned with at least two dozen letters. He picked two at random and set them down on the counter.

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* John Richard Jefferies (6 November 1848 – 14 August 1887) was an English writer who died of tuberculosis.

† Tuberculosis was known as consumption, phthisis, and the great white plague.

‡ Tuberculosis was romanticized in art, especially during the 19th century, where it was represented in a flattering manner, thus taking the name "the romantic disease."

*The first scratch attempted on my child's arm with the point of the contaminate vaccinator's lancet shall be a declaration of war - war to the knife - before my little one shall suffer blood poisoning, and the insertion in his robust system of the vile scum of human immoralites and impurities, pus putridities, bovine virus and cattle disorders.* *----Archdeacon Thomas Colley* [*]

The TRUTH I now give, and they cannot deny it, while they dare not admit it. This then is the truth, that vaccination neither protects from smallpox – or mitigates its severity – but it increases smallpox and exposes to death from it – and multiplies diseases of various kinds four-fold. ---Benjamin Scott [†]

The Doctor looked at her companions and then at Mr. Jefferies. She sighed and thanked Mr. Jeffries, wishing him improved health, as the trio started back to their time machine. Upon exiting the office, Nate exclaimed, "Science has advanced and improved over the past 150 years, but it is frustrating that our logic and emotions haven't." Nicola, wondering about what she learned in biology courses regarding both normal mild reactions to vaccines and the rarer, more serious side effects, paused before asking: "How much of this public reaction is just based on fear and ignorance and how much is possibly justified?"

The Doctor regarded her companions thoughtfully and said, "Sometimes fear of vaccines has no rational basis, but if we want to understand and improve vaccine uptake, we need to be honest and transparent about not just the benefits but also the risks associated with vaccination." Her eyes brightened, and she closed the door to the time machine. "I have just the idea!" she said merrily. "Off we go to our next stop!"

## Questions

1. Provide at least four common reasons for vaccine hesitancy between the late 1800s and our current time.

2. Vaccines evolve as science advances. Briefly describe these six types of vaccines (from more "traditional" to more "modern"): live attenuated, inactivated, toxoid, subunit/conjugate, mRNA, and viral vector.

3. Vaccines are given to healthy individuals, so safety standards and efficacy must be exceptionally high. This includes the potential use of vaccine preservatives and adjuvants. Define these two additional vaccine components and explain why they are used.

4. Why do some vaccines require booster shots in order to fully protect individuals from severe disease?

5. *Challenge question:* Compare and contrast these three vaccine-preventable diseases in terms of symptoms and severity (morbidity and mortality): smallpox, chickenpox, and mpox. To better understand vaccine safety related to these diseases, compare the types of adverse reactions seen with the Jynneos vaccine used to prevent both smallpox and mpox and the Varivax vaccine against chickenpox. The FDA has vaccine prescribing documents, and the World Health Organization has resources that can help you explore this.

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[*] Colley, Thomas. (1882). *Vaccination, a Moral Evil, a Physical Curse, and a Psychological Wrong: A Sermon : Preached on Sunday Evening, August 6, 1882, in Christ Church, Addington, Durban, Natal.* Reprinted for the London Society for the Abolition of Compulsory Vaccination, 1882.

† Scott, Benjamin. (1874). *Vaccination Weighed in the Balances Of Reason, Humanity, Health, Truth and Common Sense and Found Wanting.* Woolard, 1874.

## Part II – Nigeria, 2004*

The last time the Doctor found herself in the sub-Saharan area was during the 1970s, to witness Fela Kuti and his Africa 70 band recording in the Kalakuta Republic commune of Nigeria. World music was one of the treats she granted herself (another one being witnessing important historical events like the 1965 civil rights march from Selma to Montgomery, Alabama led by John Lewis among others). Now she was back in Nigeria with Nate and Nicola, several decades later, far away from anything that resembled an urban landscape. "This land has been inhabited for centuries by the Hausa people," the Doctor mentioned as they found themselves standing in front of a mud wall with the word "ASIBITI" hand-painted on a piece of wood by the entrance.

They walked into the courtyard and saw a queue of approximately 50 women outside a stone house with thatched roofing. The doctor approached a young woman with a baby in a back carrier. "*As-salamu alaikum.* I'm Dr. Wanda and these are my companions, Nate and Nicola. Are you from this area?"

"*Wa alaikum salam*. I'm Djamila. Yes, I'm originally from this area. I used to study in Manchester, England but I had to come back here to my hometown and take care of my sister's baby." She paused, her eyes filling with sadness. "Our family lost her to *kanjamau*." †

"We are so sorry to hear that. Please accept our condolences," shared Nicola.

"Could you tell us what you all are waiting here for?" asked Nate.

Djamila responded, "Most of us are waiting to vaccinate our children against polio." Suddenly a woman in the courtyard started speaking loudly, almost yelling, to no one in particular. With a sad look on her face, Djamila continued, "She speaks against the government. She asks what the point of a vaccine is when their villages don't have water and electricity. There are many problems with diarrheal diseases and poverty here. When public health officials announced that we had to vaccinate our children against polio, a lot of people got angry. They recalled how they were used to test a meningitis drug a few years ago. Eleven Nigerian children died and dozens more were disabled during that drug trial."

"I remember reading about that," Nicola softly replied.

Djamila continued, "It is understandable that they do not trust the authorities. After 9/11, everybody is suspicious, and we are sometimes treated like terrorists just because of our religion or skin color. A lot of mothers worry that vaccines will cause them to become infertile or make their children sick. Some mothers want to vaccinate their kids, but their husbands won't let them. But the government has made it mandatory and now they don't know what to do."

"I understand," said the Doctor gently. "What do you plan to do?"

"I will vaccinate little Hana. His name means 'born in a family while they are mourning a family member.' I need him to be protected. There are so many illnesses that I cannot protect him from. From my studies, I know that viruses can jump from one species to another; I think they call it 'spillover' or something like that. So we must always be vigilant against infectious diseases. I will do my best to help my family and neighbors learn about vaccines. I am educated and have lived abroad. But I also understand and feel for my people. Their fear is valid, and their voices need to be heard."

"Thank you, Djamila," replied the Doctor. "It was lovely meeting you. I hope Hana grows up healthy and you are able to continue your studies someday." As they walked away, the Doctor started talking about trusted messengers, the current global polio eradication campaign, and a book published in 2020 called *Stuck* from anthropologist Dr. Heidi Larson. "I believe we have a lot to learn from this community," she said in deep reflection.

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* Based on the New Yorker article (June 12, 2021) "Heidi Larson, vaccine anthropologist: the world's richest countries are now its most vaccine-hesitant. Can we learn to trust our shots before the next pandemic?" by Danielle Ofri. <https://www.newyorker.com/science/annals-of-medicine/heidi-larson-vaccine-anthropologist>.

† A team of language and medical experts from various Nigerian universities and specialist hospitals, led by Professor Herbert Igboanusi of the University of Ibadan, have created new names for HIV and AIDS in Hausa, Igbo, and Yoruba with the aim of eliminating stigmatisation and discrimination of persons living with HIV and AIDS. In Hausa, *karya-garkuwa* (that which weakens the body immune system) has been chosen for HIV while *kanjamau* ("capable of emaciating one's body") has been chosen for AIDS. See: Igboanusi, H. (2025). Linguists, medical experts adopt new names for HIV, AIDS and prostitutes in Hausa, Igbo and Yoruba. [Webpage]. University of Ibadan. <https://ui.edu.ng/news/linguists-medical-experts-adopt-new-names-hiv-aids-and-prostitutes-hausa-igbo-and-yoruba>

## *Questions*

1. Socioeconomics, culture, and history, including the effects that colonialism has had on trust of the Western world, all play a role in vaccine hesitancy in many parts of the globe. In this context, how is vaccine hesitancy in Part II different from the situation described in Part I? And explain why you think Djamila said "Their fear is valid, and their voices need to be heard."

2. What is a trusted messenger or cultural mediator in terms of public health? Why might Djamila be a good choice for one?

3. Why might it be important to be transparent about both mild vaccine side effects and rare more serious reactions? How might you approach this type of discussion so you don't scare people away from vaccines? To help with this question, you might want to look into the Vaccine Confidence Project, communication techniques such as the "framing effect," and psychological concepts such as the "prevention paradox."

4. What is the current global state of morbidity and mortality for measles, a vaccine preventable disease? What might be some of the reasons that measles is still a major public health problem in specific countries despite a safe and highly effective vaccine?

5. *Challenge question:* What is vaccine-derived polio and why is it a problem for global polio eradication?

## Part III – NUSA , 2521*

Dr. Wanda and her companions next found themselves in the outer atmosphere, looking at a 26th-century Earth as if it were a globe in a child's room. However, the land formation was not what they knew. Rising sea levels had reshaped continents and many islands, with parts of the continent of North America having disappeared. Based on the Doctor's indicator tools there were both low- and high-density residential areas. They decided to land first on a low-density one.

The atmosphere was rather foggy and gray, with a type of smoke in the air that was thinner in consistency than what felt comfortable to breathe. Most of the buildings seemed abandoned; huge piles of garbage and the vehicles resembled something one might see in a science fiction B-movie. Inhabitants, regardless of age, had filtration helmets to protect against both chemicals and germs, and they wore gloves and thick clothes. People kept their distance from each other, but this was not so hard as only few people were walking around. "Oh my, is this a ghost town or a zombie city?" gasped Nicola.

They tried to talk to a few inhabitants, but nobody was willing. "Look, is that a hospital?" asked Nate. "There's something like an ambulance parked outside. Or an Ecto-1, if this is indeed a ghost town."† As they went closer and walked in, there were people packed in the corridors, lying wherever possible, even two or three persons per bed.

the Doctor approached an exhausted looking nurse and said, "Hello. I'm sorry to interrupt, but why are so many people ill?"

The nurse quickly replied, "Yes, yes, well, these people have 'Blue Flu,' a strain so severe that it is hard to breathe, and one's skin starts to turn blue from lack of oxygen. Only healthcare professionals reliably take the universal shot to protect one from all strains of flu. Most citizens are either unaware of the vaccine or hesitant to take it. Some of them are fully against vaccination. There has been a recent referendum with a new law: no vaccine is compulsory. There is no regulation of mis- or disinformation regarding vaccines. We have had many deaths due to this flu the last couple of years and the number keeps climbing. We are exhausted and ready to give up not only because of the sheer number of other diseases we need to deal with on top of this flu, but also because the politicians have destroyed years of trust building between scientists, healthcare professionals, and the people." The scenario was so dramatic that Nate and Nicola stood there with their jaws dropped before the Doctor rushed them back toward the time machine.

When they cautiously landed in a second, more densely populated area in NUSA the situation looked extremely different. People seemed happy as they greeted and embraced each other on the streets. Public transport was clean, punctual, and packed with people. The hospitals were calm and serene as they were almost empty. In pharmacies, Nate and Nicola only saw things like cosmetics, lotions, and toothpaste; there was no cold or flu medication as no one seemed to get sick from respiratory diseases. This seemed like a paradise to the twins.

Everyone they spoke to seemed to have strong health literacy. One smiling older woman explained, "Well, everybody is vaccinated. It's mandatory for parents to comply. We have universal vaccination that is free and easy to access."

"And everyone's okay about it being mandatory?" asked Nate.

"Why shouldn't they be?" replied the older woman.

"How about any adverse effects from vaccines?" inquired Nicola.

the Doctor explained, "I think they follow precision medicine protocols, which allow scientists and physicians to know in advance who might be likely to have an adverse reaction to a vaccine component based on genetics, and an alternative vaccine is offered in those rare cases. If no vaccine is available, the fact that everyone else is vaccinated will protect those that can't be. Whenever biologically possible, vaccines have been optimized to protect against asymptomatic and symptomatic illness, not just severe disease, so human-to-human transmission of most diseases has stopped, even when there is an animal reservoir. Vaccines have few to no side effects, I think for at least two centuries now."

Nate and Nicola had their jaws wide open once again but this time for a happier reason.

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* New United States of America, a fictitious 26th century landmass.

† The Ecto-1 is the fictional vehicle from the movie *Ghostbusters*.

"Is the economy booming because fewer people get sick?" Nate asked.

With a broad grin, the older woman replied, "Well, I wouldn't put it exactly like that. Society is booming, including the economy. We get to focus on things that matter. Our families, art and culture, having fun, you know. Health, security, and safety are priorities, which enables everyone to be more productive, in work *and* play. We try not to take that for granted."

## *Questions*

1. There are several types of cognitive bias that can affect health decision making. Define the following three and explain, in your own words how they might influence vaccine hesitancy.
   - Confirmation bias:
   - Omission bias:
   - Availability bias:
2. When it comes to certain public health interventions like seatbelts, good sanitation, or employee handwashing after using the bathroom, people do not tend to feel that their personal freedoms are being imposed upon. Why might vaccination be perceived differently?
3. Do you agree with a government mandating vaccines? What about an employer requiring them to ensure a safer workplace? Does it depend on the vaccine, and if so, which vaccines should be mandated and which should be optional? Rationalize your choices with peer-reviewed scientific evidence.
4. What is the relationship between vaccine hesitancy and health literacy?
5. The cost of vaccines can have an impact on vaccine hesitancy, but in the scientific literature there are conflicting reports as to whether monetary incentives actually improve vaccine uptake. Why might monetary incentives sometimes help and sometimes not help in improving vaccine uptake? Are monetary incentives ethical in your opinion?
6. What is herd immunity and why is it important to achieve?
7. *Challenge question:* Choose a European, an African, and an Asian country to compare with the United States in terms of which vaccines are recommended for children. Are there some already developed vaccines that are not available in your country but should be in your opinion? What might account for differences in vaccine recommendations between the countries?

## Part IV – Europe, 2021

Before traveling back home to their current time, the trio made one more time stop in Europe, during the height of the COVID-19 pandemic but before the roll-out of public vaccinations. They landed the time machine near the border of France and Switzerland, on a mountain overlooking Geneva. Their first instinct was to open their phones and log into the Internet via the time machine's Wi-Fi. Once they did so, they were bombarded with social media posts, podcasts, and TV news programs all giving conflicting information about the COVID-19 vaccines.

One piece of news mentioned a far-right politician from Spain who argued on the radio that he was not sure about the vaccine and probably would not take it. In France, they learned that lower income populations were apparently more reluctant to get the vaccine. In the United States, a significant proportion of healthcare professionals were not willing to get vaccinated and public hesitancy was also associated with ethnicity and socioeconomic status. In general, some of the largest losses in vaccine confidence seemed to be among young adults, a concerning trend with the potential for long-term implications. It was clear to Nate and Nicola that people were frustrated, and authorities were not able to provide a clear message.

When they mentioned this to Dr. Wanda, she read to them an older news story by Dr. Seema Yasmin in a Stanford University podcast regarding some of the challenges of science communication with the public and how mis/disinformation can result:*

> On July 9, 1999, the United States Public Health Service and the American Academy of Pediatrics asked U.S. vaccine makers to remove thimerosal, a mercury-containing preservative, from vaccines. That same day, the AAP issued a statement which included the following language:
>
> > *The current levels of thimerosal will not hurt children, but reducing those levels will make safe vaccines even safer. While our current immunization strategies are safe, we have an opportunity to increase the margin of safety.*
>
> The consequences of this messaging were devastating. The decision to remove thimerosal—an antibacterial preservative used in medicines since the 1930s, and long-stated to be safe by agencies such as the Centers for Disease Control and Prevention and the Food and Drug Administration—signaled to already concerned parents that thimerosal must be unsafe: why else would the nation's leading public health agency demand its removal? Anti-vaccine groups were founded on the core belief that this decision to remove thimerosal from vaccines was proof that the medical establishment had long-known thimerosal caused harm to children.

Seeing their tired faces, the Doctor told the twins it was time to go home to make progress on their capstone projects, but not before giving them a big smile and reassuring them that there was much that could be done to work towards a happier future, full of vaccine-protected people with strong health literacy thanks to teams of well-rounded, knowledgeable, and compassionate health communicators with a global perspective.

### *Questions*

1. What is the difference between vaccine misinformation and disinformation?

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* Stanford medcast: COVID-19 mini-series. Medicine and misinformation. <https://edhub.ama-assn.org/stanford-medicine-cme/audio-player/18592150>

2. Explore how social media is influencing vaccine disinformation through the report "The Disinformation Dozen" from the Center for Countering Digital Hate (CCDH). These individuals often use "FLICC" tactics of science denial. What are these tactics? What might motivate people to spread disinformation? How does social media contribute to this problem and what can be done to improve it?

3. What should Nate and Nicola's sister be vaccinated against before she becomes pregnant? What should they recommend that a new family member get vaccinated against once they are born?

4. Not all vaccines provide 100% protection against symptomatic illness as this is extremely difficult to do on a biological level. Most are designed to protect against severe disease, hospitalization, and death. This fact has sometimes been used to instill doubt about vaccine effectiveness. Explain, in your own words, why not completely preventing symptomatic illness or disease spread is *not* a failure for vaccines. (*Note:* The resource below may be helpful.)

- Baron, M. (2024, March 11). Why do some vaccines work better than others? [Webpage]. American Society for Microbiology. <https://asm.org/Articles/2024/March/Why-Some-Vaccines-Work-Better-Than-Others>.

5. *Challenge question:* Nate aspires to become an influencer with his new social media account entitled "InFLUenzer." Choose a vaccine-preventable disease and design an Instagram infographic for InFLUenzer that will improve vaccine uptake. Make sure you have a clear vision of the population that your post is targeting (for example, people of a certain age, ethnicity, nationality, or parental status). Include whatever reliable, accurate scientific sources you use and triple check any facts you include. How has what you learned in this case study influenced how you design your infographic?