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## The Effects of Vaccinations on Public Health

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## **Caitlin Reveal**

Caitlin Reveal graduated from Coastal Carolina University cum laude in May 2017. In addition to her research on vaccinations, she also contributed to research evaluating the trauma patient population at a tertiary care center. Since 2015, she has worked as a medical scribe in a local emergency department, where she has gained first-hand experience in the medical field. Her interest in medical research continued to develop throughout her senior year, and she plans on applying for medical school in the near future to further her education and passion for medicine.

## The Effects of Vaccinations on Public Health

### *Abstract*

*This is a review of scholarly literature of the importance of vaccinations and the effects of vaccination uptake and vaccination refusal on public health. It assesses how vaccinations came to exist and what they do in the human body. It highlights reasons parents opt not to vaccinate their children and the side effects vaccinations may cause. There is a major emphasis on the effectiveness of vaccinations, especially in schools, where children are much more likely to be exposed to diseases than the general public. Because health care workers are often at the front line of contracting and/or transmitting diseases, the importance of vaccinations in health care professionals is examined. In all, this review is meant to provide evidence that vaccinations are safe, effective and help to implement a healthy population.*

*Keywords: vaccinations, public health, U.S. vaccination debate, disease eradication*

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### **Introduction**

Since its discovery about 200 years ago, vaccinations have had an overwhelming amount of success in eradicating or minimizing the instance of diseases in the general public. There is abundant scientific, medical, and public health evidence by creditable physicians, health care professionals and scientists agreeing that current vaccinations are both safe and effective (DiMaio, 2016). Since the introduction and use of vaccinations, there has been approximately a 95% decrease in vaccination preventable diseases worldwide. Vaccinations have completely eradicated smallpox and have nearly eradicated polio internationally. In the United States alone, vaccinations have nearly eliminated polio, measles, mumps, rubella, and diphtheria (Hinman, Orenstrin and Schuchat, 2011).

Multiple studies have outlined the decreased instance of school absences of children who are vaccinated compared to children who are not. Likewise, there are vast amounts of research supporting the implementation of vaccinations for health care workers, as multiple studies have found that receiving vaccinations, the influenza vaccination, in particular, promotes both staff and patient safety as it reduces the risk of transmitting or contracting influenza, which can be fatal for some patients.

There are many religious or philosophical reasons parents forego getting their children vaccinated, such as concerns about possible adverse effects of vaccinations, concerns about the ingredients in vaccinations, and that many people do not see vaccination preventable diseases as a threat anymore in this day and age since they are often rare. Due to their rarity, however, if someone were to contract a vaccination preventable disease, many physicians today have little to no experience in treating these types of diseases,

therefore they emphasize the importance of getting vaccinated to ensure protection against vaccination preventable diseases (Hu, 2015). Despite reasons that parents do not vaccinate their children, there is endless research supporting that vaccinations have an overall positive effect on public health. To date, there are no United States laws that mandate vaccinations; however, all 50 states require certain vaccinations in order for children to start public schools.

In all, this report aims to provide a wide array of research and data into one source in order to help promote the uptake of vaccinations and prove that they are safe, effective, and help implement a healthy population. Given the overall positive effects of vaccinations, a mandate should undoubtedly be enforced to ensure the protection of public health as a whole.

## **Literature Review**

### *Groundbreaking Discoveries*

In the 1800s, smallpox was the biggest killer of its time. The disease claimed the lives of more than 300 million people. To put into perspective, this is more than civilian and military deaths in World War I and World War II combined. With a major contribution by Edward Jenner, an English physician, smallpox became the only disease that has been completely eradicated worldwide thanks to the smallpox vaccination. Since a little over 200 years ago when vaccinations were initially introduced, scientists and physicians have been able to control many infectious diseases (DiMaio, 2016).

Milkmaids in the 1800s often contracted a mild disease known as cowpox from their cows. It was observed from time and time again that milkmaids who had recovered from cowpox never developed the more serious disease, smallpox. Edward Jenner changed the world of medicine when he inoculated an eight-year-old boy, James Phipps, with the cowpox virus. Six weeks later, Jenner inoculated the boy with the smallpox virus, which was the biggest cause of fatality of its time. Jenner confidently repeated the study on several other subjects, including his own children. On May 14, 1796, Jenner presented his findings to an eager and curious crowd. To their amazement, Phipps and the other subjects had not developed smallpox. This groundbreaking study was considered to be the “birth of vaccinations” (DiMaio, 2016).

The next groundbreaking development of vaccinations came from Louis Pasteur, who developed attenuated vaccinations, or “live vaccinations.” Attenuated vaccinations contain living antigens of a disease, but the antigens are significantly weakened to the point where it increases one’s immunity to the disease, but provides protection against full-blown strength and symptoms of the disease. Pasteur was the first to develop this concept in a laboratory

setting, making him the innovator of laboratory-created vaccinations (Tolsma, 2015).

### *Improving Immunity*

In 2014, the Centers for Disease Control and Prevention painted a clear picture of what vaccinations are and what they do in the body. Before understanding how vaccinations work in the body, first, it is important to understand how the human body fights against diseases and infections. Everyone is born with an immune system composed of cells, glands, organs, and fluids. The immune system recognizes foreign antigens and produces antibodies to fight against them.

When a child initially contracts a specific antigen, the immune system produces antibodies, which takes time to take effect. Since antibody production for initial antigen contraction is not fast enough to protect the child from the disease, the child typically gets sick but the immune system “remembers” that specific antigen. If that specific antigen enters the body in the future, the immune system recognizes it and is then able to produce antibodies fast enough to fight against it before the child gets sick a second time (CDC, 2014).

Vaccinations contain antigens, or parts of antigens, that cause diseases. In the production of vaccinations, the antigens are killed (inactivated vaccinations) or weakened (attenuated vaccinations) to the point that they do not cause diseases (CDC, 2014). A study by Carrillo-Marquez and White in 2013 examined several different controversies regarding childhood vaccinations. One of the controversies examined was a parental concern for immediate infection after the child is vaccinated. Because the antigen is killed or weakened, it is nearly impossible for the child to contract that specific disease. Attenuated vaccinations, which contain weakened antigens, may cause a very mild form of the disease but it is highly unlikely that the vaccination would cause full-blown symptoms of the disease (Carrillo-Marquez and White, 2013). According to the CDC, antigens in vaccinations are strong enough for the immune system to produce antibodies resulting in creating an immunity against the disease (2014).

### *Mistrust in Mercury*

Vaccination mistrust often stems from conspiracy theories. Many parents tend to search the internet to learn more about vaccinations rather than consulting with their child’s pediatrician. When searching the internet, rather than reading evidence-based scholarly literature, they more often than not read a few “top hit” websites found on Google. Many of these websites support the anti-vaccination movement and parents who are looking for information regarding vaccinations end up reading an array of conspiracy theories and anecdotes that give false information about vaccinations (Jolley and Douglas, 2014).

One of the most popular theories that make parents feel unsafe vaccinating their children is the association between the MMR vaccination and autism.

This debate began in 1998 when Andrew Wakefield et al. released an article in the British medical journal *The Lancet* suggesting this association by mainly highlighting an ingredient contained in the vaccination, mercury, as a cause for neurodevelopment disorders connecting to autism (White, 2014). Wakefield's study, however, was flawed in many different aspects. The study had no controls, linked three common conditions and relied heavily on parental anecdotes (Godlee, 2011).

A seven-year study was conducted in Denmark specifically analyzing the assumed connection between the MMR vaccination and autism. Data on all children born in Denmark between 1991 through 1998 was collected and their MMR vaccination status. Of the 537,303 children born during this time, 440,655 had received the MMR vaccination. Of those children, only 316 were diagnosed with autism and 422 were diagnosed with other autism-spectrum disorders. The study concluded there was no association between the age at the time of vaccination uptake, time since uptake of the vaccination, the date of vaccination uptake, and the development of autism (Madsen et al., 2002). Despite fraudulent findings and many other studies disputing the association between the MMR vaccination and autism, it took *The Lancet* 12 years to retract Wakefield's article. Years later, despite debunking and retracting Wakefield's essay, some parents still find trust in his study and have a common fear of the vaccination (Godlee, 2011).

To this day, the MMR vaccination rates in the United Kingdom and the United States are still below the level recommended by the World Health Organization to help ensure herd immunity (Godlee, 2011). Full herd immunity is formed when a minimum of 95% of the population has received vaccinations for MMR, DTaP, poliovirus, hepatitis B, and varicella. Herd immunity provides protection not only those who are vaccinated, but also for those who are not vaccinated since the instance a disease outbreak is significantly low due to the high average of those who are vaccinated (Tolsma, 2015).

In light of Wakefield's assumed connection between autism and mercury, it was addressed by Carrillo-Marquez and White in their article in 2013 that mercury exposure in vaccinations was considered to be "less than the recommended level." Therefore, it was considered to be safe by several credible agencies including the U.S. Environmental Protection Agency, U.S. Agency for Toxic Substances and Disease Registry, and the Food and Drug Administration. Despite this, many study results have been inconclusive, therefore many government agencies concurred that the elimination of all mercury containing vaccinations was sensible until further research could definitely accept or reject the association between mercury and neurodevelopment compromise.

### *Nonspecific Effects*

Not only are vaccinations effective in preventing diseases, but some are also preventative for other causes, known as nonspecific effects. Research on nonspecific effects of vaccinations began on accident in 1994. Nonspecific effects of vaccinations are determined by vaccination schedule with the idea that one vaccination cancels out the negative effects of another vaccination when given in a specific order. This theory is relatively new and may not even be true. There have been only two studies done to support the theory, while ten other studies were inconclusive. Research continues; however, no action has been taken by researchers in opposition of the theory. This idea of nonspecific effects of vaccinations emphasizes the importance of vaccination scheduling and the order in which vaccinations are administered (Schor, 2014).

Additionally, the Rotavirus vaccination was found to have a protective association between childhood febrile seizures. After receiving the vaccination, there was an overall 18-21% decrease risk of seizures requiring inpatient or emergency department evaluation (Payne et al., 2014). Parents often forego vaccinations for their children due to concerns of adverse effects. Studies such as these, in fact, prove that there are often more “beneficial adverse effects” from vaccinations, while the severe negative adverse effects, such as skin necrosis at injection site, severe hepatitis, acute renal failure, encephalitis, Guillain-Barré syndrome, and permanent neurological disability are extremely minimal (Ehrenstrin et al., 2010).

### *Missed Opportunitites*

In contrast to parental concern resulting in their refusal of vaccinations, it was actually found by Smith et al., in their 2015 study that children and adolescents tend to go unvaccinated, specifically against the measles, due to missed opportunities rather than negative vaccination related beliefs from the parents. When compared to vaccinated children and adolescents, parents of this population tended to have a lower assessment of their child’s risk of contracting a vaccination preventable disease and the effectiveness of vaccinations to reduce the threat of diseases. Given that the measles vaccination requires two doses for full immunization, many children and adolescents identified in this study missed the second dose, which considers them to be unvaccinated. Additionally, these children were found to lack health insurance coverage, affecting their ability to be vaccinated while at doctor checkups due to financial reasons.

### *Decrease School Absences*

There have been numerous studies done that indicate the overall effectiveness of vaccinations, mainly highlighting school-aged children as they tend to be more susceptible to

diseases than the general public. A study in 2006 by Wiggs-Stayner et al. provided the FluMist vaccination to school children in a free, mass immunization program. At the conclusion of the study, the authors compared school attendance rates to the year prior and found that there was an overall improvement in attendance rates in the children who received FluMist compared to the control schools where the children did not receive the vaccination.

Likewise, another study by Pannaraj et al. (2014) analyzed school attendance rates in eight Los Angeles elementary schools. They compared children who received the influenza vaccination and those who did not. The authors found that unvaccinated children missed more school days due to flu-like symptoms compared to vaccinated children. In fact, even with one-fourth of school enrollees having been vaccinated against influenza, the instance of influenza decreased by more than 30%.

While school-aged children are often more susceptible to contracting and transmitting diseases, professionals feel that vaccinations in children are extremely important in protecting not only themselves but their families as well, contributing to overall better public health. Geographical sections of low vaccination coverage and/or high vaccination exemption rates place children at a higher risk for contracting diseases that would otherwise be prevented by vaccinations (Seither et al., 2015). Monitoring areas of low vaccination coverage is important since there is a higher potential for disease outbreak and spread. Communities with low vaccination coverage place everyone in that area at a higher risk for contracting and transmitting diseases.

### *American Vaccination Laws*

School vaccination laws date back to 1827 where Boston became the first city to require school-aged children to provide documentation confirming vaccination uptake prior to school enrollment. Due to the success of requiring vaccinations, the concept began to spread to neighboring cities and states then across the entire country. In 1905, the City of Cambridge in Massachusetts issued a mandate requiring all adults to receive a smallpox vaccination after a smallpox outbreak. Those who refused the vaccination were penalized with a five-dollar fine. A minister, Jacobson, refused both the vaccination and refused to pay the fine as he felt the vaccination law was “unreasonable, arbitrary and oppressive.” He was taken to court and was found guilty of disobeying the vaccination law. The case was addressed in the U.S. Supreme Court in *Jacobson v. Massachusetts* (Lobo, 2016).

At the conclusion of the case, the Court relied on police power of the state and imposed limitations on the states’ police power to mandate vaccinations. Three limitations were issued: 1) mandates needed to address a public health necessity; 2)



the means of the mandate needed to be reasonable and proportional; 3) mandates needed to avoid harm (Lobo, 2016).

### *Exemption Beliefs*

In present-day America, all 50 states require documentation confirming inoculation of certain vaccinations in order for children to start public schools. While vaccinations are mandatory in order for children to begin school, most states also allow for vaccination exemption for religious and philosophical reasons, allowance for which has been an ongoing debate since the 1830s (Lobo, 2016).

Those who defy vaccination mandates or recommendations are classified into three groups, according to Tolsma (2015). The three groups are identified as: 1) opposition due to religious beliefs; 2) opposition for being political libertarians; 3) opposition for self-interest maximizers.

Those who rely on opposition or exemption of vaccinations due to their religious beliefs generally disregard the current state of public health and reasons for foregoing vaccinations vary based on their specific religion. Political libertarians base their beliefs on the idea that everyone has the right to treat their body and health in a way that they find suitable. This group classifies vaccination mandates as being “forced” and consequently “an assault on their body and therefore a violation of their fundamental liberty.” The final group, the self-interest maximizers, base their theory of opposition on the assumption that each individual can make their own decisions based on their own presumed risks and benefits of each vaccination in each situation that the vaccination may be utilized. This group is often influenced by their peers, creating what is known as the “collective action problem” (Tolsma, 2015).

### *Protecting Patients*

Compared to school-aged children, health care workers incur a greater risk than the general public for contracting and transmitting diseases, specifically influenza (Music, 2012). Hospital-acquired illnesses such as influenza can be fatal for vulnerable patients, including babies, the elderly, pregnant women, and the immunocompromised who have been admitted to hospitals (Murana, 2014). There are between 3 to 5 million cases of influenza annually with 1 million of those cases ending in fatality (Music, 2012). Dr. Cores-Penfield determined in 2014 from his abundant research on the influenza vaccination that it should be considered standard care that health care workers receive an influenza vaccination annually. Mathematical modeling predicts that hospital-acquired influenza can be prevented by up to 60% if health care workers received the vaccination worldwide. While the vaccination does not offer 100% prevention, the vaccination

continues to be the most profitable national public health intervention in reducing influenza related mortality and morbidity (Murana, 2014).

There are many other studies that fully support the implementation of health care worker vaccinations, further enforcing its importance. It is deemed important by the World Health Organization for health care workers to receive a seasonal influenza vaccination in order to promote both staff and patient safety. A study by the International Federation of Pharmaceutical Manufactures and Associations surveyed the vaccination recommendations of 26 countries and found that 88% of those countries recommended vaccinations for health care workers. Likewise, another study analyzed the 56 countries that accounted for providing the majority of the world's influenza vaccinations. The survey found that 77% of those countries actually recommended the vaccination specifically for health care workers as they are considered a high-risk population. In addition to patient safety, providing and enforcing vaccinations for health care workers helps to reduce staff absences, and provides financial savings and economic benefits (Music, 2012).

While vaccinations are mandatory for health care workers at some facilities worldwide, it has been argued that making vaccinations mandatory is a breach of ethics. Deontology and utilitarianism are the two main ethical theories concerning biomedical or health care practice. Deontology is the concept of one's duty and obligation while utilitarianism is defined as the doctrine that actions are right if they are useful or for the benefit of a majority. For health care workers, however, it is argued that it is their ethical duty to protect and do good to their patients, which includes administering vaccinations to protect them. If a health care worker refuses vaccinations due to religious, philosophical, or other reasons, it is the ethical and professional obligation of the practitioner, employer, or administrator to decide if they are going to respect the individual's choice or to make other recommendations that the individual should not be employed at that facility given they work in a high-risk area (Murana, 2014).

A study conducted in a German hospital by Ehrenstein et al. in 2010 evaluated whether concerns for adverse vaccination effects is based on correct or misperceived incidence rates for influenza vaccination adverse effects. The survey was voluntary and was distributed among physicians, nurses, and administrators at a tertiary care university hospital in Germany. Questions on the survey examined the responders' knowledge about the annual instance of influenza, ability to differentiate between true/false questions regarding the vaccination, estimate the rates of non-severe and severe possible adverse effects of the vaccination, estimate the proportion of vaccination recipients who experience no adverse effects, and to indicate if they received the vaccination that season as well as their age, sex, professional group, and how many times they have received the vaccination in the past.

Of the surveys administered, 34% were completed from which data was interpreted. Of those who completed the survey, 304 respondents did not receive the influenza vaccination and 348 did. Of those who received the vaccination, about 57% stated that patient safety was the most important factor in their decision to receive the vaccination. About two-fifths of those who did not get vaccinated related the cause to concerns about adverse effects of the vaccination. When comparing results between physician answers and nurse answers, it was found that each group has very different perspectives on the influenza vaccination, their knowledge of the vaccination and concerns about adverse effects. It was also deemed that those who did not receive the vaccination were significantly more likely to overestimate rates of adverse effects. Results of the study indicated another major problem that hinders vaccination uptake in the community: education about vaccinations (Ehrenstein et al., 2010).

### *Education and Ethics*

Unless a patient is unable to give consent (e.g., if they were unconscious), it is mandatory that patients give consent for their practitioner to perform any type of treatment or care. In the event of vaccinations, this also applies. It is the physician's duty to provide information about the particular vaccination the patient is receiving, including what the vaccination is, what the vaccination does, what it is protecting them against, and possible risks and adverse effects from the vaccination. Unfortunately, communicating possible risks can cause concern for some parents and patients establishing "fright factors," which can cause some to opt against receiving the vaccination (Murana, 2014).

Some argue that if education about the vaccination causes "fright factors," then it may be beneficial to decrease the emphasis of risks during communication in efforts to help enhance vaccination uptake. In contrast, however, this would limit the recipient's knowledge about the vaccination, limiting their autonomy, and could be deemed as an act of omission by the physician (Murana, 2014). Education about vaccinations are important, but it is considered to be a complex process. Education about vaccinations needs to be structured differently depending on the population to which it is targeted to ensure optimal vaccination uptake.

In an attempt to promote vaccination uptake in the general public, a study was conducted in India in attempts to promote the MMR vaccination through a series of education interventions. Parents who participated in the study were randomly assigned to four vaccination education interventions: 1) information focused on correcting misinformation in regard to the misperceived link between the MMR vaccination and autism; 2) information on risks associated with measles, mumps, and rubella that the vaccination would prevent as well as adverse effects of the MMR vaccination; 3) dramatic

narrative of a parent discussing the experience of her child contracting the measles; 4) a visual intervention using images of children suffering from the measles, mumps, and rubella (Mathew, 2014).

Results of the study revealed that those who received information focused on correcting misinformation in regard to the misperceived link between the MMR vaccination and autism had a significantly lower perception of believing that the MMR vaccination causes autism. However, this group also showed to have significantly lower intentions of having their child vaccinated. Those who received the message of the dramatic narrative of a parent discussing the experience of her child contracting the measles actually had higher chances of having perceptions about adverse effects of the MMR vaccination. Those who received the message of a visual intervention using images of children suffering from the measles, mumps, and rubella had higher chances of believing the association between MMR and autism. Consequently, at the conclusion of all four interventions, it was found that the messages did not yield positive attitudes toward the MMR vaccination and overall did not enhance the parent's likelihood of getting their child vaccinated (Mathew, 2014).

To contrast, a similar educational intervention study was conducted in China to: 1) examine parents' knowledge on vaccinations; 2) evaluate the effectiveness of a health education seminar for improving parents' knowledge of vaccinations; and 3) compare the parents' knowledge level across different socio-demographic variables. Parents were given a pre-assessment then viewed a lecture through a PowerPoint presentation regarding the importance of vaccinations, vaccination schedules, the vaccination policy in China, vaccination doses, adverse effects of vaccinations, and vaccination contradictions then were given a post-assessment. When reviewing pre and post-assessment answers, there was a significant increase in knowledge after the educational intervention, demonstrating that this type of intervention was effective (Hu, 2015).

### *Synthesis*

Vaccinations are considered to be sufferers of their own success in health care. Many parents do not vaccinate their children because they feel vaccination-preventable diseases are not a threat due to the high average of vaccinated individuals and the rare instance of a vaccination-preventable disease outbreak (Carrillo-Marquez, 2013). According to DiMaio (2016) "there is overwhelming scientific, medical, and public health evidence that vaccines in current use are remarkably safe and effective, and claims to the contrary largely reflect an uninformed position not supported by the facts."

Additionally, DiMaio feels that some people are ignorant of how horrible, and often fatal, some diseases were that are now prevented, or eradicated, thanks to the use of

vaccinations (2016). It is undeniable that vaccinations work. Since the introduction of the smallpox vaccination, the deadly disease has been completely eradicated. Likewise, polio was nearly eliminated since the introduction of the polio vaccination just years after it was developed. Parents who believe in the anti-vaccination movement today are often concerned about the side effects of the vaccinations. Serious side effects are so rare that they might as well be non-existent. Vaccination-preventable diseases, however, are still prevalent today, and all it takes is one infected individual to cause a mass out-break. Parents must take into consideration which they would prefer: taking the extremely rare chance of their child having a severe adverse reaction to a vaccination, or forgoing vaccinations and taking the much more likely chance of their child contracting a life-threatening disease that could have been prevented by a little shot. Furthermore, parents would be taking the chance of their infected child infecting hundreds or even thousands of others which can lead to mass casualties.

Vaccinations are proven to have an overall positive impact on public health, and it is strongly encouraged that people get educated about the effects of vaccinations and their positive impact by a trusted source before deciding to forego getting vaccinated. In the United States, physicians are considered to be the most trusted source for information about vaccinations (Mathew, 2014). In the face of increasing vaccination refusal, it is important for people to build a strong, trusting relationship with their health care provider and get more educated about the benefits of vaccinations.

### *Discussion*

This proposal highlights the positive effects of vaccinations on public health. While vaccinations are widely accepted, there is still some public fear of vaccinations and some parents still forego getting their children vaccinated, according to the CDC recommended vaccination schedule, which is recognized worldwide.

Given the allowance for religious and philosophical vaccination exemptions, mandating vaccinations has been an ongoing debate. Despite this, however, courts have determined time and time again that the public good outweighs individual autonomy in the case of vaccinations, yet exemptions are generally still allowed. In the face of the ongoing “anti-vaccination movement,” if the federal government were to discredit religious and philosophical exemptions, it would ensure herd immunity in order to protect not only those who are vaccinated, but those who cannot be vaccinated due to medical reasons, babies, the elderly, pregnant women, and the immunocompromised.

Vaccinations clearly have endless scientific, medical, and public health evidence supporting their effectiveness. Those who forego vaccinations face a higher risk of contracting a serious, life-threatening disease that could have been prevented by a

vaccination than a serious, life-threatening adverse effect from a vaccination. It is extremely important for parents who are unsure or opposed to vaccinations to discuss the effects of vaccinations, including the risks versus benefits with their physician rather than reading about vaccinations from a “top hit” Google website.

Vaccinations have contributed to the eradication and/or significant decrease in many life-threatening diseases worldwide. Given that some people medically cannot get vaccinated, all it takes is one infected person to cause a mass outbreak, which can easily be avoided by complying with the CDC-recommended vaccination schedule, which in turn helps implement a healthy world population. The United States government should enforce a vaccination mandate to ensure the protection of public health as a whole.

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