Vaccines: The Controversies and Effects Surrounding the MMR Vaccine

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Abstract

The MMR vaccine serves to prevent the onset of severe illness and transmission of measles, mumps, and rubella. Vaccines benefit an individual by strengthening their immunity to a virus or bacteria through a small or weakened introduction of the disease in the body. However, in recent years, people have blamed the MMR vaccine for the development of several health risks in children, namely autism. Although multiple studies have indicated that there exists no link between the MMR vaccine and autism, some parents choose not to vaccinate their children due to misinformation or lack of education. This thesis seeks to explore important concepts in vaccination as well as demonstrate the lack of correlation between the MMR vaccine and the onset of autism.

Vaccines: The Controversies and Effects Surrounding the MMR Vaccine

The discovery of vaccination is widely considered one of mankind's greatest medical achievements. Diseases that once devasted entire communities of people have since become increasingly rare with the discovery of vaccines. For example, since the success of vaccines, polio has been completely eradicated in the United States. Another eliminated disease from vaccines is tetanus, which leaves the body in a debilitated, unmoving state if untreated. These often-fatal diseases along with countless others have ceased to infect people due to the continued vaccination of infants and children. However, the topic of vaccination remains as one of the most controversial conversations among the population. Although left to the choice of the parents, some choose to refrain from vaccinating their children. This choice is often due to misinformation or lack of knowledge. Vaccination remains one of the most important aspects of keeping this country free of deadly diseases, and one must be educated on the vitality and necessity of vaccines.

Vaccination and immunization have been topics of heated controversy and debate in the years and advances of science and medicine. Specifically in terms of the measles, mumps, and rubella (MMR) vaccine, parents are greatly concerned regarding the effectiveness and potential dangers of this vaccine. The introduction of the MMR vaccine in the late 1980s coupled with a seemingly correlated rise in numbers of children diagnosed with autism caused people to believe that autism was linked with the MMR vaccine. However, multiple research studies have shown no significant relation between autism and the MMR vaccine, yet the concern among parents is still present. Some studies have even linked the MMR vaccine with the potential benefit in the therapeutic treatment of juvenile-onset recurrent respiratory papillomatosis (Wang et al., 2019). Despite the controversies concerning the effects and/or worth of the MMR vaccine, its ultimate

importance in keeping communities healthy and safe outweighs the concern. Prior to vaccination, it is estimated that 400-500 individuals died as a result of measles in the decade prior to vaccination (Boonstra, 2017). However, since the introduction of the MMR vaccine, the last outbreak was about 20 years ago and had a death rate of 1 per 3000, which varied by country (Boonstra, 2017). This thesis seeks to educate readers on different aspects of the MMR vaccine through various research studies, as well as provide some myths and future studies regarding vaccination.

A Brief History of Vaccines

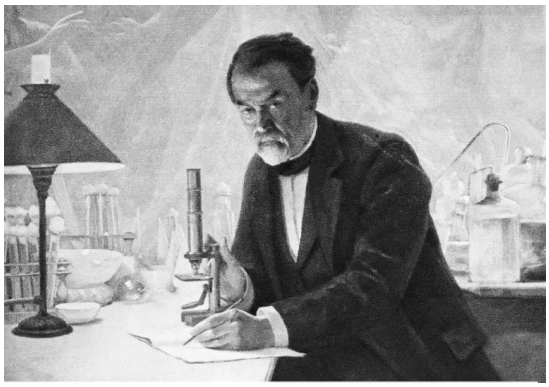
The history of vaccines begins hundreds of years ago in 17th century China where Buddhist monks drank snake venom to gain immunity to snake bites as well as practiced variolation—controlled infection—with the cowpox virus (*A brief history of vaccination*, 2016). However, Edward Jenner is formally considered the founder of vaccines when he began experimenting with live bacterial cultures of cowpox in 1798 (Punt et al., 2019). His studies began by observing that the milkmaids who had contracted a mild case of cowpox appeared to be immune to smallpox. Through inoculating an 8-year-old-boy with the cowpox virus, he demonstrated immunity to the fatal smallpox. Because of this world changing breakthrough, the smallpox vaccine was first introduced in 1798. Since then, the mass implementation of smallpox immunization allowed for global eradication of the disease in 1979.

Figure 1.
Edward Jenner

Note. From *The New York Times* [Photograph], by Ernest Board, 1776, (https://www.nytimes.com/2020/05/25/well/family/covid-vaccine-smallpox-coronavirus.html).

Edward Jenner's major discovery of vaccination spread like wildfire to Europe. However, his techniques were not used against other diseases until almost 100 years later (Punt et al., 2019). Louis Pasteur rediscovered vaccination through his studies with fowl cholera. In his experiments, he allowed the cultures to age and weaken before injecting into a specimen. After successful testing with a weakened strain of *Bacillus anthracis* in sheep, Pasteur extended his studies to other diseases. In 1885, he administered his first vaccine to a young boy who had been bitten by a rabid dog (Punt et al., 2019). Through a series of several inoculations of the attenuated rabies virus, Pasteur saved the boy and became the founder of the rabies vaccine. Although several other early scientists are marked as influential in the discovery of vaccines, Edward Jenner and Louis Pasteur remain two of the most important founders in vaccination.

Figure 2.
Louis Pasteur



Note. From *Bettman Archive* [Photograph]. (n.d.). (https://www.thoughtco.com/louis-pasteur-biography-1992343).

What is a Vaccine?

A vaccine is a medical prophylactic against transmissible diseases. In other words, a vaccine introduces specific diseases able to be passed from person to person in a smaller or weakened dose. The Center for Disease Control and Prevention defines a vaccine by saying, "A vaccine stimulates your immune system to produce antibodies, exactly like it would if you were exposed to the disease. After getting vaccinated, you develop immunity to that disease, without having to get the disease first" (*Immunizations: The Basics*, 2021). They allow the body to recognize and fight the bacteria or vaccine before the onset of illness. If ever exposed to it later

in life, the body activates the stored memory in order to combat the disease and prevent any serious symptoms. Interestingly, vaccines are dissimilar to medicines in the sense that they prevent diseases, while medications work to treat or cure a disease. In the ever-changing world of medicine, vaccines are a powerful tool for the immune system to fight illnesses and prevent diseases from causing worldwide chaos.

Vaccines are present in four different types: live virus vaccines, killed or inactivated vaccines, toxoid vaccines, and biosynthetic vaccines (*Vaccine types*, 2021; Ada, 2005). The Office of Infectious Disease and HIV/AIDS defines the types of vaccines as follows. A live vaccine is a weakened form of the virus which easily introduces the body to the virus without causing illness (*Get vaccinated*, 2021). Killed vaccines involve proteins or small pieces of the virus or bacteria that are no longer active. A toxoid vaccine is beneficial in that it introduces the body with a chemical made by the virus or bacteria instead of the actual infection. This allows the body to fight against the effects of the infection. Lastly, a biosynthetic vaccine are manmade vaccines that are similar but not exact replicas of a piece of a particular virus or bacteria (*Get vaccinated*, 2021). Doctors administer the MMR vaccine in its live form, meaning that it is a weakened form of the virus and will not cause major if any illness.

Vaccines as Pathogen-Imposters

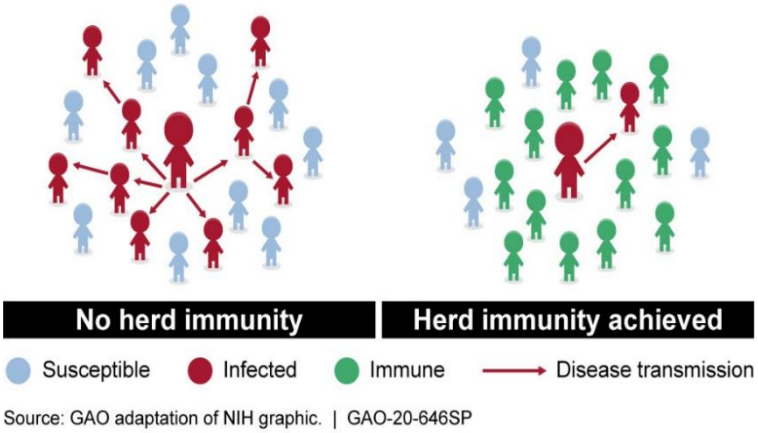
The molecular pathology of vaccines is complex and involves numerous parts of the body's immune system. A vaccine equips the body with the biological preparation that helps to improve immunity. The agent that resembles a disease—bacteria, virus, toxin—enters the body and elicits an immune response. White blood cells quickly recognize, destroy, and remember that pathogen for an efficient destruction if future infection occurs.

As mentioned earlier, vaccines come in five main types. Once this altered pathogen enters the bloodstream, an antigen presenting cell captures, ingests, breaks apart, and displays part of this newly discovered antigen on its surface (*How do vaccines work?*, 2015). It then travels to areas of the body where immune cells cluster together (lymph nodes). Here, naïve T cells that are specific to this antigen recognize it as "non-self" and become activated. Additionally, the T cells stimulate activation of helper T cells and naïve B cells for attack and defense. Some of the naïve B cells will mature and produce antibodies with a protein in the shape of a "y" (*How do vaccines work?*, 2015). Each antibody then attaches to its specific target antigen like a lock and key to prevent it from entering a cell or to mark it for destruction. Memory cells then develop and essentially memorize the vaccine antigen to aid in future recognition of the real pathogen.

Herd Immunity

Many people are familiar with the term *herd immunity*, but many fail to understand its full meaning. Either through vaccination or recovering from an infection, people acquire protective immunity. As this critical mass becomes protected, they serve as a buffer for the rest of the population (Punt et al., 2019). The principle of herd immunity seeks to decrease the number of people who carry and spread an infectious disease, which significantly reduces the chances of susceptible individuals becoming infected. The concept of herd

Figure 3.
Illustration of Herd Immunity



Note. From *GAO* [Photograph], (n.d.), 2020, (https://www.gao.gov/products/gao-20-646sp).

immunity surfaces an interesting idea: many people can survive infectious diseases for which there is a vaccine, but many cannot. Several reasons prevent some individuals from receiving a vaccine, such as age or suffering from a condition that leaves them immunocompromised. Additionally, vaccines are not guaranteed to be 100% effective. Therefore, those individuals who are nonimmune can benefit from the immunity of their neighbors. However, this idea generates a debate: where is boundary of personal choice and the good of the public?

Vaccination: A Debate

Vaccinations are an important part of a child's health for several reasons. The first and most significant being that immunizations can save children's lives. Because of the advances in science, doctors and scientists have been able to develop more vaccines to protect against more diseases. Some diseases that once killed thousands of children, such as polio, have been completely irradicated in the United States due to vaccines. Likewise, vaccines protect communities of people from infection. Through herd immunity, critical masses of people receive vaccines to protect the whole community. Additionally, vaccination is continuously under intense review by healthcare professionals, doctors, and scientists to ensure their safety and effectiveness when administered to children. Vaccines can cause minor discomfort around the injection sight, and allergic reactions are rare (*Get vaccinated*, 2021). Although several other reasons for the importance of vaccinations exist, one can easily see the benefits that vaccinations provide to not only children, but also whole communities.

In one research article, the authors examined the statistics of vaccines and their effectiveness in eliminating diseases. In short, it is obvious that vaccination save lives. In the

Table 1.

Comparison of 20th century annual morbidity and current estimates vaccine-preventable diseases

Disease	20th Century annual morbidity (2)	2016 Reported cases (3)	Percent decrease (%)
Smallpox	29,005	0	100
Diphtheria	21,053	0	100
Measles	530,217	69	>99
Mumps	162,344	5,311	97
Pertussis	200,752	15,737	92
Polio (paralytic)	16,316	0	100
Rubella	47,745	5	>99
Congenital rubella syndrome	152	1	99
Tetanus	580	33	94
Haemophilus influenzae	20,000	22*	>99

*_Haemophilus influenzae_ type b (Hib) < 5 y of age.

United States, it is recommended that children receive vaccinations against 16 diseases (Orenstein & Ahmed, 2017). Table 1 highlights nine diseases and their annual numbers of cases in the 20th century compared to cases in 2016 (Orenstein & Ahmed, 2017).

As mentioned before, vaccines provide protection for not only the individuals who are vaccinated, but also whole communities of people. Infection is spread when a transmitting individual comes in contact with one who is susceptible. However, if this transmitting case only encounters immune individuals, then the infection does not rapidly spread and is controlled within a population (Orenstein & Ahmed, 2017). An interesting thought then arises: it is not vaccines that save lives, but rather it is vaccination that saves lives. A vaccine that resides in its vial is 0% effective regardless of its importance. Thus, it becomes necessary that the population continues a high level of coverage for the diseases for which vaccines are recommended.

Life Before Vaccines

In order to better understand the current push for vaccination, the reader may benefit from a glance at what life before vaccines looked like. In a time where vaccines did not exist, people and communities had to encounter infectious diseases in a vastly different way than people do today. They did not have the advances of science that the population is blessed with in

the 21st century. Because of this, many diseases that completely devastated civilizations are not known to this generation. In one book, the author examines life over the last several hundred years and surfaces the fact that many armies would not even make contact with the enemy when an infectious disease epidemic would enter the camp as it would severely decrease the number of soldiers (Ada, 2007). Additionally, migrating groups of people frequently kept groups of animals that consequently housed infectious agents that would adapt to human pathogens, causing mass death.

Despite the severe effects of infectious diseases on civilizations, populations of people in historical times were able to survive and expand. Interestingly, families of developed countries typically had more children than seen today. However, this is sadly due to the fact that several of the children had a high possibility of dying from childhood infections (Ada, 2007). Conversely, death from these infections is rarely seen in developed countries, and life expectancies are much longer today.

Anti-Vaccination: A Debate

Despite the importance and significance of vaccines, the world is seeing an increase in emerging diseases, and anti-vaccination plays a large role in this. Some parents may choose not to vaccinate their children, and there are several reasons for this choice. The first reason is their lack of firsthand knowledge of the dangers of diseases. This can cause people to wrongly fear the vaccine more than the disease. Anti-vaxxers—those who do not choose to vaccinate—can have detrimental effects on the country by leading to a re-emergence of nearly extinct diseases. However, there are reasons such as religious belief or underlying health belief that prevent people from receiving vaccines. It is clear that immunizations prevent diseases from re-

Figure 4.
Child with measles infection.

Note. From *NPR* [Photograph], (April 30, 2019). (https://www.npr.org/sections/health-shots/2019/04/30/718220586/is-measles-here-to-stay).

emerging, and those who do not vaccinate by choice can be detrimental to the eradication of deadly diseases.

The routine and highly researched immunization schedule for children has sent many diseases to the books of history, yet countless people think vaccines are ineffective or unnecessary. A large influencer of their hesitation takes its roots in human nature (Marshall et al., 2013). People often have the tendency to only take on the risk when it is outweighed by the benefits. So, it is difficult for some to see the benefits of vaccines when the diseases in question are no longer prevalent in society. In contrast, past generations understand the vitality of vaccines as they have seen children hospitalized, paralyzed, or killed by infectious diseases. Recently, however, people are becoming fearful of the vaccines themselves rather than the disease.

As mentioned before, misinformation plays a considerable role in the fear of vaccines. One journal informs the readers that a quick search into Google about vaccines can quickly lead to a host of articles claiming vaccines cause autism (Marshall et al., 2013). Another lead cause in anti-vaccination is the influential people who hold these claims. For example, those against vaccinations tend to make emotive appeals, which paint a picture of "us versus them" that essentially ignores medical research. Additionally, some celebrities have reached out to the public with false claims that vaccines cause autism. Unfortunately, a large portion of the population is susceptible to misinformation and opinions, and it is because of these reasons that parents deny vaccinations.

MMR (Measles, Mumps, and Rubella) Vaccine

The MMR is a live vaccine, introduced in the late 1900s, and serves to prevent the measles, mumps, and rubella diseases. As a result of this vaccine, the measles, mumps, and rubella diseases have been nearly eliminated in the United States. Doctors and healthcare workers generally administer two doses of the MMR vaccine to children at 12 to 15 months and then at 4 to 6 years of age. Young adults/teenagers, adults, international travelers, and healthcare professionals may also receive the vaccination upon consulting their doctor. According to the CDC, "Two doses of MMR vaccine are 97% effective against measles and 88% effective against mumps" (*Measles, mumps, and rubella (MMR) vaccination*, 2021). However, despite the MMR's effectiveness, there exists controversy concerning this vaccine due to its proposed health risks in children.

What are the Measles, Mumps, and Rubella?

In order to better understand the importance of receiving this vaccine, it may benefit the reader to receive some background information on what these three diseases are. Measles is a childhood disease that is typically characterized by a skin rash made up of flat blotches that flow into one another (*Measles*, 2020). Children can catch this disease through coming in contact with someone else infected with the virus. Additionally, doctors see an incubation period of two to three weeks for this disease and recommend isolation and vaccination in other vulnerable patients. The mumps tends to affect individuals with mild to no symptoms (*Mumps Signs and Symptoms*, 2021). As a result of swollen salivary glands, this disease is characterized by puffy cheeks and a tender, swollen jaw. Lastly, the rubella disease is similar to measles in terms of their symptoms, but they are not the same illness. Dissimilar to measles, the rubella disease is less infectious and severe and is caused by a different virus (*Rubella – Symptoms and causes*,

2020). The MMR vaccine is highly effective for all three of these diseases, and doctors recommend early vaccination in children for prevention and/or treatment.

The Risks of Vaccination

To minimize the trauma of receiving the MMR vaccine, it consists of three attenuated viruses (Mersiha et al., 2017). Additionally, studies show high effectiveness of preventing the spread of this disease throughout the household. Side effects of this vaccine are extremely rare, and the benefits of being vaccinated from these diseases vastly outweighs the risks. However, practically no drug exists without the risk of side effects, and this vaccine is no exception. After receiving the MMR vaccine, one may experience mild symptoms such as fever, rash, or swelling of the glands in the cheeks or neck (Mersiha et al., 2017). More moderate symptoms include seizures, temporary arthritis, or thrombocytopenia. In the very rare and severe cases, some individuals have experienced allergic reactions.

A central argument against the MMR vaccine is its belief among parents to introduce the onset of autism. When the MMR vaccine was first introduced to the community, an unknown cause to a rise in numbers of children diagnosed with autism also arose. Due to lack of knowledge along with other reasons, the public blamed the MMR vaccine for the cause of autism in their children. However, several studies have been conducted to investigate the correlation between MMR and autism as seen in the proceeding paragraphs. If any correlation exists, it would be too small to consider significant.

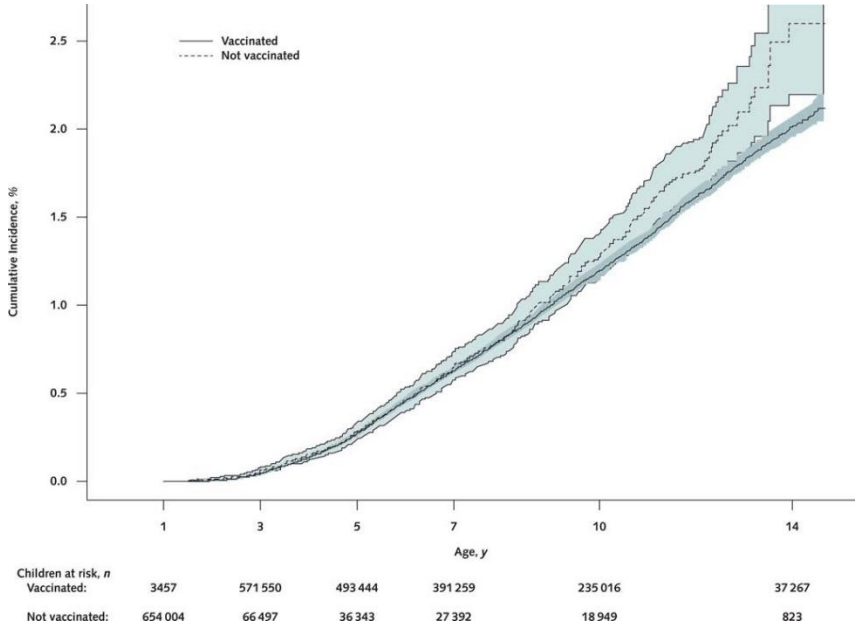
Does the MMR Vaccine Cause Autism?

Since 2014, the United States has seen an increase in vaccine-preventable diseases such as diphtheria, pertussis, tetanus, measles, mumps, and rubella (Gostin, 2015). This increase is likely due to parents who delay or choose to selectively immunize their children, or, at times,

even completely refuse immunization for their children. The recent outbreak of the measles, mumps, and rubella diseases has resurfaced some historical debates on the MMR vaccine. In 1998, the Wakefield et al. study was published, which reported to find a link between the MMR vaccine and the onset of autism in children (Chang, 2018). Since the publication of the Wakefield study, there have been numerous and thorough research articles that repudiate the claims of the Wakefield study. However, the misconception that the MMR vaccine causes autism is still very persistent in parents today.

One of the reasons for the significant attention that the public gave to the Wakefield study was its publication in *The Lancet*, which is a well-known and acclaimed journal (Chang,

Figure 5.
Graph displaying cumulative incidences of autism



Note. Cumulative incidences of autism (unadjusted and with 95% CI bands) in 657 461 children born in Denmark between 1 January 1999 and 31 December 2010, by vaccination status and age. (Hviid et al., 2019).

2018; Wakefield et al., 1998). The evidence listed in the Wakefield study have since been refuted by several scientific research studies, which show no significant correlation to the MMR vaccine and the onset of childhood autism. One recent research designed a nationwide cohort study where they compared two groups of autistic children: one vaccinated and one not vaccinated

against the MMR diseases. This study yielded an autism hazard ratio—a measure of how often an event happens in one group compared to another group over time—of 0.93, which strongly supports the idea that the MMR vaccination does not produce an increased risk for the onset of autism (Hviid et al., 2019). Additionally, their findings provide no support for the claim that the MMR vaccine triggers autism in susceptible groups of children as well as no support for rise in autism cases at specific time periods after receiving the MMR vaccine.

Another interesting study examined autistic spectrum disorders (ASD) by the MMR vaccine in US children who had older siblings with and without autism. They sought to study the associated risk of ASD for children vaccinated with the MMR vaccine when autism ran in the family (Jain et al., 2015). However, they found no significant correlation in the increased risk of autism after vaccination with MMR, regardless of if older siblings had ASD. The study offers the conclusion that their findings offer no harmful association between children who receive the MMR vaccine and the onset of autism despite having a higher risk for ASD.

Some suggest that parents' hesitation with vaccinating their children against the measles, mumps, and rubella stems from education. In other words, a mother's education can affect her children's health and vaccine take-up (Chang, 2018). Literature has pointed towards a positive correlation between one's education, health status, and health utilization. Grossman hypothesizes that individuals with higher education levels tend to take in medical information more quickly and integrate it into their health behaviors (Grossman, 1972). With this in mind, it is clear that a portion of the public has not received proper education on the safety and necessity of the advances in medicine, namely vaccines.

In short, according to the literature, the MMR vaccine poses no significant risk for the development or triggering of autism in children who receive this vaccination. The publication of

the Wakefield study has since been retracted in its original publication (*Wakefield study linking MMR vaccine, autism uncovered as complete fraud*, 2011). Interestingly, the MMR-autism controversy was a rare circumstance where high-profile research that proposed a serious negative side effect of a standard medical procedure was later deemed as false in a public way. Unfortunately, due to lack of education and knowledge, parents today still see a risk with the MMR vaccine in their children, despite the countless research articles that provide vital information in its safety and importance. It is important that the public understands the necessity of certain vaccines not only for the health of their children, but also for the health of those surrounding them.

Myths of Vaccines

The topic of vaccination and immunization remains highly debated and controversial in the public. Several myths and ideas that people generate are based off of misinformation and lack of knowledge. Unfortunately, this results in wide-spread fear and hesitation regarding vaccination, despite the credible studies that demonstrate the safety and importance of promoting health through vaccines. This section highlights several myths and facts with respect to vaccination in hopes of educating the reader on various misconceptions that remain untrue.

Myth 1: Vaccinations Early in Life are Dangerous

One common myth with vaccination is the theory that an infant's immune system is too weak to handle all the vaccines, making them unnecessary so early in life. However, it is important to note that many diseases which vaccines prevent are most deadly in those of a young age (*8 myths about vaccines and kids*, 2005). Moreover, waiting to vaccinate children until they are older puts them at increased risk for some potentially life-threatening diseases.

The belief that an infant's immune system is not strong enough to handle vaccination is entirely false. An infant's immune system is quite capable of handling certain vaccinations. As an example, if all 14 scheduled vaccines were given to the baby at once, their immune system would only be using about 0.1% of its capacity (*Vaccine myths debunked*, 2021). Likewise, vaccinations given today are far more efficient than vaccinations given in past decades. A baby's immune system was designed with the strength to withstand these helpful medicines. Therefore, the claim that too many vaccinations will harm an infant is not supported by evidence.

However, one may wonder why certain vaccines are given earlier or later than others. The scheduling for vaccinations was determined based off of several factors. Some of these factors include the type of vaccine, the vulnerability to the disease by age, and the age at which the immune system can tolerate vaccine components (*The Childhood Immunization Schedule and Safety*, 2013). For example, an infant's immunity given by maternal antibodies wanes after birth, and they become more susceptible to pathogens. Therefore, certain vaccines should be administered early to avoid fatal outcomes by disease. While it is true that certain vaccinations should be given earlier, some are given later due to the type of vaccine and the age of the child. However, there is no explicit reason to refrain altogether from giving infants vaccines. Considering these factors and more, the vaccine schedule was made in order to promote the safest outcome for children receiving immunizations.

Additionally, vaccines were created with the purpose of fighting infection without significantly harming the body. The rate of adverse reactions for the MMR vaccine are considerably low. One in every 20,000 individuals who receive the MMR vaccine will have an adverse reaction, which can include febrile seizures or thrombocytopenic purpura (Spencer et al., 2017). A vaccine deemed unsafe for a child's immune system would not be administered by

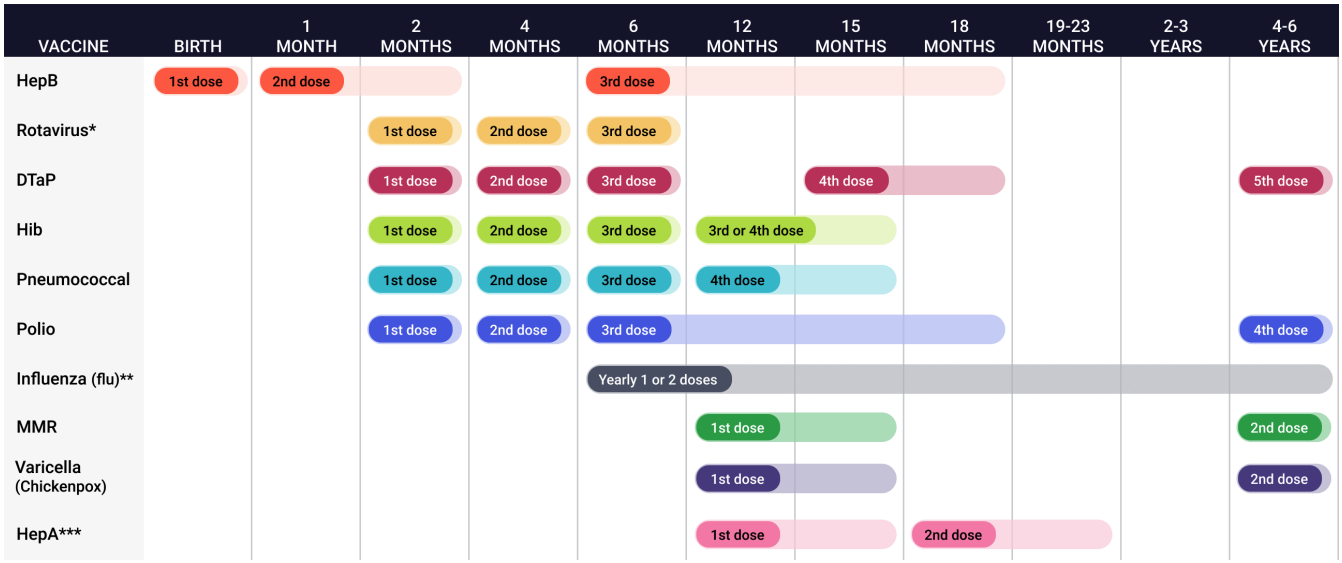
healthcare professionals. So, the claim that the body cannot handle so many vaccinations at one point is based on no scientific evidence and holds no truth.

Myth 2: Vaccine Schedules Are Too Aggressive

Some hold the claim that the vaccination schedule created and recommended by doctors is too aggressive for children and should be spaced out. However, these schedules were built as a result of decades of medical evidence and research. These studies indicate the optimal window of time when a vaccine is most effective in preventing a disease as well as the time when children are most vulnerable to the disease (*8 myths about vaccines and kids*, 2005). By spacing out vaccinations, parents slow down the vaccine schedule, which results in more office visits and more injections for their children. Although it is ultimately up to the parent's decision, it should be noted that the vaccine scheduling was created with heavy research and emphasis on the safety and health of children.

In order to determine the optimal age as to when the MMR vaccine should be administered, seroconversion rates are typically assessed. Seroconversion is the transition from

Figure 6.
Immunization schedule for children.



Note. From *CDC* [Photograph], (n.d.). (https://www.drugwatch.com/health/vaccine-schedule/).

the point of infection to where the antibodies are seen in the blood (*What is seroconversion?*, 2020). In one study to determine the optimum age for vaccination, seroconversion was assessed at ages 9, 12, and 15 months (Singh et al., 1994). Their findings showed that responses to measles antigen was better (>95%) at 12 or 15 months than at 9 months (80%). They also found that the responses to the mumps antigen was higher (92%) at 12 months than at 9 months (75%). These findings demonstrate that a better response to the MMR vaccine was acquired at or after 12 months than earlier.

Myth 3: Vaccines are Toxic

People tend to say that the use of formaldehyde, mercury, or aluminum in vaccines makes them toxic. While these chemicals are toxic to the body in certain levels, the FDA has approved only trace amounts for their use in vaccinations (*Vaccine myths debunked*, 2021). Interestingly, the body's metabolic system produces formaldehyde at higher rates, and there are no studies that show low levels of formaldehyde, mercury, or aluminum are harmful. Contrary to people's thoughts, these chemicals aid in making vaccines safer as well as ensuring their sterilization and job efficacy (*8 myths about vaccines and kids*, 2005).

The FDA reports that there is 50 to 70 times more formaldehyde in an average newborn's body than is present in a single dose of a vaccine (*What goes into a vaccine?*, 2021). The highest amounts of formaldehyde seen in a vaccine is 0.02 mg per dose, while a two-month-old baby has about 1.1 mg of formaldehyde normally circulating through their bodies (*What goes into a vaccine?*, 2021). Another adjuvant used in vaccinations that raises concern is aluminum. Next to oxygen and silicon, aluminum is the third most naturally occurring element (*What goes into a vaccine?*, 2021). Aluminum is frequently accessible to animals and humans through a variety of ways including inhalation or aerosols/particles, ingestion of food, water and medicine,

vaccinations, and more (Igbokwe, 2019). Interestingly, an infant who is nursed by the mother will ingest about 7 milligrams of aluminum in their diet within the first six months of life, while a combination of all the scheduled vaccines given to an infant contains only 4.4 milligrams of aluminum (*What goes into a vaccine?*, 2021). Although acute aluminum toxicity can occur at levels of 500 µg/L or more, vaccines do not contain these levels of aluminum concentrations (Flora, 2014).

In 1999, concerns were raised regarding the amount of mercury in an infant's immunization schedule. Thiomersal, which has 49.6% of ethyl mercury, has been used as a preservative for vaccines beginning in 1930 (Bose-O'Reilly et al., 2010). Ethyl mercury does not accumulate in the fatty tissues of the body, and the gut works to actively secrete it. Therefore, in 2006, the WHO Global Advisory Committee on Vaccine Safety claimed that no changes in current immunization practices should be changed (Bose-O'Reilly et al., 2010). Yet, the topic remains a controversial one that the WHO continues to review using evidence for preterm and malnourished infants.

Myth 4: The Decision to Vaccinate or Not Only Affects My Child

Parents often skip vaccinations with the mentality that once deadly diseases have now been made quite rare today thanks to vaccines. However, if every parent chose to refuse vaccination for their children, this nation would likely see a dramatic outbreak of once eradicated diseases. As previously mentioned, herd immunity is when a certain high enough percentage of people in a population become immune to a disease, making it difficult for the disease to spread. This concept is vitally important to individuals who cannot receive *certain* vaccinations, such as infants, pregnant woman, immunocompromised, and the elderly (*Vaccine myths debunked*, 2021). However, if too many people choose not to vaccinate their children, they open up

opportunities for diseases to reestablish themselves and spread throughout a population. Additionally, the Center for Disease Control (CDC) has warned that with growing international travel, diseases that are not a threat in some countries can become common elsewhere as unvaccinated people spread the infections.

Myth 5: It is Better to Acquire Natural Immunity Than to get a Vaccine

In some instances, actually catching a disease, getting sick, and fighting it off produces a stronger immunity than a vaccine. However, in some diseases, the dangers strongly outweigh the benefits. For example, some parents may desire for their children to gain immunity to the measles by getting the virus. But this disease surfaces a 1 in 500 chance of death from the symptoms, whereas the chances of developing an allergic reaction as a result of the vaccine is one-in-one million (*Vaccine myths debunked*, 2021).

The frequency of permanent problems resulting from infection versus vaccination is striking. It is estimated that upon infection with the mumps virus, 1 in 5000 children will develop brain inflammation (*Comparisons of the effects of diseases and the side effects of vaccines*, 2021). On the other hand, children who have been vaccination have a 1 in 100 chance of experiencing swelling of the salivary glands. In infection with the measles virus, 1 in 1000 develops encephalitis (brain inflammation), while those receiving the vaccine experience mild reactions such as a rash or swelling at the injection site (*Comparisons of the effects of diseases and the side effects of vaccines*, 2021). Just based on these statistics, one can make the claim that the risks accompanying the virus as compared to the vaccine are arguably greater and more impactful to a child's health.

The myths surrounding current vaccines are a result of lack of information as well as information that has been misconstrued. People's mistrust in doctors and medicine leads to their

negligence in vaccination, which ultimately affects the public around the individual. Often, people fear the unknown or the health risks that are associated with vaccines. However, as a result of hundreds of studies, vaccines have been determined to be safe and effective in the improvement of health in an individual. Additionally, vaccines are under constant research for the purpose to safely promote healthy communities around the world.

A Note About COVID-19

Another vaccine that has received the spotlight in recent months is the COVID-19 vaccine. COVID-19 is defined as a severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that falls into a category with many other coronaviruses (*Coronavirus disease 2019 (COVID-19) – Symptoms and causes*, 2021). Since the first outbreak of this disease in December of 2019, the public has been patiently awaiting the arrival and approval of its vaccine. However, now that the vaccine is available to the public, many present with concerns regarding the speed with which this vaccine came about. They also fear the long-term effects of receiving the vaccine since studies are inconclusive in this area. The COVID-19 vaccine has spurred significant controversy in the eyes of the public, and it will no doubt continue to induce hesitation for several years to come.

Vaccines will always be a topic of controversy. To support this claim, one can see the obvious controversy over the MMR vaccine, which has been around for several years now. Despite the numerous and well-known published research articles that provide evidence to support its safety and efficacy, people continue to hold reservation about its effects on the health of their children. Therefore, if history is a predictor of the future, the COVID-19 vaccine will receive push back from the public for years to come. Studies on this vaccine are severely limited in their data, simply because the vaccine has not existed long enough to conduct long-term

research. Without this research, there is insufficient data on the effects of this vaccine over a long period of time. However, similar to the MMR vaccine, even with future research suggesting the COVID-19 vaccine's safety in the long-term effects, people will still doubt its safety.

Future Prospects

One important concept in the world of medicine is that it is continually evolving and seeking ways to improve current methods or develop entirely new ones. In light of this, the methods of vaccination are always sought to be improved for the health of those receiving it. Furthermore, the measles, mumps, and rubella vaccine falls into this category where researchers are evaluating its safety and efficacy. The areas that are currently being studied for improvement are vaccine strain selection, virus propagation techniques, and vaccine platforms (Almansour, 2020).

Vaccine Strain Selection

In current licensed MMR vaccines, the strain of mumps that is used originated from the circulating strains of the mid-20th century (Almansour, 2020). The strains contain different genotypes, which scientists represent with a letter of the alphabet. Genotype A is the most commonly used vaccine strain, especially with the reemergence of mumps in the public. Several different genotype strains are currently circulating around America, Australia, New Zealand, India, China, Europe, and Asia. However, recent studies have failed to detect the wild-type genotype A mumps virus in areas where individuals are vaccinated with the genotype A vaccine. This can lead to a vaccine-based selection pressure on the virus, which can in turn increase the heterogeneity and emergence of genotypes having increased virulence. So, in future studies, it will be necessary to perform cross-neutralization studies with the genotypes that are in circulation. Additionally monitoring of the strains that are currently in circulation help lead to a

determination of which strains are predominate in different regions, and thus which vaccine strains should be used for that region or population. A limited number of studies have been published on the antigenic relationship between the various mumps genotypes and strains, making this area of research necessary for improvement.

Vaccine Propagation

Vaccine propagation involves how the different strains of infections are grown. For example, the MMR vaccine is grown from chicken embryo fibroblasts (Almansour, 2020). However, it is vitally important that vaccines are produced without serial passaging in the host cells in order to avert antigenic drift of the viral strains. Therefore, if strains of the mumps were grown in human tissue culture, they would retain the immunogenic epitopes of the virus. One example could be using human embryonic kidney cells for vaccine growth to improve its efficacy (Almansour, 2020).

Vaccine Platforms

The development and production of improved mumps vaccines is a progress that advances slowly. The current vaccine platforms exist as plasmid DNA, mRNA, self-amplifying mRNA, or viral subunits. In future studies, these platforms should be analyzed for their applicability to the development of the mumps vaccine. The DNA and mRNA platforms are rapid, easily scalable, and do not require propagation. Additionally, researchers have been able to select the specific immunogen that is needed for the triggering of the adequate immune response. So, progress has been made on the subunit, recombinant, and DNA vaccines in the treatment of measles, mumps, and rubella infections.

Conclusion

The development of vaccines has tremendously improved public health. Because of the studies and experiments done by Edward Jenner, Louis Pasteur, and countless others, vaccines have existed for the purpose of eliminating infectious diseases and promoting healthy living among communities. The different types of vaccines seek to terminate different pathogens, depending on their unique viral characteristics. In a time where vaccines did not exist, fatal diseases wiped out entire communities of people and devasted the populations. Yet, because of the developments of science today, most of those diseases have been entirely eradicated, including the measles, mumps, and rubella.

The measles, mumps, and rubella (MMR) vaccine was an important development for the health and safety of communities in the United States. Its success has nearly cleared the nation of the measles, mumps, and rubella diseases. Yet, many associate the MMR vaccine with the onset of autism, and thus do not vaccinate their children. This is potentially dangerous as an increasing number of people who continue to refuse vaccines influence a re-emergence of these diseases. However, several studies show that the MMR vaccine does not trigger the development of autism. Therefore, with an education on the background of vaccines and their effectiveness therein, parents are strongly encouraged to vaccinate their children with the MMR vaccine for the purpose of keeping families and communities healthy.

The claim that the MMR vaccine causes autism is a topic of heavy concern and debate between the public and doctors. The beginning of this controversy arose when the Wakefield study was published which signified the MMR vaccine was correlated with the rise in the numbers of children who were diagnosed with autism. However, since that study's publication, several studies have been conducted to investigate these claims and have concluded no such

correlation exists. Yet, the public still fears this vaccine, due to human nature, lack of knowledge, and misinformation. It is important that these individuals recognize the importance of this vaccination so that a nationwide reemergence of the measles, mumps, and rubella viral infections is avoided.

People tend to fear statistics and numbers when they point to something negative. Vaccinations do not exist without risks. Virtually no part of medicine exists without potential side-effects of medication or certain methods of care. However, in the case of the MMR vaccine, the benefits clearly outweigh the foreseen risks. Similar to the controversy surrounding the MMR vaccine is the COVID-19 vaccine. Since the introduction of the SARS-CoV-2 virus and the production of its vaccine, the public has displayed questions and fear concerning its safety. Long-term effects of this vaccine have not been studied due to its short time of existing among the public. Moreover, with the continued debate in the MMR vaccine, which has existed for several years, the COVID-19 debate will likely continue long into the future.

Vaccines give the body an interesting opportunity to fight pathogens before ever being exposed to the viral infection. By presenting the body with a weakened or killed form of a pathogen, the body has the ability to develop resistance to the disease, which lowers the severity of infection if ever exposed in the future. Although several questions and debates envelop the topic of vaccination, and specifically the MMR vaccine, their safety and efficacy trump the perceived risk. The studies surrounding vaccination are continually growing and seeking to identify new ways to provide improvement to existing vaccines. The fear surrounding the MMR vaccine is based off of the public’s lack of information, but its safety and effectiveness has been shown in countless studies. Therefore, it is essential that the public recognizes the benefits of the

MMR vaccine and understand their responsibility to vaccine their children for the purpose of improving health and preventing reemergence of deadly diseases.

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