Spring 5-12-2017

Vaccines: What You Really Need to Know

Victoria Milano
vmilano@uwyo.edu

Sydney Schneider
sschnei5@uwyo.edu

Vaccines: What You Really Need to Know

By: Victoria Milano and Sydney Schneider

University of Wyoming Honors Program

Mentor: David Bruch, Pharm.D.

Abstract:

The first vaccine created was for smallpox in the late 1700s. In the two centuries following many vaccines have been developed to prevent life-threatening diseases, and decrease human suffering. However, there are still many misconceptions about them. These misconceptions have led to a decrease in the use of vaccines, leading to the reemergence of diseases that were once nearly eradicated from first world countries. In this paper we will address ten common misconceptions held by the public in the United States, and present a review of the literature to either support or reject these beliefs.

Misconception 1: Vaccinations Cause Autism

In February 1998, a study titled, "Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children" by Andrew Wakefield, et al. was published in The Lancet. The study documented an association between the measles, mumps, and rubella vaccination and the onset of symptoms of autism. Only 12 children were studied, and only eight of the 12 children were noted to have an association between the MMR vaccine and the onset of autism symptoms. According to the study, some of the parents linked the MMR vaccine to the cause of behavioral problems, not the physician. Another flaw in the study was that there was no control group to compare to.

Other issues surrounding the Wakefield study have arisen since the original publication as well. It was discovered that Wakefield had filed for a patent for a single measles vaccine that was purportedly supposed to be safer than the combined MMR vaccine. He did not reveal this conflict of interest in his study. Other research by journalist Brian Deer also surfaced, revealing that Wakefield completely fabricated the diagnoses and histories of the children who were researched in the study (Do Vaccines Cause Autism).

Two studies were posted previously to the study conducted by Wakefield, et al. that suggested an association between vaccinations and autism and were cited in the publication by Wakefield. In a study done by Fudenberg in 1996 studying the cause and treatment of autism he wrote, "Fifteen of the TA (true autistic) patients developed symptoms within a week after immunization with the measles, mumps, and rubella vaccine (MMR)…" Fudenberg suggested that autism may be an autoimmune disorder and that individuals with certain genetic predispositions should avoid live vaccines like MMR until 3 years of age (Fudenberg, 1996). This fits with recommendations today that any person with a compromised immune system

should first talk with a doctor before receiving any live vaccination. Another study published by Gupta in 1996 also suggested that patients with autism presented shortly after receiving the MMR vaccine. Unfortunately, these studies had little hard data other than observations, and other studies conducted around this same time did not show the same associations.

As a result of these incomplete studies, parents began to fear that the MMR vaccine may be causing autism. According to the CDC, measles cases began to rise to a record number of 667 cases from 27 states in 2014, the highest on record since 2000 when measles was eliminated from the United States. These measles outbreaks can be attributed to lower MMR vaccination rates. The CDC also reported an increase in cases of mumps. "Before the U.S. mumps vaccination program started in 1967, about 186,000 cases were reported each year…Since the pre-vaccine era, there has been a more than 99% decrease in mumps cases in the United States" (Mumps Cases and Outbreaks). As seen in the following figure, mumps cases appear to have risen recently.

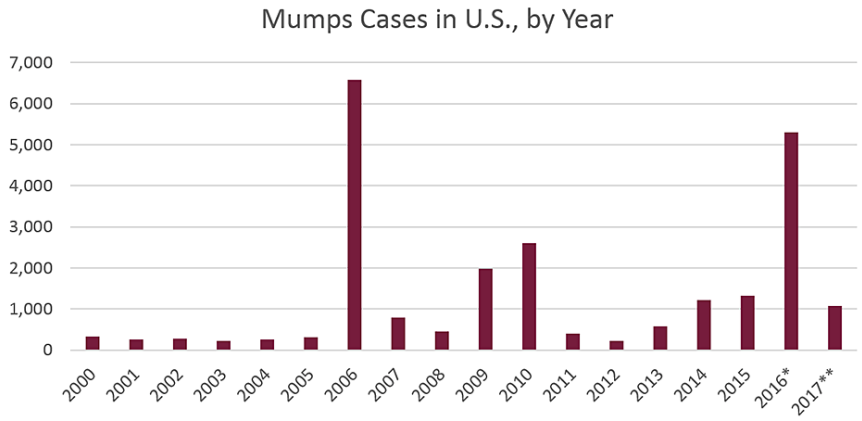

Image from https://www.cdc.gov/mumps/outbreaks.html

Numerous studies were conducted in response to the publication by Wakefield, et al. One cohort study done in Denmark with 537,303 children found no increase in the risk of autism

between unvaccinated and vaccinated children (Madsen et al., 2002). Several ecological studies; retrospective, observational studies; and prospective, observational studies completed after the Wakefield study found no association between the MMR vaccine and autism. In 2004, 10 of the original 12 authors of the Wakefield study retracted the original interpretation that there was found to be a causal link between the MMR vaccine and autism.

Another concern related to vaccines was the use of thimerosal in vaccinations and the possible association of it causing autism. Thimerosal, a compound containing approximately 50% mercury by weight, was used as a preservative in vaccines for many years until 1999 when the "…Public Health Service, Center for Disease Control and Prevention and Health Resources and Services Administration, and the American Academy of Pediatrics issued two Joint Statements urging vaccine manufacturers to reduce or eliminate thimerosal in vaccines as soon as possible" (U.S. FDA, 2015). There was concern that thimerosal used in vaccine products may have been causing mercury poisoning in children resulting in autism symptoms presenting in children. The FDA conducted a review on the use of thimerosal in vaccines and found no evidence to support that thimerosal causes any harm other than local hypersensitivity reactions.

A paper published by Bernard, et al. in 2001 found differently. The authors hypothesized that mercury poisoning presents very similarly to how autism presents and that children were developing autistic symptoms after receiving vaccinations containing thimerosal as a preservative. A publication by Nelson and Bauman in 2003 disagreed with the findings of Bernard. They stated, "On the basis of current evidence, we consider it improbable that thimerosal and autism are linked" (Nelson and Bauman, 2003). Regardless of the argument, all vaccines recommended in children immunization schedules no longer contain thimerosal as a

preservative except for some formulations of the inactivated influenza vaccine (U.S. FDA, 2015).

The numerous studies conducted since the publication of Wakefield have found no link between autism and the MMR vaccine, and prove that it is highly unlikely that the MMR vaccine causes autism. Many of the authors of the original Wakefield study retracted their original interpretation, and even The Lancet retracted the article in 2010. Clearly, Wakefield's study was not conducted properly. The thimerosal hypothesis has also proven to be highly unlikely as noticed by the large amount of evidence finding no association between vaccines containing thimerosal and autism. Thimerosal has been removed as a preservative from childhood vaccines, yet the rate of autism continues to rise. Clearly, there is more evidence to prove that there is no link between vaccines and autism than there is evidence to prove otherwise.

References

1) Bernard S, Enayati A, Redwood L, Roger H, Binstock T. Autism: a novel form of mercury poisoning. Med Hypotheses 2001;56:462–71.
2) "Do Vaccines Cause Autism?" *History of Vaccines*. The College of Physicians of Philadelphia, n.d. Web. 26 Apr. 2017. Gerber JS, Offit PA. Vaccines and Autism: A Tale of Shifting Hypotheses. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America*. 2009;48(4):456-461. doi:10.1086/596476.
3) Fudenberg HH. Dialysable lymphocyte extract (DLyE) in infantile onset autism: a pilot study. *Biotherapy*. 1996; 9(1-3): 143-147.
4) Gupta, S. Immunology and immunologic treatment of autism. *Proc Natl Autism Assn Chicago*.1996;455–460
5) Madsen KM, Hviid A, Vestergaard M, Schendel D, Wohlfahrt J, Thorsen P, Olsen J, Melbye M. A Population-Based Study of Measles, Mumps, and Rubella Vaccination and Autism. *The New England Journal of Medicine.* 2002; 347:1477-1482.
6) "Measles (Rubeola)." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 06 Apr. 2017. Web. 26 Apr. 2017.
7) "Mumps Cases and Outbreaks." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 06 Apr. 2017. Web. 26 Apr. 2017.
8) Murch SH, Anthony A, Casson DH, Malik M, al e. Retraction of an interpretation. *The Lancet*. 2004;363(9411):750.
9) Nelson KB, Bauman ML. Thimersol and Autism? *Pediatrics* Mar 2003, 111 (3) 674-679; DOI: 10.1542/peds.111.3.674

10) "Vaccine Safety & Availability - Thimerosal in Vaccines." *U S Food and Drug Administration Home Page*. N.p., n.d. Web. 26 Apr. 2017.

11) Wakefield AJ, Murch SH, Anthony A, et al. Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children. Lancet. 1998;351:637–41.

Misconception 2: Natural immunity is better than vaccine acquired immunity

A common belief is that it is better to gain immunity from diseases naturally than from vaccines. Natural immunity is thought by some to provide better protection against diseases. Natural immunity can last longer than immunity from vaccines, but there are many more risks from natural infection than from vaccines (Misconceptions about Vaccines).

Vaccine acquired immunity produces the same response from the immune system that immunity from a natural infection does. Whenever a person is exposed to an infection or vaccine, the body mounts a response by activating T cells and B cells to fight off the infection. Once the infection is cleared, memory T and B cells are formed. These memory cells persist in the body so that whenever a person is re-exposed to the infection, the body is able to quickly mount an immune response and fight off the infection before it progresses to a major infection like the first exposure. The body responds the same to vaccines, but the vaccine component is altered so that it does not result in an actual infection.

Natural infections can cause extreme complications that vaccinations do not. For example, measles infection results in encephalitis in one in 1,000 individuals and death in two in 1,000 individuals. "The combination MMR (measles, mumps, rubella) vaccine, however, results in encephalitis or a severe allergic reaction only once in every million vaccinated individuals, while preventing measles infection" (Misconceptions about Vaccines). The varicella infection can result in complications like pneumonia. *Haemophilus influenza* type b (Hib) infection can cause intellectual disability. Birth defects are common if a patient is infected with rubella. Infection with Hepatitis B virus can cause complications like cirrhosis, liver cancer, and liver failure (The Children's Hospital of Philadelphia).

Natural immunity can also be passed from mother to child through breast milk. Unfortunately, this natural immunity does not last as long as actually being infected with the disease, or being immunized against the disease. This type of natural immunity, also called passive immunity, only lasts for a few weeks.

The human papillomavirus (HPV), *Haemophilus influenzae* type b (Hib), tetanus, and pneumococcal vaccines provide better immunity than a natural infection with these diseases would provide. According to a study by Margaret Stanley, "HPV L1 VLP vaccines are highly immunogenic generating antibody concentrations after the 3rd immunization that are 1-4 logs higher than those in natural infections" (Stanley, 2010). HPV vaccines provide higher concentrations of antibodies to fight off HPV infections than natural infection with HPV would. Stanley also noted that, "…neutralizing antibody persists with geometric mean titres about 1 log greater than natural infection for the 7-9 year duration of the published studies" (Stanley, 2010). The HPV vaccine produces higher antibody levels than natural infection and these higher antibody levels persist for a longer time as well. In the article by Stanley, she hypothesizes that natural infection with HPV does not provide the same antibody response that the HPV vaccine does because the natural infection is acquired through epithelial cells, and does not have direct access to lymphatic tissue that an intramuscular injection with the vaccine would have (Stanley, 2010). The cells that respond to the natural infection vs. the HPV vaccine are also thought to be different. Macrophages and Langerhans cells most likely are the antigen presenting cells in natural HPV infection, whereas dendritic cells are the antigen presenting cells that first respond to the HPV vaccine. Dendritic cells act quickly to recruit T and B cells to fight off the infection (Stanley, 2010).

The Hib and pneumococcal vaccines have been shown to provide a better immune response in children under 2 than infection naturally would. Children under 2 do not yet have the full B-cell response from their immune system that older children and adults do. Without this fully activated B-cell response, children do not respond as well to the polysaccharide on the surface of Hib and pneumococcal pathogens and are more susceptible to infection. The vaccines for these bacteria contain a helper protein that creates a better response from the immune system to help it recognize the polysaccharide complex (Offit, et al., 2002). Due to this finding, children under 2 who are infected with these bacteria are still recommended to get the vaccinations because they provide a better long-term immune response.

The tetanus toxin is so potent that it takes a much smaller amount to actually get the disease than it does to get long-term immunity. The vaccination contains a much higher amount of inactivated toxin that produces a longer lasting immunity than natural infection does. People that develop tetanus should still get vaccinated because the natural infection does not provide long-lasting immunity. Booster shots every 10 years are required for tetanus vaccinations because the vaccine does not produce lifelong immunity (The Children's Hospital of Philadelphia).

Another advantage that vaccines provide that natural immunity does not, is that vaccines provide protection against several strains of an infection, whereas the infection only provides immunity against that one strain of the disease. The seasonal influenza vaccine is a prime example. There are four types of influenza viruses, three of which cause disease in humans. Only two types, A and B, are included in the seasonal influenza vaccine. Of these two types, there are many subtypes and strains that can occur. For example, for influenza A virus, there are 18 different hemagglutinin subtypes and 11 different neuraminidase subtypes. The seasonal flu

vaccine only covers for two of the A subtypes and one or two of the B strains depending on the vaccination that is received. When a person is infected with the influenza virus naturally, they only have future immunity against that one strain that caused the disease. The flu vaccine is covering immunity for three or four strains that a person could potentially be introduced to (Influenza, CDC).

Natural immunity does produce better immunity than vaccine acquired immunity. Natural immunity can last much longer, sometimes for a lifetime. Immunity from vaccines does not usually last as long, thus requiring booster vaccines to keep the immune system active against diseases. The risks of natural immunity far outweigh the benefit of the potential longer lasting immunity. Infection with disease can result in death, encephalopathy, pneumonia, hepatitis, and other complications. Vaccinations provide immunity to protect against these diseases without actually having to get sick from them.

References:

1) Anderson P, Ingram DL, Pichichero M, Peter G. A high degree of natural immunologic priming to the capsular polysaccharide may not prevent Haemophilus influenza type b meningitis. Pediatr Infect Dis J. 2000;19:589–591
2) The Children's Hospital of Philadelphia. "Vaccine Safety: Immune System and Health." *The Children's Hospital of Philadelphia*. The Children's Hospital of Philadelphia, 05 Nov. 2014. Web. 26 Apr. 2017.
3) "Influenza (Flu)." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 14 Apr. 2017. Web. 26 Apr. 2017.
4) "Misconceptions about Vaccines." *History of Vaccines*. The College of Physicians of Philadelphia, n.d. Web. 26 Apr. 2017.
5) Offit P, Quarles J, Michael G, et al. Addressing Parents' Concerns: Do Multiple Vaccines Overwhelm or Weaken the Infant's Immune System? *Pediatrics* 2002;109;124-9 DOI: 10.1542/peds.109.1.124
6) Rijkers GT, Dollekamp EG, Zegers BJM. The in vitro B-cell response to pneumococcal polysaccharides in adults and neonates. Scand J Immunol.1987;25:447–452
7) Stanley M. HPV - immune response to infection and vaccination. *Infectious Agents and Cancer*. 2010;5:19. doi:10.1186/1750-9378-5-19.

Misconception 3: Vaccines Contain Unsafe Toxins

A common myth surrounding vaccinations is that they contain many harmful toxins. The ingredients in vaccines actually serve very useful purposes and are not harmful in the amounts given. Truly, the components added to vaccinations are in minute amounts. For most of the ingredients found in vaccines, more is consumed from everyday lifestyle than the vaccine components contain. The ingredients in vaccines help to ensure the vaccine remains sterile, potent, and stable.

One of the most common ingredients found in vaccinations is suspending fluid. Suspending fluids include things like sterile water, saline, and fluids with protein. The purpose of a suspending fluid is to keep vaccine nanoparticles evenly dispersed so that each dose is consistent. Sterile water is produced through distillation and is free from particulate matter, microorganisms, and endotoxins. Generally, sterile water is considered to be safer than tap water. Sterile saline is identical to sterile water with added sodium chloride to prevent injection pain from vaccinations that are not isotonic.

Other common excipients included in vaccinations are preservatives. Preservatives help to prevent potential contamination and growth of microorganisms, specifically in multi-dose vials. With multi-dose vials, the same vial can supply multiple injections. This can potentially increase the risk for contamination so preservatives are included to ensure that if microorganisms are introduced, they are not viable. History has proven that without preservatives, contamination can be deadly. In South Carolina, 4 children died after receiving a typhoid vaccine contaminated with *S. aureus* in 1916, and in 1928 12 children died in Australia after receiving a diphtheria toxin-antitoxin mixture from a multi-dose vial (Ball, et al., 2001). Common preservatives include thimerosal, phenol, benzethonium chloride, and 2-phenoxyethanol.

The most controversial preservative is thimerosal. Thimerosal is a mercury-containing preservative. In an article published by Bernard, et al., it was hypothesized that autism presented very similar to mercury poisoning and that thimerosal included in vaccines was causing autism (Dórea, et al., 2013). Multiple well conducted studies have since proven that thimerosal is safe in the amounts used. Two forms of mercury exist that people are exposed to: methylmercury and ethylmercury. Thimerosal contains ethylmercury not methylmercury. The body metabolizes ethylmercury differently than it does methylmercury thus removing ethylmercury from the body sooner. Methylmercury is the dangerous form of mercury that people are exposed to. It can be attained through eating fish and other seafood. Ethylmercury has been shown to be less toxic then methylmercury due to the faster degradation of ethylmercury. In addition, numerous well-conducted studies have found that thimerosal does not cause autism. Thimerosal was removed from all childhood vaccines in the United States except for some forms of the influenza vaccines. Autism rates have still continued to rise even after thimerosal was removed as an ingredient.

Another common ingredient included in vaccinations are stabilizers. These are added to help ensure that vaccines remain unchanged. This is essential for the vaccine to remain effective. Vaccinations can be exposed to variable temperatures and pH changes that can cause hydrolysis and aggregation of vaccine components and result in the loss of effectiveness. Many vaccines are also freeze-dried and ingredients must be added to protect the active components during this process. Stabilizing ingredients include sugars, amino acids, salts, and proteins. We are exposed to all of these ingredients commonly and they all occur naturally in our bodies as well (Center for Biologics Evaluation and Research).

Adjuvants are commonly added to vaccinations to enhance our bodies' immune response to the vaccine. Aluminum hydroxide, aluminum phosphate, alum, or mixed aluminum salts are

common adjuvants in vaccines (Center for Biologics Evaluation and Research). Adjuvants are especially important in inactivated vaccines as they improve our immune response to help guarantee that we gain immunity against the disease for a longer time. Aluminum has been shown to be safe in the amounts used in vaccines with over six decades of use (Center for Biologics Evaluation and Research). Food and water are the most common exposures of aluminum.

Antibiotics are sometimes added to vaccines to prevent against bacterial contamination during the manufacturing process. Fortunately, antibiotics such as penicillins, cephalosporins, and sulfa drugs that are known to sometimes cause allergic reactions are not included. The antibiotics that are sometimes used include neomycin, polymyxin B, streptomycin, and gentamicin (Center for Biologics Evaluation and Research). The antibiotics are used early in the production process of vaccines so that they are present in minute amounts after the final purification steps.

Formaldehyde is used in vaccines to inactivate the viral or bacterial component so that they do not actually cause disease. The amount of formaldehyde left in the final vaccine product is extremely small and in some cases so minute that formaldehyde concentrations are found higher in the body naturally than in the actual vaccine (Center for Biologics Evaluation and Research). All cells produce formaldehyde naturally to help the body form amino acids. An article published by the FDA stated that formaldehyde levels in vaccines is less than or equal to 0.02% (Mitkus et al. 2013). The FDA study showed that even in infants, the small amount of formaldehyde in vaccines is removed from the injection site within 30 minutes and that peak concentrations of formaldehyde in the blood from vaccines was found to be <1% of the amount

of formaldehyde found in the body naturally (Mitkus et al., 2013). The amount of formaldehyde exposure in vaccinations is not a concern.

Chicken eggs are used to prepare influenza and yellow fever vaccines so egg protein can be found in these vaccines (Ingredients of Vaccines-Fact Sheet). Egg protein can occasionally cause a problem if a person is allergic to eggs. There is a formulation of the influenza vaccine that is made without egg protein that can be used for someone that has an allergy to eggs.

Vaccines contain many components that all serve an important purpose to keep the vaccine safe, effective, and potent. Many years and studies have shown that the components used in vaccines are safe in the amounts used.

References:

1) Ball L, Ball R, Pratt RD. An Assessment of Thimersol Use in Childhood Vaccines. *Pediatrics* 2001;107;1147-1154. DOI: 10.1542/peds.107.5.1147
2) Bernard S, Enayati A, Redwood L, Roger H, Binstock T. Autism: a novel form of mercury poisoning. *Medical Hypotheses* 2001;56(4);462-471.
3) Center for Biologics Evaluation and Research. "Vaccine Safety & Availability - Common Ingredients in U.S. Licensed Vaccines." *U S Food and Drug Administration Home Page*. Center for Biologics Evaluation and Research, n.d. Web. 26 Apr. 2017.
4) Dórea J G, Farina M and Rocha J B T. Toxicity of ethylmercury (and Thimerosal): a comparison with methylmercury. *J. Appl. Toxicol.*, 2013;33: 700–711. doi:10.1002/jat.2855
5) "Ingredients of Vaccines - Fact Sheet." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 22 Feb. 2011. Web. 26 Apr. 2017.
6) Mitkus R, Hess M, Schwartz S. Pharmacokinetic modeling as an approach to assessing the safety of residual formaldehyde in infant vaccines. *Elsevier.* 2013;31:2738-2743.

Misconception 4: Vaccines are 100% Effective

A common myth is that as soon as an immunization is received, that person is 100% immune to that disease forever. Vaccinations are not always perfect and they take awhile to build up the immune response in your body. Every year a new influenza vaccine is created leading to possible errors in the formulation for that year. Everyone has a unique immune system that can respond to immunizations differently, and unfortunately, some do not generate an adequate response to a vaccine.

Fortunately, vaccine effectiveness is extremely high. 97% of people vaccinated with two doses of measles, mumps, and rubella (MMR) are immune to measles and 88% of people are immune to mumps. The polio vaccine is 99% effective after receiving three doses. After one dose, 85% of individuals vaccinated with varicella are immune from varicella infections and 100% immune from moderate and severe chicken pox (Top 20 Questions about Vaccination), (Vaccines & Immunizations), (MMR Vaccination). Influenza vaccine effectiveness varies from year to year but is estimated to be between 50-60% when the vaccine viruses chosen match most of the circulating flu viruses (Vaccine Effectiveness).

The flu vaccine is the most variable vaccination for effectiveness. The effectiveness of the flu vaccine depends on who is being vaccinated and how well the similarity is between the flu vaccine and flu viruses circulating that season. Occasionally, the flu vaccine is not well matched to the flu viruses that are common that season. If the match is not accurate, the vaccine is not effective.

Vaccinations, specifically the flu vaccine, are most effective in healthy adults and older children. In some people with chronic illnesses and suppressed immune systems, their immune

system does not mount a sufficient immune response, so they are not immune against the disease when exposed in the future. For this reason, herd immunity is encouraged so that if the person's immune response was not adequate against the disease, they may still be protected. Herd immunity occurs when a large number of people are immune to a disease so that they do not spread the disease to others around them that may not have protection against that disease. Older adults sometimes have weaker immune systems that produce a lower immune response to a flu vaccination.

The CDC continually studies the benefits of seasonal flu vaccine. The U.S. Flu Vaccine Effectiveness (VE) Network consists of the CDC and researchers at universities and hospitals that have five study sites in the United States measuring flu vaccine's effectiveness by testing patients that present with flu symptoms for the flu using rRT-PCR (Influenza, CDC). These testing sites have been collecting data since the 2003-2004 flu season. Overall, the adjusted vaccine effectiveness for the flu varies from 10%-60% with the lowest effectiveness in 2004-2005 and the highest effectiveness in 2010-2011 (Influenza, CDC). In 2014-2015, the adjusted vaccine effectiveness for seasonal flu was at 19%, the lowest effectiveness since 2004-2005 (Influenza, CDC).

A misconception that many believe is that the flu vaccine causes one to get the flu. Unfortunately, the bodies' immune system requires time to fully activate the immune response against the influenza viruses from the vaccine, and in the time it takes for ones body to build up the immune response, one may have been exposed to the flu virus. All vaccinations take some time for the immune response to work. Generally, it takes about two weeks for one's immune system to build an adequate response to the vaccine (Frequently Asked Questions).

For some diseases, multiple vaccinations are required to build up the full immune response. For example, a tetanus and diphtheria shot is required every 10 years to ensure one's body still produces an adequate response to the disease if exposed. The varicella, HPV, MMR, pneumococcal, hepatitis A, and hepatitis B vaccines all require booster doses to maintain an active immune response (Adult Immunization Schedule).

Varicella vaccine is used to prevent chicken pox. One dose of the varicella vaccine is extremely effective with 85% efficacy at preventing any form of varicella and 100% effective against severe varicella (Vaccines and Immunizations). Two doses of varicella vaccine have been shown to be 88-98% effective at preventing any form of varicella (Vaccines and Immunizations). The exact length of duration for varicella immunity is unclear, but there is data that shows people vaccinated with varicella have immunity for 10-20 years and possibly longer (Vaccines and Immunizations).

Immunization schedules recommend two doses of the measles, mumps, and rubella (MMR) vaccine. According to the CDC, "two doses of MMR vaccine are 97% effective against measles and 88% effective against mumps. One dose of MMR vaccine is 93% effective against measles, 78% effective against mumps, and 97% effective against rubella" (MMR Vaccination). One dose of MMR vaccine is surprisingly effective, but two doses increase the efficacy and duration even more. Two doses of the MMR vaccine in children provide protection against measles, mumps, and rubella for life (MMR Vaccination). In the few cases where the MMR vaccine was not effective, the disease usually presents as a milder form of the illness and they are less infective thus decreasing spread to others.

The Tdap vaccine prevents against tetanus, diphtheria, and pertussis. Unfortunately, the Tdap vaccine is one of the shortest lasting. The Tdap vaccine is effective against pertussis for

about 7 out of 10 people in the first year, but decreases to only 3-4 out of 10 four years after receiving the Tdap vaccine (Effectiveness of Whooping Cough Vaccines). Vaccines immunizing against tetanus are almost 100% effective, but the duration only lasts for around 10 years (Tetanus). Vaccines protecting against diphtheria are about 95% effective, and the duration of efficacy only lasts for about 10 years thus requiring booster doses (Diphtheria).

Fortunately, most vaccines are extremely effective at preventing diseases, but there are rare cases where immunized individuals still present with a disease they were vaccinated against. Most cases where individuals obtain a disease they were vaccinated against are usually milder and less infectious. Some immunosuppressed people and older adults do not produce adequate immune responses to vaccines. Many vaccines require booster doses because their duration of efficacy is not lifelong. Although vaccines are not always 100% effective immediately, they do help protect against diseases becoming widespread.

References

1) "Adult Immunization Schedule." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 06 Feb. 2017. Web. 26 Apr. 2017.
2) "Diphtheria." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, n.d. Web. 26 Apr. 2017. <https://www.cdc.gov/vaccines/pubs/pinkbook/downloads/dip.pdf>.
3) "Effectiveness of Whooping Cough Vaccines." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 28 Sept. 2016. Web. 26 Apr. 2017.
4) "Frequently Asked Questions." *Immunise - Frequently Asked Questions*. Australian Government Department of Health, n.d. Web. 26 Apr. 2017.
5) "Influenza (Flu)." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 19 Apr. 2017. Web. 26 Apr. 2017.
6) "MMR Vaccination | What You Should Know | Measles, Mumps, Rubella | CDC." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 22 Nov. 2016. Web. 26 Apr. 2017.
7) "Tetanus." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, n.d. Web. 26 Apr. 2017. https://www.cdc.gov/vaccines/pubs/pinkbook/downloads/tetanus.pdf
8) "Top 20 Questions about Vaccination." *History of Vaccines*. The College of Physicians of Philadelphia, n.d. Web. 26 Apr. 2017.

9) "Vaccine Effectiveness - How Well Does the Flu Vaccine Work?" *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 15 Feb. 2017. Web. 26 Apr. 2017.

10) "Vaccines & Immunizations." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 30 Aug. 2012. Web. 26 Apr. 2017.

Misconception 5: Vaccine-Preventable Diseases are not that Dangerous

A common misconception is that diseases that vaccines prevent really are not that dangerous. It is understandable why some may believe this. Thanks to vaccinations, many diseases that used to be extremely common are no longer heard of. Many doctors today have never seen some of the diseases that are prevented by vaccines. Families have never had a family member that has been killed from vaccine-preventable diseases. Many have never seen first hand the harm that these diseases can cause. One disease, smallpox, has been completely eradicated from earth. We are close to eradicating many others, but we must continue to vaccinate or these unheard of diseases can easily make a come back and cause devastating effects.

Measles was such a commonplace disease that before vaccinating against it, nearly everyone got measles and it resulted in death for some. According to the CDC, "Before the measles vaccination program started in 1963, an estimated 3 to 4 million people got measles each year in the United States. Of these, approximately 500,000 cases were reported each year to the CDC; of these, 400-500 died, 48,000 were hospitalized, and 1,000 developed encephalitis…" (Measles Vaccination). It is difficult to imagine a time when measles was widespread and resulted in numerous deaths. Thanks to vaccination, measles cases are less than 99% of what they were before vaccination began. Few doctors have ever even seen a case of measles today.

Rubella killed 2,000 babies and caused 11,000 miscarriages in the United States in 1964-1965 (What Would Happen If We Stopped Vaccinations). Rubella affects pregnant women and developing babies the most seriously by commonly causing miscarriages or death soon after birth (Rubella, CDC). If the baby survives, there is a likely chance that they will be born with serious birth defects also known as congenital rubella syndrome including heart problems, loss of hearing and eyesight, intellectual disability, and liver or spleen damage (Rubella, CDC). Rubella

can result in complications including brain infections, bleeding problems, and arthritis in adults as well (Rubella, CDC). Fortunately, only 15 cases of rubella have been reported in the last 5 years due to vaccinating against rubella (What Would Happen If We Stopped Vaccinations).

In 1921, Diphtheria caused the death of more than 15,000 Americans (What Would Happen If We Stopped Vaccinations). Today, we have only had two reported cases in 10 years between 2004-2014 (What Would Happen If We Stopped Vaccinations). In addition to a fatality rate of around 5-10%, diphtheria can also cause myocarditis and neuritis (Diphtheria, CDC). These complications can lead to heart failure, paralysis, and even death. Diphtheria can also cause less severe side effects including otitis media and respiratory insufficiency (Diphtheria, CDC). Thanks to diphtheria vaccines, diphtheria is now a rare disease in the United States.

Tetanus, also known as lockjaw, is a serious disease. Complications of tetanus include laryngospasm, bone fractures, pulmonary embolism, pneumonia, and breathing difficulty (Symptoms and Complications). Tetanus results in death for 1-2 out of ten cases (Symptoms and Complications). Thanks to vaccination, tetanus cases are at historically low rates in the United States (Vaccines and Preventable Diseases).

Hepatitis rarely causes severe clinical manifestations, but the rare manifestations are extremely deadly. Hepatitis A can cause fulminant hepatitis with mortality rates up to 80% (Hepatitis A, CDC). According to the CDC, "In the prevaccine era, fulminant hepatitis A causes about 100 deaths per year in the United States" (Hepatitis A, CDC). Hepatitis B causes fulminant hepatitis in about 1-2% of infected patients resulting in the death of around 200-300 Americans every year (Hepatitis B, CDC). Although rare, the complications from hepatitis can be deadly.

If we do not continue to vaccinate against these deadly diseases, they can make a return. There have been reported cases of measles outbreaks around the country that have occurred in areas with especially low vaccination rates. In 2013, there were outbreaks of measles in New York City and Texas (What Would Happen If We Stopped Vaccinations). Luckily, many vaccine-preventable diseases are almost non-existent in the United States due to vaccination rates, but these diseases are still common in other countries around the world. One plane trip can introduce many diseases to people living in the United States. In 2011, 90% of measles cases in the United States were introduced from outbreaks in other countries (What Would Happen If We Stopped Vaccinations).

Vaccination rates keep diseases under control, but that does not mean vaccination should stop. In 1974 in Japan, around 80% of children received the pertussis vaccine and only 393 cases of pertussis were reported with no deaths. Soon after, immunization rates dropped so that only around 10% of children received the vaccine and in 1979, over 13,000 cases were reported resulting in 41 deaths (What Would Happen If We Stopped Vaccinations). Without vaccines, diseases can quickly spread. Diseases that are unheard of can reappear as soon as vaccination rates drop.

Impact of Vaccines in the 20th & 21st Centuries

Comparison of 20th Century Annual Morbidity & Current Morbidity

Disease	20th Century Annual Morbidity*	2010 Reported Cases†	% Decrease
Smallpox	29,005	0	100%
Diphtheria	21,053	0	100%
Pertussis	200,752	21,291	89%
Tetanus	580	8	99%
Polio (paralytic)	16,316	0	100%
Measles	530,217	61	>99%
Mumps	162,344	2,528	98%
Rubella	47,745	6	>99%
CRS	152	0	100%
Haemophilus influenzae (<5 years of age)	20,000 (est.)	270 (16 serotype b and 254 unknown serotype)	99%

Sources:

* *JAMA*. 2007;298(18):2155-2163

† CDC. *MMWR* January 7, 2011;59(52);1704-1716. (Provisional *MMWR* week 52 data)

Chart from the CDC

As seen in the chart above, the reported number of cases is nearly non-existent for many diseases that used to cause extreme rates of morbidity. We have had over a 99% decrease in morbidity for many diseases thanks to vaccinations. The complications from vaccine-preventable diseases are serious, with many resulting in death. Thanks to vaccines, there are many diseases that used to be common just a few generations ago that have never been seen by many people alive today.

References:

1) "Diphtheria." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, n.d. Web. 26 Apr. 2017. <https://www.cdc.gov/vaccines/pubs/pinkbook/downloads/dip.pdf>.
2) "Hepatitis A." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 15 May 2015. Web. 27 Apr. 2017.
3) "Hepatitis B." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 16 Mar. 2017. Web. 27 Apr. 2017.
4) "Measles Vaccination." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 22 Nov. 2016. Web. 27 Apr. 2017.
5) "Rubella (German Measles, Three-Day Measles)." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 31 Mar. 2016. Web. 27 Apr. 2017.
6) "Symptoms and Complications." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 10 Jan. 2017. Web. 27 Apr. 2017.
7) "Vaccines and Preventable Diseases." *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 22 Nov. 2016. Web. 27 Apr. 2017.
8) "What Would Happen If We Stopped Vaccinations?" *Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 10 Mar. 2017. Web. 27 Apr. 2017.

Misconception 6: Infant immune systems cannot handle multiple vaccines at once

When babies are first born, they have antibodies from their mother that protect them from some diseases, but these antibodies last only a few weeks. Even though some antibodies are passed from mother to baby, most babies do not get antibodies against many major diseases including diphtheria, whooping cough, polio, tetanus, hepatitis B, or *Haemophilus influenza* type b from their mothers. Since these diseases can lead to major health problems, and even death, it is important for infants to receive vaccinations for these diseases. Children are normally given multiple vaccines in the same doctors' visit to get children covered by the vaccines as quickly as possible to protect them, as well as to reduce the number of doctors' visits needed saving time, money, and traumatization to the child. (Vaccine Safety: Multiple Vaccines and the Immune System)

A common belief is that giving multiple vaccines at the same time can overwhelm an infant's or child's immune system, and increase the risk of harmful side effects. This concern for parents has grown as we have developed more and more vaccines to give children, especially with some of the vaccines being given as a single injection. If vaccines are given at the same time they must be studied together to ensure that they are equally effective given together, as they are given separately. Scientific data has also shown that getting several vaccines at the same time does not cause any chronic health problems. While this is the case it does not mean that giving multiple vaccines at once does not come without some concerns. Vaccines given together can sometimes cause fevers, and if the fevers get high enough they can lead to febrile seizures. However, these are temporary and do not normally cause any lasting damage to the child. (Vaccine Safety: Multiple Vaccines and the Immune System)

Since there has not been shown to be any lasting damage from administering multiple vaccines at one time, it is recommended both by the Advisory Committee on Immunization Practices and the American Academy of Pediatrics to get all routine childhood vaccines on the recommended schedule. Also, when considering the number of antigens a child is exposed to daily from normal activities, the burden of antigens from vaccines is not significant. Per the CDC's website, "From the moment babies are born, they are exposed to numerous bacteria and viruses on a daily basis. Eating food introduces new bacteria into the body; numerous bacteria live in the mouth and nose; and an infant places his or her hands or other objects in his or her mouth hundreds of times every hour, exposing the immune system to still more germs. When a child has a cold, he or she is exposed to up to 10 antigens, and exposure to 'strep throat' is about 25 to 50 antigens. Each vaccine in the childhood vaccination schedule has between 1-69 antigens. A child who receives all the recommended vaccines in the 2014 childhood immunization schedule may be exposed to up to 315 antigens through vaccination by the age of 2" (Vaccine saftey). Meaning that there is not a concern for a child's immune system being exposed to these antigens in vaccinations, since overall there is no significant increased antigen burden than what is seen through everyday life.

When looking at the concerns parents have about giving multiple vaccines at the same time and the effect these could have on the child it is important to look at the benefits of combination vaccines, and how they become approved for use. Looking at the article *Immune overload: Parental attitudes toward combination and single antigen vaccines* it states, "Combination vaccines contain the antigens of multiple diseases and are used in place of single antigen vaccines to decrease the number of injections a child must receive. Other benefits of combination vaccines include less paperwork, less time spent in the healthcare facility, fewer

office visits, higher coverage rates, reduced vaccine administration costs for the family, and increased safety for both the child receiving the injection and the nurse administering it. They also decrease the risk for medical errors and errors in recordkeeping, and save money because the healthcare practice does not need to stock as many vials. However, combination vaccines pose unique challenges as well, mainly in the areas of research and development. Pharmaceutical companies must ensure that each component vaccine is compatible and will not decrease the effectiveness of the others, and costly drug trials must be performed even if the component vaccines have already been proven safe and effective. Before being licensed it must be shown that a new combination vaccine does not increase the risk of adverse effects above that of the component vaccines" (Hulsey 2015). Since these vaccines must be shown not to cause additional side effects when given together than the components do on their own, it shows that parents concern about giving multiple vaccines at the same time is unfounded. It also shows that there are many benefits to giving multiple vaccines at the same time, with little to no risk involved in doing so.

In the article, *Immune overload: Parental attitudes toward combination and single antigen vaccines,* it discusses different parental concerns about multiple vaccines including overwhelming the immune system, and fear of more side effects coming from the administration of multiple vaccines at once. In the section addressing immune system overload the article states, "With the constantly increasing number of immunizations, parents perceive that the number of antigens is increasing as well. However, thanks to the swapping of the whole cell pertussis vaccine for acellular pertussis, the opposite is actually true" (Hulsey 2015). With the movement of vaccines being composed of inactivated or dead cells, the number of antigens children are being exposed to is decreasing, or at least staying the same, even though they are being protected

against more diseases. In the section discussing concerns about side effects this article discusses how many concerns stem from the media reporting partial truths or concerns that have not been validated. Since the multiple vaccines had to be proven not to cause more side effects before being approved for use, this concern is created by the media.

While there is a lot of concern from parents about giving multiple vaccines at the same time, studies do not back up these concerns. Receiving vaccines on schedule protects children from diseases that can be very serious, and even deadly, while there are no increased risks from the vaccines themselves. From this research, it should be recommended to parents to get their children vaccinated, and to get them vaccinated according to the schedule recommended by the CDC. Doing so could save lives.

References:

1) Hulsey, Ella, and Tami Bland. "Immune overload: Parental attitudes toward combination and single antigen vaccines." ScienceDirect. Elsevier Journal, 17 Apr. 2015. Web. 26 Mar. 2017.
2) "Vaccine Safety: Multiple Vaccines and the Immune System." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, 07 Oct. 2016. Web. 26 Mar. 2017.

Misconception 7: Better hygiene is responsible for decreased infections, not vaccines

When thinking about diphtheria, tetanus, pertussis, measles, and all the other diseases that we vaccinate for, we commonly associate them with the past. Mainly because it was in the past that they were so deadly and common. We also think about the past as not having good hygiene or sanitation practices. Putting these two things together, it is believed by some that the decreased infection rates of these diseases is due to improved sanitation and hygiene, not the vaccinations. While improved sanitation, nutrition, and the development of antibiotics helped decrease infections, there is also evidence that vaccines played a major role (Six common misconceptions about immunizations).

One example that we can look at to see the role vaccines has played is measles. According to the CDC, "before the measles vaccination program started in 1963, an estimated 3 to 4 million people got measles each year in the United States. Of these, approximately 500,000 cases were reported each year to CDC; of these, 400 to 500 died, 48,000 were hospitalized, and 1,000 developed encephalitis (brain swelling) from measles. Since then, widespread use of measles vaccine has led to a greater than 99% reduction in measles cases compared with the pre-vaccine era" (Measles Vaccination). From this it is clear that measles used to be a devastating disease, and that vaccines led to a huge drop in its infection rate. In addition to the information from the CDC, we can see from the graph below that the prevalence of measles was high. As time progresses we can see that the rates of infections were dropping as time passed, indicating that improved hygiene and sanitation as well as other factors were helping to decrease infections. However, we can see that once the vaccine was implemented, the rates of the disease dropped rapidly until the number of cases reached almost zero. The drop in infections rates were more

gradual with time improving hygiene, compared with the radical drop when vaccines were started.

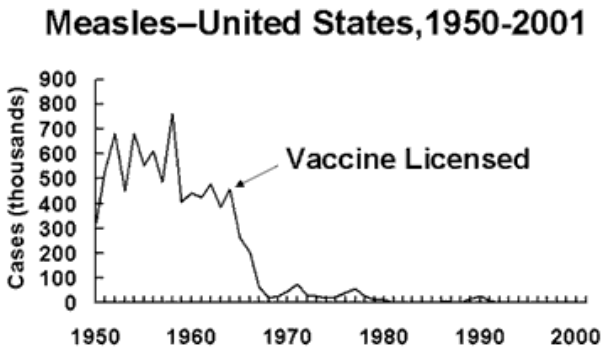

Image From: https://sciencebasedmedicine.org/vaccines-didnt-save-us-intellectual-dishonesty-at-its-most-naked/

Looking at more recent incidences of measles in the United States reported by the CDC there is a correlation of disease rates going up in unvaccinated individuals. In 2000 measles elimination was document in the United States, but as the antivaccination movement grew, measles started making a reappearance, especially in areas that had high levels of unvaccinated individuals. "In 2014, the United States experienced a record number of measles cases, with 667 cases from 27 states reported to the CDC's National Center for Immunization and Respiratory Diseases" (Measles Cases and Outbreaks). This was the highest number of cases reported since 2000. Even though measles was reported as eliminated in the United States, it was and still is prevalent in other parts of the world including some countries in Europe, Asia, the Pacific, and Africa. When people travel to these areas, they bring the disease back into the United States, and people who are unvaccinated are at risk for contracting the disease (Measles Cases and Outbreaks). The measles outbreak linked to Disney theme parks was the most publicly known reemergence of measles in the United States from December 2014-February 2015 (Zipprich). Measles, a disease once eliminated in the United States, reemerged as the rates of unvaccinated individuals increased, even though hygiene and sanitation are the best they have ever been.

Another example that we can look at to see the effects of vaccines compared to hygiene and sanitation is *Haemophilus influenza* type b (Hib). According to the National Vaccine Information Center, "for infants and children under age 6, the most common types of invasive disease caused by Hib are meningitis, epiglottitis, pneumonia, arthritis, and cellulitis. Meningitis is an infection of the membranes covering the brain and spinal cord, and Hib was responsible for 50 to 65 percent of meningitis cases before the vaccine was introduced in the mid-1980s" (What is Haemophilus influenza type B). From the chart seen below we can see that the introduction of the Hib vaccine significantly dropped the rates of infections, even though it was introduced after good hygiene and sanitation practices were well established.

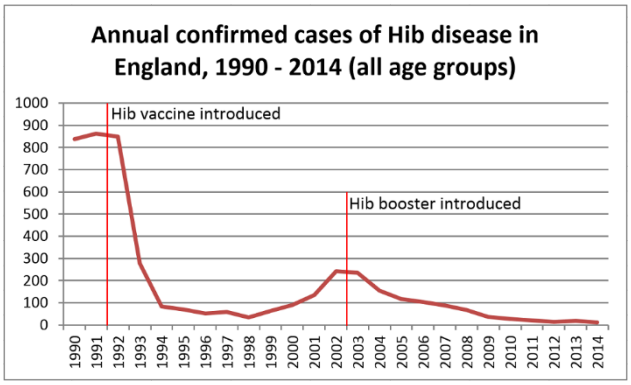

Image From: http://vk.ovg.ox.ac.uk/sites/default/files/u77/Hib%20disease%201990-2014.png

There is no doubt that improved nutrition, hygiene, sanitation, antibiotic development, and many other factors of living in a developed nation helped to lower rates of infection. However, these factors were only able to lower the infection rates of these diseases by slow and small amounts. When vaccines for these diseases were introduced they were able to drop the rates of infection to almost nothing, and in the case of measles, the vaccine was able to eliminate the disease in the United States at one point. The importance of vaccines and the difference they made from hygiene and sanitation can be seen from the resurgence of measles that happened when the rates of unvaccinated individuals increased.

References:

1) "Measles Cases and Outbreaks." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, 06 Mar. 2017. Web. 02 Apr. 2017.

2) "Measles Vaccination." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, 22 Nov. 2016. Web. 02 Apr. 2017.

3) "Six common misconceptions about immunization." World Health Organization. World Health Organization, n.d. Web. 02 Apr. 2017.

4) "What is Haemophilus Influenza Type B (Hib)?" National Vaccine Information Center. National Vaccine Information Center, n.d. Web. 02 Apr. 2017.

5) Zipprich, Jennifer, Kathleen Winter, Jill Hacker, Dongxiang Xia, James Watt, and Kathleen Harriman. "Measles Outbreak — California, December 2014–February 2015." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, 20 Feb. 2015. Web. 02 Apr. 2017.

Misconception 8: Vaccines aren't worth the risk

Many parents are choosing not to get their children vaccinated because they are worried about the risks associated with vaccinations. With all the stories going around about the potential risks, it is understandable that some parents would be concerned. Concern is especially understandable if they are not hearing the other side of the story, the studies showing what the true risks are, and what risks are just propagated fear and stories. Many of these stories come from a single, or just a handful, of case events that are exaggerated as it gets passed from person to person and especially when the media gets involved.

The basis for most of these stories come from the side effects that can be seen with any vaccine. Specific side effects vary between vaccines. We can examine the risks of vaccines by looking at an example of a common vaccine, DTaP, which vaccinates against diphtheria, tetanus, and pertussis. The side effects we can see with this vaccine vary from mild reactions to some that can be severe, if not life threatening. According to the CDC some of the mild reactions that are seen include fever, redness or swelling where the shot was given, and soreness or tenderness where the shot was given. "These problems occur more often after the 4^{th} and 5^{th} doses of the DTaP series than after earlier doses. Sometimes the 4^{th} or 5^{th} dose of the DTaP vaccine is followed by swelling of the entire arm or leg in which the shot was given, lasting 1-7 days" (Possible Side-effects from Vaccines). Some other mild reactions that can be seen 1-3 days after the shot include fussiness in children, tiredness or poor appetite, and vomiting.

While these mild risks can happen, they are not what lead parents to be afraid to get their children vaccinated and deciding against it. It is when we start looking at the moderate and severe reactions that can be seen with vaccines that we start to understand some of the fears. Even though these reactions are uncommon, when they do occur it can be serious and very

concerning. Some of the moderate problems that can be seen with the DTaP are seizures, non-stop crying for 3 hours or more in children, and high fevers about 105ºF. Some of the very rare severe reactions are serious allergic reactions, long-term seizures, coma, lowered consciousness, and permanent brain damage. However, these severe reactions occur so rarely it is hard to tell if they are even caused by the vaccines when they do happen. When seizures do occur, they are normally caused by high fevers, so it is imperative to control fevers in children, especially if they have a history of seizures (Possible Side-effects from Vaccines). It is easy to understand how hearing about these potential reactions can scare parents, especially if they hear about them without any connection to the rates of the occurrences. It is therefore important to educate parents on the risks that are associated with vaccines along with the information about how often they occur, and the risks involved if they choose not to vaccinate.

The risks associated with not getting children vaccinated is that they will contract the diseases that they are not vaccinated against, and potentially expose others that cannot be vaccinated to these deadly diseases. Two main groups of people that are at risk of contracting these diseases are infants that are too young to have been vaccinated, and those that have weaker immune systems like cancer or transplant patients. When choosing not to vaccinate their children, parents are risking not only their child's life but these other lives as well. If a parent chooses not to vaccinate their children it is important to educate them about the importance of notifying doctors of their vaccination status. Doctors need to know if they need to consider vaccine preventable diseases in their diagnosis if a child has not been vaccinated, when they would normally rule these diseases out. It is also important so that they can isolate the child if they have the disease to prevent its spread, or if there is a known case of the disease in the same

facility so they can do everything they can to prevent the child from contracting the illness (If You Choose Not to Vaccinate Your Child).

Children that are not vaccinated are at risk of contracting the vaccine preventable diseases, and therefore, the risks of the diseases need to be looked at. While it is not common for children to contract these diseases since we have been vaccinating against them for many years, it is still possible since in other areas of the world these diseases are still prevalent. If a child contracts a vaccine preventable disease, in most cases, there is no way to know beforehand if it will be a mild or serious case (If You Choose Not to Vaccinate Your Child). Therefore, it is important if choosing not to vaccinate that parents know the early signs and symptoms of vaccine preventable diseases, so that if their children do contract these diseases it can be recognized and treated early to prevent serious complications.

There are also other responsibilities that these parents will have if they choose not to vaccinate their children to protect the rest of their community. It is important to inform the child's school of their vaccination status so that if there is a reported case the proper steps can be taken to protect all parties. Parents also need to know that if their child has one of these diseases they need to take steps to protect those individuals that cannot receive the vaccination from getting the disease as well. To do this, if their child has one of these diseases, "To prevent transmission to others, he or she should not travel by plane, train, or bus until a doctor determines the person is no longer contagious" (If You Choose Not to Vaccinate Your Child). Parents should also avoid, if possible, taking their children to busy public places where the chances increase of spreading the disease. These are also ways that children who are not vaccinated can get the disease, so parents should be vigilant to watch for any symptoms after

traveling or taking their children to crowded public places, an example of this would be any amusement parks.

References:

1) "If You Choose Not to Vaccinate Your Child, Understand the Risk and Responsibilities." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, 03 Aug. 2016. Web. 09 Apr. 2017.

2) "Possible Side-effects from Vaccines." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, 10 Mar. 2017. Web. 08 Apr. 2017.

Misconception 9: Vaccines can infect the child with the disease it's trying to prevent

A common misconception that parents, and the public in general, have about vaccines is the thought that the vaccine can cause the disease that it is trying to protect against. This belief normally stems from people mistaking common mild reaction symptoms from the vaccine as symptoms of infection. There has only been one recorded instance in which a vaccine was shown to cause disease, and this was with the oral polio vaccine that is no longer used in the United States (Vaccine Myths Debunked).

Since this vaccine has been reported to have caused the disease for which it was meant to prevent, it is worth looking at closer. The oral polio vaccine is an attenuated (weakened) vaccine-virus. This means that the virus in the vaccine was live and just weakened so that when a child was administered the vaccine they would mount an immune response to the virus. A major benefit of this vaccine is that while the vaccinated individual is mounting an immune response to the virus, it is also being excreted. This excreted vaccine-virus can then spread to others in the community and can offer protection to others through what is called 'passive' immunization, before it eventually dies out. Being able to pass on this immunity is seen as a huge benefit in countries that are still developing, since multiple people could potentially gain protection from the direct vaccination of one person (What is vaccine-derived polio).

"On rare occasions, if a population is seriously under-immunized, and excreted vaccine-virus can continue to circulate for an extended period of time. The longer it is allowed to survive, the more genetic changes it undergoes. In very rare instances, the vaccine-virus can genetically change into a form that can paralyze- this is what is known as a circulation vaccine-derived poliovirus" (What is vaccine-derived polio). From this we can see that it takes a community of unvaccinated people to allow polio caused by the vaccine to happen. If, as a whole, the

community has high vaccination rates, the virus cannot live long enough to develop into a strain that can cause the disease. “Generally, the strain will have been allowed to circulate in an un- or under-immunized population for a period of at least 12 months” (What is vaccine-derived polio).

Overall, this vaccine can be used safely if the rates of vaccination are high, and if this is not the case, there are other options for vaccination against polio. “Since 2000, more than 10 billion doses of oral polio vaccine have been administered to nearly 3 billion children worldwide. As a result, more than 13 million cases of polio have been prevented, and the disease has been reduced by more than 99%. During that time, 24 circulating vaccine-derived poliovirus outbreaks occurred in 21 countries, resulting in fewer than 760 vaccine-derived poliovirus cases” (what is vaccine-derived polio). So, while we can see there is a small risk of developing a form of polio when the oral polio vaccine is used, it is a very small risk. The oral polio vaccine is no longer used in the United States. Now in the United States, “a person is considered to be fully immunized if he or she has received a primary series of at least three doses of inactivated poliovirus vaccine” (Polio Vaccination). With the use of an inactivated virus instead of just a weakened one it takes away the risk of developing vaccine-derived poliovirus.

Looking past this one vaccine that has been reported to, in rare cases, cause the disease it is supposed to be preventing, it is important to look at what people are mistaking as signs of infections. One common example where people believe to have gotten the disease a vaccine is supposed to be protecting against is the seasonal flu shot. “The flu shot can cause mild side effects that are sometimes mistaken for flu. For example, people sometimes experience a sore arm where the shot was given. The needle stick may also cause some soreness at the injection site. Rarely, people who get the flu shot have fever, muscle pain, and feelings of discomfort or weakness. If experienced at all, these effects usually last 1-2 days after vaccination and are much

less severe than actual flu illness" (Seasonal Flu Shot). One of the main reasons that people believe that vaccines have made them ill is because the side effects of the vaccine mimic the signs of infection, just to a much milder degree.

The purpose of vaccines is to allow the body to mount an immune response to the diseases they are trying to protect against. We are basically tricking the body into thinking it is sick so it will make the antibodies necessary to fight off the real disease. It is therefore not surprising that the side effects of vaccines resemble that of infection, since we are making the body think it is infected. While health professionals know this about vaccines, it is important to educate our patients about this so they do not jump to the conclusion that the vaccine made them sick. Telling patients that this is how vaccines work, and telling them what symptoms to expect in the couple days following their vaccine, will help prevent them from having the fear that either themselves or their children will get the disease from the vaccine. It will also help prevent the spreading of word of mouth fears that stop parents from vaccinating their children, which can potentially lead to children contracting life threatening diseases and spreading them.

It is easy to understand how individuals and parents can believe that vaccine reactions are instead signs of infections that are caused by contracting the disease they are trying to prevent. These beliefs can be prevented through proper education about what vaccine reactions are, and how vaccines work. While there is one vaccine, the oral polio vaccine, that has been reported to cause a form of the disease, this is rare and this vaccine is no longer used in the United States. The risks that are associated with contracting the diseases themselves far outweigh the risks of the vaccine and the potential reaction symptoms that can be caused by them.

References:

1) "Polio Vaccination: What Everyone Should Know." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, 19 Aug. 2016. Web. 15 Apr. 2017.

2) "Seasonal Flu Shot." Centers for Disease Control and Prevention. Centers for Disease Control and Prevention, 25 Aug. 2016. Web. 15 Apr. 2017.

3) "Vaccine Myths Debunked." PublicHealth.org. Public Health, 27 May 2016. Web. 14 Apr. 2017.

4)"What is vaccine-derived polio?" World Health Organization. World Health Organization, 01 Oct. 2015. Web. 15 Apr. 2017.

Misconception 10: We do not need to vaccinate because infection rates are already so low

Many parents choose not to vaccinate their children because they believe that the diseases we vaccinate against have already been eliminated in the United States, or that infection rates of the diseases are already so low that there is not a risk. The reason that infection rates of these diseases are so low is due to what is known as herd immunity. Herd immunity is, "when a critical portion of a community is immunized against a contagious disease, most members of the community are protected against that disease because there is little opportunity for an outbreak. Even those who are not eligible for certain vaccines-such as infants, pregnant women, or immunocompromised individuals-get some protection because the spread of contagious disease is contained" (U.S. Department of Health and Human Services). It is only because we keep our rates of immunization high that we keep herd immunity, and protect those that cannot receive immunizations.

If parents stop vaccinating their children because they believe the rates of disease are low enough, we will lose herd immunity and the rates of infection will spike as the disease is allowed to spread. Even though the current rates of infection for diseases that we immunize against are low in the United States, this is not the case in other countries around the world. If individuals are not immunized and travel internationally they can contract these illnesses and then bring them back to the United States where they can pass them to other unimmunized individuals. It is important to keep our herd immunity since there are many individuals that cannot receive immunizations that count on those around them being immunized so they do not contract these diseases. One of the biggest populations that depend on herd immunity is children. "Vaccines are one of the great pillars of modern medicine. Life used to be especially brutal for children before vaccines, with huge portions being felled by diseases like measles, smallpox, whooping cough,

or rubella, to name just a few. Today these ailments can be completely prevented with a simple injection. So as science continues to advance and tackle new challenges, people should not forget how many deaths and illnesses vaccines have prevented, and how they continue to protect us from potentially devastating forms of infectious disease" (Vaccine Myths Debunked).

Throughout history we have seen outbreaks of preventable diseases happen due to the number of unimmunized people reaching a level where the diseases can take root in the community. When this happens children and other individuals suffer unnecessarily, and even die, from contracting these diseases. One example that we can look at where herd immunity failed is a break out of pertussis, also known as whooping cough, in 2010. "Whooping cough is a highly contagious bacterial disease that can be spread by coughing. People with pertussis have severe coughing attacks that can last for months. Infants too young for vaccination area at greatest risk for life-threatening cases of pertussis. Over 9,000 cases of pertussis were reported in California during 2010, the most in over 60 years, including 10 infant deaths" (Pertussis (Whooping Cough)). This outbreak prompted a new law in California requiring all students entering grades 7 through 12 to provide proof that they received a vaccine for whooping cough. "Public health experts call this problem a breakdown in 'herd immunity,' and they say it's happening more often nationwide as states make it easier for parents to opt out of the vaccinations that are usually required to enroll in school" (Mascarelli). Laws requiring students to be immunized before going to school are needed to maintain herd immunity and keep schools safe, instead of them being a place to potentially catch or spread a life-threatening disease.

While it is our goal to achieve, and maintain, herd immunity to protect those that cannot get immunizations, it is important to realize that we are not going to be able to eradicate these diseases completely since they are still prevalent in other countries and international travel is

popular. All we can strive for is to keep the rates of these diseases as low as possible, and try to prevent complications and fatalities when patients do contract these diseases. As can be seen from the table below, looking at measles rates, there are good years and bad years. However, even in the good years when rates are low, they still are not at zero. We try to get the rates of outbreaks as low as possible to prevent spread, and reduce the damage these diseases can do. Looking at the table below, we can also see the dangers of allowing immunization rates to drop. When parents choose not to immunize their children we see spikes of infection rates, which also signify a breakdown of herd immunity.

Number of Measles Cases by Year Since 2010

Year	Cases
2010	63
2011	220
2012	55
2013	187
2014	667
2015	188
2016*	70
2017**	28

*Cases as of December 31, 2016. Case count is preliminary and subject to change.

**Cases as of March 25, 2017. Case count is preliminary and subject to change.

Table from: https://www.cdc.gov/measles/cases-outbreaks.html

The reason that infection rates are low in the United States is due to high immunization rates that establish herd immunity. If parents believe that immunizations are no longer necessary due to decreased infection rates, and then choose to not immunize their children, the infection rates will spike. Then there is a push to immunize again and media coverage over outbreaks which lead to infection rates being low again. Once infection rates are down parents again believe that immunizations are not necessary, and the cycle continues. To break the cycle, we need to educate parents about herd immunity and how it works so that we can maintain the needed immunization levels to protect as many people as possible from these diseases.

References:

1) Mascarelli, Amanda. "Doctors see chinks in vaccination armor." Los Angeles Times. Los Angeles Times, 05 Aug. 2011. Web. 15 Apr. 2017.

2) "Pertussis (Whooping Cough)." California Department of Public Health. California Department of Public Health, n.d. Web. 15 Apr. 2017.

3) U.S. Department of Health and Human Services. "Community Immunity ("Herd Immunity")." Vaccines.gov. U.S. Department of Health and Human Services, 11 Oct. 2006. Web. 15 Apr. 2017.

4) "Vaccine Myths Debunked." PublicHealth.org. Public Health, 27 May 2016. Web. 15 Apr. 2017.