

Expert Commentary Series

Ignoring Context and a Lack of Common Sense: Antivaccinationists Absurdly Misusing Dr. Paul Offit’s “each infant would have the theoretical capacity to respond to about 10,000 vaccines at any one time”

**By Joel A. Harrison, PhD, MPH
March 18, 2016**

A recurrent concern among parents is that the mounting number of vaccines now administered to babies is a major challenge to the infantile immune system. Leading advocate of childhood immunizations, Dr. Paul Offit, has sought on numerous occasions to reassure parents by emphasizing how robust and effective babies’ immune systems are at responding to the daily threats from the enormous number of bacteria and viruses they are exposed to. He has illustrated this by showing how - in theory - a baby's immune system could cope with the number of epitopes (parts of a microbe recognized by our immune system) represented by 10,000 vaccines at one time. While 10,000 seems like a lot, as Dr. Offit explains, even this number is small compared to the capacity of our immune system and, yet, it is exponentially greater than the epitopes represented by all the vaccines given to children.

Well-organized, well-funded groups have sprung up trying to persuade parents of the alleged dangers of vaccines. Their arguments are mistaken, confused, lack scientific rationale and logical cohesion. There is one claim, based on one statement/sentence made by Dr. Paul Offit, repeated umpteen times all over the blogosphere, that I think encapsulates their flawed thinking. This claim takes one sentence out of context, ignoring the entire lead in to it. However, even without the context, antivaccinationist’s use of it contradicts common sense. Rather than doing their homework, they amplify each other in a near hermetically sealed self-reinforcing closed circle.

I believe that there is not a single book or paper that I couldn’t find one or two sentences that I could take out of context in order to prove any point I wish to. The purpose of this paper is to once again explain how our immune systems work, how vaccinations fit in the picture, and to show just how flawed antivaccinationist thinking is.

Note that many of the longer quotes are double-indented. Also, I bold and italicize key phrases within the quotes.

A Sampling from the Blogosphere

One website, Vactruth, gives the heading, “10,000 Crazy Vaccines!” and goes on to write:

There was a storm of amazement and disbelief when Dr. Paul Offit, vaccine industry insider and perhaps the most widely stated defender of vaccine safety, made the outrageous statement that each infant would have the theoretical capacity to respond to about 10,000 vaccines at any one time. . . The statement is not supported by facts. It is based on a purely theoretical calculation with no relation to reality and it should have been dismissed as having no practical application. . . On asking epidemiologist Tetyana Obukhanych Ph.D, about the capacity of the immune system I gathered the following information, in a nutshell: The immune system has a theoretical capacity to respond to an unlimited number of antigens, but not all at the same time.

So here is my polite message sent to Dr. Offit. It concludes with,

*“I am asking that you consider making a public statement to clarify and to emphasize that the statement in the study “each infant would have the theoretical capacity to respond to about 10 000 vaccines at any one time” is based on a purely theoretical immunological calculation in a study, that it does not imply the toxicological aspect of a large number of vaccines administered concomitantly and that **it should not be quoted out of context.** [my emphasis]” [Dr. Offit’s article is listed in the references]*

The National Vaccine Information Center (NVIC) (accessed 2016) writes:

“Q: Is it true that a baby's immune system at birth can handle 10,000 vaccines at a time?

A: This statement has not been backed up by scientific studies. To our knowledge, there is no scientific evidence that a baby's immune system is fully developed at birth and/or can safely handle any particular number of vaccines, let alone 10,000 vaccines at once. . . When statements are made that **contradict common sense** [my emphasis], such as the idea that a small

infant can handle 10,000 vaccines at once, it is important to check out the potential ideological biases and conflicts of interest associated with individuals making such statements.”

Note that despite NVIC’s pretentious title, they are not in any way affiliated with the government and their headquarters is a small private office located in Virginia.

Sharyl Attkisson (2008) writes: “Then there's Paul Offit, perhaps the most widely-quoted defender of vaccine safety. He's gone so far as to say babies can tolerate ‘10,000 vaccines at once.’”

Suzanne Humphries (2012) writes: “You may also recognize Dr. Offit as the one who says that all vaccines are perfectly safe and infants can tolerate theoretically 10,000 of them at once.” [Dr. Offit’s article is listed in the references.]

And John Stone (2010) writes in a paper entitled, “Paul Offit’s 10,000 Vaccines and the Milgram Experiment”:

Offit gives us to understand that even if our children were to receive 10,000 vaccines in one go it would still be safe: therefore, there can be no issue over 5 or 10 in one go, or dozens over the course of a childhood . . . But it is interesting to note that Offit provides a theoretical proposition which does not even depend upon the product: never mind how many there are (and how different they are) they are all safe and perfectly manufactured – it is as if they do not even have to be tested. Indeed, however dramatic the adverse effect they know in advance it wasn’t the vaccine.

Arguing with authority in the middle of the past decade in the UK it was alarming how frequently the fall-back position was Offit’s vacuous claim. Even the UK’s vaccine supremo Prof David Salisbury could appear on television declaring it was safe to give an infant 1000 vaccines. Meanwhile, he admitted to me:

"Turning to my comments on Newsnight - I suggest you read Paul Offit's paper - as I have done. On page 126, he states: "Current data suggest that the theoretical capacity determined by diversity of antibody variable gene regions would allow for as many as 10^9 (1,000,000,000) to 10^{10} (100,000,000,000) different antibody specificities". And "... then each infant would have the theoretical capacity to respond to about 10,000

vaccines at any one time" - not antigens. I was speaking very specifically about the infant immune system's ability to respond [my emphasis], in the context of the ridiculous suggestion that the new vaccine combination, containing far fewer antigens than the one it will replace, would overload the immune system. My words were "The immune system of a baby has got huge spare capacity to deal with challenge [my emphasis]. If we didn't, the human race wouldn't survive. But let's look specifically at vaccine. This has been studied carefully. A baby's immune system could actually tolerate perfectly well 1,000 vaccines" [my emphasis]." (Email August 26, 2004 10:03 am)

In an exchange of comments to another of his articles, Stone (2016) writes:

Our British health officials cite Offit but actually Offit cites a 1990 paper by Cohn and Langman - I can't download the Cohn and Langman paper so the context of that and how Offit adapted it for his purposes is unclear. ***It does not look like a paper on vaccination at all*** [my emphasis]. However, in the interview linked to by Angus below we see Offit breezily telling an audience in 2008 that an infant could happily withstand 100,000 vaccines a day (yes, every day). ***I see very little alternative to the view that that is exactly what he meant, crazy though the proposition is*** [my emphasis]. Maybe he should have spoken more carefully if he did not want to be misunderstood. (Posted by: John Stone | January 06, 2016 at 04:48 AM)

In another comment, Stone (2016) writes:

I wasn't going to post you again making the same assertion that you understand things and we don't but should there be any doubt about what Dr. Offit has said about this matter here he is in a CHOP pamphlet saying just what he said about "one" being able to take 100,000 vaccines every day only about babies specifically:

"But it should be the least of your worries. ***Children have an enormous capacity to respond safely to challenges to the immune system from vaccines*** [my emphasis]," says Dr. Offit. 'A baby's body is bombarded with immunologic challenges - from bacteria in food to the dust they breathe. Compared to what they typically encounter and manage during the day, vaccines are literally a drop in the ocean.' In fact, Dr. Offit's studies show that in theory, healthy infants could safely get up to 100,000 vaccines at once."

Admittedly there seems to be an obsession with the decimal system, and ***I am prepared to go with 10,000 if that is his final decision.*** [my emphasis] (Posted by: John Stone | January 07, 2016 at 11:14 AM)

And one additional comment from Stone (2016): “A simple criticism both of the video and his comments in the CHOP pamphlet is that being injected with toxic substances in order to provoke an immune reaction is not remotely like casual environment exposure over the course of 24 hours. It should be obvious that two thing [sic] are not remotely comparable. (Posted by: John Stone | January 07, 2016 at 12:38 PM)

Dr. Offit’s Quotes in Context

Note that I intentionally give below extensive extracts so that the reader can see just how clear the context and meaning was within which Dr. Offit’s single sentence occurred. I encourage the reader to read the entire article and/or listen to his talk on YouTube (see references with URLs below).

In a 2002 article in the journal *Pediatrics*, Dr. Paul Offit discussed how our immune systems work:

Beginning with the birth process, the newborn is exposed to microbes from the mother’s cervix and birth canal, then the surrounding environment. Within a matter of hours, the gastrointestinal tract of the newborn, initially relatively free of microbes, is heavily colonized with bacteria. The most common of these colonizing bacteria include facultative anaerobic bacteria, such as *Escherichia coli* and streptococci, and strict anaerobic bacteria, such as *Bacteroides* and *Clostridium*.

Although infants can generate all functional T-cells (ie, Th1, Th2, and cytotoxic T-cells), infant B-cell responses are deficient when compared with older children and adults. Infants respond well to antigens (such as proteins) that require T-cell help for development. However, until about 2 years of age, the B-cell response to T-cell-independent antigens (such as polysaccharides) is considerably less than that found in adults. For this reason, infants are uniquely susceptible to bacteria that are coated with polysaccharides (such as *Haemophilus influenzae* type b [Hib] and *Streptococcus pneumoniae*).

Current data suggest that the theoretical capacity determined by diversity of antibody variable gene regions [my emphasis] would allow for as many as 10^9 to 10^{11} different antibody specificities. But this prediction is limited by the number of circulating B cells and the likely redundancy of antibodies generated by an individual. A more practical way to determine the diversity of the immune response would be to estimate the number of vaccines to which a child could respond at one time. If we assume that 1) approximately 10 ng/mL of antibody is likely to be an effective concentration of ***antibody per epitope (an immunologically distinct region of a protein or polysaccharide)*** [my emphasis], 2) generation of 10 ng/mL requires approximately 10^3 B-cells per mL, 3) a single B-cell clone takes about 1 week to reach the 10^3 progeny B-cells required to secrete 10 ng/mL of antibody (therefore, ***vaccine-epitope specific immune responses*** [my emphasis] found about 1 week after immunization can be generated initially from a single B-cell clone per mL), 4) each vaccine contains approximately 100 antigens and 10 epitopes per antigen (ie, 10^3 epitopes), and 5) approximately 10^7 B cells are present per mL of circulating blood, ***then each infant would have the theoretical capacity to respond to about 10,000 vaccines at any one time (obtained by dividing 10^7 B cells per mL by 10^3 epitopes per vaccine)***. [my emphasis]

However, because naive B- and T-cells are constantly replenished, a vaccine never really “uses up” a fraction of the immune system.

Children are Exposed to Fewer Antigens in Vaccines Today Than in the Past

Although we now give children more vaccines, the actual number of antigens they receive has declined. Whereas previously 1 vaccine, smallpox, contained about 200 proteins, now the 11 routinely recommended vaccines contain fewer than 130 proteins in total. Two factors account for this decline: first, the worldwide eradication of smallpox obviated the need for that vaccine, and second, advances in protein chemistry have resulted in vaccines containing fewer antigens (eg, replacement of whole-cell with acellular pertussis vaccine).

Note that in the references to Dr. Offit’s article is: “Cohn M, Langman RE. The protecton: the unit of humoral immunity selected by evolution. *Immunol Rev.* 1990;115:9–147”

In a presentation given by Dr. Offit in 2008 [doing my best to transcribe the talk, starting about minute 22:38], he states:

“Too Many Vaccines, Too Soon” When you pass through the birth canal. . . you become colonized with trillions of bacteria. Literally, trillions . . . and, in fact, you have 10^{14} bacteria that live on the surface of your bodies, and by the surface of your bodies, I mean skin, nose, throat, intestines. That is, 100 trillion bacteria. 10^{14} separate bacteria that is 100 trillion bacteria. You actually have 10^{13} , 10 trillion cells in your body. So you have more bacteria on the surface of your body than you have cells in your body. For parents, frankly, and it is understandable, I think when they watch four or five vaccines getting lined up at the end of the table, and they are seeing their two or four month old about to get all these shots, the feeling that that is more than they can handle is perfectly understandable. But if they really want to get scared, just take a cotton swab, swab the inside of the nose, put it on a microscope slide and look at it. It is teeming with bacteria to which you make an immune response because if you did not make an immune response to colonizing bacteria, those bacteria would not stay as colonizing bacteria. We see children born with, for example, essentially, that have an absence of an immune system called severe combined immunodeficiency disease who have those bacteria invade, bacteria like staph and strep, which live on our surfaces. And children who have acquired immunodeficiencies and so, for example, in our hospital children who have solid organ transplant or bone marrow transplants or who get cancer chemotherapy have acquired immunodeficiencies. Those are the organisms that you worry about.

If you look at the immunological challenge. Today we get 14 vaccines by two years of age, 14 different vaccines. 100 years ago, we got one vaccine. Do you remember what that vaccine was? Smallpox vaccine, right. Well, today, we get 14 and you could argue that 14 is more than one, but I am going to argue that one is actually more than fourteen because ***if you look at the number of immunological components, and by immunological components, I mean bacterial protein or viral protein or bacterial polysaccharide which is just the complex sugar that is used to make bacterial vaccines.*** [my emphasis] If you count each one of those as an immunological component, the smallpox vaccine which is a pox virus, the largest of the mammalian viruses, actually the only one that can be seen by a light microscopy, had 200 separate immunological components. If you

added up all 14 vaccines today there's about a hundred and fifty. So there is actually less in vaccines today. It is not so much the number of shots as what is in those shots that matters. And so the reason that there are fewer ***immunological components in vaccines*** [my emphasis] today is because we have had advances, in things like protein purification, protein chemistry and recombinant DNA technology that have allowed us to do that.

The other thing is the ***capacity of the immune system***. [my emphasis] There is a researcher at Massachusetts Institute of Technology whose name is Susumu Tonegawa who was the one who figured out how many different types of antibodies one can make. He did that by figuring out the number of different genes that are used to make those antibodies. He described all those different genes and he postulated that a human can make a billion or a hundred billion different types of antibodies every day for which he won the Nobel Prize. I know it's not Playboy's Playmate of the Year, but is still a prize worthy of consideration. So I think he should be taken seriously. And so ***that is often used as an answer as to how many different vaccines we can respond to***. [my emphasis] I think that's only part of the answer.

The better answer, the more practical answer was developed by two immunologists at U Cal San Diego named Mel Cohn and Rod Langman, who took into consideration the fact that we do not have infinite number of cells in our bodies that can make antibodies and you need a certain amount of an antibody to neutralize a particular protein. They came up with something called "Protecton Theory," a wonderful article actually in *Immunological Review* it is a little dense but great. ***Conservatively, one could say that, based on their caveat, that one could probably respond to about 100,000 different vaccines at one time***. [my emphasis]

Now remember, you are constantly making new B and T cells to help us make immune response, so I would say you probably could get 100,000 vaccines every day. I'm not saying you should get it. I'm just saying you could get it and in fact you do get it. If you look, actually, at what one is typically challenged with in the environment, with the dust you inhale that is not sterile and the food that you are eating that is not sterile. ***We are constantly challenging our immune system***. [my emphasis] I think we do respond to a tremendous immunological challenge from our environment and vaccines, although they are very visible, they are a very miniscule component, or contributor, to that challenge.

Ignoring Context

To repeat John Stone:

Our British health officials cite Offit but actually Offit cites a 1990 paper by Cohn and Langman - I can't download the Cohn and Langman paper so the context of that and how Offit adapted it for his purposes is unclear. ***It does not look like a paper on vaccination at all.*** [my emphasis] However, in the interview linked to by Angus below we see Offit braazily telling an audience in 2008 that an infant could happily withstand 100,000 vaccines a day (yes, every day) ***I see very little alternative to the view that that is exactly what he meant, crazy though the proposition is.*** [my emphasis] Maybe he should have spoken more carefully if he did not want to be misunderstood.

(Posted by: John Stone | January 06, 2016 at 04:48 AM)

A simple criticism both of the video and his comments in the CHOP pamphlet is that being injected with toxic substances in order to provoke an immune reaction is not remotely like casual environment exposure over the course of 24 hours. It should be obvious that two thing [sic] are not remotely comparable. (Posted by: John Stone | January 07, 2016 at 12:38 PM)

So, Stone couldn't download the Cohn and Langman paper; but then states: "It does not look like a paper on vaccination at all." And Stone goes on to state: "being injected with toxic substances in order to provoke an immune reaction is not remotely like casual environment exposure over the course of 24 hours. It should be obvious that two things are not remotely comparable."

I too could not download the Cohn and Langman (1990) article; but was able to get it through the assistance of the Interlibrary Loan Department. Stone's "guess" is correct that the article does not specifically mention vaccines; nor does it need to. The article addresses our immune system's capacity; vaccines trigger an immune response, and the immune system's capacity is directly relevant to understanding infants' capacity to respond to vaccines. From Stone's remarks it is obvious he doesn't understand even the basics of how our immune systems work.

And, finally, Stone writes: "Maybe he should have spoken more carefully if he did not want to be misunderstood." I think it quite obvious that, in both his article and his talk,

Dr. Offit made it quite clear that he was discussing the capacity of our immune system to deal with an extremely large number of antigens.

Note that the letter Vacctruth allegedly sent to Dr. Offit concludes with: “It should not be quoted out of context.” Well, they are right, so why did they quote it out of context in their article?

A Brief Primer on the Immune System

There are two basic arms to our immune systems, the innate immune system and the adaptive immune system. The innate immune system includes physical barriers such as skin and mucus membranes, various enzymes such as lysozyme in our saliva and tears, chemical messengers, cells that attack foreign intruders such as macrophages and neutrophils, and cells that take in intruders, disassemble them into component parts, transport them to lymph nodes where they present the parts to antibodies and T-cells. Sometimes the innate immune system can stop intruders cold. Sometimes it can slow them down, and sometimes with the microbes that cause human diseases, it mainly alerts the adaptive immune system and contributes to a coordinated defense. The adaptive immune system, on the other hand, is composed of B-cells that produce antibodies and T-cells of which there are two basic types, T-killer cells that attack mainly virus-infected cells and T-helper cells that secrete substances to “help” activate other T-cell subsets and to drive B-cells to produce antibodies, thereby coordinating the immune response. The most important thing to understand is that neither B-cells nor T-cells recognize whole microbes and that the first time confronted with an intruder it takes considerable time for them to be trained to recognize it and to respond effectively.

Epitopes/Antigenic Determinants:

An antigen is anything that is recognized by and responded to by the adaptive immune system. An epitope/antigenic determinant is the specific part of an antigen that is recognized by the immune system, specifically by antibodies, B-cells, or T-cells. The epitope is the specific piece of the antigen that an antibody or T-cell binds to. T-cells recognize and bind to peptides (small protein fragments), ranging between 6 to 25 amino acids in length (Sompayrac, 2016, pp. 43-45). The peptides that are recognized as epitopes for B-cells range between 6-12 amino acids (ibid, p.29). B-cells can also recognize sections of polysaccharides and lipids. Our immune system produces literally billions of B- and T-cells with slightly different configurations, specific for one or a small range of epitopes/antigenic determinants. The first time the immune system is confronted with a threat, it takes time for specific B-cells and/or T-cells to pair with the specific epitopes and once paired, additional time to produce a clonal army for repelling

the invader. Once confronted with an antigen, the immune system not only responds to the direct threat but creates memory cells. These memory cells shorten the response time to a subsequent invasion to the extent that it can often be blocked completely or, at least, weakened and/or shortened in duration.

Our immune system can recognize epitopes/antigenic determinants whether they are dead or alive in the same way one can recognize fingerprints or teeth from a cadaver or living person and, as police can use fingerprints or dental records to identify someone, our immune systems can use epitopes/antigenic determinants to identify and react to a threat. Vaccines are designed to stimulate the immune system to recognize a threat without the vaccine itself causing actual illness. This is accomplished by either using as the vaccine (1) killed microbes, (2) microbes that have been attenuated (severely weakened) or, (3) genetically engineered protein segments that contain the epitopes recognized by the immune system as the antigenic target.

As a possible analogy, imagine bank robbers that are known to case the banks days before the robbery. Through descriptions given by bank employees and customers, a composite sketch of the robbers is made. A bank employee recognizes one of them, informs the police, and the police place undercover officers at the bank, successfully apprehending the robbers when they show up a couple days later. The composite sketch does not have to be perfect and it certainly isn't in color nor more than just a two-dimensional view of the face; but it is often good enough. Well, just as the composite sketch, a rough part of the picture, results in the police being alerted, our immune systems don't react to a whole microbe, just small component parts.

Dr. Offit's article and his talk both explained just how robust our immune systems are, just how many specificities, that is, epitopes/antigenic determinants, our immune systems can respond to at one time. From the context of either, it should have been obvious as he wrote in the article:

- a. "Current data suggest that the theoretical capacity determined by diversity of antibody variable gene regions"
- b. "vaccine-epitope specific immune responses"
- c. "then each infant would have the theoretical capacity to respond to about 10,000 vaccines at any one time (obtained by dividing 10^7 B cells per mL by 10^3 epitopes per vaccine)".

And in the presentation he said:

- a) “if you look at the number of immunological components, and by immunological components, I mean bacterial protein or viral protein or bacterial polysaccharide which is just the complex sugar that is used to make bacterial vaccines”
- b) “immunological components in vaccines”
- c) the capacity of the immune system. . . that is often used as an answer as to how many different vaccines we can respond to.”
- d) And, after explaining Cohn and Langman’s article, he says: “Conservatively, one could say that, based on their caveat, that one could probably respond to about 100,000 different vaccines at one time.” And, finally, Dr. Offit says: “We are constantly challenging our immune system.”

So Stone’s not seeing the connection between vaccines and the immune system simply displays his ignorance of how our immune systems work, and would, by analogy, be the same as not seeing the connection between antibiotics and bacterial infections. Stone didn’t need to read the entire article by Cohn and Langman to understand the connection as Dr. Offit made it quite clear both in his article and in the talk. That said, Stone’s apparent lack of effort to obtain the actual article, dismissing it out of hand, is just another example of the poor scholarship and deficient science of antivaccinationists. If you do not understand the relevance of a reference from the reference itself, you should make the effort and read it. Vaccines work and are designed to work to take advantage of how our immune systems work. It should have been obvious from Dr. Offit’s paper and talk that he was discussing the capacity of our immune system to deal with an immense number of intruders.

Stone’s: “A simple criticism both of the video and his comments in the CHOP pamphlet is that being injected with toxic substances in order to provoke an immune reaction is not remotely like casual environment exposure over the course of 24 hours. It should be obvious that two thing [sic] are not remotely comparable.” But they are exactly comparable, given that Dr. Offit was, when viewed in context, referring to the epitopes/antigenic determinants that 10,000 or 100,000 vaccines would represent, as with fingerprints, whether they are killed, attenuated, or limited to specific DNA-developed specificities. He was not referring to actually giving vaccinations which I will discuss further in the next section.

Note that, besides Stone, Vactruth and Suzanne Humphries both listed Dr. Offit’s paper in their respective references so one assumes they read it.

For those not living in a fantasy world of how vaccines work and how our immune system works, I highly recommend a delightful little book by Lauren Sompayrac, “How

The Immune System Works, 5th Edition”, 2016. For more intrepid souls, in order of difficulty, try William E. Hall, “Immunity”, 2015, “Richard Coico & Geoffrey Sunshine, “Immunology: A Short Course, 7th Edition”, 2015 (I have an earlier edition) and, finally, Kenneth Murphy & Casey Weaver, “Janeway’s Immunobiology, 9th Edition, 2016 (I have an earlier edition) There are also a number of excellent articles going back 30 years or more in *Scientific American*.

100 Trillion Microbes:

The Human Body is composed of about 10 trillion cells. On and in our bodies are about 100 trillion microbes. Many are beneficial. Some actually transform food into essential vitamins. Others help break down food into more easily used constituents. And some simply help keep out the bad guys by taking up space so there is little room, by using up nutrients, and even by secreting enzymes, bacteriocides, that kill other species. However, it is a mistake by those antivaccinationists who emphasize the Human Microbiome to believe that it acts alone. Without our immune system, we would survive a very short time. One of the problems with antivaccinationists is their focus on one or two factors, ignoring the complex multifactorial interactions of the human body. For instance, Thomas writes: “The gut is of central importance for the body and overall health: for instance, the gut has a surface area of 300 m²; uses 40% of the body’s energy expenditure; contains 10⁸ neurons and 50% of the body’s immune cells.” (Thomas, 2012, p.S1). The immune system and Human Microbiome are intricate players in a complex web. Both are important.

Of the 100 trillion microbes, several are direct threats if not held in check, e.g. streptococci, enterococci (Arumugam, 2011; The Human Microbiome Project Consortium, 2012; National Institutes of Health, Human Microbiome Project; Qin, 2010; Wikipedia “Gut flora”, Wikipedia “Human microbiota”; Wilson, 2005) There is even new evidence that babies in the womb, previously thought to be sterile, are exposed to bacteria in the womb (Park, 2015).

Human Feces:

Just as an example of the enormous numbers of bacteria within our bodies, one study found that “about 55% of faecal solids are bacteria” (Stephen, 1980, p.53); however, other studies have found a range of 24-54% (Wikipedia “Human feces”).

Additional Microbial Exposures:

Besides keeping in check the potential pathological microbes among the 100 trillion in and on our bodies, our immune systems must deal with additional microbes from the air

we breathe, the food and water we drink, and minor abrasions to our skin on a daily basis. According to the American Academy of Pediatrics: “Infants and children are exposed to many germs every day just by playing, eating, and breathing. Their immune systems fight those germs, also called antigens, to keep the body healthy. The amount of antigens that children fight every day (2,000-6,000) is much more than the antigens in any combination of vaccines on the current schedule (150 for the whole schedule).” (American Academy of Pediatrics, 2008) One article, for instance, lists the number of bacteria found in swabs of various surfaces in our environment, e.g., dish sponge - 775,460,560 or a doorknob - 8643. (new.com.au, 2013). Much of this research is based on Dr. Charles Gerba of the University of Arizona (Marston, 1999).

As for the Vactruth quote from “Tetyana Obukhanych Ph.D: The immune system has a theoretical capacity to respond to an unlimited number of antigens, but not all at the same time,” given the total number of microbes in and on our bodies, together with our ever present exposure to numerous microbes in our environments, it shouldn’t be surprising that our immune systems are capable of simultaneously defending us against a myriad of potential threats. While Dr. Obukhanych is correct that our immune system can’t respond to an unlimited number of antigens at the same time, it certainly can respond to an extremely large number. In other words, Dr. Offit’s explanation of how our immune system rises to the task, together with his discussion of Cohn and Langman’s estimates, gives the context as to why a few vaccines do not overwhelm one’s immune system, and clearly indicate that the “10,000” or “100,000 vaccines” was referring to our immune system’s ability to cope with the antigens that 10,000 or 100,000 vaccines would represent. If nothing else, Dr. Offit’s use of the word “theoretical” should have, at least, elicited some level of questioning, not blanket believing he was referring to actual vaccinations. However, even without the context of his article or talk, common sense together with a few minutes of inquiry should have made it clear.

A Lack of Common Sense

I wonder if the first picture entering the minds of antivaccinationists when hearing “10,000 vaccinations at one time” is an infant placed in some Vincent Price-like movie small horror chamber studded with needles? Could one even find enough places on an infant’s body to target?

In an exchange of comments to an article by John Stone (2016), someone calling themselves Hera posted:

“So, for example you can give five vaccines (pentacel) in 0.5 ml. 2ml in a syringe could therefore easily contain 20 vaccines, and be well under the amount allowed for a single thigh injection in an infant.

Posted by: Hera | January 05, 2016 at 02:45 PM”

I responded with:

Given current technology and that they have found that certain vaccines can affect each other if injected at the same site, currently not likely they could combine 20; but, *for sake of argument* [my emphasis], let’s accept that one could put 20 vaccines in one injection. Then 10,000 vaccines would require 500 injections. You wrote: “2 ml in a syringe could therefore easily contain 20 vaccines, and be well under the amount allowed for a single thigh injection in an infant.” Multiply 2 ml * 500 = 1000 ml. Last time I looked, 1,000 ml = 1 liter. Sounds like a lot to me? Don’t you think it ABSURD that anyone would believe Paul Offit or anyone in their right mind would advocate sticking an infant or even an adult 500 times in one day, besides the pain, it would total 1 liter?

Posted by: Joel A. Harrison, PhD, MPH | January 05, 2016 at 05:03 PM

John Stone then posted a comment to which I responded:

You write, quoting Dr. Salisbury’s BBC interview: “A baby’s immune system could actually tolerate perfectly well 1,000 vaccines”. First, where does he mention Offit? Second, 1,000, not 10,000. But, more important is exactly what he is saying. Yes, our immune systems, even an infant’s could tolerate the antigens from 1,000 vaccines; but that isn’t saying the infant could tolerate 1,000 sticks of a needle. I realize that being literal about this probably taxes your ability to understand things; but try. As I wrote in my comment to Hera, only someone like you would think that Salisbury or any other rational being would be actually claiming that we could stick an infant 1,000 times. I admit that he could have done a better job of phrasing what he said; but assuming those listening are rational, it should be clear.

Posted by: Joel A. Harrison, PhD, MPH | January 05, 2016 at 08:16 PM

In a later comment, based on 20 vaccines per injection, I wrote:

If one really believed that Offit meant literally that a child could be given 10,000 or even 100,000 actual shots, not meaning from the overall context of what he wrote or said, then it would entail 500 or more needles and 1

liter of fluid for the 10,000 shots and 5000 or more needles and 10 liters of fluid for the 100,000 shots, all given either at once or over a very short time interval since he said at one time. So, do you really envision Offit placing a child in some type of chamber as in some old Vincent Price movies, pushing a lever, and 500 to 5000 needles darting out at once, while the excess fluid spurted everywhere?

Posted by: Joel A. Harrison, PhD, MPH | January 06, 2016 at 10:44 AM

I encourage the reader to go to Stone's article (2016), start from the bottom and follow the exchange of comments. Common sense would dictate that a reasonable person would understand that neither Dr. Offit, Dr. Salisbury or anyone else would contemplate actually injecting anyone with even a small proportion of 1,000 vaccines, let alone 10,000 to 100,000 at one time; yet, antivaccinationists refuse to even consider this, to investigate further, to read books on our immune system, to even pay heed to what I wrote in my comments.

I think one comment submitted by someone calling themselves Linda1 who both writes articles for *Age of Autism* and submits quite a few comments, given that Stone posted it, says a lot:

More importantly, I think Paul Offit envisions himself "placing a child in some type of chamber as in some old Vincent Price movies, pushing a lever, and 500 to 5000 needles darting out at once, while the excess fluid spurted everywhere".

That's about right.

Very perceptive of you, Dr. Harrison. You get one point.

Posted by: Linda1 | January 06, 2016 at 03:30 PM

Perhaps, Linda1 was just being humorous; but her humor belies the *ad hominem* attacks used to discredit and even demonize anyone who disagrees with them and, of course, given other of her writings, she may really believe what she writes. I'm sure in future articles I will have more examples from Linda1.

How Many Vaccines Are Currently Approved and How Many Are Being Developed?

It took only a few minutes to find the answer to the above. The World Health Organization (WHO) currently lists 27 available vaccines and 19 pipeline vaccines (being developed). (WHO, Accessed 2016 Jan) With the Zika virus in the news,

developing a vaccine would increase the pipeline vaccines to 20. While WHO lists the vaccines by individual microbe, the FDA list is by vaccines “Complete List of Vaccines Licensed for Immunization and Distribution in the US” (FDA updated 2015 Dec 3). However, a number of these vaccines are either NOT currently used, e.g. smallpox vaccine, are restricted for use by specific groups, such as certain segments of the military (e.g., adenovirus Type 4 and Type 7 vaccine or anthrax vaccine), or travelers to countries where certain diseases are endemic (Japanese encephalitis virus vaccine, rabies vaccine, yellow fever vaccine). Others are not given to children, e.g. zoster (shingles) vaccine. Many of the licensed vaccines listed are for prevention of the same pathogens, but just manufactured by different companies or formulated differently. For example, there are well over a dozen different formulations of tetanus and diphtheria toxoid-containing vaccines, and no less than 20 different licensed influenza virus vaccines. When you go for your annual flu shot, you only receive one of these formulations, not all 20+.

Note that a report from the Pharmaceutical Research and Manufacturers of America (2012) lists almost 300 vaccines currently in development. However, many have not been submitted to the FDA or WHO as they are in early stages of development. The list includes the vaccines listed by the FDA or WHO in development. In addition, a number are not for prevention; but for treatment, e.g. a genetically-modified vaccine designed for the treatment of pancreatic cancer. Numerous preventive vaccines listed are for the same microbe, different companies developing different formulations, and many are for microbes not found in the UK or the US, so only a few, if successfully developed, would be added to the list for UK and/or American infants and children.

For children through six years of age, vaccines for a total of 17 microbes are recommended, many in multivalent formulations, such as the trivalent MMR and DTaP vaccines, or the pentavalent DTaP, Inactivated Poliovirus types 1,2, and 3, and Haemophilus b conjugate vaccine. (Note that I am referring to specific microbe species. Some vaccines, such as Pneumovax, protect against 23 different strains of Streptococcus pneumoniae. So, it is actually composed of 23 different antigens.) Many of the recommended vaccines are given during different visits. In the first six months, the maximum recommended is nine at six months (six single shots and DTaP); but three (HepB, IPV, Influenza) of these are given an age range, so needn’t be given at the same time, can even be given months later than six months (CDC, 2016). As discussed above, the number of antigens even in nine vaccines is miniscule compared to those in and on our bodies and in our environments.

Note that for sake of argument above I included 20 vaccines per injection. If one assumes, for instance, only trivalent vaccines being used, dividing 10,000 vaccines by

three would involve giving at one time 3,333 shots and over six liters of fluid. Even 1,000 vaccines would involve 333 shots at one time and about one half liter of fluid. Again, only antivaccinationists, in their lack of common sense, would believe this even remotely feasible.

Given that vaccines for children currently protect against 17 microbe species, even with vaccines being currently developed only a few will be for children. Knowing this, how can any rational reasonable person using basic common sense even believe that 10,000 vaccines or even 1,000 vaccines would be remotely possible? Keep in mind that there are only a limited number of microbes that pose a threat to children in the US that a vaccine might be eventually be developed for. So, besides the virtual impossibility of administering even a miniscule percentage of 10,000 vaccines at one time, the number of needles and amount of fluid, simply looking at the number of current vaccines and the number of potential vaccines given threats to children in the US should have led to a clear understanding that Dr. Offit and others were NOT referring to actual vaccinations, except in the warped minds of antivaccinationists. So, if one is not discussing 10,000 actual vaccines, then what is going on?

Let me give a possible analogy. When I was young, cars were advertised with 450 horsepower engines. I never envisioned 450 horses someone compressed inside the engine and I never imagined harnessing 450 horses for pulling a car. In fact, since horses can only reach sustainable speeds of 25 to 30 mph, no matter how many horses one harnesses to a car it will never reach sustained speeds in excess of 25 to 30 mph. So 450 horsepower was not based on actual horses at all. What does this have to do with 10,000 vaccinations at one time? Well, since in the same way that no one in their right mind would believe that horsepower should be taken literally, Dr. Offit's "theoretical" number of vaccinations would NOT be taken literally by any reasonable person using basic common sense. A reasonable understanding would be the microbes or more exactly, the antigens, that our immune system protects us against. If not immediately understood, it would easily be found in books on immunology, microbiology, and various websites, not, of course, those created by antivaccinationists who continue to maintain that 10,000 actual vaccinations is what is being discussed.

Keep in mind that prior to vaccinations, almost 100% of children experienced most, if not all, of the current vaccine-preventable diseases, missing school, requiring a parent to stay home, suffering, hospitalizations, disabilities, and even deaths (CDC, 1999, 2015ab; Roush, 2007). And sometimes these were experienced in short succession; yet, though these were full blown illnesses, not killed or attenuated vaccines, their immune systems usually coped quite well.

Vaccinating Against 20 Microbes in One Shot:

In another comment to his article, John Stone (2016) writes:

Joel

You said at the start:

"It is also absurd to even believe that Offit or anyone else would believe giving 10,000 or even 20 vaccines at one time reasonable." The point that it would not be physically possible to administer 10,000 vaccines doesn't hold for 20. I can't believe that Prof Offit wouldn't [sic] be happy with 20 (irrespective of their common unpleasant side effects).

Posted by: John Stone | January 07, 2016 at 12:38 PM

Note above that since Hera suggested 20 vaccines in one shot, "for sake of argument" and given that if one includes strains as well as species this is already a reality, I used her numbers to calculate the number of needles and total fluid that would be involved. And note that Stone now admits that "it would not be physically possible to administer 10,000 vaccines." But he originally believed even 100,000 vaccines would be possible: "we see Offit braazily telling an audience in 2008 that an infant could happily withstand 100,000 vaccines a day (yes, every day). I see very little alternative to the view that that is exactly what he meant, crazy though the proposition is." He then assumes that 20 vaccines would have "unpleasant side effects." Perhaps Stone doesn't recognize the incredible discrepancy in numbers between 10,000 or 100,000 which he and his fellow antivaccinationists have been pushing for years and 20; but most reasonable people would understand that 20 is a far cry from 10,000. One question is: Will Stone now alert his fellow antivaccinationists to stop pushing the 10,000 vaccinations at one-time mantra, that it makes them look foolish? Will he write something in an article for *Age of Autism* or will his admission remain but an obscure comment to one of his articles?

Currently, the highest multivalent vaccine (species, strains, as mentioned above, can be higher) approved in the US is a pentavalent vaccine (FDA, 2015). However, research is being conducted for even heptavalent vaccines (Decker, 2013, p.1004). For children, two trivalent vaccines are currently in use, the MMR and the TDaP.

Despite what Stone's fantasy world tells him, research has been and is being carried out to minimize side effects. It would take another article to review all of them. However, as an example, the Decker *et al.* (2013) chapter on Combination Vaccines includes 365 references. And Halsey writes: "Combining multiple vaccines into one injection can reduce the amount of preservatives and other additives that are required to deliver vaccines to children." (2001, p.S41) and "Numerous studies have shown that the

incidence of adverse events after combination vaccines is similar to the rates when the vaccines are administered separately. The incidence of adverse events when with a combination product usually reflects the safety profile of the most reactive component. . For some combination vaccines, such as DTaP, the rates of adverse effects are lower than would be observed if each of the component products were administered separately.” (ibid, p.S42) Apparently Stone’s: “I can't believe that Prof Offit wouldn't [sic] be happy with 20 (irrespective of their common unpleasant side effects),” reflects his ignorance of the reduction of other ingredients other than antigens in combination vaccines as well as studies looking at immunogenicity and side effects of combination vaccines, simultaneously given vaccines, and monovalent vaccines (e.g. Kroger, 2013, pp.93-99).

Summary and Discussion

For those who actually either read Dr. Offit’s article or listened to his talk, it should have been obvious that his “10,000” or “100,000” vaccines, when taken in context, was clearly referring to the number of antigens that our immune systems can deal with at one time. In fact, the actual quote in his article: “then each infant would have the theoretical capacity to respond to about 10,000 vaccines at any one time (obtained by dividing 10^7 B cells per mL by 10^3 epitopes per vaccine),” makes it quite clear by including B cells and epitopes per vaccine. If this wasn’t obvious, then for both those who read the article and/or listened to the talk and those who solely read quotes of only the out-of-context sentences, common sense should have made it obvious. First, just using one’s imagination should have made it quite clear that one could NOT give 10,000 or 100,000 vaccines to an infant at one time. It would be impossible, whether one gave it as separate injections for each vaccine or even packed 20 vaccines per injection, impossible except for antivaccinationists such as Linda1. Secondly, there are only 17 vaccines mandated or recommended for infants and even their administration is staggered. Not even in one’s wildest imagination could we jump from 17 to 1,000 or 10,000 or 100,000.

Research in vaccine development focuses on the microbes that pose the greatest risk. In fact, there are only 27 currently approved vaccines against distinct pathogens and 19 in development (other vaccines are in early stages of development, various different formulations for the same microbe, or for treatment of cancers). These numbers include vaccines for microbes that don’t exist in the US or UK, only given when traveling abroad, or are not a risk for infants. So, Dr. Offit’s cited 10,000 or 100,000 vaccines doesn’t pass the common sense muster. Reasonably intelligent people would ask what he is talking about? Unfortunately, antivaccinationists, in their fervor to attack anyone who promotes vaccines, in their lack of logic, in their lack of rationality, in their

deficient understanding of immunology, microbiology, infectious diseases, historically and currently in the world, in their deficient understanding of epidemiology and in their LACK OF COMMON SENSE, jump at whatever seems to confirm their rigid ideology, display incredibly poor scholarship by not taking even the least time to investigating further. Why should they, given that they know they are right?

Stone, a major contributor to *Age of Autism*, believes that the more antigens per shot the greater the risk. However, besides the fact that even the antigens from 20 microbes would be far below what our immune system is capable of, he is NOT aware that multivalent vaccines reduce the pain from multiple shots and usually the amount of additional ingredients such as stabilizers and adjuvants. In other words, exactly the opposite of his fears.

Monitoring antivaccination websites, it becomes obvious that they represent a near hermetically-sealed self-reinforcing circle. Someone cited Dr. Offit's "10,000" vaccines and, without thinking, the antivaccinationists have been repeating it ever since. One example of just how absurd their thinking is.

I welcome parents questioning. Not only do they have the right to; but they should. However, when they do this, they should listen, their questions should not be rhetorical ones, and they should do the research, take the time to learn some of the basics, starting with, perhaps, Sompayrac's excellent little book, "How the Immune System Works", not relying on articles found on websites such as *Age of Autism*, articles deficient in so many ways.

Acknowledgements

For valuable feedback and suggestions, thanks to: Sandi Berman, PLS, Dr. Michael Fitzpatrick, Dorit Rubinstein Reiss, PhD, and Steven A. Rubin, PhD. For help in obtaining needed articles and documents, thanks to the Interlibrary Loan Department, San Diego State University.

References

American Academy of Pediatrics (2008 Oct). The Childhood Immunization Schedule: Why Is It Like That? Available at: <https://www.aap.org/en-us/advocacy-and-policy/Documents/Vaccineschedule.pdf>

Arumugam M, Raes, J, Pelletier E *et al.* (2011 May 12). Enterotypes of the human gut microbiome. *Nature*; 473: 174-180.

Attkisson, Sharyl (2008 Jul 25). How Independent Are Vaccine Defenders? *CBS News*. Available at: <http://www.cbsnews.com/news/how-independent-are-vaccine-defenders/>

CDC (1999 Apr 2). Achievements in Public Health, 1900-1999 Impact of Vaccines Universally Recommended for Children — United States, 1990-1998. *MMWR Weekly*; 48(12): 243-248. Available at: <http://www.cdc.gov/mmwr/preview/mmwrhtml/00056803.htm>

CDC (accessed 2016a Jan 31). Immunizations and Developmental Milestones for Your Child from Birth Through 6 Years Old. Available at: <http://www.cdc.gov/vaccines/parents/downloads/milestones-tracker.pdf>

CDC (2015a). Appendix E: Reported Cases and Deaths from Vaccine Preventable Diseases, United States, 1950-2013; E1-E6 in *Epidemiology and Prevention of Vaccine-Preventable Diseases: The Pink Book* - 13th Edition. Available at: <http://www.cdc.gov/vaccines/pubs/pinkbook/downloads/appendices/E/reported-cases.pdf>

CDC (2015b). Appendix E: Impact of Vaccines in the 20th & 21st Centuries: E7.in *Epidemiology and Prevention of Vaccine-Preventable Diseases: The Pink Book* - 13th Edition. Available at: <http://www.cdc.gov/vaccines/pubs/pinkbook/downloads/appendices/E/impact.pdf>

Cohn M, Langman RE (1990 Jun). The Protecton: The unit of humoral immunity selected by evolution, *Immunological Reviews*; 115: 5-261.

Decker, Michael D, Edwards, Kathryn M, Bogaerts, Hugues H (2013). Chapter 40: Combination Vaccines. In Plotkin, Stanley, Orenstein, Walter A, Offit, Paul A (Eds.) *Vaccines*, 6th Edition. Elsevier: 981-1007.

FDA (updated 2015 Dec). Complete List of Vaccines Licensed for Immunization and Distribution in the US. Available at: <http://www.fda.gov/BiologicsBloodVaccines/Vaccines/ApprovedProducts/UCM093833>

Halsey, Neal A (2001). Safety of combination vaccines: perception *versus* reality. *Pediatric Infectious Diseases Journal*; 20: S40-4.

Hart, Elizabeth (2016 Jan 7). Comment following John Stone's (2016 Jan 5) "Bexsero: More Questions for the British and Scottish Governments Over Vaccines Committee

Chair. *Age of Autism*. Available at: <http://www.ageofautism.com/2016/01/bexsero-more-questions-for-the-british-and-scottish-governments-over-vaccine-committee-chair.html>

Hilts, Philip J (2003). *Protecting America's Health: The FDA, Business, and One Hundred Year of Regulation*. New York: Alfred A. Knopf.

The Human Microbiome Project Consortium (2012 Jun 14). Structure, function and diversity of the healthy human microbiome. *Nature*; 486: 207-214.

Humphries, Suzanne (2012 Aug 26). In Vaccines We Trust? Paul Offit threatens religious and philosophical vaccine exemptions. A response by Suzanne Humphries, MD. *Vaccination Council*. Available at: <http://vaccinationcouncil.org/2012/08/26/paul-offit-threatens-religious-and-philosophical-vaccine-exemptions-a-respose-by-suzanne-humphries-md/>

Kroger, Andrew T, Atkinson, William L, Pickering, Larry K (2013). Chapter 8: General immunization practices. In Plotkin, Stanley, Orenstein, Walter A, Offit, Paul A (Eds.) *Vaccines*, 6th Edition. Elsevier: 93-99.

Lunoe, Sandy (2012 Apr 16). 10,000 Crazy Vaccines! *Vactruth*. Available at: <http://www.ageofautism.com/2010/05/paul-offits-10000-vaccines-and-the-milgram-experiment.html>

Marston, Wendy (1999 Feb 23). Scientist at Work: Charels Gerba; On Germ Patrol, at the Kitchen Sink. *New York Times*. Available at: <http://www.nytimes.com/1999/02/23/health/scientist-at-work-charles-gerba-on-germ-patrol-at-the-kitchen-sink.html?pagewanted=print>

National Vaccine Information Center (Accessed 2016 Jan 14). FAQ (Frequently Asked Questions): Topic: Vaccine Safety & Immunity. Available at: <http://www.nvic.org/faqs/vaccine-safety-immunity.aspx#>

National Institute of Health. Human Microbiome Project. Accessed January 27, 2016. Available at: <http://hmpdacc.org/overview/about.php>

[news.com.au](http://www.news.com.au) (2013 Mar 27). The shocking bacteria count of daily items. Available at: <http://www.news.com.au/lifestyle/home/the-shocking-bacteria-count-of-daily-items/story-fneuz5ql-1226606341167>

Offit, Paul (2002 Jan). Addressing Parents' Concerns: Do Multiple Vaccines Overwhelm or Weaken the Infant's Immune System? *Pediatrics*; 109(1); 124-129. Available at: <http://pediatrics.aappublications.org/content/pediatrics/109/1/124.full.pdf>

Offit, Paul (2008 Jun 18). Are Childhood Vaccines Safe? 2008 Congressional Biomedical Research Caucus Briefings. Available at: <http://pediatrics.aappublications.org/content/pediatrics/109/1/124.full.pdf>

Qin J, Li R, Raes J *et al.* (2010 Mar 4). A human gut microbial gene catalogue established by metagenomic sequencing. *Nature*; 464: 59-67.

Park, Alice (2015 Dec 28). Babies in the Womb Aren't So Sterile After All. *Time Magazine*. Available at: <http://time.com/4159249/baby-microbiome-womb/>

Pharmaceutical Research and Manufacturers of America (2012). *Medicines in Development Vaccines*. Available at: <http://www.phrma.org/sites/default/files/pdf/vaccines2012.pdf>

Roush, Sandra W, Murphy, Trudy V *et al.* (2007). Historical Comparisons of Morbidity and Mortality for Vaccine-Preventable Diseases in the United States. *JAMA*; 298(18): 2155-2163.

Sompayrac, Lauren (2016). *How The Immune System Works*, 5th Edition. Wiley Blackwell.

Stephen, Alison M, Cummings, JH (1980 Feb). Microbial contribution to human faecal mass. *Journal of Medical Microbiology*; 13(1): 45-56. Available at: <http://www.microbiologyresearch.org/docserver/fulltext/jmm/13/1/medmicro-13-1-45.pdf?expires=1454182012&id=id&accname=guest&checksum=83E13384A525AA6440564C5092327B04>

Stone, John (2010 May 10). Paul Offit's 10,000 Vaccines and the Milgram Experiment. *Age of Autism*. Available at: <http://www.ageofautism.com/2010/05/paul-offits-10000-vaccines-and-the-milgram-experiment.html>

Stone, John (2016 Jan 10). Bexsero: More Questions for the British and Scottish Government Committee Chair. *Age of Autism*. Available at: <http://www.ageofautism.com/2016/01/bexsero-more-questions-for-the-british-and-scottish-governments-over-vaccine-committee-chair.html>

Thomas, Linda V, Ockhuizen, Theo ((2012 Jan). New insights into the impact of the intestinal microbiota on health and disease: a symposium report. *British Journal of Nutrition*; 107 Suppl 1: S1-S13. Available at:
http://journals.cambridge.org/download.php?file=%2FBJN%2FBJN107_S1%2FS0007114511006970a.pdf&code=082eafd1b438e8efa22b52fd9ff5084a

Vaccine Education Center, The Children’s Hospital of Philadelphia (reviewed by Paul A. Offit, 2014 Nov 5). “Vaccine Safety: Immune System and Health: Vaccines impact on the immune system: Do vaccines overwhelm the immune system? Available at:
<http://www.chop.edu/centers-programs/vaccine-education-center/vaccine-safety/immune-system-and-health#.VpfcwjYlenQ>

Vactruth (2012 Apr 16). 10,000 Crazy Vaccines! Available at:
<https://vactruth.com/2012/04/16/10000-crazy-vaccines/>

WHO (2016 Jan). Vaccines and diseases. Available at:
<http://www.who.int/immunization/diseases/en/>

Wikipedia. Gut flora. Available at: https://en.wikipedia.org/wiki/Gut_flora

Wikipedia, Human feces. Available at: https://en.wikipedia.org/wiki/Human_feces

Wikipedia. Human microbiota. Available at:
https://en.wikipedia.org/wiki/Human_microbiota

Wilson, Michael (2005). *Microbial Inhabitants of Humans: Their Ecology and Role in Health and Disease*. Cambridge University Press.