What really happens when I get a #Flu vaccine?

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Abstract

Seasonal flu is a serious, highly contagious respiratory illness caused by the influenza virus. In the United States, approximately five to 20 percent of individuals get the flu each year; more than 200,000 are hospitalized, and tens of thousands die from flu-related complications.[1] So why do people not vaccinate against flu or for that matter other infectious diseases? In my personal and professional experience, I believe it has to do with a breakdown in health literacy and science communication. Individuals have varying levels of awareness/attitudes toward the flu vaccine, side effects, and overall effectiveness.[2] Importantly, many people usually report misconceptions about the side effects of the flu vaccine, which can perpetuate fear and create vaccine avoidance. Unfortunately, on more accounts than I care to say, my colleagues, students, friends, and others report a reluctance to be vaccinated due to concerns that the vaccine would either cause illness or be ineffective at preventing flu. This commentary / editorial will attempt to explain in common terms what really happens when one gets the flu (and other) vaccines.[3]

Main Article

Whether it is in my classroom, in face-to-face interactions, through social media, or in my television / entertainment viewing, I continue to come across individuals who do not want to vaccinate for any number of reasons. It is clear that misinformation on how vaccines function have spurred much of these reactions. Very few people know how the body responds to a vaccine, as well as some of the basic facts surrounding a vaccine process. Since it is flu season, I thought that it might be a useful story to tell – about how one's body responds to vaccines and why they are so critical for public health.[3]

The Immune System – the Basics

Our immune system is perhaps one of the most brilliant early alarm systems ever created. Even in today's era of amazing technology and innovation, the United States Department of Defense can only dream of creating the types of weapons and early alarm systems that the human body utilizes on a daily basis. Our immunity is a complex network of cells and organs that evolved to fight off infectious agents and microbes. A military of diverse specialized cells with specific roles in fighting disease work together to perform this in all of our own bodies.

When we are invaded (infected) by any foreign microbes, they first run into the front line units of our human military, which includes white blood cells called macrophages. Roughly translated, these "big eaters" engulf as many of the microbes as they can. The invasion into our bodies itself can be by any number of covert maneuvers such as breathing in the respiratory droplets from another sick person, eating / drinking from contaminated sources, or by being bitten by

a carrier (vectors, like a mosquito for certain diseases like malaria).[4,5] Before we continue, it is important to mention that one way to help our immune system is by not allowing these invasions to occur. The old saying “an ounce of prevention is worth a pound of cure” still holds true today. Therefore, preventative practices such as proper hand-hygiene can have significant impacts in reducing the spread of these diseases.

Microbes Camouflage

Cells of our own bodies, as well as microbes wear a “uniform” made up of unique marker molecules, known as antigens that cover their surfaces to signal that they are our own. These signals are unique, and individual, which is why a person (recipient) that is trying to receive a donor kidney, for example, must have medical laboratory tests conducted to ensure compatibility. This match ensures the organ / tissue (or blood) will not be rejected or “attacked” by our immune system.

Microbes display different marker molecules unique to them as well, which are usually identified as foreign by our bodies. The macrophages and other cells of your immune system use these antigens (uniforms) to distinguish among the cells that are part of your body, harmless (normal) bacteria that reside in your body, and harmful invading microbes that need destroying.[4,5] Vaccines target these unique microbial antigens (uniforms) to protect us.[4,5]

Macrophages kill most parts of the microbes but save the antigens and carry them back to the lymph nodes, which are organs scattered throughout your body where immune system cells congregate. You can visualize these lymph nodes as your immune military “command posts,” strategically placed around your body. In these nodes, macrophages sound the alarm by presenting the antigens, displaying them on their surfaces so other cells, such as specialized defensive white blood cells called lymphocytes, can learn to recognize them.[4,5]

The Calvalry – Lymphocytes

Lymphocytes are in two forms – T cells and B cells, and they do their own jobs in fighting off microbial attacks (infection). T cells function either offensively or defensively. The offensive T cells attack the microbe indirectly by using chemical weapons (enzymes) to eliminate the human cells that are already infected.[4,5] They have been “programmed” by their encounter with the microbe’s antigen (uniforms) to become cytotoxic T cells (also known as killer T cells) that can sense diseased cells that are harboring the microbe. Chemical warfare ensues when killer T cells recognize and target these cells and releases chemicals that destroy the infected cells. Defensive T cells (helper T cells), defend the body by secreting chemical signals that notify other cells in our immunity arsenal to call for aid. Helper T cells assist in activating killer T cells, and can also stimulate and work closely with B cells. T cell military activity is known as the cellular or cell-mediated immune response.[4,5]

B cells, another part of the military calvalry, make and secrete extremely important molecular weapons called antibodies. One might think of an antibody as a missile that can neutralize a foreign microbe. Antibodies usually work by targeting the microbe’s antigen (uniform), and then sticking to and coating the microbe.[4,5] Antibodies and antigens fit together like a lock and key – if their shapes fit together, they bind to each other. Each missile (antibody) can usually fit with only one antigen (uniform). The immune military keeps a supply of millions and possibly billions of different antibodies stockpiled for any foreign invader. Millions of new B cells are constantly in production in the military war (immune) system. Approximately 50 million B cells circulate in a teaspoonful of human blood and almost every B cell—through random genetic shuffling – produces a unique missile (antibody) that it displays on its surface.

When these B cells encounter their matching enemy (microbial antigen), they are stimulated to divide into many larger cells, called plasma cells, which secrete significant quantities of antibodies to bind to the microbe.[5] As you can see, the human military is on a constant state of alert and production of fighters!

Antibody Missiles on the Attack

The antibody missiles secreted by B cells patrol the human body and attack the enemy microbes that have not yet infected healthy cells, but are lurking in the blood or the spaces between cells. When antibodies target and stick to a microbe's uniform, it becomes coated and is unable to function. Antibodies then signal other macrophages and other defensive cells to come destroy (eat) the enemy microbe. Antibodies also work with other defensive molecules that circulate in the blood, called complement proteins, to destroy microbes.[5] Interferon is another unit of our military immune system that works in concert with lymphocytes to target viruses. The work of B cells is called the humoral immune response, or simply the antibody response.[5] One can think of the B cell calvalry is taking care of the external spaces in the body (extracellular defense) while the T cell calvalry is responsible for targeting infected cells (intracellular defense). The goal of most vaccines is to stimulate this response.

Military Memory and Natural Immunity

When our calvalry (T cells and antibodies) begin to eliminate the enemy microbe faster than it can reproduce, the military immune system will gain the "higher ground" and begin to win the war. Gradually, the virus (or other enemy microbe) disappears from the body. After the body eliminates the disease, some microbe-fighting B cells and T cells will convert into memory cells.[4,5] These memory cells can quickly divide into plasma cells (memory B cells) and make more antibody if needed or into memory T cells that can divide and grow into a microbe-fighting army. If re-exposure to the infectious enemy microbe occurs, the immune system will quickly recognize how to stop the foreign attack, preventing the infection before it begins. We can think of these memory cells as "military units" that have information about past wars and invasions. Remember, "An ounce of prevention…."

So, how do Vaccines Mimic a True Foreign Invader?[4,5]

Vaccines teach the immune system by mimicking a natural enemy (microbe infection). For example, the influenza (flu) vaccine contains weakened forms of the virus that does not cause disease or reproduce very well.[4] The 2017 flu vaccine is available in both trivalent (IIV3 – two A and one B virus) and quadrivalent (IIV4 – two A and two B viruses) forms. Influenza viruses come in different "strains" or types of enemies.[6] Type A flu viruses are said to be pandemic (global). Type B flu viruses are said to be epidemic (in certain regions), and Type C flu viruses are non-clinical (not of human significance).[6]

Human macrophages (military front line units) cannot tell that the vaccine viruses are weakened, so they engulf the viruses as if they were dangerous. In the lymph nodes (command posts), the macrophages present influenza antigen(s) to the calvalry, T cells and B cells. A response from flu-specific T cells is activated. B cells secrete flu antibodies. The weakened viruses in the vaccine are quickly eliminated. Most importantly, memory T and B cells are created for future protection against flu.[6]

#VaccinesWork

Vaccines are like a military training exercise for the immune system. They prepare the body to fight disease without exposing it to disease symptoms (true war). When foreign invaders such as bacteria or viruses (like flu) enter the body, immune cells called lymphocytes respond by producing antibodies, which are protein molecules. These antibodies fight the invader known as an antigen and protect against further infection. According to the Centers for Disease Control and Prevention (CDC), a healthy individual can produce millions of antibodies a day, fighting infection so efficiently that people never even know they were exposed to an antigen.[1]

Unfortunately, in a first encounter, it can take several days to ramp up this antibody response. For truly dangerous or life threatening enemies like the measles virus or whooping cough bacteria, a few days is too long. The infection can spread and kill the person before the immune system can fight back.[2] This is where vaccines become so important to not only your own health but also the health of a community.

Vaccines Also Work On A Community Level

Vaccines also work on a community level. Some people may not be able to get a vaccine; either because they are too young, or because their immune systems are too weak, according to the CDC.[1] However, if everyone around them is vaccinated, unvaccinated people are protected by something called herd immunity.[1,5] In other words, they are unlikely to come in contact with the microbe (disease), so they are unlikely to get sick. When it comes to vaccines, following the crowd can save lives. Can vaccines carry risk? Of course, they can as with any medical intervention. However, research and practical sense has shown repeatedly the benefit far outweighs the risk in most instances.

While it is difficult to predict how bad of a flu season the U.S. will experience this year, I and other experts are concerned about the upcoming 2017-18 flu season. Presently Australia, Hong Kong, and other areas of the Southern Hemisphere have experienced terrible influenza seasons.[6,7] Viruses, especially RNA viruses like the influenza virus, are diabolical in their ability to recombine and modify their genetic makeup. This incredible and rapid adaptation is why we need annual flu vaccines. Unlike some DNA microbes which are more stable genetically, RNA microbes like flu are very nasty in their ability to mutate faster than we can create vaccines sometimes. The flu strain that caused so much havoc three years ago, known as H3N2, has recreated subtypes of itself again making us worry about this season. In other words, those camouflage foreign coats that microbes like to put on to hide from our military immune system are changing into several new camouflage outfits this year.[6,7] That could be bad news if you are not vaccinated!

#HealthLiteracy and #ScienceCommunication are critical in helping the public, as well as those of us in academia, industry, and healthcare to begin to get back to the basics of why it is so important to vaccinate. I hope you will join in our efforts to prevent these and other deadly infections by rolling up your sleeves and protecting not only yourself, but those around you. Help us to spread the message that #VaccinesWork.[3]

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