Vaccines: A Shot Worth Taking

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Vaccine providers contribute to what is recognized as one of the greatest public health achievements of the 20th century—immunization. The vaccines given as part of the routine childhood immunization schedule have led to a nearly 99% reduction in what were once very high burdens of disease and illness. Annually, there were 900 cases of diphtheria in Canada with a 10% case fatality rate due to:

- suffocation,
- heart failure
- kidney failure, or
- paralysis.

Whooping cough alone killed five children out of every 1000 children born, before they could celebrate their fifth birthday. Measles infected virtually everyone before the age of 18, with 300,000 cases a year in Canada, resulting in:

- 5000 hospital admissions,
- 400 cases of encephalitis and
- several hundred deaths.

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Tetanus was responsible for 40 deaths to 60 deaths every year in Canada. Paralytic polio wreaked havoc in the 1950s with summer outbreaks that led to widespread limitations on social gatherings and continues to cause problems today for the survivors who have developed symptomatic post-polio illnesses.

In the face of these achievements, the growth of anti-vaccine movements, as well as ambivalence towards immunization—expressed not only by the general public, but also by health care providers—seems surprising, if not downright shocking. Perhaps, it should not be so surprising since anti-vaccine movements have existed for as long as there have been vaccines. Further, it is inevitable that as disease burdens drop and literally fade from public memory, issues related to the safety of vaccines become paramount. Finally it must be acknowledged that education for the knowledge, attitudes and skills required to conduct or inform about immunization have been less than adequate for many years. Yet, the opinions of healthcare professionals—whether or not they are vaccine providers—carry great weight for individuals deciding on whether or not to immunize themselves or their children.

Immunization can be viewed as a social contract in which healthy individuals are asked to accept an intrusion of their body for societal good, with no absolute guarantee of either personal benefit or freedom from harm. It is appropriate to point out that vaccines are neither entirely effective, nor completely safe; while at the same time comparing the risks related to the vaccine to those of the disease the

Table 1

Comparing the risks of vaccines vs. vaccine-preventable infections*

Pathogen	Complication	Vaccine	Vaccine-preventable disease
B. pertussis (whooping cough)	Death	Nil	1% case fatality rate among infants < 6 months
Measles	Encephalitis	1 case/ million immunized	1 case/1000 infections
Mumps	Viral meningitis	1 case/800,000 doses	1 case/20 infections
Rubella	Congenital rubella syndrome	0 of > 1000 infants born to mothers who were immunized during the first two months of pregnancy**	85% if the mother is infected during the first 10 weeks of pregnancy
C. tetani (tetanus)	Death	Nil	10% case fatality rate

* These are examples and are not meant to be exhaustive. The information presented in this table has been taken from the *Canadian Immunization Guide* and/or *Your Child's Best Shot* (see recommended reading)

** Note that vaccine is contraindicated in pregnancy

B. pertussis: *Bordella pertussis*

C. tetani: *Clostridium tetani*

vaccine is meant to prevent. The vaccine is virtually always the best alternative, with limited exceptions, such as:

- a prior episode of anaphylaxis to one of the vaccine components,
- contraindication against live vaccines for use in immunocompromised individuals, or
- pregnant individuals.

Still it is important to provide accurate information on what to expect and what to do should an adverse event follow immunization. The Canadian Paediatric Society's publication entitled: *Your Child's Best Shot*, as well as the *Canadian Immunization Guide* are both excellent resources that provide much of the needed information for each recommended vaccine.

Myth-understandings

Misperceptions abound regarding immunization. Most of these can be readily dispelled, but a word of caution: the myths may be more memorable than the arguments used to dispel them. Thus, in the discussion that follows, the focus is on fact, not myth.

Vaccine-preventable diseases

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Vaccine preventable diseases have been largely forgotten, but are definitely not gone!

An often repeated misperception is that vaccine-preventable diseases have been virtually wiped out, thanks to immunization as well as social advances, such as improved hygiene and so there's no need to continue immunizing. Without question, immunization has dramatically reduced the occurrence of vaccine-preventable infections, but the pathogens that cause them are not gone. The following diseases are caused by highly contagious, well adapted human pathogens that still have active reservoirs in the world:

- dipththeria,
- whooping cough,
- polio,
- measles,
- mumps,
- rubella and
- chickenpox.

Unlike finding the needle in the haystack, these pathogens are extremely efficient at finding the susceptible human among a population of mostly immune individuals. *Clostridium tetani*, the bacterium that causes tetanus, is a soil organism and will never be eliminated. The preventable causes of bacterial meningitis are successful colonizers of the human nasopharyngeal mucosa. These preventable causes are:

- *Haemophilus influenzae* type B,
- *Streptococcus pneumoniae* and
- *Neisseria meningitidis*.

While the conjugate polysaccharide vaccines have been successful in reducing colonization, it is unlikely that these pathogens will ever be entirely eradicated from the human population.

There are many examples of outbreaks of vaccine-preventable diseases among unimmunized, or poorly immunized, subgroups living within a larger, well immunized population.

Wherever vaccine coverage has dropped significantly, the diseases have returned. One of the most dramatic examples is in Japan where there were > 100,000 cases of whooping cough disease annually before the whole-cell pertussis vaccine was introduced in the 1950s. With vaccine coverage rates of around 90% by the early 1970s, there were only 200 cases to 400 cases of whooping cough detected each year. In 1975, confidence in immunization was significantly reduced when the program was temporarily suspended for two months, while two infant deaths temporally associated with the pertussis vaccine were investigated. Though it was concluded that the deaths were not caused by the vaccine, public concern resulted in plummeting vaccine coverage rates down to 40%. In 1976 and 1979 two major outbreaks of whooping cough occurred exceeding 13,000 cases and > 100 deaths. An acellular pertussis vaccine was first developed in Japan and since its introduction, coverage has again risen and the rate of whooping cough is back down to what it was prior to the 1975 crisis. There are many examples of outbreaks of vaccine-preventable diseases among unimmunized, or poorly immunized subgroups living within a larger well immunized population.

Examples of these include:

- a diphtheria outbreak in Russia following the soviet breakup (1991),
- a measles outbreak in Holland (1998),
- a rubella outbreak in Ontario (2004) and
- an outbreak of the mumps in the US (2006).

Vaccine-induced immunity

Vaccine-induced immunity is effective and far safer than relying on natural disease induced immunity. The perception that natural is better than unnatural is inherent in the way people perceive risk. It is true that the immunity following natural infection with measles, varicella, pertussis and several other vaccine-preventable diseases is stronger and longer-lasting than that induced by a vaccine. However, there is a major price to pay for that immunity. The immune response takes days to weeks to develop, usually well after the disease has run its course—a course, which may include serious complications, permanent disability and death. Table 1 compares and contrasts the frequency of selected complications following disease as opposed to vaccine for several vaccine-preventable infections. In every case, vaccine is clearly a safer alternative than infection. The weaker immune response induced by the vaccine, as opposed to natural infection is, in part, related to how the vaccine is made and is reflected in the recommended immunization schedule. Live attenuated vaccines, such as measles, mumps, rubella (MMR) and varicella have been deliberately weakened so they are less virulent than natural infection. Despite this, the immune response is generally very good and long-lasting. Nevertheless, 5% to 10% of vaccinees may not respond to a single dose and this is why a second dose of the MMR vaccine has become part of the child immunization schedule. Whether or not this will be necessary for varicella is yet to be determined in Canada. Subunit vaccines contain purified or artificially made antigens chosen because they induce a protective immune response against the natural infection. These vaccines include:

- acellular pertussis,
- diphtheria,
- tetanus,
- Hepatitis B and
- all the vaccines to prevent:
  - *pneumococcal*,
  - *meningococcal* and
  - *Haemophilus influenzae* type B meningitis.

Repeated doses of such vaccines are required to induce an initial immune response and in some cases booster doses are required as well.

Inactivated whole organism vaccines such as influenza and Hepatitis A contain more of the antigenic content of the natural organism and as a result are often closer in immunogenicity to the natural pathogen.

Vaccines are a healthy lifestyle choice and they complement other healthy lifestyle choices, such as:

- breastfeeding,
- good hygiene and
- proper nutrition.

A corollary of the perception that natural is better is that healthy lifestyle alternatives, including breastfeeding, good hygiene and proper nutrition, are alternatives to vaccines. In reality, these should all be seen together as choices for health, as opposed to disease. Breastfeeding provides protection against a number of viral causes of respiratory and GI infection during a child's most vulnerable period. However, the protection is incomplete and temporary. Good nutrition and hygiene are clearly important, but they also do not provide specific protection against vaccine-preventable pathogens. Diseases such as measles, whooping cough, diphtheria and bacterial meningitis

occurred among rich and poor, well-nourished and malnourished alike. In essence, vaccines train the immune system to recognize foreign invaders before they cause damage. As such, they provide specific protection that complements other healthy life choices.

Vaccines as a defense against infectious pathogens

Vaccines engage and stimulate the immune system to provide a lasting defense against infectious pathogens. The concepts that the immune system can be weakened or overwhelmed by vaccines are simply erroneous. In fact, the immune system has an enormous capacity to respond, even in infancy. The routine immunizations given to infants in the first year of life, engage, as opposed to use up, a minute fraction of that capacity. The article by Offit, *et al* clearly explains the concepts and principles related to this fact.

Vaccine effectiveness

In highly immunized populations, most people who get vaccine-preventable infections will have been immunized, but that does not mean the vaccines don't work! The above statement seems counterintuitive, but it is usually true. The best way to understand is to use a theoretical example and do the math. Imagine a grade school somewhere in Canada with 1000 pupils during the time when only a single dose of MMR was given routinely. Immunization coverage is 95% in the community, meaning that 50 students have never been immunized and are susceptible. Of the 950 who have been immunized, assume the worst, that the vaccine failed to induce protection in 10% of students; this means that 95 vaccines are susceptible. Measles is highly contagious and conservatively, 50% of those susceptible will be infected. The immunized children make up 66% of those who got measles. Some would suggest this means the vaccine doesn't work, but they ignore the fact that only 48 of 950 exposed vaccinees developed measles giving an attack rate of 5%. The correct conclusion from this example is that the vaccine was 90% effective in preventing measles, in that it reduced the attack rate from the expected 50% down to 5%! Communities differ in terms of immunization coverage rates, vaccines differ in terms of the completeness and duration of protection and pathogens differ in terms of attack rate. All these must be considered in any actual outbreak before conclusions can be drawn regarding vaccine effectiveness.

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Suggested reading

1. Dittman S: Vaccine safety: Risk communication: A global perspective. Vaccine 2001; 19 (17-19): 2446-56.
2. Gold R: *Your Child's Best Shot: A parent's guide to vaccination.* Second Edition. Canadian Paediatric Society, 2002.
3. Halperin SA: How to manage parents unsure about immunization. CJCME 2000; 12(1):62-75.
4. *National Advisory Committee on Immunization: Canadian Immunization Guide.* Sixth Edition. Canadian Medical Association 2002.
5. Offit PA, Quarles J, Gerber MA, et al: Addressing parents' concerns: Do multiple vaccines overwhelm or weaken the infant's immune system? Pediatrics 2002; 109(3):124-9.
6. Wolfe RM, Sharp LK: Anti-vaccinationists past and present. BMJ 2002(7361):430-2.

Recommended websites

1. Canadian Coalition for Immunization Awareness and Promotion http://www.immunize.cpha.ca.
2. Canadian Paediatric Society http://www.cps.ca.
3. Public Health Agency of Canada http://www.phac-aspc.gc.ca/im/index.html.
4. World Health Organization http://www.who.int/topics/vaccines/en/.