Immunizations and the immune system

Q: Do vaccines overwhelm the immune system?
A: Studies on the diversity of antibody specificities indicate that the immune system has the capacity to respond to extremely large numbers of immunologically distinct regions of viruses and bacteria. Current data suggest that the theoretical capacity determined by the genes that make different antibodies would allow for as many as 10^{9}-10^{11} different kinds of antibodies (i.e., 1 billion to 100 billion). But this theoretical capacity is limited by the number of circulating antibody-producing cells (B cells or lymphocytes) and the likely redundancy of antibodies generated by one 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. Assuming the quantities of antibodies likely generated by an individual in 1 ml of blood (one-fifth of a teaspoon) during seven days after exposure to a vaccine, and the number of different specificities of those antibodies, then each infant would have the capacity to respond to about 10,000 vaccines at any one time. Using this estimate, one would predict that if 11 vaccines were given to infants at one time, then about 0.1 percent of the immune system would be “used up.”

However, because B cells and other lymphocytes are constantly replenished, a vaccine never really “uses up” a fraction of the immune system. For example, the immune system has the ability to replenish about 2 billion lymphocytes each day. This replacement activity illustrates the enormous capacity of the immune system to generate lymphocytes as needed.

Parents may also take comfort in knowing that children are exposed to fewer immunologic components (like proteins and sugars [polysaccharides]) in vaccines today than in the past. The table below summarizes the number of proteins and polysaccharides contained in routinely recommended vaccines administered over the past 100 years. Although we now give children more vaccines, the actual number of immunologic components in vaccines has declined. Whereas previously one vaccine, smallpox, contained about 200 proteins, now the 11 routinely recommended vaccines contain fewer than 130 immunologic components (i.e., proteins or polysaccharides). 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 (e.g. replacement of whole-cell with acellular pertussis vaccine).

Number of immunogenic proteins or sugars (polysaccharides) contained in vaccines over the past 100 years

Date	Vaccine	Proteins/Sugars	Totals
1900	Smallpox	~200	~200
2000	Diphtheria	1	123-126
	Tetanus	1	
	Acellualar pertussis	2-5	
	Polio	15	
	Measles	10	
	Mumps	9	
	Rubella	5	
	Hib	2	
	Varicella	69	
	Pneumococcus	8	
	Hepatitis B	1	

Offit PA, et al. Addressing parents' concerns: Do vaccines weaken or overwhelm the infant's immune system? *Pediatrics* 2002;109:124-129.

Q: Do vaccines weaken the immune system?
A: Vaccinated children are not at greater risk of other infections (infections not prevented by the vaccines) than unvaccinated children. On the contrary, in Germany, a study of 496 vaccinated and unvaccinated children found that children who received immunizations against diphtheria, pertussis, tetanus, *Haemophilus influenzae* type b (Hib) and polio within the first three months of life had fewer infections with vaccine-related and unrelated pathogens than the non-vaccinated group.

Bacterial and viral infections, on the other hand, often predispose children and adults to severe, invasive infections with other pathogens. For example, children with pneumococcal pneumonia are more likely to have had a recent influenza infection than other children. Similarly, varicella infection increases susceptibility to the 'flesh-eating bacteria (i.e., group A strep).

References

Black SB, Cherry JD, Shinefield HR, et al. Apparent decreased risk of invasive bacterial disease after heterologous childhood immunization. *Am J Dis Child* 1991;145:746-749.

Davidson M, Letson W, Ward JI, et al. DTP immunization and susceptibility to infectious diseases. Is there a relationship? *Am J Dis Child* 1991;145:750-754.

Otto S, Mahner B, Kadow I, et al. General non-specific morbidity is reduced after vaccination within the third month of life – the Greifswald study. *J Infect* 2000;41:172-175.

Storsaeter J, Olin P, Renemar B, et al. Mortality and morbidity from invasive bacterial infections during a clinical trial of acellular pertussis vaccines in Sweden. *Pediatr Infect Dis J* 1988;7:637-645.

Q: Can children who are sick receive vaccines?

A: Some parents may be concerned that children with acute illnesses are less likely to respond to vaccines or are more likely to develop severe reactions to vaccines than are healthy children. Alternatively, some parents may believe that children who are ill shouldn't further burden an immune system already committed to fighting an infection. However, vaccine-specific antibody responses and rates of vaccine-associated adverse reactions of children with mild or moderate illnesses are comparable to those of healthy children. For example, the presence of upper respiratory tract infections, ear infections, fever, skin infections or diarrhea does not affect the level of protective antibodies induced by immunization.

Data on the capacity of vaccines to induce protective immune responses in children with severe infections (such as those with bacterial pneumonia or meningitis) are lacking. Although a delay in vaccines is recommended for children with severe illnesses until the symptoms of illness resolve, this recommendation is not based on the likelihood that the child will have an inadequate immune response to the vaccine. Rather, the reason for deferring immunization is to avoid superimposing a reaction to the vaccine on the underlying illness or to mistakenly attribute a manifestation of the underlying illness to the vaccine.

References

Dennehy PH, Saracen CL, Peter G. Seroconversion rates to combined measles-mumps-rubella-varicella vaccine of children with upper respiratory tract infection. *Pediatrics* 1994;94:514-516.

Halsey NA, Boulos R, Mode F, et al. Response to measles vaccine in Haitian infants 6 to 12 months old: influence of maternal antibodies, malnutrition, and concurrent illness. *N Engl J Med* 1985;313:544-549.

King GE, Markowitz LE, Heath J, et al. Antibody response to measles-mumps-rubella vaccine of children with mild illness at the time of vaccination. *JAMA* 1996;275:704-707.

Ndikuyeze A, Munoz A, Stewart J, et al. Immunogenicity and safety of measles vaccine in ill African children. *Int J Epidemiol* 1988;17:448-455.

Ratnam S, West R, Gadag V. Measles and rubella antibody response after measles-mumps-rubella vaccination in children with afebrile upper respiratory tract infection. *J Pediatr* 1995;127:432-434.


The Children's Hospital of Philadelphia®
A pediatric healthcare network

www.chop.edu