The role of vaccination in global health

Past, present, and future

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ABSTRACT

Perhaps the greatest medical advancement in history was the development of the vaccine. While previously helpless to stop the spread of deadly infectious diseases, humanity has since harnessed the power of vaccination and decreased the incidence of infectious disease across the globe. Smallpox was the first disease to be eradicated—the greatest of our triumphs. This success was due to the global coordinated effort of the Intensified Smallpox Eradication Program. Presently, measles is the top cause of vaccine-preventable death in the world, and despite enormous vaccination efforts, eradication is still distant. This is due in part to the antivaccination movement, which was fueled by an article by Wakefield, published in the *Lancet* in 1998. The future of vaccination is an ambitious and unclear one—with tremendous financial support and involvement, the Global Vaccine Action Plan (GVAP) aims to eliminate vaccine preventable illness within what they call the “Decade of Vaccines”.

PAST: SMALLPOX

The most illustrative example of the power of vaccination to alter disease prevalence around the world is undoubtedly the eradication of smallpox. The earliest signs of smallpox were found in mummified Egyptian remains approximately 3000 years old. It existed throughout China and India, was established in Europe during the Crusades, and was spread to the Caribbean and Americas following European colonization.¹

Smallpox was an exclusively human disease (there is no animal reservoir, nor does it exist in the environment), meaning that in order to propagate, the disease had to be transferred between human hosts; this factor made the disease amenable to eradication.¹ Nonetheless, in its time, smallpox was a disease of historical significance. By the end of the 18th century, smallpox had killed approximately 400 000 people each year in Europe—notably, 5 monarchs—and caused one-third of all blindness. During the 20th century, about 500 million people died from smallpox worldwide, particularly as a result of large epidemics in Asia, Africa, and South America.^{2,3}

While Dr Edward Jenner is commonly considered the father of vaccination, his smallpox vaccine was pre-dated by the practice of variolation, in which susceptible individuals had their skin scratched and the scratches inoculated with material from smallpox lesions. Variolation resulted in mortality in about 2% of cases (lower than the rate of natural infection) and was practiced throughout Asia and Africa for centuries. In 1796, Jenner began inoculating susceptible individuals with cowpox as a vaccine for smallpox—he called his inoculum *variole vaccine* (from the Latin, *vacca*, for “cow”), a term which was redefined by Louis Pasteur to mean any protective inoculation. While these early attempts slowed the disease, they were not responsible for its eradication.²

The true potential for vaccination was fully realized with the Intensified Smallpox Eradication Program, initiated in 1967 after the success of mass vaccination in Western Europe, North America, Japan, and several other developed nations. In 1964, the World Health Organization (WHO) recommended vaccination of 100% of the population, and in 1966 the WHO allocated US \$2.4 million from their budget to carry out this recommendation. Several breakthroughs proved key to the successful eradication of the disease, including the development of the quality-controlled, heat-stable, freeze-dried vaccine, and its highly efficient partner, the bifurcated needle, both of which enhanced the delivery, efficiency, and cost-effectiveness of the vaccine. Specific surveillance strategies were developed to help detect and report smallpox; this was particularly critical for eradication in endemic areas with poor health services since it allowed outbreaks to be rapidly identified and isolated.⁴

In 1977, the last naturally occurring case of smallpox was found in Somalia. Two years later, the WHO declared worldwide eradication of smallpox on December 9, 1979. As a result of global eradication—which cost US \$300 million—US \$1 billion are saved annually.⁴

More than a lesson in history, the eradication of smallpox can act as proof of the power of vaccination to save both lives and money, and its tale offers many lessons that can be applied to current and future diseases.

PRESENT: MEASLES

Measles is among the top causes of death in developing nations, and is the top vaccine-preventable killer with a death toll around 138 000 in 2010.⁵ The WHO reports that it is moving towards eradication of the disease less aggressively than with the eradication of smallpox; in 2010, the WHO agreed on a target of 95% reduction in measles mortality by 2015 as the next step towards its eventual eradication.⁶ Indeed the prevalence of measles has been drastically reduced since the release of the vaccine; while previously 3 to 4 million people in the United States were infected each year, and 400 to 500 died, as of 2012, only 55 cases of measles were reported in the United States. This represents a greater than 99% reduction, but unfortunately is not typical of all countries. In underdeveloped nations, where health care is poor, vaccine coverage for measles was approximately 15% lower than developed nations in 2010.⁷⁻⁹ Thus, successful eradication and control of disease is dependent on the addressing of logistical needs specific to underdeveloped areas. The WHO has some strategies for overcoming this lack of coverage, such as the incorporation of vaccine programmes focused on eradication into national health programmes.⁶

A major setback in the battle against measles has been the recent antimeasles vaccine movement in developed countries. This controversy began initially in 1998 with the publication in the *Lancet*

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of research that demonstrated a link between the measles, mumps, and rubella (MMR) vaccine and gastrointestinal disease and developmental regression (notably autism spectrum disorder) in children.¹⁰ This article sparked uproar in the medical community, with numerous editorials appearing in the *Lancet* and several independent investigations looking at the methods and circumstances surrounding the research. The article was partially retracted in 2004 and completely retracted in 2010 by the *Lancet*, due to proof and admissions by some of the authors that the research was fraudulent.¹¹ An investigative journalist, Brian Deer, discovered undeclared conflicts of interest, manipulation and fabrication of evidence, and the violation of several ethical codes on the part of the primary author, Andrew Wakefield, resulting in the loss of his license to practice medicine in the United Kingdom.¹²⁻¹⁴ Despite the retraction of the article and the exposure of Wakefield's research as fraudulent, there were immediate population consequences of underimmunization. For example, between December 1999 and July 2000, an outbreak of measles occurred in Ireland, resulting in 111 hospitalized children and 3 deaths; this outbreak was the result of suboptimal (< 70%) vaccination following the Wakefield article.¹⁵

Even now, the antivaccination movement challenges the MMR and other vaccines, threatening eradication efforts being undertaken worldwide. One reason the movement is still alive is due to the work of semicelebrity figureheads, such as Jenny McCarthy, an American model, and Jim Carrey, a Canadian actor, who garner media attention for the cause through outlets such as Oprah, Larry King Live, and Good Morning America.¹⁶ In fact, Jenny McCarthy has stimulated the American antivaccination movement to such an extent that an online counter was made at jennymccarthybodycount.com to record approximately how many preventable illnesses and deaths resulted from her endorsement of the movement.¹⁷ Aside from following the advice of these figureheads, parents give many reasons for refusing vaccination, including religious objection, complementary or alternative medicine preference, doubts about vaccine safety, and personal ignorance.¹⁸ Ultimately, to win the battle against measles and other vaccine preventable illnesses both at home and abroad, public trust in vaccination must be re-established.

FUTURE: GLOBAL VACCINE ACTION PLAN (GVAP)

In May 2012, the World Health Assembly developed a framework meant to provide "immunization to all people, regardless of where they are born, who they are, or where they live." This was the Global Vaccine Action Plan (GVAP), a vaccination strategy for global health that receives major contributions from the WHO, the US National Institute of Allergies and Infectious Diseases, the United Nations Children's Fund (UNICEF), and the GAVI Alliance (formerly the Global Alliance for Vaccines and Immunization), a branch of the Bill & Melinda Gates Foundation. This plan sets a deadline of 2020—the end of the Decade of Vaccines.¹⁹ The goal is to eliminate vaccine preventable illness within the decade.²⁰ The GVAP embraces 6 strategic objectives:

1. All countries commit to immunization as a priority: this requires countries to pass legislation providing a budget for immunization, monitoring, and reporting, and to set specific

morbidity and mortality reduction targets. It also asks that countries continue to act as immunization advocates for their own populations, and for other countries.

2. Individuals and communities understand the value of vaccines and demand immunization as both their right and responsibility: this asks countries to promote vaccination through education, and to create incentives for households and health workers to receive immunizations. It emphasizes particularly the need for professionals trained to address vaccine hesitancy and respond to reports of adverse events in order to maintain public trust of vaccines.
3. The benefits of immunization are equitably extended to all people: this asks countries to reach out to underserved or marginalized groups, and to develop immunization strategies specifically tailored to the needs of each particular group. It encourages the use of existing health care systems and professionals to track individual immunization histories, and aims to develop new approaches to engage urban and peri-urban areas.
4. Strong immunization systems are an integral part of a well-functioning health system: this asks countries to focus on eradication, elimination and integration of immunization into existing national health programs. It also encourages the improvement of monitoring and surveillance systems through better data collection and analysis, and of the availability and reliability of vaccines through increased cold storage capacity.
5. Immunization programmes have sustainable access to predictable funding, quality supply, and innovative technologies: this seeks to increase funding toward immunization, especially in low- and middle-income countries, and to increase the affordability of vaccination.
6. Country, regional, and global research and development innovations maximize the benefits of immunization: this encourages the development of vaccine innovations such as nonsyringe delivery, thermostable vaccines, and more affordable manufacturing facilities, and also research into fundamental knowledge about vaccine-preventable illnesses, including epidemiology, behavior in the body, and response to vaccination efforts.²¹

The GVAP is the largest concerted effort to immunize the world's population against vaccine preventable diseases. Though these efforts are well underway, whether or not the goal of the Decade of Vaccines will be reached remains unclear. With 6 years remaining, anything could happen. Learning from our previous successes with smallpox, vaccine preventable diseases can surely be made obsolete. Though it may require dedication, innovation, and education in equal measure, the demise of vaccine preventable diseases is on the horizon.

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