

Lessons from the eradication campaigns

D.A. Henderson

The John Hopkins School of Hygiene and Public Health, Candler Building, Suite 850, 111 Market Place, Baltimore, Maryland, 21202, USA

Abstract

Of seven global eradication programs this century, only two have relied primarily on vaccines for control measures — those against smallpox and poliomyelitis. Smallpox is history and polio could possibly achieve a similar status within the next decade. The hallmarks of these successful programs were surveillance and community outreach and involvement. However, a research agenda, so crucial to smallpox eradication, has largely been ignored or dismissed by polio program managers. This could prove to be a serious, even fatal error. © 1999 Elsevier Science Ltd. All rights reserved.

1. Introduction

The historical record is clear that no medical intervention comes close to being so important to the present health of mankind as does disease control through vaccination. The ultimate expression of disease control is eradication and one might have expected vaccines to have played a major role in the great eradication campaigns but, until smallpox eradication, they did not.

Many have forgotten that there have been, so far, seven international eradication programs launched during the 20th century. They played important roles in defining international health agendas but until the campaign against smallpox, all had proved disappointing, leaving little as a legacy [1] despite the expenditure of enormous energy and funds. The first, a global campaign against hookworm, mounted by the Rockefeller Sanitary Commission in 1909, eventually extended across 52 countries on six continents and to 29 island groups [2]. It relied primarily on the treatment of patients and the provision of sanitary facilities. It was scientifically unrealistic and eventually had to be abandoned. It was followed by more than 50 years of eradication campaigns which relied primarily on vector control measures, programs designed to eradicate yellow fever and then malaria. The programs proved to be extraordinarily difficult to implement; they were extremely costly and eventually they had to be aban-

doned. The most extensive program of all was that for malaria which, over 15 years, commanded more than two thousand million dollars. One further program was mounted, that for yaws [3], which relied on patient treatment with penicillin and that too failed.

Not until smallpox eradication was there an eradication campaign based on the use of a vaccine rather than on vector control or drug treatment. This is puzzling because vaccines represent the optimal intervention for disease control. Programs that require treatment necessitate that individual patients be seen when ill and drugs administered. Logistically, this is a serious barrier. Moreover, even for a single treatment, drugs are almost invariably more expensive than vaccines. Thus, past eradication programs for hookworm and yaws fared badly. Efforts today to effectively control diseases such as leprosy or tuberculosis would be vastly simpler and far more efficacious were a vaccine available. Likewise, disease campaigns which have relied on vector control, such as yellow fever and malaria, have had to be abandoned altogether because of costs and the practical problems of implementation.

Of the two vaccine-based programs, smallpox was declared eradicated in 1980; polio was banished from the Americas some 7 years ago [4] and similar successes have now been registered in Europe and Eastern Asia as well as in northern and southern Africa [5]. It is also worth noting that with measles vaccine, it has been possible to interrupt transmission in many

countries of the Americas [5] as well as in the United Kingdom. Unfortunately, the high transmissibility of measles and the frequency of importations through travel make eradication, as yet, an uncertain proposition. Measles is, however, the next likely candidate for eradication should polio eradication succeed. If the measles vaccine could be administered successfully at, or soon after, birth, the possibility of eradication would be greatly heightened. For reasons I shall describe, it is unlikely that such an improved vaccine will be developed.

Successes in eradication only demonstrate the intuitively obvious — that an ounce of vaccine prevention is worth far more than a pound of control measures provided through drugs or vector abatement programs. One can only wonder why we have so far expended so little either in money or effort in developing vaccines for the three major global disease problems today — HIV, malaria and tuberculosis.

2. Strategy

The successful eradication programs have embraced a two-part strategy — a population-wide vaccination campaign and a disease surveillance program [1]. Principles for the application of each of these strategies evolved during the course of the smallpox, polio and measles campaigns. Three important themes deserve to be highlighted: vaccine delivery, surveillance and research.

Special programs to achieve high levels of vaccination-induced immunity in the population are necessary to diminish the kinetics of transmission so as to facilitate the interruption of chains of infection. Originally, expectations that satisfactory immunisation levels could be achieved without special efforts, simply by routine distribution of vaccines at hospitals, health centres and clinics proved almost universally disappointing. In developing countries, such an approach seldom achieved immunisation levels higher than 60%, however much community health education was conducted. Such vaccine as was administered at these sites was often improperly stored and vaccination techniques often left much to be desired. Even in the industrialised countries, special efforts were needed to achieve truly satisfactory, high levels of vaccination coverage. In Britain, for example, financial inducements were provided to practitioners who vaccinated more than 90% of those registered with them. In the United States, vaccination has been made compulsory for those in day care and at the time the child enters school. Even with these provisions, substantial special efforts have been required to persuade physicians, and even parents, of the need for and importance of vaccination. The simple fact is that preventive medicine,

even today, remains a subject of comparatively low priority for most physicians and health care institutions that normally provide curative services.

In developing countries, it became clear in the eradication campaigns that when the active participation of community leaders and the community itself was sought; when vaccine was provided at a convenient time and place; and when it was apparent to all that the program enjoyed widespread popular support, vaccination levels of 90% and higher were readily achieved. Moreover, it was possible to assure with greater certainty during special campaigns that the vaccine was properly refrigerated up to the time of administration, wastage was far less and the vaccination technique could be more closely monitored. Eventually, many of the vaccination campaigns were to mature as annual or semi-annual vaccination days in many countries around the world.

A special bonus, deriving from the widespread application of vaccine over a very short period of time, was, frequently, the interruption of transmission of the circulating wild viruses, be they poliomyelitis, measles or smallpox. As population immunity surged, at least transiently to very high levels, herd immunity served to interrupt transmission.

The eradication programs were to demonstrate again and again the efficacy of disease surveillance both for monitoring progress in the program and for providing epidemiological data which served to alter program strategy. However logical it would seem to use disease incidence as the ultimate measure of progress in a control program, few do so even today, relying instead on process indicators such as numbers of vaccinations performed. Such, in fact, was the history of smallpox control prior to the launching of the global program in 1967. Surveillance for cases of smallpox was a hallmark of the eradication campaign and surveillance for cases of acute flaccid paralysis (which included poliomyelitis) was a hallmark of the polio eradication program in the Americas [4]. The smallpox program met its goal little more than 10 years after beginning. In little more than 5 years, polio eradication was achieved in the Americas. In contrast, surveillance in the global polio eradication program was generally ignored over most of its first 5 years of existence and, without it, the program stumbled badly. Today the program is in its 11th year and eradication sooner than 5 years hence would require a miraculous effort.

3. Research

Finally, but not least, has been the importance of research to a successful eradication effort, a subject that regrettably is often given short shrift in public

health programs. Attitudes toward research in eradication efforts were characteristically and most explicitly stated at the time of launching of the malaria eradication effort in 1955. Program directors said in so many words, “we have the tools (DDT); we know what need to be done; it is simply a matter of going out and doing it” [6]. The challenge was defined as being, in essence, an administrative problem, not a scientific one. Some 10 to 15 years after the eradication program had begun, as insecticide resistance was increasing, as prescribed techniques failed to work as anticipated, help was sought from malariologists but, as the leadership wistfully noted, the program had done a far better job in eradicating malariologists than malaria. The needed resources were no longer extant.

The nihilistic view of the value of research has continued to predominate in public health circles. At the time of launch of smallpox eradication, senior WHO leadership took a similar view stating: “we have a good vaccine; we can assume that if we vaccinate everyone, the disease will vanish. In brief, it is purely an administrative task of operating an effective global vaccination program.” The simplistic belief that one could ever vaccinate everyone in any community was surprisingly naïve. Resources are such that campaigns inevitably must be frugally operated both with respect to funds and manpower; new born susceptibles are continually entering the population; immunity among those previously vaccinated is waning, and migrants and refugees, difficult to locate and difficult to vaccinate, are a commonplace occurrence in the modern world.

Only because of research efforts conducted during the course of the smallpox program was the achievement of eradication possible. To be noted, in particular, was the discovery and application of a more efficient vaccination device that used 75% less vaccine. The discovery that the epidemiological pattern of spread of smallpox was very different to that described in the textbooks, changed the pace and character of the surveillance effort. The demonstration that vaccine efficacy did not fade over 3–5 years but was 90% at 20 years shifted vaccination goals from vaccinating and

revaccinating everyone to assuring that all had a vaccination scar. The vaccine strains in use were standardised to those that were effective but had the fewest adverse responses; production methods were improved; and vaccine stability heightened. Had these and other findings not been made and incorporated into the program, smallpox would be with us today, of that I am confident.

Research, however, has been, at best, a largely ignored effort on the agenda of WHO’s Expanded Program on Immunisation, the follow-on effort after smallpox eradication. Indeed, the polio program, in an extraordinary act of ignorance, deliberately scrapped its limited but promising efforts to develop an improved vaccine. In consequence, we are today still labouring with the same old oral polio vaccine that was licensed 35 years ago. It is a vaccine that is far from sufficiently antigenic for use in third world countries and so heat labile as to require refrigeration wherever it goes. However, it must be noted that none of the vaccines in common use today are fully satisfactory and yet, research has been effectively nil, for most, since the time of licensure. I believe this is a poignant message for all of us, scientists and program managers alike, both in the public and private sector. Without a substantially greater investment in research, the promise of vaccination will never be realised.

References

- [1] Fenner F, Henderson DA, Arita I, Jezek Z, Ladnyi ID. Smallpox and its Eradication. Geneva: World Health Organization, 1988.
- [2] Fosdick RM. The story of the Rockefeller Foundation. New York: Harper and Brothers, 1952.
- [3] Guthe T. The treponematoses as a world problem. *British Journal of Venereal Disease* 1960;36:67–77.
- [4] deQuadros D, Henderson DA. Disease eradication and control in the Americas. *Biologicals* 1993;21:335–43.
- [5] World Health Organization. Progress towards global poliomyelitis eradication, 1988–1997. *Weekly Epidemiological Record* 1998;73:161–8.
- [6] Jeffery GM. Malaria control in the twentieth century. *American Journal of Tropical Medicine and Hygiene* 1976;25:361–71.