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# Incorporating Cholera Vaccine Herd Protection into Economic Cost-Benefit and Cost-Effectiveness Models

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**Abstract**

Ignoring the indirect effects of vaccination has led to two types of inaccuracies in cholera vaccine policy analysis in endemic settings. First, when herd protection is ignored, the social benefits and cost-effectiveness of vaccination programs are underestimated, such that the programs are rarely considered to be a wise use of scarce public health resources. Once vaccine herd protection is included, use of the vaccine can satisfy both social welfare objectives and benchmark cost effectiveness criteria. Second, design recommendations to implement programs considered most attractive without accounting for the effect of herd protection may not allow the capture of the greatest social benefits. The analysis summarized in this paper demonstrates that it is possible to account for herd protection in both cost-effectiveness and cost-benefit calculations. In the former case, however, it does pose significant interpretation challenges. When herd protection is incorporated into a cost-effectiveness model, cost-effectiveness measures such as costs per DALY avoided become a function of vaccination coverage. When this is the case, there is no obvious decision objective in a cost-effectiveness analysis. Cost-benefit metrics, on the other hand, provide a clear economic argument for when to pursue vaccination efforts and how to design them. More sophisticated measurements of the economic benefits of vaccination should therefore become standard practice when evaluating the potential of vaccination programs.



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## 1. Introduction

Cholera is an infectious disease caused by exposure to the bacterium *Vibrio cholerae* O1 or O139, resulting in acute dehydration and sometimes death. In 2008 the World Health Organization (WHO) reported more than 190 000 cases worldwide and 5 143 deaths, although these estimates are widely regarded as low due to underreporting [1]. Severe cholera is treatable with intravenous rehydration therapy if the patient is diagnosed promptly and has access to basic health care facilities, but mortality risks in epidemic situations can reach 20 percent and higher [2]. Recent upward trends in WHO-reported cholera cases, the reemergence of cholera in parts of West Africa, and the continuing problem of endemic cholera in East Africa and several parts of Asia have prompted increasing concern over vulnerability to infection of poor populations living in unsanitary conditions.

Most public health experts believe that improved sanitation and hygiene is the best method for controlling cholera. However, such improvements have remained elusive in many locations, as evidenced by the persistence of cholera in many developing countries. Another approach is to combine prevention and preparedness activities. Surveys to determine the economic benefits have been shown to produce very plausible measures of the benefits of vaccination [10-13]. This strategy might involve more widespread use of new, safe, and more effective oral cholera vaccines (OCV), of which four have been licensed in some countries. One of these has been licensed in India following a trial in Kolkata and appears particularly promising because it is inexpensive, relatively easy to administer and can be taken out of cold storage for some time during vaccination campaigns, facilitating delivery [3]. Furthermore, there is evidence that cholera vaccination can result in significant herd protection: diminished risk of infection among non-vaccinees and enhanced protection of vaccinees [4, 5]. In 2009, the WHO began recommending vaccination of children in places where incidence exceeds 1 in a thousand (6), and also stated that “the role of OCVs needs to be further assessed in view of their introduction into areas where they can make a difference” [1].

Arguments over the merit of such programs have typically focused on their low cost-effectiveness. The Disease Control Priorities (DCP) Project ranked cholera immunization for infants with WC/rBS (Dukoral) vaccine, which costs about $6-8 per dose, among the least cost-effective interventions targeting diarrheal disease, with cost effectiveness ratios of US$1 402 to US$8 357 per DALY (disability-adjusted life year) averted [7]. Murray et al. [8] found that vaccination was less cost effective (about $3 000/DALY averted) than several other control strategies, including cholera disease treatment ($10-160/DALY averted) and certain types of water and sanitation improvements ($430/DALY averted). However, recent analyses for the new, low-cost vaccine (which only costs about $1 per dose), show that cost-effectiveness can be much higher, especially when herd protection effects are included [9].

Herd protection however raises new difficulties for policy-makers who would base cholera vaccination program design on cost-effectiveness outcomes. In the presence of herd effects, measures such as average costs per DALY avoided become a function of vaccination coverage, such that there is no obvious decision objective in a cost-effectiveness analysis. For example, choosing a coverage level that minimizes the costs per DALY avoided could result in a very low coverage level; expanding coverage might still save DALYs at low cost. Maximizing the number of DALYs avoided may result in very high marginal costs per DALY avoided if herd protection can reduce disease burden significantly at lower coverage rates.

Cost-benefit metrics, on the other hand, provide a clear economic argument for when to pursue vaccination efforts and how to design them. These measures require careful nonmarket valuation studies of the demand for vaccines within a target population, which can be difficult because the vaccines are not usually available in private markets. Such studies are nonetheless possible and of vaccination should therefore become part of the standard toolkit for evaluating the potential of vaccination programs.