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Estimating the cost of cholera-vaccine delivery from the societal point of view: A case of introduction of cholera vaccine in Bangladesh

Abdur Razzaque Sarker[a,*], Ziaul Islam[a], Iqbal Ansary Khan[b], Amit Saha[a], Fahima Chowdhury[a], Ashraful Islam Khan[a], Alejandro Cravioto[a], John David Clemens[a], Firdausi Qadri[a], Jahangir A.M. Khan[a,c,d]

[a] International Centre for Diarrheal Disease Research, Bangladesh (icddr,b), Dhaka, Bangladesh
[b] Institute of Epidemiology, Disease Control and Research (IEDCR), DGHS, Dhaka, Bangladesh
[c] Liverpool School of Tropical Medicine, Pembroke Place, United Kingdom
[d] Karolinska Institutet, Stockholm, Sweden

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ABSTRACT

Cholera is a major global public health problem that causes both epidemic and endemic disease. The World Health Organization recommends oral cholera vaccines as a public health tool in addition to traditional prevention practices and treatments in both epidemic and endemic settings. In many developing countries like Bangladesh, the major issue concerns the affordability of this vaccine. In February 2011, a feasibility study entitled, "Introduction of Cholera Vaccine in Bangladesh (ICVB)", was conducted for a vaccination campaign using inactivated whole-cell cholera vaccine (Shanchol) in a high risk area of Mirpur, Dhaka. Empirical data obtained from this trial was used to determine the vaccination cost for a fully immunized person from the societal perspective. A total of 123,661 people were fully vaccinated receiving two doses of the vaccine, while 18,178 people received one dose of the same vaccine. The total cost for vaccine delivery was US$ 492,238 giving a total vaccination cost per fully-vaccinated individual of US$ 3.98. The purchase cost of the vaccine accounted for 58% of the overall cost of vaccination. Attempts to reduce the per-dose cost of the vaccine are likely to have a large impact on the cost of similar vaccination campaigns in the future.

1. Introduction

Cholera represents a substantial health burden in the developing world and is endemic in Africa, Asia, South America and Central America. It is a highly infectious disease, which is transmitted through the fecal-oral route and can lead to outbreaks within a short period of time through contaminated water and food. Cholera affects all ages and if it is not addressed properly, can lead to death within a very short time. In Bangladesh, there is no well-documented data on the actual number of cholera cases but expert estimates suggest an incidence of approximately 450,000–1,000,000 cases each year, of which, at least 300,000 are severe cholera cases [1–4]. During a cholera outbreak, the major response should focus on case detection, rehydration-based treatment and provision of safe water, in conjunction with adequate sanitation, hand washing and safe food preparation [5]. Cholera control through vaccination has recently received increased attention from public health officials [6] and the WHO recommends oral cholera vaccines as an added public health tool to traditional methods for prevention and treatment in both endemic and epidemic settings [7]. Additionally, international donors have recently advocated for expanded vaccination programs to combat cholera and other diseases [8] although in most developing countries affordability remains the key issue. Shanchol and Dukoral are two types of WHO-prequalified, safe and effective oral cholera vaccines currently available in the market [9]. Shanchol showed an overall protective efficacy of 66% against culture-confirmed cholera 3 years after administration [10]. Shanchol, unlike Dukoral, does not require administration with a buffer, thereby greatly simplifying its use under field conditions.

The Expanded Program on Immunization (EPI) in Bangladesh is one of the successful programs in health sector which aims to reduce child morbidity and mortality from vaccine preventable diseases. EPI started in 1979 with six conventional vaccines against six

* Corresponding author.
E-mail addresses: arazzaque@icddrb.org (A.R. Sarker), zia@icddrb.org (Z. Islam), iqbalansary@gmail.com (I.A. Khan), amit@icddrb.org (A. Saha), fchowdhury@icddrb.org (F. Chowdhury), ashrfk@icddrb.org (A.I. Khan), dracravioto@hotmail.com (A. Cravioto), jclemens@icddrb.org (J.D. Clemens), fqadri@icddrb.org (F. Qadri), jahangir.khan@icddrb.org (J.A.M. Khan).

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diseases and introduced later hepatitis B vaccine, pentavalent vaccine, measles second dose and MR (measles and rubella) vaccine in 2012. It has been planned to introduce pneumococcal vaccine in 2014 for prevention of some forms of childhood pneumonia and meningitis. Additionally, other vaccine options in the coming years include vaccines for prevention of cervical cancer and vaccine to prevent rotavirus diarrhea, typhoid and cholera, hepatitis B (birth dose), inactivated polio vaccine are also planned to introduce [11]. Cost analyses of cholera vaccine delivery may provide useful information regarding actual resource needs and/or inputs required for introducing a new vaccine in future immunization programs. Such information is required for both health planning and decision-making, as well as for entering into agreements with development partners. The aim of this paper is to estimate the total cost of vaccination, the cost per fully-vaccinated individual, and to identify the related cost drivers. Cost analysis was based on empirical data using a societal-cost perspective.

2. Setting of the study

This study was conducted under the feasibility study entitled, "Introduction of Cholera Vaccine in Bangladesh (ICVB)" that was carried out between 17th February and 30th April 2011. The project was in joint collaboration between the government of Bangladesh and icddr,b and examined the effectiveness of using an oral cholera vaccine (two doses) in reducing incidence of cholera in an urban setting, in this case, Dhaka. The study was conducted in six wards (lowest administrative units) of Mirpur (an urban area), Dhaka, Bangladesh. Mirpur is a densely populated area of approximately 2.5 million people with a large proportion of the population at high risk for cholera and other diarrheal diseases [12]. The wards from which the highest reported number of diarrheal patients came to icddr,b's Dhaka hospital over the previous five years were selected. Estimated rates of hospitalization due to cholera were 2–6 per 1000 diarrheal hospitalizations in these selected wards [13]. Participants received two doses of the oral cholera vaccine, the first on day 1 and the second at least after 14 days. A total of 141,844 people were vaccinated from the six wards with 123,661 people receiving the complete two-dose schedule (fully vaccinated) and 18,178 receiving only one dose (incomplete). Pregnant women and children under one year of age were excluded from the study. Written, informed consent by the adults and consent from parents/guardians for children, as well as ascent by children aged between 11 and 17 years of age, were given prior to vaccination.

3. Materials and methods

3.1. Methodology

The societal cost of any vaccination program comprises three main components: first, the cost of acquiring the vaccine from the manufacturer; secondly, the cost of delivering and administering the vaccine to the target population, and thirdly, the time and pecuniary costs incurred by household members to travel to the vaccination sites and to wait to receive the vaccine [14]. In this study, all resource items used for vaccine delivery activities were captured using an ingredients approach, which means listing all types of input by activity and quantity, as well as the cost of each input [15]. All fixed and variable costs were captured through a comprehensive list of activities during the time of vaccination. Fixed costs included those necessary to set up and run the vaccination campaign no matter how many people were vaccinated. Variable costs varied with the number of people being vaccinated.

The major activities related to the ICVB were vaccinating a large population, obtaining the vaccine from abroad, cold chain and waste management, training, and social mobilization. In reality, many items (cold box, vaccine carrier, etc.) used for vaccination were supplied to the ICVB program at no cost by the Government of Bangladesh. Although actual expenditure for these items was zero, the shadow prices for each item were obtained and included in our analysis. Capital items such as all types of vaccine cold box, vaccine carrier, and dial thermometer were annualized for their respective functional lifetime and the inflation-adjusted discounting rate was applied for calculating the costs of such items. In this case, we applied a 3% discounting rate [16]. This rate was then adjusted according to the average inflation rate, which was 7.96% for the period 2008–2011 as reported by the Bangladesh Central Bank [17]. Using this discounting rate, the cost per year of every capital item over its estimated lifetime was calculated.

Shared cost items (cold chain storage, refrigerator) were apportioned according to the proportion of time-usage of the relevant item or activity. The vehicles (pick-ups, trucks) were rented for the vaccination periods. The rental price of the vehicles was used in the analysis. Some senior level management staffs of various projects were also engaged during the vaccination campaign. We estimated their time involvement in the project (as a percentage of full time work) during the vaccination campaign and adjust it for final calculation. For calculating the time-cost of end-users (vaccine recipients), we considered age-specific wages [12,18]. For this purpose, three groups were created: all children between 1 and 9 years of age, adolescents between 10 and 17 years, and adults over 18 years of age among the fully-vaccinated cohort which constitutes 23%, 17% and 60% of the total population [19]. As per a previous study [14], we assumed that the cost of traveling and waiting to be vaccinated was zero for the first two age groups. For adults, the travel and waiting times were captured and then valued according to the hourly wage of the working people [14]. Finally, sensitivity analyses were conducted to determine the range of cost estimates for different scenarios and delivery activities. We examined the effect of changes in the price of vaccines and salary levels of the staff as the lower salary level may be appropriate for Bangladesh rather than the project staff of icddr,b. All costs were converted into US dollars ($) using the average official government exchange rate in 2011 of 72 Bangladeshi Taka (BDT) to US$ 1 [17].

3.2. Vaccination campaign

Vaccination, defined as the administration of a vaccine, was conducted in the six wards of urban Mirpur, Dhaka. The six wards were divided into ninety clusters with two-thirds (60 clusters) being randomized to the vaccine group and one-third of the clusters to the control group (Fig. 1). Data from disease surveillance over the previous few years in Mirpur showed that January to March were the months when disease transmission was lowest [13]. Accordingly, the cholera vaccination campaign was conducted from 17th February to 16th April 2011. As a feasibility study, the ICVB had chosen the fixed outreach site vaccine delivery strategy to deliver vaccine in the selected clusters. The strategy involved the administration of two doses of the cholera vaccine at least 14 days apart allowing for 12 clusters to be covered over a three-day period.

With regards to the fixed sites at which the vaccine was administered, there were three vaccination sites for each cluster. Sites were selected to maximize accessibility for the surrounding cluster population. Sites were established in open spaces (50% of total sites), schools and colleges (16%), the ground floor of car parks or garages (14%), clubs and cooperatives (10%) and government and non-government health facilities (10%). During the vaccination sessions, the vaccination team was stationed at the selected sites in each cluster and motivated the target population to visit the site for vaccination on a prefixed date and time. Using the process of volunteer involvement on national immunization days (NIDs), volunteers