Estimating the Costs of Responding to a Measles Outbreak: Buvuma Islands, Lake Victoria, Uganda, February-May 2017

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ABSTRACT

Introduction: Despite the strong prevention efforts by the Uganda Ministry of Health (MOH), measles outbreaks continue to occur. The MOH responded to a measles outbreak in the hard to reach areas of Buvuma Islands, identifying 54 case-patients, 4 of whom developed complications and were hospitalized. We defined a measles case as; Any suspected case with a positive measles IgM antibodies or detection of measles viral RNA by PCR in a suspected case. We estimated the provider cost of responding to this outbreak, cost of prevention, and the cost the government would have saved with effective prevention. **Methods:** We interviewed health facility in charges, record clerks, and measles cases to collect information on patient management and days of illness. Using an itemized form, we systematically collected data on quantities and unit costs of all the resource inputs for both direct and indirect costs at national, district, and facility levels. Medical costs referred to hospital and clinic costs for medications, supplies, utilities, transport, and personnel; non-medical costs included those associated with person-hours spent on the outbreak investigation and control effort. **Results:** The overall cost of investigating and controlling this outbreak was $16,459.50 (including $5,526.30) of medical costs, $10,733.20 of non-medical costs) and the cost per capita of number of children 6months-5years was $117.80 (16,259.5/138 (number of children 6months-5years. This is the target for measles intensified immunization following an outbreak). **Conclusion:** The total cost incurred in this outbreak is four fold the amount needed to vaccinate all children in Buvuma which would have averted the outbreak. We recommended strengthening vaccination services in the entire country, especially hard-to-reach areas, to enable the government forego the extra cost and morbidity associated with outbreak control.

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Introduction

Measles is a highly-transmissible acute infection caused by a paramyxovirus, and characterized by fever, conjunctivitis, generalized maculopapular skin rash, and respiratory symptoms [1]. Management of measles involves symptom management including fever, rash, conjunctivitis and coryza. Prior to the availability of measles vaccine, measles infected over 90% of children before they reached 15 years of age. These infections were estimated to cause more than two million deaths and between 15,000 and 60,000 cases of blindness annually worldwide [2].

In 2005, the WHO set a goal of eradicating 90% of measles mortality by 2010; this was adopted globally by African countries [1]. Despite remarkable progress towards global reduction of measles morbidity and mortality, measles cases are still high in developing countries especially in Africa [3].

According to Uganda MOH reports, the Uganda National Expanded Program on Immunisation (UNEPI) has documented huge successes in terms of vaccination coverage since 1983 and concentrated on vaccination efforts to cover the target population. In Uganda, the measles containing vaccine (MCV1) has been given at 9 months as part of the routine immunization schedule since 1995 [4]. The government of Uganda has for several years improved measles vaccination coverage through routine immunization, periodic intensified routine immunization (PIRI), and supplementary immunization activities (SIAs). According to routine health information reports and coverage surveys, measles immunization coverage increased from 17% in 1985 to 82% in 1995, declined between 1996 to 1998, and then stabilized from 1999 to 2001 at approximately 61% [5]. In 2014 and 2015 the administrative vaccination coverage for measles stood at 94% and 106% respectively [5].

Clear evidence is also exhibited in Uganda where measles control strategies for the period 2002-06, including the measles SIAs for children under 15 years in 2003, led to a dramatic (93%) and 100% reduction in measles incidence and measles mortality respectively [6, 7]. These numbers are consistent with the global estimate of 86% for MCV1 and 69% for the second dose (MCV2). Even without MCV2 added to the EPI, the Ministry of Health conducted several SIA, with the latest in October 2015 [8]. In addition, WHO/UNICEF Estimates of National Immunization Coverage (WUENIC) for MCV1 grew from 59% in early 2000 to 79% in 2017, 86% in 2018 and 88% in 2019 [9]. Between 2016 and 2018, the government could not fund SIA to help achieve the 90% measles immunization coverage required to effectively stop measles transmission [10].

The District Health Information System (DHIS2) data for 2013, 2014, and 2015 puts national measles coverage, at 97%, 96%, and 106% respectively. However, the 2016 national preliminary multi-indicator cluster survey report, recorded the coverage at 80%. Although administrative data shows that the measles immunisation coverage is high, Uganda has in the past several years been experiencing recurrent measles outbreaks, which have been attributed to low immunisation coverage in some of the districts [5, 6, 11].

Numerous studies have demonstrated the cost-effectiveness and significant net economic benefits of measles and rubella vaccination efforts [12]. In 1985, White and colleagues reported economic benefits that significantly exceeded the costs associated with using Measles Mumps Rubella (MMR) vaccine for routine vaccination in the United States of America (USA) [13].

In addition to the cost incurred due to individual measles cases, investigating and responding to outbreaks imposes an economic burden on the healthcare system and community [14].

On 14th March 2017, the Uganda Ministry of Health (MoH) was notified of a measles outbreak on the Islands of Lake Victoria, Buvuma District. The MoH preparedness and response plan included key pillars, namely: coordination, logistics, surveillance and laboratory, case management and Infection prevention and control, risk communication and social mobilization. All the public health measures associated with these pillars required substantial financial and human resources to expedite the response. A response team from the Ministry of Health including the Uganda Public Health Fellowship Programme (PHFP), Uganda National Expanded Programme on Immunisation (UNEPI), and Uganda Virus Research Institute (UVRI) supported by the African Field Epidemiology Network (AFENET) and the Buvuma District Health Team conducted a thorough investigation

and controlled the measles outbreak. The composition of the field response team included epidemiologists, laboratory technologists and district health workers. By the end of the outbreak, a total of 54 cases were identified; 4 were hospitalized with complications.

Several studies have provided estimates of the cost of responding to measles virus infections and containing outbreaks in high income countries however, the economic burden of measles outbreaks in low and middle countries is not clear [15]. While the costs associated with vaccination are well-known, cost analyses of vaccine-preventable diseases among children below 5 years of age in Uganda are limited, particularly the costs of responding to outbreaks. Cost estimates of measles outbreaks and response activities in Uganda would provide evidence for improving national immunization policies, and demonstrating the economic benefits of measles eradication. We estimated the provider cost of responding to this outbreak, and cost of prevention.

Methods

Study design

We conducted an incidence-based costing of the outbreak alongside a descriptive measles outbreak field investigation and systematically collected cost data on resource inputs at national, district, and facility levels. We defined the study period as March to May 2017 (when the MoH was first notified about the measles outbreak through to the date when the outbreak was declared over). We defined a provider as public entity where services are offered for free and was in charge of coordinating the outbreak response activities. Calculating the cost of illness involved quantification of the direct medical costs and non-medical costs involved in measles treatment and care. We used a case definition to classify all identified patients as suspected or confirmed measles cases. We defined a measles case as; Any suspected case with a positive measles IgM antibodies or detection of measles viral RNA by PCR in a suspected case. A total of 20 people participated actively in managing the outbreak; these included; 5 District Health Team (DHT) members, 5 implementing partner representatives who financially supported the outbreak response, 6 MOH staff and 4 drivers. The DHT were involved in patient management, health education, and surveillance whereas all the partners and MOH staff were involved in the measles investigation. The investigation of the measles outbreak lasted 30 days.

Study population and site

The study took place in Buvuma District, that comprises a collection of 52 Islands in Lake Victoria, in Eastern Uganda with no territory on the mainland, and include ~55,300 people[16] Figure 1. The measles vaccine coverage in Buvuma District in 2016 was 88% (UNEPI target: 90%).

At that time, Buvuma was a small rural district with no hospital. Therefore, based on the recommendation of the district health office staff, we considered all health facilities where cases sought medical care; 2 government health facilities including the main health centre IV, a health centre II, and three private clinics/drug shops on the affected sub-island of Kibibi. We selected cases based on their discharge diagnosis, which we defined as a confirmed measles patient based on the WHO clinical case definition [17].

Data management and quality assurance

Data collection and Costing methods

The data were pretested in a pilot study of 10 patients to ensure the feasibility of the study and its methodology as well as give an understanding on the overall cost of treatment. We recorded all the data in our costing checklist (additional file 1). The data were cleaned and any errors or omissions corrected. The data were then transferred onto Excel spreadsheets, which were only accessed by the investigators.

We interviewed health facility in charges, their administrators, National response team, and key partners. At district level, we interviewed the chief administrative officer (CAO), and district health officers including medical staff, data officers, surveillance focal person, laboratory focal person and a storekeeper. This enabled us to obtain resource utilization and expenditure data from the health care provider´s perspective, thus making a list of resource inputs with their data sources and compared them to form the basis of a set of itemized sheets for the different activities. Healthcare facility costs included

operating costs: labour and overhead costs, itemized costs for medical supplies and medications used for diagnostic tests, hospitalization and treatment [18]:. Whenever possible, we used administrative data and reports to adjust any reported estimates. We did not include capital costs of medical equipment like microscopes, laboratory instruments, and labour costs. The required quantities of inputs and resources were based on estimates by the Uganda Clinical Guidelines (UCG) 2017, for measles management and using expert opinion (physician) Table 1. We also reviewed patient files to obtain more information from the health facilities that were managing measles patients from March to May 2017 at the time. Patient information extracted included; place of residence, length of hospital stay, disease severity, history of measles vaccination, and treatment regimen to help estimate cost of treatment.

The assessed costs that included medical costs and non-medical costs are shown in Table 2. The resource inputs were valued, measured, and summed to get the total cost. All costs were expressed in Uganda shillings and later converted into US dollars as of May 2017 exchange rates.

Medical costs

We collected information on the number of health facility visits and number of complicated and uncomplicated measles cases from health facility in-charges (usually nurses or doctors), lay caretakers (usually family members). We compiled lists with names of all measles cases, and we searched other medical records of the same cases for any other patient details that were missing in the line list. Using phone calls, we obtained more information about the cases from their caretakers. We calculated personnel costs by multiplying a person´s daily salary by the number of days spent particularly on the measles outbreak. According to the Uganda Clinical Guidelines, 2017, measles complications (otitis media, pneumonia, conjunctivitis, diarrhea, vomiting, dehydration, encephalitis and upper respiratory infection) do not require treatment but rather symptom management. We estimated the cost of treating a measles case at $6.00 based on estimates from global eradication for measles that included Uganda[19]. The estimate cost was multiplied over an average time of illness, which was 4 days with a range of 5-7 days.

Non-medical costs

Personnel hours

We calculated the personnel hours lost which included both business and nonbusiness hours (weekends) allocated to the response team. We estimated the number of hours lost, converted them to days and then valued the days based on average pay per day. We estimated the salary for the response team based on unpublished reports from the Uganda Bureau of Statistics (UBOS).

Costs at the National Level-National coordination team

We calculated personnel time of the National Task Force (NTF) by hours dedicated to surveillance, response, laboratory work, health education, and coordination team activities related to this particular outbreak at national level. Given the limited resources, this allocation of personnel time represents the loss of other productivity at work (i.e. opportunity costs). The departments largely involved were; UNEPI, PHFP, Epidemiology and Surveillance Division (ESD) of MOH, Uganda Virus Research Institute, and the Uganda Ministry of Health Emergency Operations Centre. The time estimates were obtained from personal interviews with personnel in the relevant departments. We calculated personnel costs by multiplying a person´s daily salary by the number of days spent on the measles outbreak and added the allowances/perdiem for the same period. We computed costs of communication in terms of telephone calls made by Emergency Operations Centre to Buvuma on a daily basis for the one week when the outbreak was first reported to MOH.

Costs at District Level

To estimate the amount of personnel time associated with local outbreak response activities, we administered a checklist to all members of the district rapid response team that were available. We also collected local reports and consulted registries for additional information. We calculated time and costs for one notified case in Kibibi village and extrapolated these estimates to all notified cases. The DHT confirmed that case finding often involved a boat ride which was time consuming and costly, so water transport costs were also included. On

average, these outbreak investigation activities required 1-2 hours per case. We also costed the internal staff meetings that were held to organize district response activities at the beginning of the outbreak. The unit cost used for a fully immunized child was estimated at $33.7 for 1 dose of measles vaccine [20].

Costs of Prevention

We estimated the cost of prevention as the total cost of vaccination for all children aged 6 months to 59 months. We abstracted secondary data from the district health office to get the number of children below 5 years in Buvuma district. We estimated the cost of immunizing a child against measles at $33.7 from the immunization costing report, 2015. We then multiplied the approximate number of children below 5 years on Kibibi Island with the cost of full immunization. We then multiplied the cost of measles vaccine per child by the targeted population for prevention.

Availability of data and materials

The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical considerations

This investigation was in response to a public health emergency and was therefore determined to be non-research. The Ministry of Health of Uganda (MOH) gave the directive and approval to investigate this outbreak. CDC also determined that this activity was not human subject research, instead, its primary intent was public health practice or a disease control activity (specifically, epidemic or endemic disease control activity). Verbal informed consent in the local language was sought from respondents or care-takers of diseased children. They were informed that their participation was voluntary and their refusal would not result in any negative consequences. Also participants were referred for free treatment at government health facilities. To protect the confidentiality of the respondents, each was assigned a unique identifier which was used instead of their names.

Results

Costs of response

Provider costs

In total, 54 cases of measles infection with 4 complications (7.4%) were reported during an outbreak on Kibibi Island, Buvuma District. All the identified cases were above the age of 1 year but below 5 years with similar proportion of males to females. All caregivers reported that the child had been vaccinated before with any vaccine, but only 24 (44.4%) had an immunization card, however with only 2 (8.3%) having evidence of measles vaccination. The overall provider cost incurred in investigating and responding to the measles outbreak was $16,459.5 (Table 2). The cost per capita for responding to the outbreak on Kibibi Island was $117.8 (16,259.5/138). The medical costs totaled $5,526.3 including treatment costs; $363, utility costs; $100 and transport and fuel costs of $5,063.3. The non-medical costs totaled to $10,733.2 including personnel costs of $10,436.2 and overhead costs of $297.2. The personnel costs included salary lost (were given salary but had not worked) during the outbreak period ($5862), allowances given to the response team ($4574) and refreshments ($200) given during staff meetings. Buvuma district health office needed $4642.3 (33.7*138) to immunize all the children 6 months to 5 years on Kibibi Island. This outbreak posed substantial logistical challenges for the DHT, most importantly with the high fuel costs ($5,063.3) needed to navigate the islands.

Cost of prevention

The total population for Kibibi Island was 760 persons and approximate target population for vaccination was 138. We estimated the cost of immunization at Kibibi Island at $6099.6 including all related costs respectively.

Discussion

We found that the overall provider cost of investigating and responding to the measles outbreak in Buvuma Islands was $16,259.5. Buvuma District health office needed $4642.3(33.64*138) to immunize all the children 6 months to 5 years on Kibibi Island. Therefore, this depicts besides responding to the outbreak, the provider needed to

spend $11,617.11 (16,259.5-4642.3) more to control this outbreak than it would have spent to prevent it. These findings agree with a study in Uganda which noted supplementary immunisation activities as a cheaper option than medical and other costs involved in managing measles cases [21].

However a study in Burundi about a measles outbreak in Muyinga Sector, Burundi documented that conducting outbreak control or disease elimination may not be the most cost effective use of limited resources but rather appropriate therapy for the diseased cases [22].

Our findings were also higher than costs ($475) of laboratory tests for 360 neonates that succumbed to a meningitis infection in Tanzania [23] This could be attributed to the differences in cost of treatment regimens for measles and meningitis

Our findings are also congruent with the USA where hospital and outbreak response costs were found to be higher than preventative costs for measles [24].

Comparable to our findings, in Japan a study concluded that the policy of immunizing infants for measles soon after their one-year birthday is economically effective [25].

Our estimated hospitalization costs are much lower than findings in Italy [26], but studies conducted in the Netherlands and Canada [21] recorded lower costs of $276 and $254 respectively. Nonetheless, the differences in outbreak control costs recorded in different countries vary with variability of currencies and standards of treatment. Even though the findings in Italy were much higher, they are in line with our findings in that the costs of response were higher than those for vaccination.

Limitations

Our findings should be interpreted in line with the following limitations. The overall cost of responding to the outbreak could have been underestimated since we did not compute boat and vehicle depreciation and building maintenance. In-addition, the total cost could have been underestimated since we may have missed unreported cases in the community. Failure to reach some areas could have caused an underestimation of the overall cost for responding to the outbreak.

Conclusion

Despite high vaccination coverage, measles outbreaks can occur among under-vaccinated children, at major costs to public health agencies. The total cost incurred in this outbreak would have been more than enough to vaccinate all children on Kibibi Island in Buvuma, which would have prevented the outbreak. This would be a recurring extra cost the government would have to expend if the routine vaccination is suboptimal and an outbreak occurs. Rising rates of intentional under vaccination e.g. were community people do not turn up for immunization campaigns, can undermine the global goal towards measles elimination. We recommend that the government should encourage people do vaccination to avert future illnesses and potentially related death instead of responding to the outbreaks.

What is known about this topic

- Measles is a highly-transmissible acute infection caused by a paramyxovirus, and characterized by fever, conjunctivitis, generalized maculopapular skin rash, and respiratory symptoms. Management of measles involves symptom management including fever, rash, conjunctivitis and coryza.
- Prior to the availability of measles vaccine, measles infected over 90% of children before they reached 15 years of age. These infections were estimated to cause more than two million deaths and between 15,000 and 60,000 cases of blindness annually worldwide.
- Prevalence of measles is higher urban and rural areas most especially the hard to reach that includes islands.

What this study adds

- While the costs associated with vaccination are well-known, cost analyses of vaccine-preventable diseases among children below 5 years of age in Uganda are limited, particularly the costs of responding to outbreaks.
- Cost estimates of measles outbreaks and response activities in Uganda would provide evidence for improving national

immunization policies, and demonstrating the economic benefits of measles eradication.
- We estimated the provider cost of responding to this outbreak, cost of prevention and the cost government would have saved with effective preventive measures including immunization and effective surveillance.

Competing interests

The authors declare no competing interests.

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Disclaimer

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Authors' contributions

JK, DK, WM, OBT and ARA took part in conceptualization of the study idea, protocol write up and conception of the manuscript idea and its write up; DB, WM and DK contributed to the data collection, compilation and conception of the manuscript idea and its write up; OBT, IA, HL, KB and ARA did compilation, conception of the manuscript idea and final review of manuscript for substantial intellectual content. All authors read and approved the final manuscript.

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Tables and figures

Table 1: Inputs classified in broad categories
Table 2: Table showing cost categories
Figure 1: Location of the affected Bweema Subcounty, Buvuma Island, Lake Victoria, 2017

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Table 1: Inputs classified in broad categories		
Cost	**Category**	**Items**
Direct (medical)	Drugs used	Vitamin A, Paracetamol. Zinc kid, Amoxyl, tetracycline eye ointment
	Medical supplies	Gauze, cotton wool, disposable gloves, Ringers lactate, alcohol swabs, cannula, plaster, IV tubing set and syringes
	laboratory supplies	laboratory tests and reagents
	Inpatient admissions	bed space, nursing care, doctors services
Direct (non-medical)	Hospitalisation cost	Transport, meals for both patient and caregiver, water, Electricity
	Overhead costs	Administrative or documentation (patient books, pens, checklists, questionnaires, costing forms), computers, venue hire, loud speaker hire, communication
Indirect	Productivity losses	Clinicians time, nurses time, epidemiologists, drivers, helmsman, District Surveillance Focal Person
	Person hours	Clinicians time, nurses time, epidemiologists, drivers, helmsman, District Surveillance Focal Person
Public health	cost per capita of number of children targeted for mass vaccination	measles immunisation and operational supplies
**All the cost categories are direct health care costs taking the public perspective*		

Table 2: Cost categories					
Costs	**Cost categories**	**Cost component/inputs**	**How measured**	**Cost ($)**	**Data source**
Medical	Provider costs	Expenditure on treatment	Costs of medicines	363	JMS
		Utilities; electricity and water	cost of units	100	Provider
		Transport	Hire and fuel cost	5063.3	Provider
Non-medical	Personnel costs	Allowances	Amount paid	4,574	Provider
		salary expended during period of investigation	Amount paid	5862	Provider
		staff meetings	Refreshments	200	Provider
	Overhead costs	Communication	Airtime	125	Provider
		Venue hire	cost of venue	83.3	Provider
		Stationery	Cost of printing	83.3	Provider
		Loud speaker hire	Cost of hire	5.6	Provider
Total				16459.5	

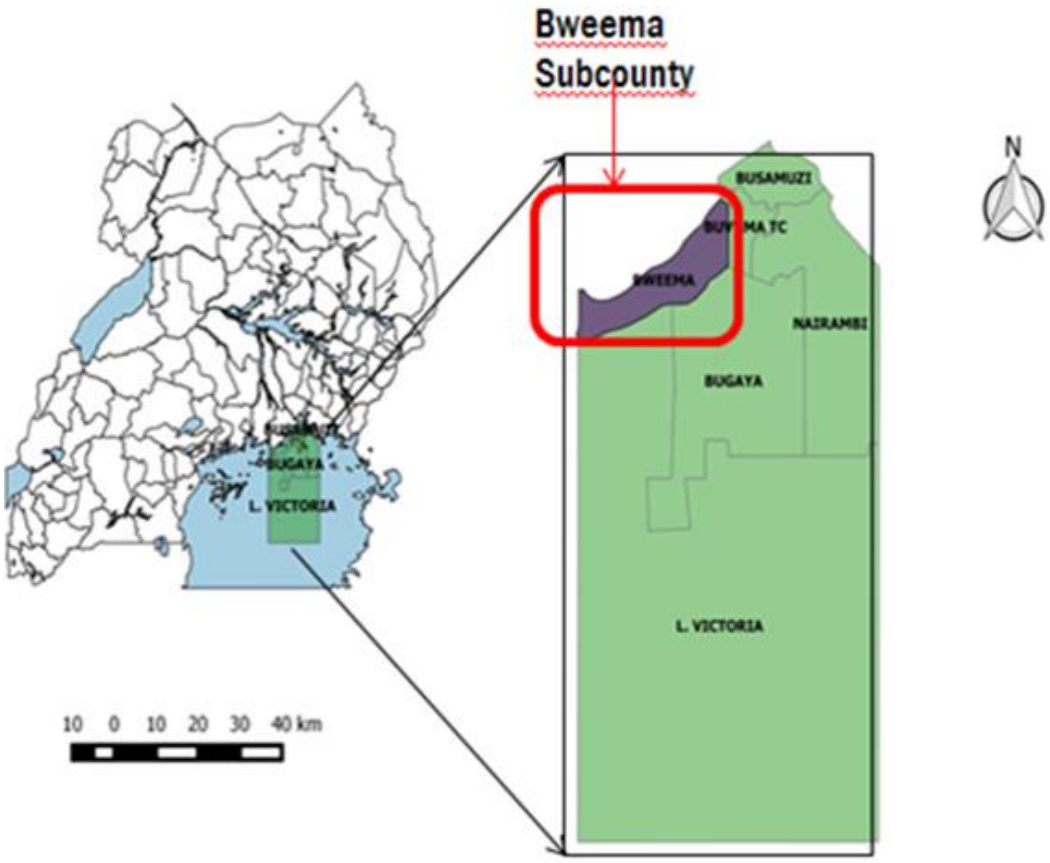

Figure 1: Location of the affected Bweema Subcounty, Buvuma Island, Lake Victoria, 2017