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Costs of illness due to endemic cholera

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SUMMARY

Economic analyses of cholera immunization programmes require estimates of the costs of cholera. The Diseases of the Most Impoverished programme measured the public, provider, and patient costs of culture-confirmed cholera in four study sites with endemic cholera using a combination of hospital- and community-based studies. Families with culture-proven cases were surveyed at home 7 and 14 days after confirmation of illness. Public costs were measured at local health facilities using a micro-costing methodology. Hospital-based studies found that the costs of severe cholera were US$32 and US$47 in Matlab and Beira. Community-based studies in North Jakarta and Kolkata found that cholera cases cost between US$28 and US$206, depending on hospitalization. Patients' cost of illness as a percentage of average monthly income were 21% and 65% for hospitalized cases in Kolkata and North Jakarta, respectively. This burden on families is not captured by studies that adopt a provider perspective.

Key words: Cholera, health economics.

INTRODUCTION

Cholera remains a serious illness because of its rapid onset, severity, and the fact that cholera outbreaks can overwhelm public health systems. In 2006, 52 countries reported 236 896 cholera cases and 6311 deaths to the WHO [1]. These numbers do not reflect the true burden of cholera due to limitations in the surveillance and notification systems of many countries and widespread underreporting [1]. Developing country policy-makers need information on the burden of cholera in order to support rational decisions on control strategies, including the use of new-generation cholera vaccines [2].

The Diseases of the Most Impoverished (DOMI) programme is assisting decision-makers by translating country-specific data – on disease burden, cholera vaccine safety, efficacy and field effectiveness, vaccine cost-effectiveness, and private demand and

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willingness-to-pay for vaccines – into rational decisions regarding the use of new-generation cholera vaccines.

This paper describes studies that measured the costs of endemic cholera in study areas in North Jakarta (Indonesia), Kolkata (India), Matlab (Bangladesh), and Beira (Mozambique) from both the provider and the patient perspective. The studies in Matlab and Beira were hospital-based, while the studies in North Jakarta and Kolkata combined both hospital-based and community-based data collection. These costs are being used to analyse the cost savings due to disease control strategies that reduce the number of cholera cases.

METHODS

The patient and public cost studies were coordinated with prospective studies of disease burden. For every patient agreeing to participate, a case-report form was completed and a stool culture was performed for *V. cholerae* O1 and O139. The study sites were mainly urban and all age groups were under surveillance in all sites except Beira, where surveillance excluded children aged <2 years. The cost studies were conducted from May 2004 to April 2005 in Beira, August 2001 to July 2003 in North Jakarta, May 2003 to April 2005 in Kolkata, and January to December 2004 in Beira.

The hospital-based studies in Beira and Matlab were conducted at the Cholera Treatment Center (CTC) and the Matlab International Center for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) hospital, respectively. Both facilities specialize in the treatment of severe diarrhoea. The CTC is a public facility treating only diarrhoeal disease. It serves 22 000 residents of an impoverished urban neighbourhood in Beira and is open only during the 6 months of the rainy season.

The Matlab hospital is a 100-bed facility serving a population of 220 000 people covered by ICDDR,B's Health and Demographic surveillance system.

In the community-based studies in Kolkata [3] and North Jakarta [4], catchment areas comprising both middle-class and slum neighbourhoods were selected, and surveillance for diarrhoea was established in public and private outpatient clinics and hospitals serving the catchment population. In Indonesia, a population of 160 257 living in two North Jakarta districts, Tanjung Priok and Koja, was under surveillance [4]. The study included residents who presented with diarrhoea to two hospitals and eight health centres (including private facilities) [5]. In India, 62 329 individuals residing in three areas in the city of Kolkata were under surveillance for diarrhoea [3]. Five project health outposts were set up in the neighbourhoods and two at the city's infectious disease and children's hospitals (public cost-of-illness (COI) data were collected at only one hospital [6]).

The annualized incidence rates measured in the disease burden studies were 0·45 cases/1000 population per year in North Jakarta, 1·64 cases/1000 population per year in Kolkata, 2·09 cases/1000 population per year in Matlab, and 4·0 cases/1000 population per year in Beira. The incidence in children aged <15 years was higher than the incidence in persons aged $\geqslant 15$ years*. The annual incidence (cases/1000 population per year) in children was 0·90 in North Jakarta, 2·88 in Matlab, 3·55 in Kolkata, and 4·27 in Beira†. The incidence in adults was 0·27 in North Jakarta, 0·93 in Kolkata, 1·03 in Matlab, and 3·85 in Beira.

Measuring patients' costs of cholera

To collect data on patients' COI due to culture-confirmed cases of cholera, two interviews were conducted at the patient's home – at 7 and 14 days after laboratory confirmation of cholera. Patients' costs include the out-of-pocket costs borne by the patient including payments for medical care, drugs, transportation, and imputed expenses, such as lost work time. For adult cases, the patient was interviewed. For cases of children, an adult familiar with both the episode and the household finances was interviewed.

Standard questionnaires were developed to ensure that similar data were collected in each study site. Local collaborators translated the questionnaires and tailored the questions and the responses to local circumstances (e.g. used the local phrases for different types of healthcare facilities and providers).

* To compute the incidence rates for these two age groups, the incidence rates measured in the burden-of-disease studies are weighed by the proportion of the study site's population in each age group. In Matlab, the incidence rates measured by the burden-of-disease study are weighted by the proportion of the total cases seen in each age group.

† The average annual incidence rates for Beira are based on 10 years of disease surveillance (1994–2003) conducted by ICDDR,B, including surveillance under the DOMI programme from May 2004 to May 2005.

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The questionnaires measured direct costs and indirect costs. The direct costs were the sum of out-of-pocket expenses on medical goods and services (i.e. examinations, diagnostic tests, medicine, bed charges) and non-medical goods and services (i.e. transportation, lodging and meals for people accompanying the patient, foods and beverages used to aid treatment). The indirect costs included lost wages due to lost work time by the patients, their caregivers, and their substitutes*, as well as estimates of the productivity losses due to forgone non-market activities including school, housework, and childcare. These productivity losses also reflect time spent waiting and traveling to receive healthcare. The estimated monetary value of non-market activities depends on the subject's age and the activity. The value of daily productivity was the product of an assumed age-specific wage and an occupation-specific wage. The assumed age-specific wages for adults, teenagers, and children were the patient's daily wage, one-half the average patient's daily wage, and one-quarter of the average patient's daily wage, respectively. The occupation-specific wages for working on a farm, working at home, going to school, and leisure were 70%, 50%, 50%, and 30% of the assumed age-specific wage, respectively. If the patient did not report their daily wage, it was replaced with the sample average. Children's losses were monetized as in previous studies [6, 7] because children are known to make important economic contributions to the household [8].

Measuring the public costs of cholera

Provider costs of treatment were measured at local health facilities using a micro-costing (bottom-up) methodology. First, data from public and private health facilities providing treatment were used to produce estimates of the cost of a day's hospitalization, the cost of a clinic visit, and the average cost of medicines and diagnostic tests. This information was combined with data from a sample of patients who were treated to estimate the provider's treatment cost per case of disease. Then, the portion of the total cost of treatment that was borne by the public sector was calculated as the provider cost of treatment minus the fees received from patients for their treatment. The fees received from patients were measured using the private COI data on direct costs paid to public health facilities for medicine, treatment, and laboratory tests.

Provider cost was drawn from facilities serving the disease burden study because they allowed for good access to facility records and they had data on culture-confirmed cholera infections, which minimized travel and logistical costs.

While the public treatment cost studies in each country measured similar components to maximize comparability of findings, the studies were not identical because of differences in the healthcare systems, availability of data, and the design of the DOMI projects in each country [5, 9–11].

In Matlab, DOMI patients were selected from the diarrhoea cases that were confirmed, admitted, and treated at ICDDR,B's Matlab hospital and experienced by patients in the Matlab Health and Demographic Surveillance System of ICDDR,B. Laboratory confirmation was done in ICDDR,B Matlab hospital for all patients followed by a full range of treatment including antibiotic, intravenous fluid and oral rehydration solution (ORS) therapy. This is atypical treatment since the hospital does not typically conduct laboratory tests and often faces shortages of medicine and other supplies.

In North Jakarta, DOMI patients were identified among the diarrhoea patients that presented and were treated in the public health facilities serving the study area. In Beira, DOMI patients were identified among those treated at the CTC. With the exception of additional diagnostic procedures to confirm cases, DOMI patients in North Jakarta and Beira received care in the same environment as the general population.

In Kolkata, DOMI patients were identified in screening clinics specifically set up for the DOMI disease burden studies. Patients were then directed to private healthcare providers and reimbursed for treatment expense. A few cases were hospitalized in the two public hospitals serving the study area. Although there is a public healthcare service provision system, many of people in disadvantaged urban areas (estimated by local team at 30%) rely on private healthcare.

* A substitute is someone who performed the patient's or caregiver's work for them while they were either sick or giving care. This is 'net' because substitute labourers result in a net increase or decrease in lost productivity. On the one hand, they can increase losses if they are not able to perform their own work. On the other hand, they reduce losses when they replace patients' lost labour. This item is equal to (substitute labourers' own lost income/production) + (substitute labourers' contributions to income/production by doing patients' work).

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Total costs per episode of cholera

The total costs due to an episode of cholera were the sum of the patients' cost and the public cost. To reflect the different cost structures, we obtained separate estimates of treatment costs for outpatient care and in-patient care.

Currency

All costs were measured in terms of local currency and converted to US dollars (US$) using the exchange rate at the midpoint of the COI study. These values were adjusted for inflation using the US Bureau of Labor Statistics' consumer price index and expressed in terms of 2005 US$.

These values are not directly comparable across countries because of differences in incomes and prices across countries.

Ethical review

The research protocols for both public and patients' costs were approved by the relevant institutional, national, and local ethical review boards. After explaining the purpose of the study, voluntary verbal consent was obtained from each respondent in the patient COI study prior to the start of the interview.

RESULTS

Patients' costs

Sample size and characteristics

In total, patients' costs were measured for 571 episodes of cholera, 291 in children and 279 in adults. The hospitalization rates used for North Jakarta (22%) and Kolkata (38%) were taken from the disease burden study, which is more accurate than similar data from the COI study because the former relied on clinical treatment data while the latter relied on self-reports. All patients were treated as in-patients in the hospital-based studies in Matlab and Beira.

The average duration of illness for child (<18 years) and adult cases was 3·6 and 3·2 days, respectively, in Matlab, 7·3 and 4·7 days in North Jakarta, 6·6 and 5·9 days in Kolkata, and 5·8 and 7·5 days in Beira. All children in the Beira sample missed school due to cholera, while only 33% missed school in Kolkata, 15% in North Jakarta, and none in Matlab. On average, children missed less than 1 day of school due to cholera in North Jakarta (0·4 days) and Kolkata (0·7 days) and children in Beira missed almost 3 days of school (2·8 days). Adult patients missed work an average of about 1 (1·1) day in North Jakarta, about 2 days Matlab (1·7) and Kolkata (2·1), and almost 4 days (3·7) in Beira. Less than a quarter of all cases used substitute labour (24% of cases in Matlab, 15% in North Jakarta, 0% in Kolkata, 22% in Beira), but the majority of cases involved caregiving (100% of cases in Matlab, 84% in North Jakarta, 70% in Kolkata, 96% in Beira).

The average daily wage of patients was US$1.4 in Kolkata (59% of the sample reporting), US$1.7 in Beira (37% of the sample reporting), US$2.1 in Matlab (12% of the sample reporting), and US$4.5 in North Jakarta (24% of the sample reporting).

Respondents were asked about all treatments sought before and after diagnosis. In Matlab and North Jakarta, most cases (78% and 53%, respectively) received some treatment at home. In Kolkata, visits to public (43%) and private (26%) health facilities accounted for the majority of treatment visits. In Beira, all patients sought treatment at the CTC.

The public treatment cost estimates rely on data from 510 episodes of illness.

Direct and indirect patient costs

When considering all cases, regardless of age, the indirect patient costs exceeded the direct patient costs in all sites except North Jakarta (Table 1). In North Jakarta, where direct costs of treatment were very high, direct patient costs were many times more than indirect patient costs for adults (Table 2), where lost work time imposes costs on the household. Direct costs exceed indirect costs for children's cases in most cases (Table 3), because indirect costs tend to be lower due to patients' having lower economic productivity. The largest components of indirect costs were the patients' and caregivers' lost productivity. Treatment costs were the largest component of direct patient costs at all sites, followed by the costs of transportation, and the costs of meals and lodging for persons accompanying the patient to treatment.

Sources of payment

North Jakarta is the only site where direct costs were paid by households in the majority (88%) of cases. In Matlab, Kolkata, and Beira, costs were paid by a combination of facilities and patients in 99%, 100%, and 96% of cases, respectively. The percent of households that borrowed money to pay

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Table 1. *Mean cost of illness* (*COI*) *per episode of cholera* (*in 2005 US$*), *by treatment setting and study site, all patients* (*standard deviation*)*

	Study site			
	Matlab	North Jakarta†	Kolkata	Beira‡
Sample size	(*n* = 277)	(*n* = 176)	(*n* = 66)	(*n* = 49)
Hospitalized cases	(*n* = 277)	(*n* = 36)	(*n* = 28)	(*n* = 49)
Patients' costs	12·4 (12·9)	134·0 (72·2)	17·9 (44·5)	18·8 (36·2)
Direct costs	5·2 (6·7)	112·1 (73·0)	6·8 (7·5)	4·6 (4·2)
Indirect costs	7·2 (8·4)	21·8 (14·7)	11·0 (44·2)	14·1 (35·3)
Public costs	19·1 (n.a.)	71·7 (n.a.)	17·6 (n.a.)	28·4 (n.a.)
Total costs	**31·5 (n.a.)**	**205·7 (n.a.)**	**35·4 (n.a.)**	**47·2 (n.a.)**
Outpatient cases		(*n* = 140)	(*n* = 38)	
Patients' costs	—	14·5 (20·2)	3·7 (4·3)	—
Direct costs	—	8·4 (15·2)	1·0 (1·6)	—
Indirect costs	—	6·0 (8·6)	2·7 (4·2)	—
Public costs	—	13·6 (n.a.)	n.a. (n.a.)	—
Total costs	**—**	**28·1 (n.a.)**	**n.a.¶**	**—**
Hospitalization rates for all cases§	100·0%	21·7%	37·7%	100·0%

* Outpatient costs were not available from the Matlab and Beira study sites because these were hospital-based studies.
† In North Jakarta the public treatment cost were US$144 for in-patient treatment, US$44 for outpatient treatment in a hospital, and US$2 for outpatient treatment in a health centre [5]. The cholera cases in public cost study cannot be matched to the cholera cases in the patient cost study. Information from the patient cost study on the healthcare facilities where patients sought treatment is used to determine which public treatment cost estimate applies to each case. After adjusting for inflation to 2005 US$ and subtracting private payments to public facilities from the public treatment cost, the public treatment costs for in-patients and outpatients are US$71.7 and US$13.6, respectively.
‡ In Beira, the difference between net public COI (US$28) and the public COI (US$30) is due to inflation adjustment and subtraction of private payments to public facilities.
§ The hospitalization rates in this table are from the DOMI Burden of Disease Studies.
¶ These estimates are not available due to incomplete information on the public cost of outpatient treatment.

for treatment was 13% in Matlab, 14% in North Jakarta, 20% in Kolkata, and 27% in Beira.

Provider and public treatment costs

Average provider treatment costs for in-patient cases (among children and adults) ranged from about US$20–30 in Matlab, Kolkata, and Beira (Table 4) and were much higher in North Jakarta (US$126 for children, US$164 for adults). The provider costs for outpatient cases in North Jakarta were US$14 for adults and US$26 for children.

Patient cost study respondents' payments to public facilities ranged from US$1 to US$4 for hospitalized cases in Matlab, Kolkata, and Beira. In North Jakarta, patients' payments to public facilities were US$87 for hospitalized cases in children and US$62 for hospitalized cases in adults. Patients' payments for public outpatient treatment were US$0.3 for children in Kolkata, US$3 for children in North Jakarta, and US$8 for adults in North Jakarta.

The average public treatment costs (provider treatment costs minus patients' payments) for hospitalized cases were about US$15–40 for children; US$18–30 for adults in Matlab, Kolkata, and Beira; and US$101 for adults in North Jakarta. The public treatment costs of outpatient cases were only measured in North Jakarta where they were US$22 for children and US$6 for adults.

The public costs of in-patient treatment were greater for adults than for children in Matlab, Kolkata, and Beira, while the opposite was true for North Jakarta.

Total (*ex-post*) *costs per episode of cholera*

For all ages combined, the average total cost of a hospitalized episode of cholera was US$32 in Matlab, US$35 in Kolkata, US$47 in Beira, and US$206 in North Jakarta (Table 1), and the costs were higher for adults (Table 2) than children (Table 3) at all sites except Beira (where the costs were the same). The

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Table 2. *Mean adult cost of illness (COI) per episode of cholera (in 2005 US$), by treatment setting and study site (standard deviation)**

	Study site			
	Matlab	North Jakarta‡	Kolkata	Beira¶
Sample size	(*n* = 127)†	(*n* = 94)	(*n* = 27)§	(*n* = 31)
Hospitalized cases	(*n* = 127)	(*n* = 19)	(*n* = 14)	(*n* = 31)
Patients' costs	17·7 (16·4)	121·6 (79·2)	28·6 (61·9)	17·1 (20·2)
Direct costs	6·5 (8·4)	100·7 (82·6)	7·5 (8·4)	5·0 (5·1)
Indirect costs	11·2 (10·8)	20·9 (14·5)	21·0 (62·0)	12·1 (18·3)
Public costs	18·2 (n.a.)	101·4 (n.a.)	20·0 (n.a.)	29·9 (n.a.)
Total costs	**36·0 (n.a.)**	**223·0 (n.a.)**	**48·6 (n.a.)**	**47·0 (n.a.)**
Outpatient cases		(*n* = 75)	(*n* = 13)	
Patients' costs	—	17·2 (19·5)	5·9 (5·3)	—
Direct costs	—	10·0 (14·4)	0·6 (1·2)	—
Indirect costs	—	7·2 (9·5)	5·3 (5·4)	—
Public costs	—	6·3 (n.a.)	n.a. (n.a.)	—
Total costs	—	**23·5 (n.a.)**	**n.a.**#	**—**
Hospitalization rate for adult cases‖	100·0 %	19·0 %	50·7 %	100·0 %

* Outpatient costs were not available from the Matlab and Beira study sites because these were hospital-based studies.
† For adults, all private COI cases (127 cases) are matched with public COI cases (136 cases).
‡ In North Jakarta the public treatment costs were US$144 for in-patient treatment, US$44 for outpatient treatment in a hospital, and US$2 for outpatient treatment in a health centre [5]. The 24 cholera cases in the public cost study cannot be matched to the cholera cases in the patient cost study. Information from the patient cost study on the healthcare facilities where patients sought treatment is used to determine which public treatment cost estimate applies to each case. After adjusting for inflation to 2005 US$ and subtracting private payments to public facilities from the public treatment cost, the public treatment costs for in-patients and outpatients are US$71.7 and US$13.6, respectively.
§ For adults in Kolkata, only 11/27 cases of cholera from the patient cost study are matched to cholera cases from the public cost studies (*n* = 57). Among the unmatched cases, three cases were treated in an in-patient setting and 13 were treated as outpatients, based on information from the patient cost study. For the three in-patients, the average value of public COI is US$18.8. The public treatment costs for the 13 outpatients are not available.
¶ In Beira, all cases of cholera from the patient cost study are matched to cases of cholera in the public cost study.
‖ The hospitalization rates in this table are from the DOMI Burden of Disease Studies.
These totals are not available due to incomplete information on the public cost of outpatient treatment.

average total cost of an outpatient case is only available for North Jakarta, where these costs (US$28) are much lower than the average total cost of a hospitalized case. In North Jakarta, the outpatient costs were higher for children (US$34) than adults (US$24).

DISCUSSION

In order to conduct economic analyses of cholera immunization programmes, there is a need for estimates of the costs that cholera imposes on society. The comprehensive cost estimates reported in this paper relied on a single research protocol to ensure comparability and are the most detailed and robust estimates available of the COI due to cholera. The studies tracked culture-confirmed cases for up to 14 days across a range of epidemiological and healthcare settings and represent a significant contribution to what is known about the COI due to cholera in developing countries. Previous studies of the costs of cholera [12–15] have not quantified patients' costs or the costs of cholera in endemic (rather than epidemic) settings, while previous studies of the costs of unspecified diarrhoeal disease [16, 17] lacked the specificity needed to assess disease-specific interventions. This study contributes to the thin literature on community-based studies of the COI due to diarrhoeal disease [18–20].

Hospital-based studies in Matlab and Beira found that the costs of severe cholera were US$32 and US$47, respectively, with the majority of costs being borne by the public healthcare system. Community-based studies in North Jakarta and Kolkata measured the costs of both severe (hospitalized; US$206 and

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Table 3. *Mean child cost of illness (COI) per episode of cholera (in 2005 US$), by treatment setting and study site (standard deviation)**

	Study site			
	Matlab	North Jakarta‡	Kolkata	Beira¶
Sample size	(*n* = 150)†	(*n* = 82)	(*n* = 39)§	(*n* = 18)
Hospitalized cases	(*n* = 150)	(*n* = 17)	(*n* = 14)	(*n* = 18)
Patients' costs	7·9 (6·0)	147·8 (62·9)	7·2 (6·8)	21·6 (55·1)
Direct costs	4·0 (4·4)	124·9 (60·3)	6·2 (6·7)	3·9 (1·9)
Indirect costs	3·9 (3·0)	22·9 (15·2)	1·0 (1·6)	17·7 (54·5)
Public costs	19·8 (n.a.)	38·6 (n.a.)	15·1 (n.a.)	26·0 (n.a.)
Total costs	**27·8 (n.a.)**	**186·4 (n.a.)**	**22·3 (n.a.)**	**47·6 (n.a.)**
Outpatient cases		(*n* = 65)	(*n* = 25)	
Patients' costs	—	11·3 (20·7)	2·6 (3·2)	—
Direct costs	—	6·6 (161.)	1·2 (1·7)	—
Indirect costs	—	4·7 (7·4)	1·4 (2·7)	—
Public costs	—	22·1 (n.a.)	n.a.	—
Total costs	**—**	**33·5 (n.a.)**	**n.a.**#	**—**
Hospitalization rate for child cases‖	100·0 %	23·5 %	29·7 %	100·0 %

* Outpatient costs were not available from the Matlab and Beira study sites because these were hospital-based studies.
† All private COI cases are matched with public COI cases.
‡ In North Jakarta the public treatment cost was US$144 for in-patient treatment, US$44 for outpatient treatment in a hospital, and US$2 for outpatient treatment in a health centre [5]. The 30 cholera cases in the public cost study cannot be matched to the cholera cases in the patient cost study. Information from the patient cost study on the healthcare facilities where patients sought treatment is used to determine which public treatment cost estimate applies to each case. After adjusting for inflation to 2005 US$ and subtracting private payments to public facilities from the public treatment cost, the public treatment costs for in-patients and outpatients are US$71.7 and US$13.6, respectively.
§ For children in Kolkata, only 10 private COI cases (out of 39) are matched with cholera cases from the public cost study (*n* = 45). Among the unmatched cases, four cases are in-patients and 25 are outpatients based on information from the patient cost data. For the four in-patients, the average value of public COI (US$19·9) is imputed. The public treatment costs of 25 outpatients are not available.
¶ In Beira, most cases of cholera from the patient cost study are matched to cases of cholera in the public cost study (*n* = 19).
‖ The hospitalization rates in this table are from the DOMI Burden of Disease Studies.
These totals are not available due to incomplete information on the public cost of outpatient treatment.

US$35, respectively) and less severe cholera. North Jakarta is the only site where public costs were less than patients' costs, due to large private payments to public facilities. The costs of cholera were highest in North Jakarta (US$206 for a hospitalized case; US$28 for a non-hospitalized case) due to higher fees relative to other sites and the study's inclusion of private treatment facilities.

Patients' COI as a percentage of average monthly income were 21 % and 4 % for hospitalized and non-hospitalized cases, respectively, in Kolkata (average monthly income = US$84) and 65 % and 7 % for hospitalized and non-hospitalized cases, respectively, in North Jakarta (average monthly income = US$207). Patients' costs in this range have been found to be catastrophic for poor households that have poor health [21, 22]. Further, limited socioeconomic data available for patients in Kolkata indicates that households with cholera patients tended to be more disadvantaged than households without cholera. This burden on families is not captured by studies that adopt a provider perspective (e.g. the WHO-CHOICE methodology).

In most cases, the costs were greater for adult patients than child patients, which reflects the fact that child patients have lower income and productivity losses than adults.

Our cost estimates may underestimate the true COI for several reasons. Respondents in North Jakarta and Kolkata indicated that 20–25 % of families sought private treatment at some point during the illness. If private treatment was under-represented in these studies (since most study facilities were public), then the private COI will understate the cost to individuals in the general population who would have had no option but to seek, and pay for, private care in

Table 4. *Mean provider costs per case, private expenditures to public facilities, and public treatment costs per case in 2005 US$ (standard deviation)**

			Matlab	North Jakarta	Kolkata	Beira
Children	Hospitalized	Provider treatment costs	20·8	126·0	18·2	27·4
		Private payments to public facilities	0·9 (1·1)	87·4 (61·4)	3·1 (4·7)	1·5 (1·0)
		Public treatment costs	19·8	38·6	15·1	26·0
	Outpatient	Provider treatment costs	—	25·5	n.a	—
		Private payments to public facilities	—	3·3	0·4	—
		Public treatment costs	—	22·1	n.a.	—
	Hospitalization rate†		*100·0%*	*23·5%*	*29·7%*	*100·0%*
Adults	Hospitalized	Provider treatment costs	19·3	163·7	23·7	31·4
		Private payments to public facilities	1·1 (1·1)	62·3 (56·4)	3·7 (6·1)	1·6 (1·2)
		Public treatment costs	18·2	101·4	20·0	29·9
	Outpatient	Provider treatment costs	—	14·3	n.a.	—
		Private payments to public facilities	—	8·1 (12·7)	0·0 (0·0)	—
		Public treatment costs	—	6·3	n.a.	—
	Hospitalization rate†		*100%*	*19·0%*	*50·7%*	*100·0%*
All ages	Hospitalized	Provider treatment costs	20·1	145·9	21·0	30·0
		Private payments to public facilities	1·0 (1·1)	74·2 (59·4)	3·4 (5·4)	1·5 (1·1)
		Public treatment costs	19·1	71·7	17·6	28·4
	Outpatient	Provider treatment costs	—	19·5	n.a.	—
		Private payments to public facilities	—	5·9 (12·9)	0·3 (0·9)	—
		Public treatment costs	—	13·6	n.a.	—
	Hospitalization rate†		*100·0%*	*21·7%*	*37·7%*	*100·0%*

* Outpatient costs are not available from the Matlab and Beira study sites because these were hospital-based studies.
† The hospitalization rates for children, adults, and all ages are reported in Tables 3, 2, and 1, respectively.

the absence of the DOMI presence. Moreover, the cost estimates do not include any of the interest payments or transaction costs that were incurred by the 13–27% of families who borrowed money*, nor do they measure the costs borne by employers and insurers. Other reasons for a discrepancy between our estimates of public cost and true public cost include the fact that data quality available at public sector health facilities in developing countries are generally poor and assumptions about how public health expenditures are allocated across services was required.

The study design may have distorted costs somewhat by offering a high standard of care that was not representative of existing healthcare. Further, since the public cost study relied on only one or at most a few facilities in the study areas, these costs may not be representative of the overall public healthcare provision system in the study country. Further, information campaigns in North Jakarta and Kolkata, which informed the study population about symptoms that should be treated and where to seek care, and the ongoing ICDDR,B disease surveillance may have sensitized the public and encouraged early treatment of cases. If so, this may have reduced the incidence of severe illness and more expensive cases.

Since sample sizes vary considerably across sites, the cross-site comparisons are limited by the varying precision of the estimates. Moreover, variation in household characteristics within and across sites, and variation in the healthcare system and quality may help explain differences in costs across sites. However, there is very little information on the socioeconomic characteristics of the households to perform these analyses.

Finally, using total cost savings as a measure of the benefits of disease prevention understates the economic impact because it does not include the costs of premature death, the discomfort of pain and suffering, and expenditures made by households, communities and governments to prevent disease (e.g. drinking water treatment, information campaigns). When used as a proxy for the social benefits of preventing disease in a social cost-benefit analysis, COI estimates should account for these missing costs.

* The percentage of families in the sample that reported borrowing money to pay for treatment was 13% in Matlab, 14% in North Jakarta, 20% in Kolkata, and 27% in Beira.

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The costs described in this paper are *ex-post* estimates because they measure costs incurred by the patient and society after an individual contracted cholera. Social cost-benefit analyses require an *ex-ante* measure of benefits, such as the annual expected cost of cholera per person [12]. The *ex-ante* cost considers these estimates from the perspective of an individual or public health system that does not know whether an infection will occur. *Ex-ante* costs are the product of the estimated *ex-post* cost per episode and the annual incidence rate.

The DOMI programme's willingness-to-pay studies have generated measures of benefits for cholera [23–26] and typhoid fever [27, 28] that are both *ex-ante* and more comprehensive than these COI estimates in that they estimate some of the missing costs mentioned above.

These data are likely to yield more accurate estimates of avoided COI for use as measures of economic benefits in the preparation of investment cases for interventions that prevent cholera.

APPENDIX

DOMI Cholera COI Study Group

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DECLARATION OF INTEREST

None.

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