The hidden health and economic burden of rotavirus gastroenteritis in Malaysia: an estimation using multiple data sources

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Technical Appendix

This section contains additional material on methodology used to estimate the health and economic burden of rotavirus gastroenteritis in Malaysia.

Supplementary Text 1 compares the present study with a previous rotavirus burden estimation in Malaysia. Supplementary Text 2 provides detailed methods and results of the systematic review we conducted of prospective, hospital-based rotavirus surveillance studies in Malaysia. Supplementary Text 3 details the estimation of direct medical costs for rotavirus gastroenteritis using multiple data sources.

Supplementary Table 1 compares rotavirus burden estimates of the present study with the 2005 study.

Supplementary Tables 2 to 3 provide the detailed workings of the estimation of incidence of acute gastroenteritis in Malaysia according to health service utilization.

Supplementary Tables 4 summarizes three hospital-based rotavirus studies selected for meta-analysis.

Supplementary Table 5 details the estimation of unit cost at five tertiary-level public hospitals.

Supplementary Table 6 shows the estimation of unit costs at healthcare facilities in Malaysia.

While, supplementary tables 7 to 9 detail the estimation of direct medical, direct non-medical and indirect costs for rotavirus gastroenteritis in Malaysia according to health service utilization.

Supplementary Text 1: Comparison of incidence estimates with the previous rotavirus burden study

One previous study by Hsu et al[1], estimated the rotavirus (RV) burden in Malaysia. We feel that this study underestimated the burden, due to under-reporting of discharges and inadequate consideration of privately treated episodes. We compare here the estimates of burden of the Hsu et al. study with the present study. (Supplementary table 1)

1.1Hospital Discharges

Since 1999, electronic records on hospital discharges are captured in a national database administered by the Ministry of Health, Malaysia (MOH). Only MOH public hospitals report to the database. Non-MOH public hospitals, like teaching and army hospitals do not report to the database. Although, discharges from private hospitals were officially collected from 2000, this collection mechanism is not reliable. In 2013, approximately 209 private hospitals were registered in Malaysia, however only 107 hospitals reported hospital discharge data [2]. Also, there is under-reporting in terms of discharges, as diagnostic coding of discharges using International Classification of Disease, tenth revision (ICD-10), is often incomplete in private facilities.

a) Under-reporting of public hospital discharges

In their paper, Hsu et al. reported that during the 2-year study period (1999-2000), there were 27,873 children under-five years of age with discharge diagnosis of AG, or an average of 13,937 AG hospitalizations annually.

This figure is much less than the 21,000 AG hospitalizations reported annually from 2008 to 2013. A possible explanation is that in the early years of establishment of the national database, not all discharges were ICD-10 coded, leading to considerable under-reporting.

a) Public hospitals not contributing data not accounted for

Hsu et al. did not account for discharges from MOH hospitals or the non-MOH public hospitals not reporting to the database.

In this present study, we adjusted for non response from hospitals by using hospital beds, which takes into consideration both the number and size of the hospitals. Please see Supplementary Table 2.

b) Private hospitals inadequately considered

The Hsu et. al study was unable to collect direct discharge data on private hospitals, and adjusted for an additional 20% of hospitalizations in the private sector, estimating a total of 13,937 AG-related hospitalizations annually in Malaysia (at both public and private hospitals).

This estimate is lesser than our current estimate, primarily because it did not directly capture private hospitalizations. From 2010 to 2013, the national database captured an average of 17,000 AG private hospital discharges annually, in children under-five years. In our study, we accounted for all diarrheal discharges in the country, including for episodes not reported, by using weights of total hospital beds. Please see Supplementary Table 2.

1.2 Outpatient visits

Hsu et al. reported an average of 60,343 AG-related outpatient visits annually to public health clinics between 1998 and 2000. In 2012, 129,424 AG-related outpatient visits in children under-ten years to public facilities were reported.

We estimated 82,568 AG-related outpatient visits under-five years, by applying weights based on age-dependent health service utilization from NHMS 2006, to the 2012 data from public outpatient facilities. Again, the difference may be due to improvement in the reporting mechanism to the MOH database over time. (Supplementary table 3)

Also, unlike our present study Hsu et al. did not estimate burden of AG outpatient visits to private clinics. We used weights from NHMS 2006 to estimate the number of children who sought treatment at private clinics for diarrheal illness.

1.3 Home-treated cases

The Hsu et al. paper did not consider episodes of diarrhea that did not require formal treatment at healthcare facilities. This is an important burden to society, as children with mild diarrhea still require caregiver's time, and thus incur productivity loss. Our estimates of home-treated episodes is based on health-utilization patterns from the only community-based study in Malaysia[3], and this gives very similar results when compared with two international studies[4, 5].

Parashar et al. estimated that for every child requiring medical attention for rotavirus gastroenteritis in developed countries, an additional three to five children develop symptomatic illness requiring only home treatment (or a mild illness) [4]. Our current study findings suggest that in Malaysia, the number of children with rotavirus diarrhoea that were home-treated (145,000)

was about 3.5 times the number who sought outpatient care (41,000). This is within the range of estimates of home-treated episodes obtained when using the Parashar et al. expansion factor of four times of outpatient episodes (range of number of home-treated episodes: 124,000 to 206,000).

Bilcke et al. estimated the global incidence of symptomatic rotavirus infections at 0.31 (0.19 to 0.50) per-person per-year in children under 2 years of age [5]. This would mean 315,000 (193,000 to 509,000) symptomatic episodes in children under 2 years annually in Malaysia. Our estimate of 218,000 episodes of symptomatic rotavirus annually in children under-five years of age in Malaysia is well below this estimate.

Supplementary Text 2: Systematic review of prospective, hospital-based rotavirus studies in Malaysia

We conducted a systematic search of prospective hospital-based rotavirus (RV) surveillance studies in Malaysia. A meta-analysis was conducted to obtain pooled RV-detection proportions for acute gastroenteritis (AG) hospitalizations.

2.1 Methods

A systematic search was conducted to select studies conducted in Malaysia that comply with WHO recommendations for hospital-based RV surveillance [6]. Criteria for eligibility were as follows: (i) prospective, hospital-based study (ii) at least one year duration, (iii) conducted in Malaysia, (iv) on children under the age of 5 years, (v) stool tested for RV with an enzyme immunoassay test.

The literature was searched systematically to locate published articles in three databases (PubMed, Scopus and Web of Science). Search terms used were 'rotavirus' AND ('gastroenteritis OR 'diarrhoea' OR 'diarrhea') AND 'Malaysia'. The search was limited to English language publications. Citation search and consultation with experts were conducted to identify additional publications.

After removing duplicates, titles and abstracts were screened to identify prospective, hospital-based RV studies. Subsequently, full text articles were read to identify studies meeting the eligibility criteria for inclusion in the meta-analysis.

A DerSimonian and Laird random-effects model [7] was used to pool outcomes from each individual study site and calculate the mean and 95% Confidence Interval (CI) for RV-detection proportion.

2.2 Results

The systematic search of three databases provided a total of 94 citations; 39 from Pubmed, 38 from Scopus and 17 from Web of Science. No further articles were identified from citation search or consultation with experts. After duplicates were excluded, 27 articles on rotavirus in Malaysia were screened by title and abstract. Of these, 15 were excluded for not being prospective, hospital-based rotavirus surveillance studies. Three papers were discarded for being results of duplicate primary studies. Full text articles of the remaining nine papers were read, and the eligibility criteria were applied. A PRISMA flow diagram of the review process is shown in Figure 2 of the main text.

From 1982 to 2012, there were nine prospective hospital-based rotavirus surveillance studies conducted in Malaysia. The studies were conducted at Kuala Lumpur, the capital city of Malaysia and other locations including Kuching in Sarawak, Kota Kinabalu in Sabah, Johor Baru in Johor and Kuala Terengganu in Terengganu. Only three studies were conducted among children under-five years old. Five of the nine studies used EIA methods to test stool specimens for rotavirus. A total of 9,510 stool specimens were tested for rotavirus, with the rotavirus detection proportion of 23% to 50% at each site.

A total of three studies met the predetermined eligibility criteria and were included in the meta-analysis [8-10]. These studies were conducted at different time-points between the year 2000 and 2010, and at different geographic locations in Malaysia. A total of 5,586 stool samples were tested

for rotavirus. The rotavirus detection proportion ranged from 32% to 50% at each individual study site. See Supplementary Table 4 for a summary of the three prospective hospital-based rotavirus surveillance studies selected for meta-analysis.

Each of these three studies were conducted at two different locations. For two studies (Hung et al., 2006 and W.S. Lee et al., 2012), results were shown separately for each individual study site [9, 11]. The Hsu et al. 2005 paper did not segregate results by study site [9]. Rotavirus detection proportion from 5 individual study sites from the three papers were pooled for the meta-analysis. A random effects model was applied to account for heterogeneity ($I^2 = 86\%$). The pooled estimate of the RV- detection proportion in children under-five years hospitalized for AG was 44.5% (95% CI: 39.6 – 49.4). See Figure 3 in the main text.

Supplementary Text 3: Estimating direct medical costs

The economic burden of RVGE in Malaysia is dependent on unit cost estimates for inpatient and outpatient care at both public and private health facilities in Malaysia. Direct medical costs were calculated based on per bed-day inpatient costs multiplied with the duration of admission for hospitalizations and costs per-visit for outpatient visits.

Since unit costs are not readily available in Malaysia, we utilize methods previously used in the estimation of the economic burden of dengue in Malaysia [12, 13]. Multiple data sources were combined for this estimation, including hospital annual reports from five tertiary-level hospitals, local costing studies at six primary-level hospitals and eleven health clinics around the country and World Health Organization-CHOosing Interventions which are Cost-Effective (WHO-CHOICE).

3.1 WHO-CHOICE project

The WHO-CHOICE (World Health Organisation – CHOosing Interventions which are Cost-Effective) project was initiated in 1998 to assist countries in making rational choices based on evidence generated by cost-effectiveness analyses [14].

The WHO-CHOICE project allows for estimation of unit cost of inpatient and outpatient care by 191 member states, through data collected from 49 countries [15, 16]. Presumably because of the lack of suitable data, Malaysia had not been included in this list of countries contributing data. Using econometric modeling, the WHO-CHOICE project predicts unit costs for countries in which data were not available. In the case of Malaysia, especially since Malaysian data was not obtained for the WHO-CHOICE project, it is preferable to use local data for costing.

The facility-types used in the WHO-CHOICE project refers to differences in service characteristics, including difference in case-mix, technical capacity and skills available in facilities [15].

In our study, costs for facility levels from WHO-CHOICE project (primary-level, secondary-level and teaching hospitals) were used for estimation of unit-costs for inpatient bed-days at public hospitals. For the estimation of unit-costs for outpatient visits (public hospital and clinics), facility levels used were health facilities with no beds, primary and secondary-level hospitals [15, 17].

3.2 Unit costs at public clinics

A 1995 costing study on the provision of outpatient services in 11 MOH public clinics in Kedah was conducted by Lim KJ provided costs per-visit of US$ 3.75 in 2013 US$ [12, 18]. Information on costs was collected for personnel, supplies, utilities, maintenance and training, and was derived mainly from the operating budget of the clinics involved. We deemed this unit cost of US$ 3.75 for public clinics in Malaysia or similar to 'health facilities with no beds' from WHO-CHOICE [14, 17].

3.3 Unit costs at primary-level hospitals

A study by Sabrina AR in 2001 estimated unit costs at six primary-level or district hospitals around Malaysia for the year 2001. This study provided us with average costs for primary-level hospitals of US$ 43 per-visit (range: US$ 10 to US$ 78 per-visit) in 2013 US$.

All the selected hospitals in this study were 93 bedded facilities with basic medical and surgical services provided by doctors without specialist qualifications, hospitals which were considered by the MOH as belonging to the category of "district hospitals without specialists" [19].

3.4 Unit costs at tertiary-level hospitals

We conducted top-down costing of five urban, tertiary-level public hospitals in Malaysia. The hospitals selected were University of Malaya Medical Center (UMMC), Hospital Sungai Buloh (HSB), Hospital Sultanah Bahiyah, Alor Setar (HAS), Hospital Melaka (HM) and Hospital Sultan Haji Ahmad Shah, Temerloh (HT).

The UMMC is a tertiary-level, teaching hospital administered by the Ministry of Education. The operating expenditure and workload of UMMC was obtained from the 2012 hospital annual report and updated to include salaries of academic clinicians. Academic clinicians are employed by the university, and as such their salaries are not included in the hospital's operating expenditure. We made the assumption that the academic clinicians spent 60% of their time on clinical service, while the remaining time was spent on academic and research duties. [12] The cost of an outpatient visit was assumed at a fifth the cost of an inpatient day at tertiary-level hospitals.

We searched hospital websites individually for annual reports of tertiary-level Ministry of Health (MOH) hospitals. We also hand-searched for annual reports at the MOH library at Putrajaya. The lack of standardized formats and availability of information on admission rates, clinic attendances, bed occupancy rate, hospital expenditure and others limited our selection to 4 tertiary-level MOH hospitals.

We estimated of unit-costs at tertiary-level hospitals based on the average costs obtained from UMMC and these 4 hospitals (Supplementary table 5). Average costs at tertiary-level hospital was estimated at US$ 341 per-bed day and US$ 68 per-visit.

3.4.1 Description of tertiary-level hospitals

University of Malaya Medical Center (UMMC)

UMMC is a 979 bedded, tertiary-level, teaching hospital administered by the Ministry of Education. UMMC is located in Kuala Lumpur, and is the only public hospital serving the bordering the city of Petaling Jaya, with a population of approximately two million people.

Hospital Sungai Buloh (HSB)

Hospital Sungai Buloh is a 620 bedded, tertiary-level hospital located about 25 km from the capital city of Kuala Lumpur, in the state of Selangor. This hospital serves about approximately 2.18 million people or 40% of the population of Selangor. It is known as a center of excellence for the management of infectious diseases, emergency medicine and traumatology, neurosurgery, maxillo-facial surgery, plastic and reconstructive surgery and spinal surgery.

Hospital Sultanah Bahiyah, Alor Setar (HAS)

Hospital Sultanah Bahiyah, Alor Setar is an 870 bedded tertiary-level hospital located in Alor Setar in the northern state of Perlis. . Hospital Sultanah Bahiyah, Alor Setar serves as a regional referral center for 12 clinics in Perlis and 8 state hospitals in the northern region of Malaysia. This hospital provides tertiary-level clinical services in 12 specialties, with 28 clinical consultants providing sub-specialty services including cardiology, nephrology, plastic and reconstructive surgery and maxillofacial surgery.

Hospital Sultan Haji Ahmad Shah, Temerloh (HT)

Hospital Sultan Haji Ahmad Shah, Temerloh is a 500 bedded, tertiary-level hospital serving approximately 900 thousand people in 6 districts in the state of Pahang. In 2012, Hospital Sultan Haji Ahmad Shah, Temerloh employed 2,042 staff, including 31 Clinical Specialists. This hospital provides tertiary-level services in 12 specialties and sub-specialty services including oral-maxillary-facial surgery, pediatric dentistry, and oral surgery.

Hospital Melaka (HM)

Hospital Melaka is a 1,091 bedded, tertiary-level hospital serving approximately 800 thousand people in Melaka and 4 neighboring districts in Johor. Hospital Melaka is second only to Hospital Kuala Lumpur, in number of operational beds among MOH hospitals in Malaysia. It provides services in 17 clinical specialties and sub-specialty services including plastics and reconstructive surgery, oral surgery, dermatology, pediatric dentistry.

3.5 Costing of hospital bed-days

In this current study, we use methods previously utilized in the estimation of dengue burden in Malaysia [12]. In 2010, a two-stage expert workshop, gathered experts from the public and private health sectors and academia to discuss issues arising in the estimation of dengue disease burden and costing, due to insufficient data [20].

Two main conclusions from this expert workshop are used in our present study.

Firstly, the workshop participants had agreed that the description of tertiary-level or teaching hospitals, as provided by WHO-CHOICE, could refer to the state-level, national referral centers or teaching hospitals in the public sector in Malaysia, including UMMC. The Malaysian district

hospitals could be categorized as either primary-level or secondary-level hospitals depending on the services provided. In the case of smaller district hospitals without specialists or with few basic specialties, the participants agreed that they should be categorized as primary-level hospitals. These would include the six district hospitals in the 2001 costing study [21]. The remaining district hospitals could be considered as secondary-level hospitals.

Secondly, inpatient care at each hospital-type was assumed to be proportional to the number of beds in these facilities. The expert panel in the dengue study, agreed that the number of tertiary-level beds made up 50% of all hospital beds in the country. The corresponding figures for secondary and primary level hospital beds were 30% and 20% respectively. [12].

We assumed that inpatient care for diarrhea at each hospital-type was proportional to the number of beds in these facilities. Distribution of hospitals by number of beds was derived from the expert workshop in the dengue study [12].

Cost estimates by facility-type from WHO-CHOICE was used to derive cost-ratios, or the ratio of unit costs for primary and secondary facilities compared to costs at tertiary-level facilities. Unit costs per bed-day for primary-level hospitals are 74% of costs at tertiary-level hospitals (average costs from UMMC and the 4 tertiary-level hospitals).

These cost-ratios were applied to unit cost estimates for tertiary-level hospitals and the distribution of healthcare facility by type, to derive average costs per bed-day at public hospitals of US$ 300.

The unit cost estimates for tertiary-level hospitals of US$ 341 per bed-day and US$ 68 per-visit (average costs from UMMC and the 4 tertiary-level hospitals), were assumed to be equivalent to costs of private facilities.

Duration of admission for an episode of RVGE (3.3 days) was obtained from a 2010 prospective study conducted in two hospitals in Malaysia [11, 22]. (Supplementary Table 6)

3.6 Costing of outpatient visits

Distribution of care to outpatient facilities was based on unpublished data from MOH, Malaysia. Clinic attendances to MOH facilities for childhood diarrhoea in 2012, showed that 56% of outpatient visits were to health facilities with no beds and the remaining were to hospitals [23]. We apportioned outpatient care at each hospital type as proportional to the number of beds in these facilities (conclusion of expert panel discussion in Dengue study). As such we distributed the remaining 44% of outpatient visits to tertiary-level (50%), secondary-level (30%) and primary-level (20%) hospitals.

Cost estimates by facility-type from WHO-CHOICE was used to derive the ratio of unit costs for secondary-level hospitals compared to costs at primary-level hospitals. Unit costs per outpatient visit for secondary-level hospitals are 141% of the costs at primary-level hospitals (from the Sabrina AR study).

Costs per-visit to public health clinics (health clinics with no beds) was derived from the 1995 costing study by Lim KJ of US$ 4. Average costs per-visit from UMMC and 4 MOH hospitals of US$ 68 was applied to tertiary-level hospitals.

Our estimate for the average cost per-visit for outpatient care is US$ 29 (US$ 4 for public clinic visits, US$ 61 for public hospital outpatient visits and US$ 68 for private clinic visits).

See Supplementary Table 6 for estimation of unit costs at healthcare facilities in Malaysia

Supplementary Table 1. Burden of rotavirus gastroenteritis in Malaysia, 2000 and 2013.

	2000				2013			
	Annual no. of cases of diarrhea		Events per 1,000 children per year		Annual no. of cases of diarrhea		Events per 1,000 children per year	
	AG related	RV related	AG related	RV related	AG related	RV related	AG related	RV related
Deaths	69	34	0.03	0.01	61	27	0.02	0.01
Hospitalizations	13,937	8,571	5.3	3.3	69,965	31,148	27.5	12.2
Outpatient clinic visits	60,342	14,482	23.1	5.5	233,806	41,260	91.9	16.2
Home Treated			-	-	1,209,128	145,095	475.3	57.0
Total	74,348	23,087	28.5	8.8	1,512,960	217,531	594.7	85.5

[a] Results from the estimation of rotavirus burden in Malaysia by Hsu et al. in 2005.

[b] By 5 years of age.

289 Birth cohort: 1998: 521,997 live births; 2012[p]: 508,774 live births from the Department of Statistics, Malaysia. [p] preliminary data

290 Note: RV: rotavirus; AG: acute gastroenteritis.

Supplementary Table 2. Diarrheal discharges to public and private hospitals in children under-five years in Malaysia

Row	Item	Source	Public hospitals	Private hospitals
(1)	Diarrheal discharges reported	MOH[a]	23,450	15,886
(2)	No. of reporting hospitals	MOH[b]	96	107
(3)	No. of hospital beds in reporting hospitals	MOH[b]	18,694	12,572
(4)	Total hospitals in Malaysia	MOH[c]	142	209
(5)	Total hospital beds in Malaysia	MOH[c]	41,639	14,033
(6)	**Total diarrheal discharges in Malaysia**	**(1) x (5)/ (3)**	**52,233**	**17,732**

[a] Discharges reported to the national database at the Center for Health Informatics, Planning Division, Ministry of Health, Malaysia.

[b] Hospitals reporting discharges to the Center for Health Informatics, Planning Division, Ministry of Health, Malaysia.

[c] Total number of hospitals and beds in Malaysia, obtained from Center for Health Informatics, Planning Division, Ministry of Health, Malaysia.

Supplementary Table 3. Diarrheal outpatient visits at public facilities for children under 10 years and under-five years, 2012

Row	Item	Source	Public hospitals	Public clinics
(1)	0-9 years	MOH [a]	56,999	72,425
(2)	Proportion of diarrheal attendances	NHMS 2006	71%	58%
(3)	0-4 years	(1) x (2) [b]	40,410	42,158

Note: 0-9 years, children under the age of 10 years; 0-4 years, children under the age of five years.

MOH, Ministry of Health, Malaysia; NHMS 2006, National Health and Morbidity Survey 2006

[a] Annual diarrheal attendances for children under ten years at public clinics obtained from Ministry of Health, Malaysia[23]

[b] Annual diarrheal attendances for children under five years are estimated by using age-specific health utilization weights for diarrhea from National Health and Morbidity Survey 2006.

Note: MOH public health facilities provide general outpatient services and/or maternal child health (MCH) services at various levels of care depending the facilities and the needs of the population (population size etc.). MCH clinics may be located in facilities together with outpatient services or in separate, smaller clinics close to villages and communities. MCH services are provided by nurses and midwifes at smaller clinics, but also by GPs and Family Medicine Specialists at larger health centres. Returns on outpatient diarrhoeal

attendances are not recorded or collected at MCH clinics. MCH clinics provide child health services, mainly Well Baby Clinics, monitoring growth, development, nutrition etc. and administering immunisations. Mild diarrhoeal illness may be treated by nurses especially in smaller community clinics, but more severe episodes would be referred to the outpatient department for treatment by medical officers. We are unable to estimate the number of mild diarrhoea episodes treated at MCH clinics because of the integrated nature of the service provided.

Supplementary Table 4. Summary of prospective hospital based studies on rotavirus gastroenteritis selected for meta-analysis

Author	Study Period	Length of study	Age group	Method of RV-detection	Location	Number of cases tested	Number of RV positives	RV-detection proportion (%)	References
Hsu *et al.* (2005)	2001-2003	2 years	<5 years	EIA	Kuala Lumpur and Kuching	2260	1130	50%	[1]
Hung *et al.* (2006)	2002–2003	2 years	<5 years	EIA	Kuala Lumpur	1756	820	47%	[9]
					Kuching	912	445	49%	
Lee *et al*. (2012)	2008–2010	2 years	<5 years	EIA	Kuala Lumpur	385	161	42%	[11]
					Kuala Terengganu	273	87	32%	

316 Note: RV- Rotavirus; EIA - Enzyme Immunoassay test.

317 **Supplementary Table 5. Estimation of unit costs at tertiary-level, public hospitals in Malaysia**

Row	Item	Source	UMMC, 2012	HSB, 2013	HAS, 2012	HM, 2013	HT, 2012
(1)	Admissions	Hospital Report [a]	53,825	45,372	72,703	74,468	39,849
(2)	Number of registered beds	Hospital Report [a]	979	620	870	1,091	500
(3)	Occupancy rate	Hospital Report [a]	78%	82%	95%	85%	91%
(4)	Occupied beds	(2) x (3)	759	507	826	923	457
(5)	Annual bed days	(4) x 365	276,935	185,000	301,609	336,970	166,659
(6)	Outpatient clinic visits	Hospital Report [a]	800,426	191,077	142,011	305,098	73,347
(7)	Emergency visits	Hospital Report [a]	110,246	150,865	275,009	137,852	69,081
(8)	Total outpatient visits	(6) + (7)	910,672	341,942	417,020	442,950	142,428
(9)	Relative cost: visit/inpatient day	Shepard et al.	0.2	0.2	0.2	0.2	0.2
(10)	Ambulatory bed-day equivalents	(8) x (9)	182,134	68,388	83,404	88,590	28,486
(11)	Total bed-day equivalents	(5) + (10)	459,069	253,389	385,013	425,560	195,145
(12)	Operating expenditure, US$	Hospital Report [a]	152,513,135	100,435,440	123,091,114	108,541,693	72,961,931
(13)	Estimated salaries of academic clinicians devoted to service	Estimated [b]	11,757,967	-	-	-	-
(14)	Revised operating expenditures, US$	(12) + (13)	164,271,102	100,435,440	123,091,114	108,541,693	72,961,931

(15)	Cost per bed-day equivalent, US$	(14)/(11)	358	396	320	255	374
(16)	Cost per outpatient visit, US$	(15) x (9)	72	79	64	51	75

Note: All costs are expressed in 2013 US$.

UMMC, University of Malaya Medical Center; HSB, Hospital Sungai Buloh; Hospital Sultanah Bahiyah, Alor Setar, HAS; Hospital Melaka, HM; Hospital Sultan Haji Ahmad Shah, Temerloh, HT.

Table adapted from Shepard et al. and Suaya et al.[12, 13, 24];

[a] Data from the 2012 UMMC Annual Report, 2013 HSB Annual Report, 2012 HAS Annual Report; 2013 HM Annual Report and the 2012 HT Annual Report.

[b] Data from the Department of Human Resources and Faculty of Medicine, University Malaya. UMMC is an academic teaching hospital and salaries of academic clinicians are paid by the university.

326 **Supplementary Table 6. Estimation of unit cost at healthcare facilities in Malaysia, 2013**

Type of facility [a]	Estimated distribution of facility [b,c]	Unit cost (2008 US$)	Ratio of cost by facility type	Unit cost (2013 US$)
		WHO-CHOICE		
Cost per bed-day				
Primary-level hospital	20%	86.60	0.74	252.93
Secondary-level hospital	30%	90.34	0.77	263.87
Teaching hospital	50%	116.81	1.00	341.19[d]
Average cost per bed-day				300.34
Cost per outpatient visit				
Health facilities with no beds	56%	7.63	0.48	3.75[e]
Primary-level hospital	20%	15.93	1.00	43.08[f]

Secondary-level hospital	30%	22.46	1.41	60.74
Tertiary-level hospital	50%	-	-	68.00 [d]
Average cost per outpatient visit at a hospital				60.84
Average cost per outpatient visit				28.87

[a] Definitions of facility levels used in WHO-CHOICE can be obtained from Barnum and Kutzin. Public hospitals in developing countries: resource use, cost, financing, 1993[17].

[b] distribution of hospital beds by facility type for estimation of cost per bed-day and cost per outpatient visits at hospitals was adopted from Shepard et al [12]

[c] distribution of health facilities with no beds are based on unpublished data from Ministry of Health, Malaysia [23].

[d] average cost per bed-day from 5 tertiary-level hospitals in Malaysia is used to represent costs of 'teaching hospital' from WHO-CHOICE. Note that there is no equivalent facility-type in WHO-CHOICE, for outpatient visits at tertiary-level facilities.

[e] Unit cost per-visit equivalent to 'health facilities with no beds' from WHO-CHOICE, obtained from the 1995 costing study on outpatient services in 11 MOH public clinics in Kedah[18].

[f] Unit cost for 'primary-level hospitals' from WHO-CHOICE, obtained from the 2001 costing study of 6 primary-level or district hospitals[19].

Supplementary Table 7. Estimation of direct medical costs for rotavirus gastroenteritis by health service utilization

	Rotavirus episodes ('000)	Unit costs per episode [a,b] (US$)	Direct medical costs ('000 US$)
Public hospital inpatients	23	961	22,349
Public hospital outpatients	7	61	434
Public clinic outpatients	7	4	28
Private hospital inpatients	8	1,126	8,888
Private clinic outpatients	27	68	1,815
Home Treated	145	0	
TOTAL	**217**		33,514

Note: All costs are in 2013 US$;

[a] Estimation of unit costs shown in Table 2 of the main text.

[b] To obtain cost per episode for a diarrheal admission, average duration of admission (3.3 days) was multiplied with cost per bed-day [11, 22].

Supplementary Table 8. Estimation of direct non-medical costs for rotavirus gastroenteritis by health service utilization

	Rotavirus episodes ('000)	Transportation costs per-episode [a] (US$)	Total transportation costs ('000 US$)	Diaper costs per-episode [b] (US$)	Total diaper costs ('000 US$)	Food costs per-episode [c] (US$)	Total food costs ('000 US$)	Direct non-medical costs ('000 US$)
Public hospital inpatients	23	15	358	3	75	0.72	17	450
Public hospital outpatients	7	8	55	3	23	0	0	78
Public clinic outpatients	7	3	20	3	24	0	0	44
Private hospital inpatients	8	16	130	3	25	0.72	6	161
Private clinic outpatients	27	4	96	3	86	0	0	182

Home-treated	145	0	0	3	468	0	0	468
TOTAL	**217**		**659**		**701**		**23**	**1,383**

Note: All costs are in 2013 US$; RVGE, rotavirus gastroenteritis.

[a] One way transportation costs obtained from the National Health and Morbidity Survey 2011. Costs are doubled for outpatient episodes and quadrupled for inpatient episodes.

[b] Diaper costs per episode obtained from the average costs for both hospitals used in the 2010 hospital-based study[25].

[c] Additional food costs for an episode of diarrhoea hospitalized at University of Malaya Medical Center applied to inpatient episodes .

Supplementary Table 9. Estimation indirect costs for rotavirus gastroenteritis by health service utilization

	Rotavirus episodes ('000)	Duration of diarrhea (days)	Average daily wage (US$)	Total indirect costs ('000 US$)
Public hospital inpatients	23	3	25	1,573
Public hospital outpatients	7	3	25	482
Public clinic outpatients	7	3	25	503
Private hospital inpatients	8	3	25	534
Private clinic outpatients	27	3	25	1,805
Home treated	145	3	25	9,815
TOTAL	**217**			**14,714**

[a] Average monthly wage of RM 2,052 for both sexes in 2013 [26]. All costs are in 2013 US$.

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