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# Cholera in selected countries in Asia

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ABSTRACT

*Introduction:* Although the current pandemic of cholera originated in Asia, reports of cholera cases and outbreaks in the region are sparse. To provide a sub-regional assessment of cholera in South and Southeast Asia, we collated published and unpublished data from existing surveillance systems from Bangladesh, Cambodia, India, Malaysia, Nepal, Pakistan, Philippines, Thailand and Vietnam.

*Methods:* Data from existing country surveillance systems on diarrhea, acute watery diarrhea, suspected cholera and/or confirmed cholera in nine selected Asian countries (Bangladesh, Cambodia, India, Malaysia, Nepal, Pakistan, Philippines, Thailand and Vietnam) from 2011 to 2015 (or 2016, when available) were collated. We reviewed annual cholera reports from WHO and searched PubMed and/or ProMED to complement data, where information is not completely available.

*Results:* From 2011 to 2016, confirmed cholera cases were identified in at least one year of the 5- or 6-year period in the countries included. Surveillance for cholera exists in most countries, but cases are not always reported. India reported the most number of confirmed cases with a mean of 5964 cases annually. The mean number of cases per year in the Philippines, Pakistan, Bangladesh, Malaysia, Nepal and Thailand were 760, 592, 285, 264, 148 and 88, respectively. Cambodia and Vietnam reported 51 and 3 confirmed cholera cases in 2011, with no subsequent reported cases.

*Discussion and conclusion:* We present consolidated results of available surveillance in nine Asian countries and supplemented these with publication searches. There is paucity of readily accessible data on cholera in these countries. We highlight the continuing existence of the disease even in areas with improved sanitation and access to safe drinking water. Continued vigilance and improved surveillance in countries should be strongly encouraged.



## 1. Introduction

Cholera is one of the dreaded diseases causing outbreaks that result in substantial morbidity and death. South Asia, particularly the Ganges-Brahmaputra delta, has long been considered as the "homeland of cholera" and six of the seven pandemics, all caused by classical *Vibrio cholerae* O1 were said to have originated there [1]. The seventh and still ongoing pandemic caused by *V. cholerae* O1 El Tor originated in Sulawesi, Indonesia, but the original strain may also have originated from South Asia via the Middle East [2,3]. Since then, outbreaks due to other strains of cholera, such as *V. cholerae* O139 [4,5] and new variants of El Tor carrying classical genes, were said to have origins in Asia [3,6].

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Despite the origins of cholera in Asia, until recently, reports of most outbreaks have been elsewhere in the world. In the 2015 cholera report from the World Health Organization (WHO), Asia reported 64,590 cases, or 37.5% of the global burden. 90% of cholera cases in Asia came from Afghanistan [7]. The updated cholera burden estimates that 29% of the annual 1.3 to 4 million cholera cases were from Southeast Asia alone [8]. This apparent discrepancy implies that the disease is either underreported or is no longer a problem as the countries progress economically and provisions for both improved water and sanitation become available to the population. Some countries in Asia also report 500,000–700,000 annual cases of "acute watery diarrhea", it is unclear what proportion of these are cholera cases [9].

To provide a sub-regional assessment of cholera cases in Asia, we collated published and unpublished data from Bangladesh, Cambodia, India, Malaysia, Nepal, Pakistan, Philippines, Thailand and Vietnam.

## 2. Methods

Data from existing country surveillance systems on acute watery diarrhea and/or cholera in nine selected Asian countries (Bangladesh, Cambodia, India, Malaysia, Nepal, Pakistan, Philippines, Thailand and Vietnam) from 2011 to 2015 (or 2016, when available) were collated. Countries were included in this review if information on cholera was readily accessible to the authors. The descriptions of available surveillance systems included in this study are in Table 1. Most countries use the WHO-recommended case definition for suspected cholera case. A suspected cholera case is defined as: (a) in an area where the disease is not known to be present, a patient aged 5 years or more develops severe dehydration or dies from acute watery diarrhea; or (b) in an area where cholera is endemic, a patient aged 5 years or more develops acute watery diarrhea with or without vomiting; or (c) in an area where there is a cholera epidemic, a patient develops acute watery diarrhea, with or without vomiting [10]. Cambodia, Nepal, Philippines and Vietnam collect information on acute watery diarrhea, and laboratory assessment for cholera among most of these cases are conducted in all except Cambodia. India, Pakistan and Thailand collect information on acute diarrheal diseases and acute watery diarrhea cases are then tested for cholera. In Malaysia, a suspected case is any case with acute severe watery diarrhea with unexplained causes, with or without vomiting. In all countries, a confirmed cholera case is a suspected case wherein *V. cholerae* O1 or O139 is identified in the stool [10]. We also collated information on acute diarrhea, acute watery diarrhea or suspected cholera cases, since in some countries no cholera cases are reported and yet have surveillance mechanisms for diarrhea.

We reviewed cholera reports from WHO published annually in the Weekly Epidemiologic Record. These are collated from reports of national surveillance systems that countries annually submit to WHO [7]. In addition, we searched PubMed using the following search terms: ("cholera" [MeSH Terms] OR "cholera" [All Fields]) AND the countries ("India" OR "Cambodia" OR "Malaysia" OR "Nepal" OR "Pakistan" OR "Philippines" OR "Thailand" OR "Vietnam" [All Fields]) AND dates ("2011/1/1"[Date - Publication]: "2017/1/31" [Date - Publication]). We did not perform PubMed search for Bangladesh to avoid duplication of data from icddr,b. Additional searches using the above keywords were conducted for India, Pakistan and Philippines, in the ProMED-mail Archives of the International Society for Infectious Diseases, since previous studies from India [11] and the Philippines [12] showed that additional information on cholera cases apart from surveillance sources may be obtained from ProMED. In Pakistan, since only watery diarrhea surveillance data and only culture confirmed cases from select hospitals were available, we also conducted a search in ProMED to supplement the

**Table 1**
Available diarrhea or cholera surveillance[a] included in the review in selected Asian countries.

| Countries | Case-based | Outbreak |
|---|---|---|
| Bangladesh | Systematic sampling of 2% of diarrhea cases at icddr,b | NA |
| Cambodia | Cambodia Early Warning Response Network includes an indicator or case-based surveillance for AWD or suspected cholera | Event-based surveillance on outbreak-prone disease with dedicated hotline for reporting to ensure faster response |
| India | Systematic sampling of 5% of admitted diarrhea cases in the Infectious Disease Hospital, run by the National Institute of Cholera and Enteric Diseases in Kolkata | Integrated Disease Surveillance Program – event based surveillance and unusual health events reporting at state and district levels |
| Malaysia | Case-based surveillance for acute gastroenteritis or suspected cholera since 1988, cholera surveillance requires mandatory notification of suspected cases to public health authorities within 24 h. Culture confirmation is required for all suspected cases and all confirmed cases are registered in a web-based platform known as e-notice. Laboratory-based surveillance complements case-based surveillance which also requires all laboratories mandatory reporting of isolation of *V. cholerae.* | To ensure faster response, the existence of any single cholera case in an area or locality is defined as an episode of an outbreak, and need to be notified to the central agency using e-outbreak. |
| Nepal | Early Warning and Reporting System (EWARS) is a hospital-based sentinel surveillance system currently identified in 81 hospitals covering all 75 districts of Nepal. Cholera is an EWARS-reportable disease. | |
| Pakistan | | Disease Early Warning System (DEWS) and Response monitors outbreaks of acute watery diarrhea/ suspected cholera (2010–2014)<br>Establishment of Integrated Disease Surveillance and Response System (IDSRS) at provincial levels, linked with a public health laboratory in the provinces of Punjab and Sindh. |
| Philippines | Philippine Integrated Disease Surveillance and Response – Indicator – based surveillance, i.e. routine reporting of cases of disease, including acute watery diarrhea cases in all age groups. If individual fulfills definition for cholera, culture confirmation performed at established regional surveillance laboratories. | Event-based surveillance and Response – Rapid detection, reporting, confirmation, assessment of public health events, including clusters of acute watery diarrhea diseases and unexpected deaths; Laboratory testing (culture confirmation) conducted on a small proportion of cases |
| Thailand | Acute diarrhea and food poisoning are included in the list of disease surveillance. Stool culture for cholera is available at provincial hospitals and large district hospitals. | Event-based surveillance and notification to sub-district health centers for verification and response by trained health officers. A cluster of acute water diarrhea suspected cholera cases and deaths are investigated and confirmed by stool culture. |
| Vietnam | National Disease Surveillance for acute watery diarrhea and suspected cholera. Culture confirmation available at provincial level | Event-based surveillance-Suspected outbreaks reported to local public health officials through a telephone hotline |

[a] Surveillance is conducted by the countries' respective ministries of health, unless otherwise indicated.

information from surveillance. For India, we used the above search terms in Google scholar and reviewed annual reports published by three Indian Council of Medical Research (ICMR) institutes: the National Institute of Cholera and Enteric Diseases in Kolkata and the Regional Medical Research Centers in Bhubaneswar and Dibrugarh. The results of the PubMed and ProMED searches were compared with annual reports of the ICMR institutes and the Integrated Disease Surveillance Program (IDSP) of the National Center for Disease Control data to remove any duplicate reports. For Pakistan, reports on acute diarrhea were collated from the Disease Early Warning System and Response (DEWS) website (Available at: http://www.emro.who.int/pak/information-resources/dews-epidemiological-bulletins.html). The enhanced DEWS used the WHO case definition for suspected cholera/acute watery diarrhea to detect outbreaks [13].

## 3. Results

From 2011 to 2016, confirmed cholera cases were identified in at least a year of the 5- or 6-year period in the countries included. Malaysia has consistently been reporting cholera cases to the WHO, however, the rest of the countries often underreported (Table 2) [9,14–17]. PubMed searches yielded no additional information on cholera cases for Cambodia, Malaysia, Nepal, Pakistan, Thailand and Vietnam.

### 3.1. Bangladesh

The Institute of Epidemiology Disease Control & Research (IEDCR) of Bangladesh estimates that every year, there are 450,000 hospitalized cholera cases including 4500 deaths in the country [18]. Since 1979, the International Centre for Diarrheal Disease Research, Bangladesh (icddr,b) established a Diarrheal Disease Surveillance System (DDSS) at its urban Dhaka Hospital and in 2000 in the rural Matlab Hospital. The DDSS in Dhaka systematically collects samples from 2% of all acute diarrhea patients irrespective of their age, sex, socio-demographic and economic status.

Annually, the icddr,b in Dhaka admits ~140,000 diarrheal patients [19]. From 2011 to 2015, in the 2% systematic sampling, there were 1426 cholera cases identified (Table 3) or a mean of 285 cases annually. All age groups were affected, with 256, 170 and 1000 confirmed cholera cases coming from the 0–4 years, 5–14 and 15+ years age groups, respectively. Considering that ~10% of the Bangladesh population are in the 0–4 year olds [20], this suggests that the youngest age group are most affected by cholera in icddr,b.

### 3.2. Cambodia

Cambodia last reported an outbreak in 2009–2010 when 15 Cambodians first presented with acute watery diarrhea in An Giang province in Vietnam. During that outbreak, 35 of 77 operational districts were affected with high-case fatality rates of up to 3%, particularly in remote villages. In 2010, there were 213, 284 and 542 cases and in 2011, 16, 5 and 30 cases among the 0–4 years, 5–14 and 15 + years age groups, respectively. There were 6 and 2 reported deaths, respectively among these cholera cases in 2010 and 2011.

Table 3 shows the acute watery diarrhea cases in Cambodia from 2011 to 2015, which ranged from 287,330 in 2013 to 363,078 in 2011. Among these cases, there were 24, 31, 14, 21 and 4 deaths in 2011, 2012, 2013, 2014 and 2015, respectively. Deaths occurred in 18 (72%) out of 25 provinces. No cholera confirmed cases were reported from 2012 to 2015.

### 3.3. India

Out of 1,825 and 21,700 reports in PubMed and Google scholar, respectively, we identified 21 peer-reviewed articles reporting cholera cases that were detected from 2011 to 2015 in India.

Annually, the IDSP recorded 19,957–22,963 acute diarrhea or suspected cholera cases from 2011 to 2016 (Table 3). From the IDSP, 24 (67%) states and union territories of India reported at least one case of cholera from 2011 to 2014 (Table 4). However, we identified 2561 additional cases in our review for a total of 23,854 cases (mean of 5964 cases annually), including 174 deaths (Table 3) [21–41]. In total, West Bengal had the highest number of cases at 6954 [38,40] but Assam had the most number of deaths at 39 [22,41]. The highest case fatality ratio (CFR) of 28.8% was in Chhattisgarh in 2013, however, India's annual CFR never exceeded 1%. There were 305 outbreaks in all of India, with Karnataka and West Bengal reporting the highest numbers at 63 and 59, respectively. Based on the 5% systematic sampling of diarrheal patients in the Infectious Disease Hospital in Kolkata, India, 10.6–20.5% of annual diarrhea admissions were due to cholera

### 3.4. Malaysia

Cholera is no longer endemic in most of Malaysia, except for Sabah where more than 90% of cholera cases occur. From 2011 to 2015, there were 1587 cases (mean of 264 cases annually) (Table 3). The incidence of cholera has been declining from 1.8/100,000 in 2011 to 0.5 /100,000 in 2016. Cases of cholera are often identified in coastal areas and illegal settlements with poor sanitation facilities. In Sabah, 20% of cases were identified among migrants coming from neighboring countries.

**Table 2**
Reported cholera cases to WHO, 2011 to 2015.

| Countries | 2011 | | | 2012 | | | 2013 | | | 2014 | | | 2015 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cases | Deaths | CFR | Cases | Deaths | CFR | Cases | Deaths | CFR | Cases | Deaths | CFR | Cases | Deaths | CFR |
| Bangladesh | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Cambodia | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| India | – | – | – | – | – | – | 6008 | 54 | 0.9 | 4031 | 21 | 0.52 | 889 | 4 | 0.4 |
| Malaysia | 586 | 10 | 1.71 | 282 | 1 | 0.4 | 171 | 1 | 0.58 | 134 | 1 | 0.75 | 244 | 2 | 0.8 |
| Nepal | 12 | 0 | 0 | 34 | 0 | 0 | – | – | – | 933 | 2 | 0.21 | 80 | 0 | 0 |
| Pakistan | 527 | 219 | 41.56 | 144 | 8 | 5.6 | 1069 | 23 | 2.15 | 1218 | 6 | 0.49 | – | – | – |
| Philippines | 120 | 3 | 2.5 | 1864 | 14 | 0.8 | 6 | 0 | 0 | 4547 | 8 | 0.18 | – | – | – |
| Thailand | 279 | 4 | 1.43 | 29 | 0 | 0 | 8 | 0 | 0 | 12 | 0 | 0 | 125 | 1 | 0.8 |
| Vietnam | 3 | 0 | 0 | – | – | – | – | – | – | – | – | – | – | – | – |
| **Total** | 1527 | 236 | | 2353 | 23 | | 7262 | 78 | | 10,875 | 38 | | 1338 | 7 | |

From References [9,14–17].

**Table 3**
Acute watery diarrhea and confirmed cholera cases in nine Asian countries, 2011–2016.

| | Acute Diarrhea or Suspected Cholera Cases | | | | | | Cholera Cases | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Countries | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
| Bangladesh[a] | 2529 | 2889 | 2303 | 2957 | 2784 | 2784 | 264 | 345 | 281 | 289 | 247 | NA |
| Cambodia[b] | 363,078 | 342,383 | 287,330 | 296,455 | 294,424 | NA | 51 | 0 | 0 | 0 | 0 | 0 |
| India[c] | 20,558 | 19,957 | 22,378 | 22,566 | 21,991 | 22,963 | 4873 | 7156 | 6746 | 5079 | NA | NA |
| Malaysia | 670 | 1453 | 616 | 1293 | 1336 | 1432 | 586 | 282 | 171 | 134 | 244 | 170 |
| Nepal[d] | 4577 | 1744 | 5042 | 4170 | NA | NA | 3 | 35 | 4 | 600 | 80 | 169 |
| Pakistan[e] | 4,029,210 | 3,202,009 | 3,040,364 | 2,757,264 | NA | NA | 527 | 144 | 1069 | 1218 | 0 | NA |
| Philippines[f] | 9769 | 12,847 | 5084 | 4658 | 2012 | 13,348 | 1539 | 2419 | 418 | 29 | 27 | 128 |
| Thailand[g] | 1,323,105 | 1,229,641 | 1,135,060 | 1,109,927 | 1,111,959 | 1,202,814 | 281 | 45 | 11 | 12 | 125 | 51 |
| Vietnam[h] | 753,714 | 720,247 | 659,327 | 567,096 | 514,299 | NA | 3 | 0 | 0 | 0 | 0 | 0 |

NA – not available
[a] Acute diarrhea and cholera cases came from the 2% systematic sampling of admitted cases in icddr,b in Dhaka, Bangladesh.
[b] In Cambodia, the tabulated cases are acute watery diarrhea cases. Cholera cases from 2011 are laboratory confirmed.
[c] In India, included are acute diarrhea cases from IDSP. Cholera cases are from the IDSP, publication search and from the 5% systematic sampling of cases admitted in Infectious Disease Hospital, Kolkata, India.
[d] In Nepal, suspected cholera cases are reported. Cholera cases are laboratory confirmed.
[e] In Pakistan, acute diarrhea cases are reported. Available data for 2014 is only until 29 November 2014.
[f] In the Philippines, suspected cholera cases are tabulated. From 2011 to 2013, information from case-based and ESR surveillance as well as ProMED sources were included. Data from 2014 to 2016 were confirmed cholera cases only from ESR and ProMED. Cholera cases follow the definitions of WHO.
[g] In Thailand, all acute diarrhea patients with unknown etiology are reported, but laboratory-confirmed cholera cases are reported as cholera.
[h] In Vietnam, reported are acute watery diarrhea cases. Cholera cases are all laboratory confirmed.

**Table 4**
Confirmed cholera cases in India from the Integrated Disease Surveillance Programme, 2011–2014.

| | 2011 | | | 2012 | | | 2013 | | | 2014 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cases | Deaths | Outbreaks | Cases | Deaths | Outbreaks | Cases | Deaths | Outbreaks | Cases | Deaths | Outbreaks |
| States | | | | | | | | | | | | |
| Andhra Pradesh | 0 | 0 | 0 | 23 | 0 | 1 | 356 | 6 | 3 | 0 | 0 | 0 |
| Assam | 1385 | 16 | 7 | 566 | 14 | 9 | 71 | 1 | 5 | 301 | 8 | 3 |
| Bihar | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 41 | 5 | 2 |
| Chandigarh | 5 | 0 | 1 | 11 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chhattisgarh | 152 | 1 | 4 | 579 | 1 | 1 | 66 | 19 | 1 | 46 | 1 | 1 |
| Dadra & Nagar Haveli | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 1 | 0 | 0 | 0 |
| Delhi | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 2 | 2 | 0 | 0 | 0 |
| Goa | 0 | 0 | 0 | 0 | 0 | 0 | 97 | 1 | 1 | 0 | 0 | 0 |
| Gujarat | 114 | 0 | 4 | 607 | 5 | 3 | 217 | 2 | 6 | 152 | 2 | 3 |
| Haryana | 5 | 0 | 1 | 247 | 0 | 5 | 267 | 1 | 4 | 1612 | 0 | 3 |
| Himachal Pradesh | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jammu & Kashmir | 0 | 0 | 0 | 300 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jharkhand | 0 | 0 | 0 | 59 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Karnataka | 333 | 2 | 13 | 1111 | 3 | 22 | 1016 | 3 | 23 | 168 | 2 | 3 |
| Kerala | 259 | 12 | 3 | 57 | 3 | 5 | 18 | 2 | 1 | 2 | 0 | 1 |
| Madhya Pradesh | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Maharashtra | 231 | 1 | 5 | 511 | 2 | 7 | 628 | 6 | 14 | 36 | 0 | 1 |
| Meghalaya | 0 | 0 | 0 | 16 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Odisha | 0 | 0 | 0 | 54 | 4 | 2 | 45 | 1 | 2 | 241 | 1 | 6 |
| Puducherry | 0 | 0 | 0 | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Punjab | 384 | 0 | 3 | 758 | 20 | 10 | 83 | 0 | 3 | 294 | 3 | 6 |
| Rajasthan | 211 | 1 | 2 | 35 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tamil Nadu | 220 | 4 | 10 | 129 | 2 | 9 | 59 | 0 | 3 | 16 | 0 | 1 |
| Uttar Pradesh | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Uttarakhand | 27 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| West Bengal | 1090 | 1 | 11 | 750 | 6 | 15 | 3064 | 10 | 30 | 2050 | 0 | 12 |
| **Total** | **4417** | **38** | **66** | **5818** | **60** | **98** | **6099** | **54** | **99** | **4959** | **22** | **42** |

### 3.5. Nepal

Cholera is endemic in Nepal, with suspected cholera cases being reported annually in all regions. Suspected cholera cases ranged from 1744 to 5042 cases annually; however, there were only 891 laboratory-confirmed cases for 2011–2016 (mean of 148 annually) (Table 3). Laboratory facilities for culture confirmation are limited in most hospitals. During outbreaks, all age groups are affected. In the Kathmandu Valley, there was a cholera outbreak from 30 June to 12 December 2016, most cases (38%) were seen in the 15–24 years, followed by the 25–34 (24%), 5–14 (14%), 45+ (11%), 35–44 (9.5%) and 0–4 years (3.5%), respectively, with slightly more females being affected with a ratio of 1.1.

### 3.6. Pakistan

The enhanced DEWS reported millions of acute diarrhea cases annually from 2011 to 2014 (Table 3), occurring in all provinces. Among these, 538, 193, 40 and 16 outbreaks of acute watery diarrhea or suspected cholera were detected in 2011, 2012, 2013 and 2014 (until 29 November). Disaggregated data from 2013 to 2016 from the Punjab province show that 8.9% (range 7.1% to 15.6%) of all acute diarrhea cases were suspected cholera cases.

There were 2,958 cholera cases from 2011 to 2015 (mean of 592 annually).

### 3.7. Philippines

A published review of cholera cases from 2008 to 2013 showed that cholera is endemic in the country with an overall CFR in sentinel sites of 0.62%, but this increased to 2% in outbreaks. The annualized incidence of cholera during this period was 9 per 100,000 individuals. No decline was seen in cholera cases from 2008 to 2013. All age groups were affected with the highest case-fatality ratio in children under 5 years [12]. In 2014–2016, we were unable to obtain routine surveillance information, only information from outbreaks (ESR) and ProMED were obtained (Table 3), hence the number of cases dropped during this period. This resulted in discrepant findings from those reported to WHO. In 2014, we identified only 24 laboratory-confirmed cases compared to 4547 cases reported to the WHO. From 2011 to 2016, there were 4560 cases identified (mean of 760 cases annually). There were 10, 8, 6, 7, 5 and 30 confirmed outbreaks in 2011, 2012, 2013, 2014, 2015 and 2016, respectively. During these reported outbreaks, there were 65, 30, 5, 27, 7 and 22 deaths in 2011, 2012, 2013, 2014, 2015 and 2016.

### 3.8. Thailand

The incidence of cholera has substantially declined in the past decade, with some reported outbreaks primarily occurring in coastal communities affecting fishermen and migrant workers near seaports. From 2011 to 2016, there were 525 cases reported (mean of 88 cases per year) (Table 3). Among 77 provinces, 13 and 6 provinces reported cholera cases in 2015 and 2016, respectively. Two large outbreaks occurred in 2011 and 2015, both were due to *V. cholerae* O1 El Tor Ogawa. In 2015, the incidence of cholera was highest among individuals aged 25–34 years at 0.38 per 100,000 followed by the 15–24 years age group at 0.33 per 100,000. Children under 5 years of age were also affected by cholera with an incidence of 0.18/100,000.

### 3.9. Vietnam

A review of cholera epidemiology was reported in 2014 showing the decline in cholera cases from 1991 to 2012 [42]. After the outbreaks of cholera from 2007 to 2010 that affected up to 22 provinces and 3 sporadic cases in 2011, no case of cholera was identified in Vietnam since 2012. During the outbreaks, adults were more affected (age ranged from 10 to 73 years), 50.9% were males and 39% were farmers. Acute watery diarrhea cases, however, continue to be reported annually (Table 3).

## 4. Discussion

Asia is second only to Africa as having the most reported cases of cholera in recent years. We present available data from routine and outbreak surveillance systems on cholera in selected Asian countries in an attempt to characterize the epidemiology of the disease in the region. Our report has several limitations. First, we only selected the countries that have readily and freely accessible information. Some countries, like Bangladesh do not have publicly available routine surveillance data on cholera, hence we included the 2% systematic sampling of icddr,b. In the Philippines, case-based surveillance data have been difficult to obtain, thus only outbreak data are included. Second, most of the countries included have limited resources for surveillance or their surveillance systems are in the nascent stage. Some countries' surveillance systems are still evolving and may require years to be fully functional. Among the countries included in the review, only Malaysia requires mandatory reporting at the clinical and laboratory settings and the reporting website can be accessed electronically, allowing early detection of cases and identification of potential outbreaks. Thailand also requires mandatory reporting of cholera cases; however, reporting is not done electronically. Third, there are differences in the application of the case definitions. In Pakistan, acute diarrhea cases are reported, including watery and bloody diarrhea. Since culture-confirmation is not always possible in these countries, we are not able to estimate the proportion of these cases that may be due to cholera. Fourth, since cholera is endemic in most of these Asian countries, some cases of cholera in the youngest age groups are not detected. In Bangladesh, India and Pakistan, *V. cholerae* was identified as a cause of moderate to severe diarrhea among children under 5 years old in the Global Enteric Multicenter Study [43]. Fifth, for India, we had to conduct a literature review and annual reports of ICMR institutes to supplement surveillance data. We followed the methodology that was used in a similar review of reports from 1997 to 2006 [11]. 24 states are now reporting cholera cases, compared to 21 in 1997–2006. In the earlier review, there were 68 outbreaks with 222,038 affected individuals including 823 deaths and an overall CFR of 0.37% [11]. We were able to identify during a 4-year period, more outbreaks affecting less people resulting in higher overall CFR of 0.7%. Recently, an analysis of the Integrated Disease Surveillance Program identified 13 states as endemic and 78 districts in the whole of India were considered as hotspots [44]. Fifth, based on the systematic hospital-based surveillance in Bangladesh and India, 10–30% [19] and 10–26%, respectively of diarrhea cases were due to cholera, suggesting that a substantial number of cases are being missed since stool culture is seldom performed. The numbers reported in this study may be underestimates of the true burden of the disease. In the latest global estimate of cholera cases, Bangladesh, Cambodia, India, Nepal and Philippines together accounted for 818,040 cases annually [8]. This is significantly higher than what we report here. No estimates are available for Malaysia, Pakistan, Thailand and Vietnam. Conversely, other etiologies of diarrhea in cholera-endemic areas are not often identified. In a prospective surveillance in six countries in Africa, laboratory confirmed cholera burden was substantially lower than that reported from previous studies that based their estimates on suspected cholera cases. Since cholera frequently occurs in poorer countries [45], improvements in laboratory capacity including identification of etiologic agents may be necessary to better allocate limited resources for control. However, surveillance in itself may require more resources from already constrained budgets that must cover diverse priorities in large populated areas. Lastly, we did not include cases from the Middle East, particularly in Yemen where a huge outbreak is ongoing.

Asia is the most populous continent, with countries in differing levels of economic and social development. Among the countries, Thailand and Malaysia have achieved near universal access to improved water and sanitation with zero open defecation (Table 5)

**Table 5**
Population access to clean water, sanitation and proportion of population practicing open defecation as of 2015.[a]

| Countries | % Population with access to improved water | % Population with access to improved sanitation | % Population practicing open defecation |
|---|---|---|---|
| Bangladesh | 87 | 61 | 1 |
| Cambodia | 76 | 42 | 47 |
| India | 94 | 40 | 44 |
| Malaysia | 98 | 96 | 0 |
| Nepal | 92 | 46 | 32 |
| Pakistan | 91 | 64 | 13 |
| Philippines | 92 | 74 | 7 |
| Thailand | 98 | 93 | 0 |
| Vietnam | 98 | 78 | 1 |

[a] Data from this table came from Reference [46].

[46]. However, cholera affects defined areas and population that may be amenable to intervention measures, such as targeted vaccination, apart from water and sanitation.

It is unclear whether the absence of cholera cases in some countries is due to inherent problems in surveillance or due to countries' restraint with cholera reporting. Because of the perceived impact of cholera outbreaks on developing Asian economies, cases may be underreported or not reported at all. If countries where tourism and exports of seafood are main drivers of growth report cholera, it may have a substantial negative impact on growing economies [47]. In an analysis of the impact of an epidemic of cholera in Mozambique or Bangladesh, it was estimated that the economic cost in either country would amount to a 2% decline in GDP, with the effects on food exports lasting for years [47]. Despite WHO guidelines that do not limit trade and travel restrictions when there is a cholera epidemic [48], Asian countries are not forthcoming with reporting cholera. Furthermore, cholera affects mostly the poor with limited access to quality health care, hence outbreaks may remain unnoticed as people die on the way to the hospital. Culture confirmation is not always performed since diarrhea can easily be managed with adequate rehydration.

## 5. Conclusion

Our review highlights the problem of cholera in selected Asian countries. The continuing existence of cholera even in countries with improved sanitation and access to safe drinking water highlights the need for a collective effort to detect and combat the disease. With increasing ease of travel, trans-border transmission of disease from endemic zones will be more likely and vibrios can easily propagate and spread in compromised areas. Continued vigilance and improved surveillance in countries should be encouraged so that appropriate plans are prepared for rapid response to minimize morbidity and mortality from this ancient disease.

Contributors

ALL and SK (for India) conducted the literature search, compiled and screened the list of articles, selected the relevant documents, reviewed the eligible articles and extracted the data. All authors provided additional data sources. ALL and SK analyzed the information and interpreted the data. ALL wrote the initial draft. All authors contributed to the writing and revision of the text and finalization of the manuscript.

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## Declaration of Competing Interest

We declare that we have no conflicts of interest.

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