

# Estimating Global Burden of Cholera in Endemic Countries: Methodological Issues

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- 2012 estimation: 2.8 million cases/87,000 deaths
  - Endemic countries: Defined based on the countries' reported cholera cases (51/148 countries)
  - Period included: 2000-2008

*Ali et al, Bull WHO 2012;90:209–218.*

- 2015 estimation: 2.8 million cases/91,000 deaths
  - Endemic countries: Defined based on a spatial regression model (69/157 countries)
  - Period included: 2008-2012

*Ali et al, PLoS Neg Trop Dis 2015;9(6):e0003832.*

# Methodological Issues

## Cholera data:

- Searching term: “cholera” and “acute watery diarrhea”
- Sources: WER, PubMed, GIDEON, ProMED, and Google)
- Period: 2008-2012

Population data: UNDP World Population Prospects, 2013

Water and sanitation data: UNICEF’s State of the World’s Children Report, 2013

World Map: DIVA-GIS

# Defining Endemic Countries

The spatial lag regression (SLR) model equation is:

$$y = \rho W y + x \beta + \varepsilon$$

- $y$  is the incidence of reported cholera (log-transformed)
- $W y$  is the weighted incidence of the 1<sup>st</sup> order neighboring countries
- $x$  is a matrix of observations of the explanatory variables
  - % of population using unimproved sanitation facility
  - % of population using unimproved water source
- $\varepsilon$  is the error term
  
- Population: At national level except for India, China, and Indonesia at sub-national level
  
- Population at risk: Percent of population which did not use sustainable improved sanitation facilities

- Presence of cholera: Predicted incidence  $>0.010/100,000$  for a given year in a country
- Endemic country: Presence of cholera in at least three of the five years (2008-2012)
- Non-endemic country: Presence of cholera in one or two of the five years (2008-2012)
- Cholera-free country: Presence of no cholera in any of the five years (2008-2012)

## WHO regions

- African Region (AFR)
- Region of Americas (AMR)
- South-east Asia Region (SEAR)
- European Region (EUR)
- Easter Mediterranean Region (EMR)
- Western Pacific Region (WPR)

## Mortality strata

- A= very low child and very low adult mortality
- B= low child and low adult mortality
- C= low child and high adult mortality
- D= high child and high adult mortality
- E= high child and very high adult mortality

## WHO sub-region

AFR-B

AFR-D

AFR-E

AMR-D

EMR-B

EMR-D

EUR-B

SEAR-B

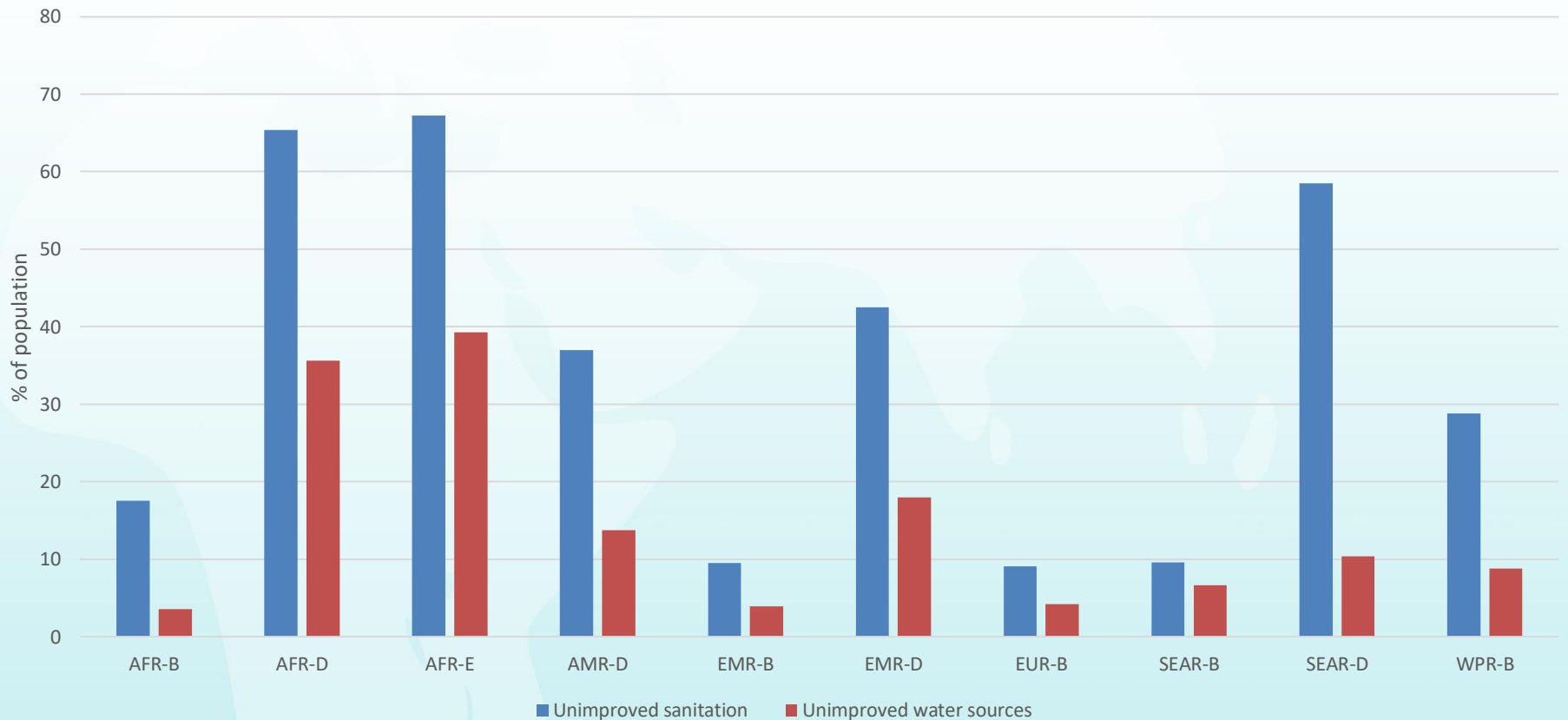
SEAR-D

WPR-B





# Percent of population using unimproved sanitation and water sources by WHO sub-region





# Age-Specific Cholera Data (from literature)

Age group	Kolkata, India (May 2003-Apr 2005)			Jakarta, Indonesia (Aug 2001-Jul 2003)			Beira, Mozambique (2003-2004)		
	Popl.	Cases	Rate/1000/ yr	Popl.	Cases	Rate/1000/ yr	Popl.	Cases	Rate/1000/ yr <sup>‡</sup>
<1y	698	10	7.16	3,121	25	4.01	-	-	-
1-4y	3,782	53	7.01	12,620	39	1.55	1,686*	9	8.8
5-14y	11,440	50	2.19	29,093	17	0.29	17,861 <sup>†</sup>	38	3.5
15y+	42,143	78	0.93	115,423	62	0.27			
<b>Total</b>	<b>58,063</b>	<b>191</b>	<b>1.64</b>	<b>160,257</b>	<b>143</b>	<b>0.45</b>	<b>19,547</b>	<b>47</b>	<b>4.0</b>

\*age group 2-<5 years

† age group ≥ 5 years



## Incidence Rate by WHO Sub-region

WHO sub-region	Incidence rate/ 1,000	Source
AFR-D	2.00	Beira, Mozambique and WER data
AFR-E	4.00	Beira, Mozambique
AMR-B: Dominican Republic	5.70	Observed rate from 2010 to 2012
AMR-B: Jamaica, St. Lucia	0.10	Assumption-based
AMR-D: Haiti	25.60	Observed rate from 2010 to 2012
EMR-D	1.64	Kolkata data
EUR-B	0.10	Assumption-based
SEAR-B	0.45	Jakarta data
SEAR-D	1.64	Kolkata data
WPR-B	0.10	Assumption-based

## Age-specific Incidence Rate

- WHO-region-specific overall incidence rates and the incidence age distribution from the Kolkata study
- Kolkata data was used because population-based age-specific incidence was unavailable by WHO mortality stratum
- Normalized age-specific incidence rates so that overall incidence for a given country matches the estimates

# Weighted CFR Calculation

Year/Date	Country	WHO region	Cholera cases	Deaths	CFR (%)	Variance (%)	Weight = 1/Variance	Weighted CFR
Oct -Jan 1995	Guinea-Bissau	AFRO-D	1,169	43	3.68	0.30	3.30	3.8
Jan -Dec 1996	Nigeria		1,384	92	6.65	0.45	2.23	
Jun 97- Mar 1998	Kenya	AFRO-E	14,275	547	3.83	0.03	38.74	
Nov -Feb 2004	Zambia		4,343	154	3.55	0.08	12.70	
Aug -Dec 1990	Malawi		1,931	68	3.52	0.18	5.68	
Oct 15, 2008	Iraq	EMRO-D	500	8	1.60	0.31	3.18	3.2
Jul 24, 1994	Yemen		150	17	11.33	6.70	0.15	
Feb 5, 2007	Somali		110	15	13.64	10.71	0.09	
Apr 21, 2006	Sudan		5,369	180	3.35	0.06	16.57	
Sep -Nov 1991	Bangladesh	SEARO-D	223,038	8,921	4.00	0.00	580.86	3.0
2002-2006	India		6,426	20	0.31	0.00	207.11	

Variance =  $CFR * (1 - CFR) / \text{Cholera cases}$

# CFR by WHO Sub-region

WHO sub-region	CFR (%)	Source
AFR-D	3.80	Calculated for AFR
AFR-E	3.80	Calculated for AFR
AMR-B: Dominican Republic	1.40	Dominican Republic
AMR-B: Jamaica, St. Lucia	1.00	Assumption-based
AMR-D: Haiti	1.20	AMR-D: Haiti
EMR-B	1.30	EMR-B
EMR-D	3.20	EMR-D
EUR-B	1.00	Assumption-based
SEAR-B	1.00	Assumption-based
SEAR-D	3.00	Calculated for SEAR-D
WPR-B	1.00	Assumption-based



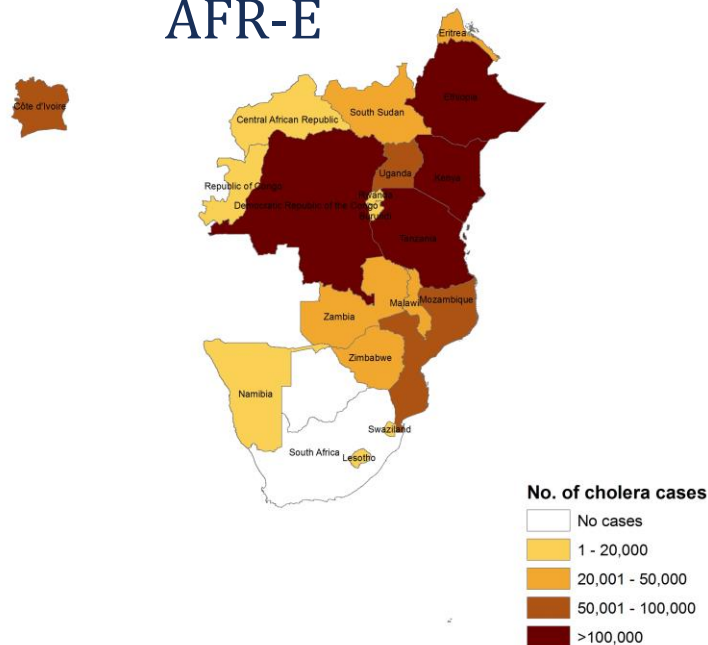
## Population at risk and number of cases and deaths by WHO sub-region

WHO sub-region	Population at risk ('000)	Cases ('000)	Deaths ('000)
AFR-D	259,603	519	20
AFR-E	295,343	1,181	45
AMR-B	2,312	10	.14
AMR-D	8,214	210	2
EMR-D	62,808	103	3
EUR-B	457	.05	0
SEAR-B	5,107	2	.02
SEAR-D	479,692	816	24
WPR-B	132,770	13	.13
TOTAL	1,246,310	2,855	95

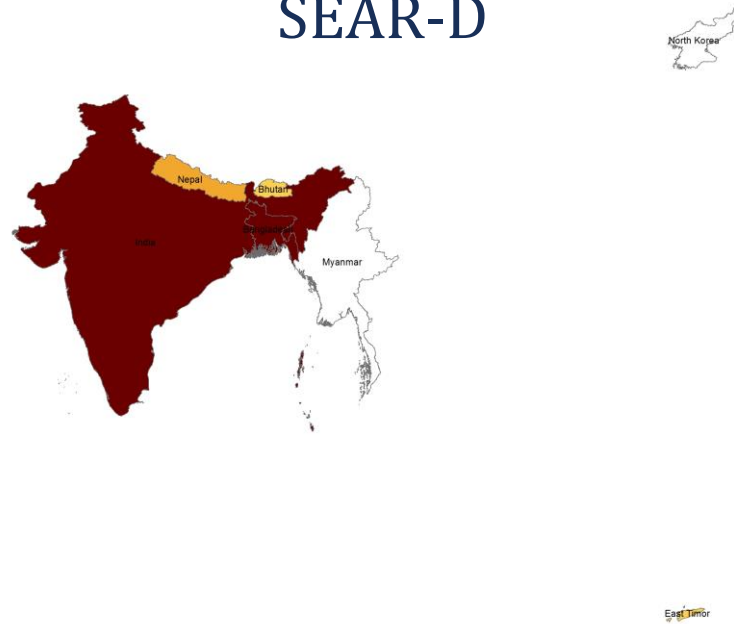
**69 Endemic countries**

# Countries with the highest cholera burden

AFR-E



SEAR-D



- Sub-Saharan Africa accounts for 60% of the global burden of cholera cases, and South-East Asia account for 29%
- Countries with more than 1,000 deaths annually are in the AFR Region except for India, Bangladesh, Haiti, and Sudan



- Countries with reported cholera were classified as non-endemic (e.g., Pakistan) or cholera-free (e.g., Myanmar, Iran, and Vietnam).
  - *Pakistan: 92% using improved water sources; no/few reported cases from neighboring countries/states*
  - *Myanmar, Iran, Vietnam: use of improved water sources and sanitation facilities is relatively high; few reported cases in the country; no/few reported cases from neighboring countries*

*Would likely be defined as endemic with better reporting systems in the country itself and in neighboring countries*
- Countries without cholera were classified as endemic (e.g., St. Lucia, Jamaica, Bolivia, and Tajikistan).
  - *St. Lucia and Jamaica for low use of improved sanitation facilities, and Tajikistan for low use of improved water sources*

*Would likely be at high risk of endemicity if cholera were to be introduced*