Are there national risk factors for epidemic cholera? The correlation between socioeconomic and demographic indices and cholera incidence in Latin America

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Background From 1991 through 1995, all Latin American countries maintained cholera surveillance systems to track the epidemic that entered the region through Peru in January 1991. These data were used to assess correlations between socioeconomic and demographic indices that might serve as national risk predictors for epidemic cholera in Latin America.

Methods Correlations between country-specific cumulative cholera incidence rates from 1991 through 1995 and infant mortality, the Human Development Index ([HDI] a numerical value based on life expectancy, education, and income), gross national product (GNP) per capita, and female literacy were tested using the Pearson correlation coefficient.

Results A total of 1,339,834 cholera cases with a cumulative incidence rate of 183 per 100,000 population were reported from affected Western Hemisphere countries from 1991 through 1995. Infant mortality rates were the most strongly correlated with cumulative cholera incidence based on the Pearson correlation coefficient. The HDI had a less strong negative correlation with cumulative cholera incidence. The GNP per capita and female literacy rates were weakly and negatively correlated with cholera cumulative incidence rates.

Conclusions Infant mortality and possibly the HDI may be useful indirect indices of the risk of sustained transmission of cholera within a Latin American country. Cumulative cholera incidence is decreased particularly in countries with infant mortality below 40 per 1000 live births. The lack of reported cholera cases in Uruguay and the Caribbean may reflect a low risk for ongoing transmission, consistent with socioeconomic and demographic indices. Cholera surveillance remains an important instrument for determining cholera trends within individual countries and regions.

Keywords Cholera, infant mortality, Latin America, surveillance

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Western Hemisphere countries to investigate possible correlations between national cumulative cholera incidence rates and a variety of demographic and socioeconomic indices that might be useful as predictors of the behaviour of epidemic cholera at the national level.

Methods

Reported cholera cases and deaths for Latin America were summarized from information submitted to the Pan American Health Organization (PAHO) by the Ministry of Health of each country. Cholera data for the US and Canada were obtained from the Centers for Disease Control and Prevention (CDC) and the Laboratory Centre for Disease Control (LCDC), respectively. Country-specific cumulative incidence rates were calculated by dividing the sum of reported cholera cases for each country during 1991-1995 by its estimated 1995 population. Total 1995 population, 1994 infant mortality rates, female literacy rates, and 1993 gross national product (GNP) per capita estimates for each country were obtained from PAHO. The Human Development Index (HDI), constructed by the United Nations, ranks countries by their relative progress toward development goals from three variables: life expectancy at birth, educational attainment (weighted between adult literacy [2/3] and primary, secondary, and tertiary educational enrolment [1/3]), and standard of living (real gross domestic product [GDP] per capita). A numerical value is calculated for individual countries as a function of the three variables. Values range from a high of 0.950 (Canada) to a low of 0.207 (Niger); a lower value signifies a lower level of development. The Pearson correlation coefficient was used to determine the correlation between cholera cumulative incidence rates from 1991 through 1995 and infant mortality and female literacy rates, GNP per capita, and the HDI of Western Hemisphere countries affected by this decade's epidemic. P-values were calculated to serve as a general guide to differentiate among the correlations between cholera incidence rates and the socioeconomic and demographic indices.

Results

From 1991 through 1995, over one million cases and 11 000 deaths due to cholera were reported from a total of 22 countries in the Western Hemisphere (Table 1). Based on the number of reported cases during 1991-1995, the cumulative cholera incidence for these 22 countries was 183 cases per 100 000 population. Country-specific cumulative cholera incidence for the
affected countries of the Western Hemisphere reporting any cholera ranged from a low of 0.06 per 100 000 in Paraguay to a high of 2738 per 100 000 in Peru (Table 1). The countries with a cumulative cholera incidence of >20 per 100 000 were concentrated in a band extending south from Mexico to the northern border of the Southern Cone countries (Figure 1). The Andean countries in South America, and Guatemala and Nicaragua in Central America had the highest cumulative incidence. Cumulative incidence rates were lowest in Chile, Paraguay, Canada, and the US. No cases were reported from any Caribbean countries nor from Uruguay.

By simple linear comparison, infant mortality rates were strongly and positively correlated with cumulative cholera incidence in Western Hemisphere countries (Table 2). The HDI values, which tend to increase with increasing levels of development, had a negative correlation with cumulative cholera incidence with a smaller absolute coefficient than infant mortality. Female literacy rates and GNP per capita were also negatively correlated with cholera cumulative incidence with smaller coefficients and P-values > 0.1.

Countries with higher infant mortality rates tended to have markedly higher cumulative incidence rates of cholera (Figure 2a). Cholera incidence was much lower (0.7–3 per 100 000 population) in countries with infant mortality rates <20 per 1000 live births (Canada, the US, Chile, and Costa Rica). With the exception of Paraguay (infant mortality rate of 42 per 1000 live births), countries with infant mortality rates >40 per 1000 live births had higher cumulative cholera incidence rates, ranging from 203 per 100 000 (Brazil) to 2738 per 100 000 population (Peru) (Figure 2a). The relationship between cumulative cholera incidence and infant mortality does not appear to be a simple linear one; when infant mortality rates increased above 40 deaths per 1000 live births the cumulative cholera incidence rose less steeply, suggesting that a threshold effect exists. Other relationships between cumulative cholera incidence and socioeconomic indices exhibited thresholds as well. Countries with an HDI <0.720 had higher cumulative cholera incidence rates, ranging from 74 (Guyana) to 2738 (Peru) (Figure 2b). Countries with a GNP per capita >US$ 2000 (Canada, Chile, Costa Rica, Argentina, Brazil, Belize, Panama, Mexico, and the US), had lower cholera cumulative incidences, as did nations with female literacy rates >90%, (Canada, Chile, Costa Rica, Argentina, Guyana, Suriname, and the US) (Data not shown).

Caribbean countries and Uruguay were not included in the above analysis because of their lack of reported cholera cases. Uruguay, with an infant mortality rate of 19, GNP per capita of US$ 3830, and HDI of 0.881 falls in the low risk group. Of the 22 Caribbean countries, all but three (Haiti, the Dominican Republic, and Anguilla) had infant mortality rates <20. Only Haiti and the Dominican Republic had an HDI <0.720, all but three countries (Haiti, the Dominican Republic, and Jamaica) were above the GNP per capita of US$ 2000, and all but five countries (Haiti, the Dominican Republic, Bahamas, Saint Lucia, and Antigua and Barbuda) had female literacy rates >90%. These general measures of development suggest that among countries not yet affected in this hemisphere, Haiti and the Dominican Republic are at highest risk for sustained cholera transmission should the epidemic be introduced there, and that much of the Caribbean may be at low risk for sustained transmission.

### Table 2 Correlation of cumulative cholera incidence rates, 1991–1995, with infant mortality and female literacy rates, the Human Development Index (HDI), and 1993 gross national product (GNP) per capita, Western Hemisphere

<table>
<thead>
<tr>
<th>Method</th>
<th>Infant mortality (per 1000 live births)</th>
<th>HDI</th>
<th>Female literacy (%)</th>
<th>1993 GNP per capita (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson correlation coefficient</td>
<td>0.55</td>
<td>-0.38</td>
<td>-0.31</td>
<td>-0.23</td>
</tr>
<tr>
<td>P-value</td>
<td>0.006</td>
<td>0.08</td>
<td>0.15</td>
<td>0.303</td>
</tr>
</tbody>
</table>

* A numerical indicator of development calculated by the United Nations based on three variables: life expectancy at birth, educational attainment, and income.²
Discussion

In the Western Hemisphere, there has been substantial variation in cumulative reported cholera incidence since the beginning of the epidemic. Infant mortality rates were strongly correlated with a high incidence of cholera within a country. The HDI was less strongly correlated, but may provide an additional estimator of risk. Although female literacy and GNP per capita had small correlation coefficients with cumulative incidence by themselves, they may also be useful variables to examine when analyzing cholera risk and are, in fact, incorporated indirectly into the HDI. We observed that in Latin America, infant mortality rates >0.720 are thresholds at which cholera risk decreases. Countries above these thresholds may be at higher risk for sustained epidemic transmission in the future.

The correlation of infant mortality with cumulative cholera incidence suggests they may be linked to the same root causes. Diarrheal diseases are a leading cause of death in children under one year old. However, the agents most commonly attributed to childhood diarrheal illnesses are enterotoxigenic and other pathogenic *Escherichia coli*, rotavirus, *Campylobacter*, and *Shigella*, not *V. cholerae*. Many of these agents are transmitted through contaminated food and water, and high infant mortality rates are in part a reflection of poor sanitation and poverty. *Vibrio cholerae* is also usually transmitted through contaminated food and water. A high cumulative incidence means that transmission has been sustained through many cycles of infection. Efforts to prevent cholera through education and improved sanitation would be expected to have an effect on infant mortality.

These general indices may be applicable outside Latin America. The continued lack of cholera cases in Caribbean countries during the recent Latin American epidemic is noteworthy. Most of these countries have socioeconomic and demographic indices that resemble the group of Latin American countries at lower risk for cholera. The indices for Haiti and the Dominican Republic fit the profile of countries at higher risk for sustained cholera transmission. It may be reasonable for those countries to prepare for the possibility of sustained transmission should the infection be introduced.

This analysis has several limitations. First, the quality of the data is variable because of varying resources and cholera reporting policies among countries. Case definitions differed between countries, introducing uncertainty into inter-country comparisons. In several countries, cholera case definitions or reporting policies changed during the epidemic, which may have distorted the year-to-year trends in reported cases of cholera. Second, the number of cases reported to the surveillance systems represents only a small fraction of the cases that actually occurred. For example, a seroprevalence study conducted in Peru in 1991 revealed that only 47% of people with serological evidence of recent infection with *V. cholerae* O1 reported gastrointestinal symptoms, and only 26% had visited a medical facility where they could be registered as a possible cholera case. Finally, the utility of general health and development indices as correlates and predictors of risk in other regions of the world remains to be shown. This may be difficult in the absence of reliable surveillance data. The degree to which different demographic and socioeconomic characteristics reflect the local risk factors for cholera transmission merits further investigation.

Surveillance data reported in this hemisphere provide a useful estimate of the magnitude and time trends of the cholera epidemic. Cholera surveillance remains an important instrument for determining cholera trends in regions as well as within individual countries. The continued expansion of seventh pandemic strains of *V. cholerae* O1 and the threat of an eighth pandemic posed by the emergence of *V. cholerae* O139 in Asia provide ample motivation for continued vigilance throughout the world.

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References


