From Cholera Outbreaks to Pandemics:

The Role of Poverty and Inequality

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Abstract: Cholera and other diarrheal diseases are the second leading cause of death among the poor globally. The tragedy of this statistic is that it need not be the case. Unlike many afflictions, the impact of cholera can be greatly reduced, if not eliminated, through the collective action of clean water services. This begs the question of why such collective action is absent in much of the world. To address this, we first develop a theoretical model which indicates that the required collective action is an increasing function of both a country's level of income and income equality. We test these predictions by analyzing 1,032 annual observations arising from 17 relatively poor countries between the years 1980 and 2002. The countries come from the Americas, Africa, and Asia. In the first part of the analysis, we find that the collective action of providing clean water is, as predicted, an increasing function of income and equality. Following this, we find that both the numbers of cases and deaths resulting from a given cholera outbreak are strongly and negatively related to the collective action.

Keywords: Cholera, diarrheal diseases, pandemics, per capita income, inequality.

JEL Classification(s): D31, H41, I10

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1. Introduction

The period of the 1960's and 1970's offers two tragically different views of cholera (and other infectious diseases, for that matter). On the one hand, serious, well-intentioned health care professionals were suggesting that the fight against infectious disease was nearing its conclusion. Consider, for example, the Surgeon General of the United States' pronouncement in 1970 that it was "time to close the book on infectious diseases, and shift national resources to such chronic problems as cancer and heart disease" (WHO, 2000, p. 1). A similar degree of optimism was expressed globally in 1978 when the United Nations adopted its "Health to All" accord which predicted that, by the turn of the century, even in the poorest countries, infectious diseases would no longer pose a serious health threat to humans (WHO, 2000, p. 7). Unfortunately, such optimism failed the test of reality since even though truly remarkable medical advances in all areas of protection from and treatment for such illnesses was advancing at very promising rates, while perhaps down, illnesses like cholera were far from out. In fact, as early as 1961, the seventh known pandemic of cholera since the middle 1800's had begun in South East Asia where it is endemic (Nations and Monte, p. 1007). And, given its nature, cholera is no respecter of peoples or societies. In fact, between 1848 and 1854 alone, cholera resulted in the deaths of a quarter of a million, primarily poor, people in Great Britain alone who regularly had little choice but to make use of water tainted with human and animal wastes in their daily lives.

Cholera is an ancient bacterial disease which predominantly spreads through contact with tainted water. As such, the poor, especially those who rely on local rivers and streams or inadequately constructed and protected wells for their drinking water and who have only the most rudimentary sanitation arrangements are most susceptible to its potentially live-threatening bouts of diarrhea and vomiting which in extreme cases can lead to the loss of upwards of a person's entire body weight in fluids within a matter of a couple of days (Nations and Monte, p. 1008). Of course, tainted water tends not to remain in one location leading to the spread of the early 1960's outbreak of cholera in Asia first to Europe and then to Africa, where it became truly endemic. Spared initially was the Western Hemisphere which had not witnessed a significant cholera outbreak for a century. This changed when, in 1991, *Vibrio cholera* O1, biotype El Tor and serotype Inaba (simply cholera henceforth) was detected in two coastal Peruvian cities (Lima and Guerrant, 1994, pps. 1-5). With nearly one-half million cases and some 3,300 deaths, Peru was shown no mercy by this ancient disease. Next to suffer its wrath was Brazil where, by 1993, 70 percent of that country's states reported confirmed cases. Given that cholera thrives with poverty and the limited access to clean water and squalid living conditions that typically accompany that living status, the hardest hit parts of Brazil were in that country's extremely impoverished Northeastern cities and states which reported 87 percent of the total Brazilian cases and a probability of death once contracting the illness that was three times the national average (Lima 1994, p. 593). And, far from being brought under control, this current pandemic of cholera shows little sign of slowing.

As is unanimously agreed upon by health care professionals, however, the primary remedy for cholera (and all diarrheal diseases for that matter) is almost too simple to point out: the provision of safe drinking water. Yet in 1990, more than a billion people worldwide depended on rivers, streams, ponds or other unsafe surface sources for drinking water (Mintz et al., 1995), where direct sewage contamination is often present.[1] Similar (and sometimes greater) risks can be involved with the modest wastewater treatment processes often found in poorer areas and countries.[2] When soil is part of wastewater treatment, microorganisms remain in the treatment area until they naturally die off, which, depending on characteristics of soil, such as its moisture content, can take a remarkably long period of time (Lane and Weaver, 1999, p. 42). And when soil is excessively saturated, many microorganisms are capable of migrating rather long distances, transport which is often aided by water flowing out of local sewers. Thus, when a significant portion of a population consumes unsafe surface and ground water, even the presence of a sewage system may provide only limited protection since very minor leaks from the sewer system can travel long distances and contaminate distant water sources. In each case, the matter is made worse through flooding which can simply overwhelm the often under-sized or poorly constructed water-treatment systems found in many poor areas.

Of course, regardless of the quality of water systems available to a population, human intervention often lies at the root of the spread of cholera. Even if clean water is available, cholera can rather effectively spread if individuals practice poor personal and/or household hygiene habits suggesting that in addition to high-level water systems, public education programs as to the causes and mitigation of cholera play an essential role in limiting its spread.

Adam Smith, upon listing 'defense and protecting the individuals against

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[1] "[I]n El Alto, Bolivia ... all families obtain water from shallow wells (2-5 meters) that they dig in front of their homes. Most households store drinking water in buckets. All families dispose of human waste on the open ground or in a nearby river. Sewage and wastewater are openly disposed in many developing countries without any treatment" (Quick et al., 1999).

[2] In Africa, for instance, virtually no wastewater receives treatment before it is disposed. In Latin America and the Caribbean region only 14% of wastewater is treated, while in Asia about 35% of wastewater is treated before it is discharged (IRC, 2001, p. 3).

violence' and 'protecting them from injustice and oppression', mentions that the remaining most important duty of the state is "the duty of erecting and maintaining certain public works and certain public institutions, which it can never be for the interest of any individual, or a small number of individuals, to erect and maintain; because the profit could never repay the expense to any individual or small number of individuals, though it may frequently do much more than repay it to a great society" (Smith, 1999, p. 134).

Why then does a very significant portion of the world's population still live with unsafe water systems? The high cost of establishing and improving public water and sewer pipeline systems is often cited as a barrier to the necessary collective action. It is estimated, for example, that a 50 percent reduction by 2015 in the proportion of people lacking safe drinking water and basic sanitation would cost $7 billion per year, which is 30 percent more than is currently been spent on all such projects (IRC, 2001, p. 6). And should global warming continue on its currently predicted path, such estimates of these costs will only increase as the world's tropical and sub-tropical regions expand.

Decision-making with respect to providing clean drinking water and proper sanitation, however, is not based on the benefits of such programs to the ones who need them the most, but rather, on a society's ability to raise the necessary funds to provide the collective action. The next section provides a theoretical explanation as to the circumstances in which a society can (and can not) come up with the resources for the provision of these services.[3]

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[3] See Anbarci, Escaleras and Register (2005) for a detailed theoretical and empirical analysis of a setup in the context of earthquake disaster hazards where in some environments different segments of society prove incapable of arriving at an equitable distribution of the tax burden of the necessary collective action, causing the relatively wealthy to simply self-insure against the potential disaster while leaving the relatively poor to its mercy.

The theoretical model has two important features. The first is rather common: the notion that the collective action necessary to provide for access to clean water services is positively related to a society's level of income. The second and more interesting feature of the model is that investment in this collective action is positively related to the degree of income equality in society.

Following this, we test the predictions of this model by analyzing 1,032 annual observations arising from 17 countries and 3 continents that reported at least one cholera outbreak during the period 1980-2002. Given that cholera is effectively mitigated by access to clean water, we limit our sample to relatively poor countries, those with per capita GDP's of less than $4,000, where rates of provision of clean water access tend to be relatively low. In this way, we avoid the potentially misleading effects brought about by what might be thought of as 'stray' cases or even minor outbreaks of cholera occurring in a relatively wealthy country that is not truly part of the current pandemic. Such cases might result from relatively isolated instances of importation of tainted food crops or tourists whose illnesses have not yet progressed to the point which would raise immigration alarms as they enter a wealthy country.

The empirical results confirm the theoretical model's predictions that per capita income and income equality are key variables in determining both a country's level of collective action (the provision of clean water) and in the extent and severity of outbreaks of cholera, when they occur. Specifically, we show that the provision of improved water is an increasing function of the levels of income and income equality existing within an economy and, equally important, that such collective action significantly reduces both the incidents of and deaths resulting from cholera when an outbreak occurs.

2. Theoretical Model

For simplicity, we assume that there are two goods: clean water and a private good that the parties' incomes are spent on. As discussed in the previous section, the more a society can afford to spend on provision of clean water and proper sanitation via collective action (i.e., via the collected taxes), the smaller is the extent and severity of any waterborne disease outbreak that might occur.

We assume for simplicity that there are two segments in society, the high-income segment (H) and the low-income segment (L). The L segment's pre-tax income level is normalized at 1, and the H segment's pre-tax income level is $a > 1$; note that a denotes the degree of pre-tax income inequality between the two segments. The government collects taxes from these segments to provide all types of infrastructure, among them, water services. Given the pre-tax income levels of the two segments, consider the simple After-Tax Possibilities Frontier $\{(1,0),(0,a)\}$. A tax system is proportional if each income group pays the same proportion of their income in taxes. Given our simplistic after-tax possibilities frontier, a proportional tax, P, would lead to after tax incomes of $y_L^P = ½$ and $y_L^P = a/2$. Then the Total Tax Revenue, TTR^P, would be $(1+ a)/2$. A tax system is progressive if lower income groups pay a lower proportion of their income in taxes than higher income groups. As an example, take a progressive tax system in which L-types pay 40 percent of their pre-tax income in taxes and H-types pay 60 percent of their pre-tax income in taxes. Such a tax system would lead to $y_L^{PR} = .6$ and $y_L^{PR} = 2a/5$ and a total tax revenue, TTR^{PR}, of $(.4+ 3a/5)$. Finally, a tax system is regressive if lower income groups pay a higher proportion of their income in taxes than higher income groups. As an example, assume a regressive tax system in which L-types pay 60 percent of their pre-tax income in taxes and H-types pay 40 percent of their pre-tax income in taxes. In this case, the tax system would lead to $y_L^R = .4$ and $y_L^R = 3a/5$ and total tax revenue, TTR^R, of $(.6+ 2a/5)$.

Typically direct taxes (those levied on private individuals, corporations, and property) make up 20 to 40 percent of total tax revenue for most developing countries while indirect taxes (such as import and export duties and excise—purchase, sales and turnover—taxes) comprise 60 to 80 percent of total tax revenue (Todaro, 2000, p. 670). It is widely documented that indirect taxes tend to be rather regressive (see Todaro (2000) and Gemmell and Morrissey (2005) and references therein); that is, with indirect taxes lower income groups tend to pay a higher proportion of their income in taxes than higher income groups. While ***Theorem 1*** flows from this notion of generally regressive taxes in relatively poor countries, it should be noted (and can be shown upon request), that the degree of regressivity needed to generate the result is extremely minor, that is, the following holds with tax regimes that approach proportionality.

Theorem 1: *As inequality increases or per capita income decreases within a society with even a mildly regressive tax regime, the level of collective action in the form of provision of improved water can be expected to decrease as government revenues fall, which will lead to both increases in outbreaks and the severity of those outbreaks arising from any waterborne disease.*

Proof: We will first show that even a minor redistribution, $\delta > 0$, in the pre-tax income distribution from L to H will decrease the total tax revenue the government collects. Suppose the regressive tax system is such that the after-tax incomes of L and H are $y_L^R = (½ -\varepsilon)$ and $y_L^R = a(½+\varepsilon)$, respectively, with pre-tax income levels of 1 and a, where $½ > \varepsilon > 0$. Then the TTR^R will be $½(a+1)-\varepsilon(a-1)$. Now consider pre-tax income levels $1-\delta$ and $a+\delta$. With the same regressive tax system in place now the after-tax income of L and H will be $y_L^R = (1-\delta)(½-\varepsilon)$ and $y_L^R = (a+\delta)(½+\varepsilon)$, respectively. Then the new TTR^R will be $½(a+1)-\varepsilon(a-1)-2\varepsilon\delta$. Thus, government revenues fall by $2\varepsilon\delta$.

Now consider a proportional decrease in pre-tax incomes, assuming no change in the degree of pre-tax income inequality. That is, suppose each segment's pre-tax income is multiplied by $k < 1$. Then the after-tax incomes of L and H decrease from $y_L^R = (½ -\varepsilon)$ and $y_L^R = a(½+\varepsilon)$, respectively, to $y_L^R = k(½ -\varepsilon)$ and $y_L^R = ka(½+\varepsilon)$, respectively, and the TTR^R will decrease from $½(a+1)-\varepsilon(a-1)$ to $k[½(a+1)-\varepsilon(a-1)]$. Thus, the decrease in the total tax revenue will be $(k-1)[½(a+1)-\varepsilon(a-1)]$. This completes the proof of ***Theorem 1***.

While this outcome for a proportional change income is quite straightforward, the former case of the impact on government revenues for a change in inequality likely deserves a bit more attention prior to moving to the empirical model. To provide some additional intuition for this outcome, consider again the regressive tax system in which L-types pay 60 percent of their pre-tax income in taxes while H-types pay just 40 percent. Recall that such a tax system would lead to $y_L^R = .4$ and $y_L^R = 3a/5$ with pre-tax incomes of 1 and a for L and H types, respectively. Suppose $a = 4$. Then we will have $y_L^R = 4/10$ and $y_L^R = 24/10$ yielding a total tax revenue, TTR^R, of $(4/10+16/10) = 2$. Now consider pre-tax income levels .5 and 4.5 for L and H-types, respectively. In this case the tax system will lead to $y_L^R = 2/10$ and $y_L^R = 27/10$ and to $TTR^R = (3/10+18/10) = 21/10 > 2$.

Of course, showing that an increase in income or income equality leads under these circumstances to an increase in government tax revenue, doesn't in itself prove that those increased dollars will be well-spent. At the outset, we assumed that government revenues were used to fund infrastructure projects such as water systems. This may well occur. At the same time, the additional revenue might, for examples, fund ridiculously lavish lifestyles for the ruling elites, be used to provide for patronage hiring, be spent on unneeded projects that benefit allies of the ruling class, or, in extreme cases, be simply stolen by those in charge, finding its way into foreign bank accounts. Examples of each abound, especially in the relatively less economically developed part of the world that we are considering. What provides a check on such behavior? One such check is the degree of political development that exists within the country. That is, while certainly not ensuring a one-to-one transfer of increased tax revenues into needed infrastructure projects in general, and into water systems specifically, it seems reasonable to assume that the greater is the ability of a country's citizens to effectively express their desires with respect to policies and leadership, the greater is the likelihood that at least part of the increased tax revenues will flow into infrastructure projects like water systems. Similarly, appropriate use of tax revenues is likely to be enhanced when the power of a country's executive is subject to effective constraint. As such, the degree of political development within a country becomes an important control for the empirical model that follows.

3. Data and Univariate Empirical Models

As discussed in the introduction, while minor outbreaks of cholera can and do occur across most of the world, since the illness is primarily a result of poor provision of clean water services, regrettably cholera tends to target relatively poor populations. During the period 1990-2002, for example, the United States, United Kingdom, France, Germany, Switzerland, Canada, and numerous other wealthy countries reported no deaths from cholera and incidence rates (cases per million persons) of less than 0.01. Even what would best be called solidly middle-income countries (those with per capita GDP's between $4,000 and $10,000 in 1996 U.S., dollars adjusted for purchasing power) with the Dominican Republic, Jordan, Poland, and Paraguay as examples, reported no deaths from cholera between 1990 and 2002 and, with the exception of Paraguay (0.1) also had incidence rates less than .01. From the opposite perspective, during the 1990-20002 period, in truly poor countries like Nepal, the Lao People's Democratic Republic, Zambia, Uganda, Bolivia, and Nicaragua, each with 1996 per capita GDP's of less than $3,000, incidence rates ranged from 250 to more than 550 persons per million, with as many as 35 per million succumbing to the disease. Another way of looking at this situation is simply to note that, much to the detriment of those living in relatively poor countries the collective action involved in the creation of high-level water systems is a typical outcome of the development process. To see how the two primary inputs detailed in our theoretical model, per capita income and equality, influence this collective action and thus cholera, we analyze 1,032 observations on countries that reported an outbreak of cholera for at least one year between 1980 and 2002 and which had per capita GDP's less than $4,000 during the year. These restrictions give us 17 countries to analyze empirically arising from the Americas, Africa, and Asia. Here, we briefly describe each of the variables used in our models and, in Table 1, offer descriptive statistics. For more precise definitions and sources, refer to Appendix 1.

We measure income as a country's GDP per capita (*GDPPC*), based on purchasing power parity, as reported in the World Bank's *World Development Indicators. GDPPC* for the entire sample has a mean of $1,641 per year with a rather broad range of just over $107 to roughly $4,000.

Income inequality is captured by using a country's Gini code (*GINI*) taken from the database constructed by Dollar and Kraay (2002) who draw on four sources for their data. The primary source is a significant extension of the often used Deininger and Squire (1996) sample known as the UN-WIDER Income Inequality Database. Added to this set are a number of observations that appear in the original Deininger and Squire sample, designated as high-quality, but which were omitted in the UN-WIDER sample. A third set of observations arising from developing countries comes from Chen and Ravallion (2000) and, finally, a fourth source of data in the Dollar and Kraay database comes from observations on, primarily, developed countries, offered by Lundberg and Squire (2000). Taken together, the Dollar and Kraay database offers the most comprehensive and consistent sample of measures of inequality, to our knowledge, available today. And, perhaps most importantly, it should be noted that this database takes into account and adjusts for the prior vagaries in inequality measures due to factors like countries using income-based versus expenditure-based measures, gross versus net income, and the like. This is a standard Gini code with the exception that we have reversed it in order to ease interpretation and discussion of the models. Given this, while G*INI* maintains its standard range of zero to100, in percentage terms, rising values indicate increases in equality. For the countries in our sample, the mean value is 55.61, again with a rather broad range of roughly 34 to 77.

Our measure of collective action reflects the percentage of a country's population that has reasonable access to an adequate amount of improved, clean water (*WATER*), taken from the World Bank's *World Development Indicators.* It should be noted that this variable is not available for each year in the sample period, a shortcoming that we address by linearly interpolating annual values from the years for which data are available. That is, we assume that the improvement that all countries in the sample experienced in terms of the provision of clean water over the time period being considered was linear. This is likely not the case, as water projects are not completed in a linear fashion, however, there is neither an alternative source for data on clean water access nor any way to take into account any non-linear changes that occur. Fortunately, however, we are at least certain of the positive direction that annual changes are taking, limiting the error that linear interpolation creates. This variable's mean indicates that the average country in the sample provides clean water to about 65 percent of its population. More importantly, we do see rather dramatic differences for this measure of collective action between countries, as reflected in its range of about 27 to 100 percent.

Finally, for cholera, we use two measures; the number of cases when there is an outbreak (*INCIDENTS*) and the number of deaths (*DEATHS*) resulting from those cases, as reported to WHO. The typical country in our sample reports a mean of roughly 2,433 cases of cholera which, on average, led to about 73 deaths when these countries experienced an outbreak during the period. Both *INCIDENTS* and *DEATHS* have rather wide ranges.

From the theoretical model, we expect to find the percentage of a population with access to improved water to be positively correlated with both *GDPPC* and *GINI*. Equally important, we anticipate that our measure of collective action (*WATER*) will be strongly and negatively correlated with both *INCIDENTS* and *DEATHS*. In each case, we expect these relations to hold even when relevant socio-demographic and institutional variables are controlled for. As a first step in testing these predictions, we evaluate the univariate relations between the key variables, as presented in Table 2.

In Panel 2a., the sample is broken into Less-Poor (*GDPPC*>$1,360) and Very-Poor (*GDPPC*<$1,360) halves, based on the median of *GDPPC*. Generally, we do see the pattern of relations predicted by the theoretical model. Specifically, Less-Poor countries offer their populations greater access to clean *WATER* and experience fewer *DEATHS* when there is a cholera outbreak than do Very-Poor countries. As is noted, each of these relations is statistically significant. In the case of *INCIDENTS*, no difference of statistical or practical importance is found.

Panel 2b. breaks the sample based on the median of *GINI*. Here we find that the average, relatively Income-Equal country (those with *GINI* values greater than 56.55) offers its population greater access to clean water and reports fewer *INCIDENTS* and *DEATHS* when it experiences a cholera outbreak than is true for the relatively Income-Unequal countries. Each of these relations is statistically significant.

Finally, in Panel 2c., the sample is divided into halves based on the median of *WATER*, showing the efficacy of this type of collective action. That is, when there is a cholera outbreak in a country with High-Quality *WATER* (*WATER* greater than 67.6), significantly fewer individuals die from the disease than is true for those in comparatively Low-Quality *WATER* countries, though no significant or practical difference exists for

INCIDENTS.

Taken together, we view these univariate results as being consistent with the predictions of our theoretical model. There is clear evidence suggesting that 1) access to improved, clean water is an increasing function of a country's levels of income and income equality, and 2) collective action, in the form of the provision of clean water, is effective in mitigating cholera, at least in terms of the number of people who die from the illness. To put these predictions to more rigorous scrutiny, we estimate two basic regression models, as detailed below.

In the first, we correlate *GDPPC* and *GINI* with our measure of collective action, *WATER*, the percentage of a country's population having access to clean water. As control variables in this estimation, we include *DEM*, *GOV*, *WARS and URBPOP.*

As discussed above, there is no necessary requirement that an increase in tax revenues will find its way into socially desirable infrastructure projects like improved water systems. At the same time, this outcome seems more likely the greater is the degree of political development or transparency that exists within a country. As such, we include the democracy index (*DEM*) provided by Polity IV. This scale, which runs from zero to ten, ranks countries annually on three elements of what might be generally called good government: 1) the extent to which the public can effectively express their desires concerning government policies and leaders, 2) the extent of constraints on the power of the executive, and 3) the extent of civil liberties in terms of both their political and non-political activities. Higher values on *DEM* are indicative of more well developed governmental institutions and, as such, we expect that it will exert a positive influence on the extent of the provision of clean water. In our sample, *DEM* has a mean of 2.62 and individual observations cover the entire potential range.

GOV and *WARS* are included as a further proxy for a country's institutional arrangements and for internal stability. *GOV*, a country's general government, final consumption expenditure, as a percent of GDP, is taken from the World Bank's *World Development Indicators*. The mean value for *GOV* is 13.58 while it ranges from 3.75 to 54.52. While we would prefer to have a measure of a country's government investment spending, such data, to our knowledge, is not available for a broad sample of countries over time, and this lack is especially acute in the developing world. Thus, while not ideal, we use final consumption expenditures to give us an idea of the nature of a country's government. We include this variable because governments tend to play very different institutional roles in differing countries. Those that are, on average, relatively benevolent, may take a comparatively large share of national resources and put it to work on various, useful collective action projects. In such countries, there is likely to be a generally high level of acceptance of this enlarged footprint of government as it is the general public that benefits. Of course, this is not always the case as, globally, there are numerous examples of government's malevolently using public resources wastefully or simply to further their own goals. In other words, institutions develop differently in various countries and these institutions have an impact on a country's investment in all types of collective action. If the former interpretation is correct, on average, we expect to find *GOV* being positively related to *WATER* indicating that countries where government tends to play a larger role, will likely have more well-developed systems for providing clean water to their populations while the opposite is expected if the latter interpretation is more common.

To control for internal instability, we take from the Banks Cross-National Time Series Data Archive information relative to para-military activities such as gorilla actions, sabotage of infrastructure, and the like. Our measure of instability, *WARS,* refers to the number of such events during the prior five years. The mean value for *WARS* is 1.18 and ranges from zero to 13. Wars and political instability can devastate infrastructure and health resources, and lead to the displacement of large parts of a country's population into often squalid, overcrowded refugee camps where illnesses like cholera can spread rapidly. A recent example of this occurred in the Goma camps in the Democratic Republic of Congo. Given this, the expectation for this variable is obvious: in such cases, water infrastructure is likely to be a prime target for insurgents thus a negative relation is expected between *WARS* and *WATER*.

Finally, *URBPOP* is the share of the total population that lives in an urban area, as reported in the World Bank's *World Development Indicators*. This variable, with a mean of 34.58 and range of 4.34 to 84.38, is included for obvious, practical reasons: even in relatively poor countries, urbanization's clustering of people drives down the marginal cost of providing clean water thus leading us to expect a positive relation between this variable and the proportion of a country's population with access to clean water.

Having established the relations between the key variables, *WATER*, *GDPPC,* and *GINI*, in the first equation, we turn our attention to the effectiveness of the collective action by estimating regressions with, alternately, *INCIDENTS* and *DEATHS* as the dependent variable. In each case, we include as independent variables, our measure of collective action, *WATER*, as well as: *GDPPC, GINI, POP*, *POP14*, *MORT*, *LIT*, *LAT,* and *FLOODS. WATER* and *GDPPC* are primary measures of development and, as such, omitting *GDPPC* from the *INCIDENTS* and *DEATHS* equations would potentially create the possibility of the *WATER* variable capturing not just the pure effect of that variable on *INCIDENTS* and *DEATHS* but also the effects of other elements of the development process. By including *GDPPC*, which is closely related to various aspects of development, this variable should point to the effect of those aspects of development, other than *WATER*, that affect *INCIDENTS* and *DEATHS*, We expect GDPPC to exert strong negative influences on both *INCIDENTS* and *DEATHS*.

GINI is included as it seems plausible that as equality increases within a country, there might be more uniform access to factors such as whatever given quantity of clean water is available, to medical facilities, and to public education as to how to mitigate the effects of the disease and, thus expect this variable to be negatively correlated with the dependent variables. We include two measures of a country's population, each taken from the World Bank's *World Development Indicators*, total population (*POP*), and the percentage of that total which is 14 years old or younger (*POP14*), since the very young tend to be especially susceptible to cholera. In our sample, the typical country has a population of about 6.5 million persons with a bit more than 42 percent being 14 or younger. In each case, we expect the variable to be positively associated with each of the dependent variables.

The next two variables are included as, admittedly, crude proxies for the state of a country's health care and education networks. Specifically, *MORT* is the probability that a newborn will die prior to reaching age five, per 1,000 live births for a given country while *LIT* is a country's basic literacy rate, each taken from the World Bank's *World Development Indicators*. The mean value for these two variables, respectively, is 86.52

and 57.51. To the extent that more developed health and education systems can serve to mitigate the outbreak of cholera, its spread, and its severity, we expect *MORT* to show a positive relation with the dependent variables with the opposite being true for *LIT*.

Finally, we include controls for location and climate, *LAT* and *FLOODS*. *LAT* measures the absolute distance of a country from the equator, taken from the CIA *Factbook.* Controlling for *LAT,* which has a mean of just 14.09 is important because, as discussed above, cholera is by nature a tropical disease, thus, *LAT* should be found to be negatively related to both *INCIDENTS* and *DEATHS*. *FLOODS*, with a mean of 3.16 in the prior 5 years, is important as a control since it has the potential to overwhelm basic water systems, spreading tainted water throughout a rather large geographic area, such as occurred following Hurricane Mitch in Central America in late 1998. The expectation here is positive on both *INCIDENTS* and *DEATHS*.

4. Multivariate Empirical Models

A. Correlates of Access to Clean Water

The theoretical model predicts that collective action, in the form of providing a population with access to clean, improved water, is a positive function of a country's income and its degree of income equality. This contention is supported in the univariate models presented above but, to more formally test it, we estimate the following two-way fixed-effects model:

$$\begin{aligned} WATER_{ist} = {} & \alpha_0 + \alpha_1 GDPPC_{ist} + \alpha_2 GINI_{ist} + \alpha_3 DEM_{ist} + \alpha_4 GOV_{ist} + \\ & \alpha_5 WARS_{ist} + \alpha_6 URBPOP_{ist} + \gamma_s + \gamma_t + u_{ist} \end{aligned} \tag{3}$$

where *WATER* is the percentage of the population having access to clean water for country *i* in continent *s* at time *t*, *GDPPC* represents per capita income, *GINI* is a measure of income equality, *DEM* reflects the extent of transparency and public input that exists within government operations, *GOV* represents general government final consumption expenditure as a percentage of GDP, *WARS* indicates the extent of internal strife occurring within the country during the previous five years, and *URBPOP* is the share of the total population that resides within an urban area.

We use year fixed-effects, $\gamma_{t,}$ to control for any time-specific effects that shift the level of clean water access for all continents which might include technological changes affecting the creation and extension of water systems, greater international cooperation with respect to development of water systems and the like, over the period under review. Giving us the second dimension of potential fixed-effects, the γ_i represent individual continents, allowing us to capture any unobserved continent-specific heterogeneity that is relatively fixed over time, such as general weather conditions, topography, cultural norms and so forth. Since our interest is on the partial effects of time-varying covariates, fixed-effects estimation is attractive because it allows any unobserved heterogeneity to be freely correlated with the time-varying covariates. In addition, continent fixed-effects permit us to take into account differences across continents in terms of a particular continent's tendency to accurately gather data on the extent of access to clean water and to report that information appropriately. To the extent that the degree of misreporting remains constant over time but varies across continents, the fixed-effects procedure will leave the estimates of the impact of the explanatory variables on water access unaffected.[4] Given this, Table 3 reports the outcomes when both continental and year fixed-effects are controlled, for all those country-year observations in the primary sample—those with *GDPPC'*s less than $4,000—and also, to assess the stability of the relations, for two subsets, those with *GDPPC'*s less than $3,000 and $2,000, respectively.

The first thing to note about the regressions of Table 3 are the models' relatively good fit, offering reasonably high R-square values and highly significant F-tests indicating the likelihood of the included independent variables being jointly equal to zero is virtually nil and that the combined fixed-effects are necessary in order to take into account continent and year heterogeneity in explaining differing access to improved water between the continents and over time, in each model. Taken together, these tests indicate that, indeed, in assessing collective action and its determinants, there is information to be had by exploiting the dataset's panel nature and the preferred way of doing so is through the use of the two-way fixed-effects estimator.

Of primary importance in Table 3 are the results across the samples for the income and income equality variables which, in each case, are consistent with both the theoretical model's predictions and the simple, univariate results reported above. Regardless of the sample employed, as income (*GDPPC)* and income equality (*GINI*) increase within a country, access to clean water increases and significantly so, beyond the .01 level for each. As discussed in detail in the theory section, it appears that income and income equality, taken together, are very powerful predictors of access to improved water. Importantly, this result holds even when the institutional variable for government

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[4] To illustrate, when Equation (3) is estimated using fixed-effects, the coefficients reflect within-continent variation in access to clean water and its determinants. Multiplying continent *i*'s access to clean water by a constant to reflect poor or incomplete reporting would not change the estimates of the coefficients.

transparency, *DEM*, is included, which is itself positive and significant (beyond the .01 level across models). Apparently, in countries with relatively high levels of political development characterized by transparency and real public input into government decision-making, the likelihood of growing tax revenues being put to socially good uses, such as investments in water systems, increases.

The remaining control variables in the estimation of Equation (3) are also well-behaved across the three samples offering the expected relations with *WATER*. Specifically, we find that as the footprint of government increases within an economy, as measured by the percent of GDP accounted for by government expenditures (*GOV*), access to clean water also increases, beyond the .01 level, in all but the case of those country-year observations for which *GDPPC* is less than $2,000 (though the relation is positive here as well). We take this to support the 'relatively benevolent' view of government discussed above. That is, in countries where institutions have evolved such that there is a comparatively stronger, accepted role played by government in general, there is an increased likelihood of all forms of collective action, including the provision of improved water. Again as expected, across samples, we find that the existence of domestic conflict (*WARS*) has a consistently significant and negative impact on the ability of a government to provide clean water to its people. This is particularly reasonable in that the variable specifically targets the types of domestic conflict that can be expected to result in attacks on public infrastructure. Finally, for each sample, the percentage of a country's population that has access to improved water is strongly correlated with the percentage of that country's population living in urban areas, *URBPOP*. While an important control, this likely reflects little more than the ease with which improved water can be made available to a population when that population is concentrated within a localized area rather than being geographically dispersed.

Taken together, the results of the estimation of Equation (3) clearly support one of our two primary contentions. That is, with a reasonably high level of confidence, we conclude that collective action in the form of the provision of clean water is an increasing function of a country's income and income equality. To complete the test of our theoretical model's predictions, we turn to the question of how effective this collective action is in mitigating cholera.

B. Correlates of Cholera Incidents and Deaths

To consider the effectiveness of collective action in mitigating cholera, we estimate the following two-way fixed-effects model:

$$\begin{aligned} CHOLERA_{ist} = \beta_0 + \beta_1 WATER_{ist} + \beta_2 MORT_{ist} + \beta_3 LIT_{ist} + \beta_4 GDPPC_{ist} + B_5 POP_{ist} + \\ \beta_6 POP14_{ist} + \beta_7 LAT_{ist} + \beta_8 FLOODS_{ist} + \beta_9 GINI_{ist} + \gamma_i + \gamma_t + \varepsilon_{ist} \end{aligned} \tag{4}$$

where $CHOLERA_{ist}$ represents, alternately, the number of *INCIDENTS* or the number of *DEATHS* from cholera for country *i* in continent *s* at time *t*, *WATER* is the percentage of the population having access to clean water, *MORT* is the probability of a newborn failing to reach age five, per 1,000 live births, *LIT* indicates the percentage of the population that has attained basic literacy, *GDPPC* is per capita GDP, *POP* is the total population of a country, *POP14* represents the percentage of the total population that is 14 years old or younger, *LAT* measures the absolute distance of a country from the equator, *FLOODS* indicates number of floods occurring within the prior five years, and *GINI* reflects the degree of income equality within a country.

As with the estimation of Equation (3), estimation of Equation (4) also takes advantage of the panel-nature of the data by utilizing the two-way fixed-effects estimator, γ_i and γ_t, controlling for both continent and year effects. In this case, the continent fixed-effects might control for factors such as social norms, climatic conditions, and public sector corruption that limits the effectiveness of any collective action which differ between the continents but vary little over time. Similarly the year fixed-effects might capture items like general improvements in the treatment of cholera that have come about over time or, as discussed in the introduction, the unexpected general increase in waterborne illnesses that have affected all areas in the past 20 years.

INCIDENTS and *DEATHS* are, of course, each non-negative counts of individual cases of cholera and the deaths arising from those cases. As such, the basic, appropriate model is the Poisson. A shortcoming of the Poisson for the current analysis, however, is its assumption of equal conditional mean and variance for the dependent variables. That is, to be appropriate in this case, the Poisson requires that the conditional mean of *INCIDENTS* to be equal to its variance and the same for *DEATHS*. As such, the Poisson is best applied in situations where there is limited variation in the dependent variable. This is not the case in the present analysis as can be easily seen in the descriptive statistics of Table 1 where the standard deviation of *INCIDENTS* is about 5.5 times that variable's mean and the standard deviation of *DEATHS* is 4.5 times its mean. In such circumstances, the use of Poisson to estimate relations typically causes a downward bias (and accompanying inflation of t-statistics) in the coefficient's standard errors. To correct for this type of over-dispersion, we use the Negative Binomial Regression model which generalizes the Poisson by expressly relaxing the assumption of equal conditional mean and variance through the introduction of a parameter that accounts for any unobserved heterogeneity between observations.

Finally, prior to discussing the results for the estimation of Equation (4), we should explicitly address the possibility, even likelihood, of colinearity in this model since we include four variables (*WATER*, *MORT*, *LIT*, and *GDPPC*), each of which is clearly an element of the process of economic development. Should colinearity exist between any or all of these variables, the undesirable outcome would be inflated standard errors potentially resulting in insignificant coefficients for some or all of these coefficients, when significant relations actually exist. We view this as a purely empirical matter. That is, should any or all of these coefficients prove to be insignificant a suspicion of colinearity will be raised and will have to be addressed. To the contrary, should each of these coefficients prove significant, it may be concluded that their natural correlation poses no substantial problem for estimation or interpretation.

Tables 4-6 report results for the *INCIDENTS* and *DEATHS* models for the three income-related samples—less than \$4,000, \$3,000, and \$2,000, respectively—which, due to their high-degree of consistency, we discuss together.[5] In terms of goodness of fit, in each model, the full-model Wald Chi-Square test of joint significance of the included independent variables is highly significant, well beyond the .001 level. Further, it should be noted that given that these are Negative Binomial specifications, all variables to be entered in natural logs.

In each model, there is strong evidence supporting our second primary contention that both *INCIDENTS* of and *DEATHS* from cholera are significantly reduced when collective action in the form of the provision of clean, improved water increases within a country. Regardless of the income-determined sample, the coefficient on *WATER*, the

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[5] Observations are lost here relative to the models presented in Table 3 due to the literacy variable.

percentage of a country’s population with access to clean water, is negative and significant, beyond the .05 level in both the *INCIDENTS* and *DEATHS* equations. Taken together with the results from Table 3, we conclude from this that, working through the channel of collective action (that is, improved water), income and income equality play a major role in mitigating the potentially disastrous effects of cholera. Further, it is equally important to note the outcomes for *MORT*, *LIT,* and *GDPPC.* As discussed, the provision of clean water is typically an element of economic development. As such, were it the only development-related variable included in these equations, it could be plausibly argued that the *WATER* coefficient was not only picking-up the true impact of access to clean water but also the effects of all other omitted development-related variables making it extremely difficult to interpret the coefficient on *WATER*. While it would be impossible to include all ‘other’ development-related variables, the inclusion of *MORT* and *LIT* allow us to control for two of the most important—access to well-developed health care and education systems. And, in every case, these variables yield the expected, highly significant relation with both *INCIDENTS* and *DEATHS*. Of course, there may well be elements of development which impact cholera and its severity beyond the provision of clean water and health and education systems. In an attempt to control for these, in an ‘all else’ approach, we include *GDPPC*. That is, the *GDPPC* coefficient should reflect the marginal impact, if any, on cholera and is severity for all other development-related factors other than the provision of clean water and health and education systems. Interestingly, such other factors are apparently at play in that *GDPPC* bares a negative and significant relation (at least at the .05 level) with both *INICIDENTS* and *DEATHS,* regardless of the sample employed.

Since in Equation (4) we include both access to clean water, indicators of health care and education systems, and, as a catch-all for other development-related factors, per capita GDP, and find each to be significant in every model, we conclude that 1) the provision of clean water is effective in mitigating cholera, independent of the level of development within a country and 2) economic development serves to mitigate cholera in ways distinct from simply the provision of clean water. That is, the significant finding for *WATER* is not simply picking up the general and much broader effects of increased economic development as might be expected were we not to be independently controlling for the other development-related variables in the model.[6]

The two population-related control variables (*POP* and *POP14*) are a bit less consistent across the models. Since the dependent variables are the number of incidents and deaths given a cholera outbreak it is not surprising that *POP* is positive and highly significant (beyond the .01 level) in all of the income-related samples. The results for *POP14* are less consistent. Specifically, as would be expected given the susceptibility of the young to cholera, *POP14* is positive and generally significant in both the less than \$4,000 and \$3,000 groups but unexpectedly turns negative in the less than \$2,000 sub-group (and actually significantly so in the *INCIDENTS* equation). There is no obvious interpretation for this result though it may have something to do with the fact that, in the latter case, we are truly analyzing very poor countries.

The two variables included as controls for the tropical nature of cholera, *LAT* and *FLOODS* each offer the expected signs showing that both *INCIDENTS* and *DEATHS* are greater, when a country is located closer to the equator and suffers through regular floods,

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[6] Not surprisingly, however, when the other development-related variables are omitted, *WATER* remains significant and of the same sign in each model but takes on a larger value.

though, other than in the full sample, these relations are only regularly significant for the *LAT* coefficient. Apparently, in very poor countries with very limited access to clean water to begin with, flooding poses little marginal risk to populations already at extreme risk of contracting cholera.

Finally, while we find consistently negative relations between income equality (*GINI*) and each of the dependent variables, as expected, the relations are only significant in the full-sample. It was expected that greater equality might translate into more uniform access to whatever clean water might be available, health care, and the like. As with *FLOODS* we have no intuitive explanation as to why income equality seems to matter, but relatively significantly only for the comparatively less poor country-year observations in our overall sample.

5. Conclusions

Cholera and other diarrheal diseases currently account for 11.3 percent of all deaths among the poor globally, making such illnesses the second leading cause of deaths among the poor. This statistic is particularly troublesome given that the origins and transmission mechanisms of cholera are not just well-understood but nearly completely preventable. Specifically, cholera is an acute intestinal infection which is spread when a victim ingests tainted water or food. As such, cholera can be suppressed rather easily through the provision of clean water and use of proper sanitation procedures. Of course, knowing how to suppress cholera is not the same as having the resources or public will to do so.

In this paper, we address these issues by first developing a theoretical model which describes the conditions in which one might expect to find effective collective action, in the form of the provision of clean water. This model shows that collective action of this sort is an increasing function of both a country's level of income and income equality. By extension, our model predicts that the effects of cholera are expected to be less severe when an outbreak occurs in a country with relatively high levels of income and income equality than would be true where income and/or equality are low. To test these predictions, we analyze a panel of 17 relatively poor countries who reported at least one outbreak of cholera during the 23 year period, 1980-2002, given us a total of 1,032 observations.

Whether we look at the number of cases of cholera or the number of deaths resulting from a given outbreak, we find consistently strong results. That is, there is strong support for the contention that income and income equality, working through the channel of the provision of clean water, our measure of collective action, are primary factors in determining the extent to which the outbreak devastates a country and that this positive effect of the provision of clean water is independent of any other development-related factors that likely also serve to mitigate the ravages of cholera, such as better education about disease transmission, expanded medical access, and the like. Interestingly, and remarkable, a practical example of these relations is offered, at a local level by Bradshaw et al. (1997, p. 225): "In the 1930s and 1940s the Mexican population of San Antonio… inhabited some of the worst slums in the USA. … The postneonatal diarrhea mortality rate (risk) was 48 per 1,000 Mexican origin infants, but only 7 per 1,000 Anglo infants. …[M]iserable living conditions without proper water supplies and sanitation in the densely settled Mexican American neighborhoods gave rise to … high diarrhea morbidity and mortality. …By 1970 this cause of death virtually disappeared in both populations. …[R]eduction of mortality from diarrhea was a consequence of specific community interventions."

As such, policies designed to increase economic growth and to improve the distribution of income resulting from that growth will likely serve to limit the impact that cholera has on a country. Of course, it is much easier to suggest improvements in economic growth and the distribution of income, especially in the developing world, than it is to actually develop policies that will bring these goals about. However, as the analysis in this paper shows, such policies are likely to have positive affects that are not immediately apparent if one simply focuses narrowly on economic measures of performance resulting from government actions.[7]

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[7] Cutler and Miller (2004) report that in major U.S. cities during the late 19th and early 20th centuries clean water was responsible for almost half of the total mortality reduction, three-quarters of the infant mortality reduction, and about two-thirds of the child mortality reduction, and that the social rate of return to clean water technologies was greater than 23 to 1.

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Table 1. Descriptive Statistics

Variable	*Mean*	*St. Deviation*	*Minimum*	*Maximum*
INCIDENTS	2,432.89	13,339.27	0.00	322,562
DEATHS	73.18	324.36	0.00	7,654
WATER	65.37	17.85	26.94	100
GDPPC	1,640.79	1,017.63	107.49	3,999.01
GINI	55.61	9.82	33.80	77.0
DEM	2.62	3.25	0.00	10.00
GOV	13.58	6.45	3.75	54.52
URBPOP	34.58	17.91	4.34	84.38
POP	6,540,000	20,200,000	300,000	126,000,000
POP14	42.47	4.86	57.45	57.46
LAT	14.09	8.51	1.00	35.00
FLOODS	3.16	4.59	0.00	26.00
WARS	1.18	2.09	0.00	13.00
MORT	86.52	41.19	15.90	192.00
LIT	57.51	23.76	7.94	98.37

Table2. Relations between Incidents, Deaths, Water, GDP per capita, and Gini

Panel 2a. GDP per capita, Water, Incidents, and Deaths

Variable	*GDPPC<1,360 Mean*	*GDPPC<1,360 Std. Dev.*	*GDPPC>1,360 Mean*	*GDPPC>1,360 Std. Dev.*	*Difference t-test*
Water	55.24	14.09	75.46	15.30	-20.22** (22.07)
Incidents	2,432.04	6,575.42	2,429.75	17,676.52	6.28 (0.01)
Deaths	114.76	429.15	31.77	152.71	82.98** (4.14)

Panel 2b. Gini, Water, Incidents, and Deaths

Variable	*GINI<56.55 Mean*	*GINI<56.55 Std. Dev.*	*GINI>56.55 Mean*	*GINI>56.55 Std. Dev.*	*Difference t-test*
Water	63.43	16.13	67.20	19.18	- 3.76** (3.40)
Incidents	3,239.37	18,337.69	1,666.04	5,150.46	1,573.33 * (1.89)
Deaths	98.52	431.21	49.09	165.71	49.42** (2.45)

Panel 2c. Water, Deaths, and Incidents

Variable	*WATER<67.60 Mean*	*WATER<67.60 Std. Dev.*	*WATER>67.60 Mean*	*WATER>67.60 Std. Dev.*	*Difference t-test*
Incidents	2,361.33	6,600.61	2,503.38	142.17	-142.02 (0.86)
Deaths	114.32	19.00	32.68	6.75	81.63** (4.07)

Note: t-statistics for differences in means are in parentheses; ** and * denote significance at the 1% and 5% levels, respectively.

Table 3. Correlates of Access to Clean Water, by Income Level

Independent Variable	***(1) GDPPC Less than $4,000***	***(2) GDPPC Less than $3,000***	***(3) GDPPC Less than $2,000***
Intercept	37.804** (3.1826)	35.236** (3.4598)	31.176** (3.8097)
GDPPC	0.005** (0.0005)	0.007** (0.0008)	0.004** (0.0013)
GINI	0.130** (0.0422)	0.147** (0.0456)	0.228** (0.0498)
DEM	0.405** (0.1365)	0.564** (0.1571)	0.928** (0.1811)
GOV	0.304** (0.0652)	0.143** (0.0734)	0.013 (0.0837)
WARS	-0.697** (0.1880)	-0.715** (0.2155)	-0.598** (0.2548)
URBPOP	0.278** (0.0310)	0.360** (0.0373)	0.455** (0.0446)
Estimation Procedure	*Two-Way Fixed Effects*	*Two-Way Fixed Effects*	*Two-Way Fixed Effects*
R-Square	0.37	0.32	0.28
F-test[a]	94.20**	69.62**	63.97**
F-test[b]	21.03**	14.09**	9.71**
Number of Observations	1,032	904	712

Notes: Standard errors in parentheses, * denotes significance at 5% level, and ** denotes significance at 1% level. [a] Test of the significance of the independent variables. [b] Test of the fixed-effect model against the ordinary least square model.

Table 4. Correlates of Incidents and Deaths: GDPPC Less than $4,000

Independent Variable	*(1)* *INCIDENTS*	*(2)* *DEATHS*
Intercept	-10.661**	-10.401**
	(2.9761)	(3.1730)
WATER	-0.535**	-0.432*
	(0.2092)	(0.1820)
MORT	0.401**	0.399*
	(0.1984)	(0.2114)
LIT	-0.328**	-0.322**
	(0.1093)	(0.1151)
GDPPC	-0.298**	-0.296**
	(0.1149)	(0.1190)
POP	0.389**	0.354**
	(0.0513)	(0.0541)
POP14	2.012**	1.983**
	(0.6318)	(0.6585)
LAT	-0.311**	-0.306**
	(0.0608)	(0.0641)
FLOODS	0.185**	0.1961**
	(0.0928)	(0.0998)
GINI	-0.498*	-0.483*
	(0.2607)	(0.2717)
Estimation Procedure	*Negative Binomial Two-Way Fixed Effects*	*Negative Binomial Two-Way Fixed Effects*
Wald Chi-Square	368.31**	286.10**
Number of Observations	1,012	1,012

Notes: Standard errors in parentheses, * denotes significance at 5% level, and ** denotes significance at 1% level.

Table 5. Correlates of Incidents and Deaths: GDPPC Less than $3,000

Independent Variable	***(1) INCIDENTS***	***(2) DEATHS***
Intercept	-5.205* (2.7341)	-8.930** (3.6282)
WATER	-0.529** (0.2167)	-0.407* (0.2334)
MORT	0.787** (0.2421)	0.721** (0.2538)
LIT	-0.525** (0.1366)	-0.564** (0.1428)
GDPPC	-0.377** (0.1215)	-0.304** (0.1258)
POP	0.366** (0.0557)	0.347** (0.0583)
POP14	0.382 (0.7655)	1.328* (0.7796)
LAT	-0.371** (0.0647)	-0.309** (0.0681)
FLOODS	0.139 (0.1001)	0.175* (0.1081)
GINI	-0.298 (0.1215)	-0.297 (0.2808)
Estimation Procedure	*Negative Binomial Two-Way Fixed Effects*	*Negative Binomial Two-Way Fixed Effects*
Wald Chi-Square	324.67**	285.42**
Number of Observations	856	856

Notes: Standard errors in parentheses, * denotes significance at 5% level, and ** denotes significance at 1% level.

Table 6. Correlates of Incidents and Deaths: GDPPC Less than $2,000

Independent Variable	***(1) INCIDENTS***	***(2) DEATHS***
Intercept	-0.606 (3.9317)	-5.260 (4.2735)
WATER	-0.751** (0.2364)	-0.703** (0.2556)
MORT	1.809** (0.3305)	1.808** (0.3465)
LIT	-0.857** (0.1835)	-0.877** (0.1969)
GDPPC	-0.326** (0.1354)	-0.242* (0.1411)
POP	0.422** (0.0641)	0.428** (0.0686)
POP14	-2.091* (1.2555)	-1.025 (0.9878)
LAT	-0.466** (0.0757)	-0.399** (0.0790)
FLOODS	0.071 (0.1151)	0.078 (0.1228)
GINI	-0.005 (0.2949)	-0.027 (0.3059)
Estimation Procedure	*Negative Binomial Two-Way Fixed Effects*	*Negative Binomial Two-Way Fixed Effects*
Wald Chi-Square	289.28**	239.19**
Number of Observations	696	696

Notes: Standard errors in parentheses, * denotes significance at 5% level, and ** denotes significance at 1% level.

Appendix 1

VARIABLE	***DEFINITION***	***SOURCE***
WATER	The percentage of the population with reasonable access to an adequate amount of water from an improved source.	World Bank *World Development Indicators 2004*
DEATHS	Total number of deaths due to cholera reported to the WHO, as provided directly.	World Health Organization
INCIDENTS	Number of cases of cholera reported to the WHO, as provided directly.	World Health Organization
GDPPC	GDP per capita based on purchasing power parity (PPP).	World Bank *World Development Indicators 2004*
GINI	An aggregate numerical measure of income inequality, reversed, ranging from 0 (perfect inequality) to 100 (perfect equality).	Deininger and Squire Dataset (1996)
DEM	An eleven category scale, from 0 to 10, with a higher score indicating greater democracy.	Polity IV database
URBPOP	The share of the total population living in areas defined as urban.	World Bank *World Development Indicators 2004*
GOV	General government final consumption expenditure as a percentage of GDP.	World Bank *World Development Indicators 2004*
POP14	The percentage of the total population that is in the age group 0 to 14.	World Bank *World Development Indicators 2004*
POP	The de facto total of population, which counts all residents regardless of legal status or citizenship.	World Bank *World Development Indicators 2004*
LAT	The absolute distance of a country from the equator.	CIA Factbook
FLOODS	Number of floods per year.	EMDAT. OFDA/CRED International Disaster Database.
WARS	Any armed activity, sabotage, or bombings carried on by independent bands of citizens or irregular forces and aimed at the overthrow of the present regime.	Banks Cross-National Time Series Data Archive
MORT	Probability that a newborn baby will die before reaching age five, if subject to current age-specific mortality rates. The probability is expressed as a rate per 1,000.	World Bank *World Development Indicators 2004*
LIT	Percentage of population ages 15 and above who can read and write.	World Bank *World Development Indicators* 2004.