WHY AMERICA *MUST* CARE ABOUT TROPICAL MEDICINE: THREATS TO GLOBAL HEALTH AND SECURITY FROM TROPICAL INFECTIOUS DISEASES*

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Fellow members of the American Society of Tropical Medicine and Hygiene, distinguished guests and friends, it is certainly an honor to be sharing this podium today with Dr. Hughes, Dr. Feachem, and Dr. Varmus. First, I thank Dr. James Hughes for his gracious introduction. I must say that one of life's greatest riches is continuing to learn from one's fellows. As the first in an extraordinary group of fellows with whom I have had the privilege to work, Jim Hughes, now director of the National Center of Infectious Diseases, has clearly led not only the Centers for Disease Control and Prevention (CDC), but also our U.S. and global awakening to emerging infectious diseases. I also want to thank you, the members of our Society, for the honor of serving as your president. There is no greater honor than recognition by one's peers. However, I must confess that my immediate concern was that you had given me a very sobering responsibility; that of representing our Society at an important pivotal moment of potentially unprecedented awareness of the threats to us all from the growing health crises in the tropics. These threats will be the focus of my talk.

After a brief overview of our history, I shall divide these threats into three areas: 1) emerging infectious diseases, 2) exploding population without improved health, and 3) erosion of our humanity and leadership if we turn our backs on the health problems of the growing majority of people on our planet. I shall then argue that we devote dangerously little attention and resources to the health problems of the growing majority of people living in the tropics. Finally, the members of this Society are the repository of insight and experience in tropical medicine. As such, *ours* is the sobering responsibility to educate modern society about the critical importance to us all of tropical medicine and global health.

HISTORY

This has truly been an eventful year for our Society with our new Journal editor, our courses and examination setting new global standards, and our biggest annual meeting ever. As so eloquently reviewed last year by Don Burke (now our archivist) and by many other past Presidents, the American Society for Tropical Medicine was founded by Thomas Fenton in 1903 to address tropical disease threats in the subtropical United States (including malaria and hookworm) and in the new U.S. possessions (Puerto Rico, Cuba, and the Philippines, with such threats as typhoid fever, yellow fever and dengue). In 1918, amid the influenza epidemic, the annual meeting was canceled. In 1920, Henry Nichols, bemoaning the national morale after the U.S. Senate failed to ratify Woodrow Wilson's League of Nations, started our American Journal of Tropical Medicine, initially as a bimonthly publication. In the 1930s, the American Academy of Tropical Medicine and the American Foundation for Tropical Medicine were formed. Before the close of World War II, Wilbur Sawyer said in his 1944 Presidential Address that *"No country can live to itself in disease prevention.... Failure of one is a failure of all."* By 1952, our parent societies merged as our current American Society of Tropical Medicine and Hygiene.

In 1964, Dr. Thomas Weller prophetically noted that: "The national interest is evermore intimately associated with the process of development of stable and healthy societies in the tropical areas of the world. Indeed, . . . prospects for the (very) survival of western civilization as we know it are in large part dependent on our ability to share the material benefits of our social system with the some 2½ billion human beings who now exist in mass misery in the poorly sanitated areas of the world."

This, of course, is the very group that has grown and will continue to grow the fastest until their health and other conditions improve. In a striking departure from Burnet's 1962 prediction that infectious diseases were about to be eliminated, by 1972, William Reeves pessimistically asked "*Can the war to contain infectious diseases be lost?*" He noted that "Experience indicates that political, social and economic considerations will increasingly dictate priorities...," and that he anticipated "... a marked decrease in the effective-ness of our infectious disease control programs."

I remember poignantly Karl Johnson's address in 1984 on "Whither this house—or wither" in which he boldly challenged this Society to move forward—challenges to which our leaders since have arisen; people like Bob Shope, Phil Russell, Joe Cook, John David, Scott Halstead, Don Krogstad, Dan Colley, Barney Cline, Carol Long, Don Burke, and of course our extraordinary Secretary-Treasurer, Peter Weller.

In the 1990s, the Society has continued to improve its scientific program, producing a timely abstract book under the leadership of Don Krogstad, Tom Monath, and Bill Petri. The Journal, under Mac Warren's past and Jim Kazura's future leadership, has increasing competition for reporting the best science yet. And our new certification training and examination, led by Michele Barry and Jamie Maguire, are now becoming global standards of excellence in tropical medicine.

These are the people and events that have defined our Society today. Building on this legacy, we now must lead modern society in recognizing and addressing the growing global threats from tropical infectious diseases. This year, Stephanie Sagebiel asked me to testify before the House Appropriations and Foreign Affairs Subcommittees in Washington. I must say, nothing focuses the mind like being given

^{*}Presidential Address given before the 46th Annual Meeting of the American Society of Tropical Medicine and Hygiene, Orlando, Florida, December 9, 1997.

five minutes to influence public funding for tropical medicine. Take a moment to think about what you would say about why America must care about tropical medicine. I concluded that at the close of the 20th century, tropical infectious diseases now pose some of the greatest threats to our future.

OUR AGENDA-THE THREE THREATS TO OUR FUTURE

I shall divide these threats into three areas (or three *E*s): I shall first address *E*merging infections, then *E*xploding population without improved health and finally, *E*rosion of our humanity and leadership if we turn our backs on the health threats to the growing majority.

Our agenda, though focused on tropical infectious diseases, is global. This is because health is an unassailable universal human value, transcending all political, geographic, and cultural barriers. No one would rather be ill than healthy. Furthermore, I shall argue that good health is linked to voluntary population control, as well as to productivity and national and international security. Finally, at the end of the millennium, health, like education, has become largely attainable with existing resources. Among other reasons, I shall argue that addressing health crises of the poor in the tropics is imperative for our self-interest and survival as a civilization.

1) Emerging infections. In his 1970 Nobel acceptance speech, Alexander Solzhenitsyn said: "What seems to us more important, more painful, and more unendurable is not really what is more important, more painful, and more unendurable but merely that which is closer to home. Everything distant which for all its important moans and muffled cries, its ruined lives and millions of victims, that does not threaten to come rolling up to our threshold today we consider endurable and of tolerable dimensions."

The message from emerging infections is that as we approach the 21st century with rapidly increasing globalization of trade and travel, *"everything distant"* now does threaten to come rolling up to our threshold today.

Perhaps one of the best recent examples of this is the raspberries that brought Guatemalan *Cyclospora* to the silver chalices of the affluent throughout the United States and Canada for each of the last two years, about which Barbara Herwaldt spoke last year.¹ Indeed, it was often the most affluent who acquired this enteric parasite at events such as country club gatherings. This year, in addition to raspberries, mesclun lettuce and basil in pesto pasta have brought *Cyclospora* to the gourmet platters of the affluent, once again showing the irretrievably increasing impact of the globalization of our food supply. Our supermarkets that had only 300 items on their shelves in the 1950s now have more than 30,000 items including fresh fruits and produce from around the world and throughout the year.

Probably more from frightening accidents of nature (like *Cyclospora, Cryptosporidium, Escherichia coli,* hantavirus, and Ebola outbreaks) and from popular documentary books like Laurie Garrett's "*The Coming Plague*" or Richard Preston's "*The Hot Zone*", or fictitious books and Dustin Hoffman's movie "*Outbreak*", than by rational education, the average American is now beginning to realize (perhaps for the first time) that we cannot live in a world of isolation.

TABLE 1

Emerging and re-emerging infectious disease threats, 1980-1997*

Viral

- Ebola—Zaire 1995
- Dengue Fever—Asia, Africa, L. America 1995; USA/TX 1995– 96
- Yellow Fever—Kenya 1993
- VEE—Venezuela, Colombia 1995–96
- Bolivian Hemorrhagic Fever—S. America 1994
- Lassa Fever—Nigeria 1992
- Rift Valley Fever—Sudan 1993
- Hantavirus—USA 1993Morbillivirus—Australia 1994
- BSE—UK 1986
- DSE---UK 1980
- New variant of Creutzfeldt-Jakob Disease(V-CJD)/Mad Cow Disease—UK, France 1995
- HIV subtype O—Africa 1994
- Influenza A/Beijing/32/92—USA 93

Parasitic

- Cryptosporidiosis—USA 1993+
- Malaria—Asia, Africa, L. America, USA/MI/GA 1995-97
- Microsporidiosis—worldwide
- Cyclospora—USA/Canada 1996–97
- Metorchis—Canada 1996
- Ancyclostoma caninum/eosinophilic enteritis-Australia 1990s

Bacterial

- Cholera-L. America 1991
- V. cholerae 0139—S. Asia 1992
- E. coli 0157-USA 1982-97, Japan 1996
- Plague—India 1994
- Diphtheria—Former Soviet Union 1993
- Anthrax—Caribbean 1993
- Lyme Disease (Borrelia burgdorferi)—USA 1990s
- Trench Fever (*Bartonella quintana*)—USA 1990s
 Cet Seretch Disease/Basillary engigmentaria (*Barten*)
- Cat Scratch Disease/Bacillary angiomatosis (*Bartonella hense-lae*)—USA 1990s
- Chlamydia pneumoniae Pneumonia/?coronary artery disease— USA et al. 1990s (discovered 1983)
- Ehrlichia chaffeensis HME—USA
- Ehrlichia phagocytophilia HGE—USA
- Helicobacter pylori ulcer/cancer—Worldwide (discovered 1983)
- Toxic Strep—USA
- Pertussis—UK, USA

Fungal

- Coccidioidomycosis—USA 1993
- Penicillium marneffi

* Adapted from references 2 and 3. BSE = bovine spongiform encephalopathy; HME = human monocytic ehrlichiosis; HGE = human granulocytic ehrlichiosis.

Brought to our attention by the National Institutes of Health (NIH) and CDC, the list of emerging and re-emerging infectious disease threats in just the last two decades of the 20th century now exceeds 35 (Table 1).^{2,3} These pose growing threats, not only to tropical developing populations, but to the entire world. The problems are further compounded by increasing drug resistance, and many diseases (like malaria, cholera, diphtheria, and tuberculosis) once thought to have been under control are now re-emerging, often with a vengeance.

As an example, dengue hemorrhagic fever was practically eradicated before 1981 in the Americas. However, it has returned throughout much of Central and South America since that time, and is now blanketing south Asia. Fewer than 30,000 cases were reported from 1956 through 1980, more than 137,000 from 1981 through 1985, and more than 267,000 cases from 1986 through 1990, illustrating the dra-



FIGURE 1. Recorded cases of dengue hemorrhagic fever between 1956 and 1990. These data are adapted from references 4 and 5.

matic increase in reported cases of dengue hemorrhagic fever worldwide (Figure 1).^{4, 5}

Burgeoning populations in the tropics, urbanization, social unrest, increasing travel, and possible climatic changes all influence emerging and re-emerging infectious diseases.

Cholera, as another example, was probably contained in south Asia for centuries, if not millennia, spread in several pandemics across Asia, Europe, and the Americas in the last century⁶ (Figure 2). It then disappeared from the Western Hemisphere for nearly a century until it erupted in Peru in 1991 and has since spread throughout nearly every country in South and Central America. Then, an entirely new strain erupted in late 1992, which has since become endemic throughout South Asia, posing fresh challenges to new vaccines. This dramatic disease produces devastating dehydration with a high mortality, approaching 50% as seen in the refugees a couple of years ago in Rwanda. Not only has cholera toxin, like *E. coli* heat-stable toxin, enlightened us about basic cell signaling,⁷ but perhaps the most important medical discovery of our century has been the finding that glucose, sugars, or simple starches can drive absorption of water and electrolytes and reduce this mortality to less than 1%. We are now excited about glutamine, and new, more stable derivatives, doing potentially even better at rehydration while also rebuilding the damaged gut mucosa, as a new oral rehydration and nutrition therapy (ORNT) for acute or persistent diarrhea.^{8, 9}

Even with the greatest cholera mortality ever recorded, this disease still constitutes less than 1% of the global diarrhea mortality; and even less of its morbidity!

As many of you know, we work with Aldo Lima and many other colleagues in Fortaleza, in northeastern Brazil, where among the poor, diarrhea constitutes the leading cause of death often exceeding all other causes combined when



FIGURE 2. Collision of the seventh and eighth cholera pandemics. Adapted from references 6 and 7.

TABLE 2 Child mortality in Guaiuba, Ceara, Brazil*

	<1	1-4	Total
Acute diarrhea	11 (31)	6 (46)	17 (35)
Prolonged diarrhea	13 (36)	4 (31)	17 (35)
Other causes	12 (33)	3 (23)	15 (31)
Total	36 (100)	13 (100)	49 (100)

* Data are from verbal autopsies over a 12-month period by J. F. McAuliffe and published in reference 10. Values in parentheses are percentages.

years of potential life lost are taken into account. However, when Jay McAuliffe met each week with the *coveiro* (gravedigger) to review child deaths over a year in a northeastern Brazil township, he found that persistent diarrheal illnesses are now emerging as a major cause of death (Table 2).¹⁰ It should be noted that the etiologies are somewhat different, with enteroaggregative *E. coli, Cryptosporidium,* and possibly toroviruses being among the major etiologies.^{11,12}

More important, however, than the staggering mortality from diarrhea and other childhood diseases (reaching as high as one in four children dying in the poor areas before their fifth birthday) may well be the impact on the other three children, who do not die, but live through repeated or persistent malnourishing and dehydrating enteric infections in their most formative first two years of life.13, 14 This creates a long-term impact not counted in the popular disabilityadjusted life years (DALYs) calculations. For example, working with us in northeastern Brazil, Joanne Leslie has calculated that diarrheal illnesses in the second year of life alone account for more than 5 cm of growth shortfall among children in our collaborative studies.13 Others and we are now finding that malnutrition may be the greatest of all emerging enteric infections, often without overt diarrhea (Figure 3),¹⁵⁻¹⁸ with profound implications for Christopher Murray's DALY calculations and his "unfinished agenda."^{19, 20}

The emerging enteric protozoa, long recognized by the veterinarians, have been brought to our attention by the AIDS epidemic. Now they hold additional lessons for developed, as well as developing countries.²¹

The water that made Milwaukee famous brought an extraordinary attack rate of more than 52% in the distribution of the South Milwaukee Water Works plant, with only a slight increase in turbidity; well within the then Environmental Protection Administration standards.²² While devastating to many, it was the impact on the National Basketball Association (when Milwaukee lost to Miami because of their cryptosporidial diarrhea) that awakened many. It was only later that the profound impact, with more than 59% dying among 82 HIV positive cases of cryptosporidiosis occurring in Milwaukee's water outbreak, was fully appreciated.²³ Since it is highly resistant to chlorine, surviving even fullstrength household bleach, *Cryptosporidium* thus challenges not only the world's water supply, but the water supply in the United States as well.

Yet another demonstration (like *Cyclospora*) of the extraordinary capacity of the food industry in industrialized countries to distribute emerging pathogens lies in the mounting sagas of enterohemorrhagic *E. coli* (EHEC). This year it was Hudson hamburger²⁴ and alfalfa sprouts that made head-



FIGURE 3. The vicious cycle between enteric infections and malnutrition. Enteric infections well be a major cause of malnutrition and other developmental shortfalls in children. Enteroaggregative *Escherichia coli* (EAggEC)¹⁵ and *Cryptosporidium*¹⁶ infections been shown to impair growth, even in the absence of overt diarrhea. Furthermore, malnutrition predisposes to increased diarrheal illnesses^{17,18} to complete this vicious cycles – interventions at any point are therefore important.

lines; radish sprouts infected more than 9,000 school children in Japan last year.²⁵

Furthermore, we may not prevent the dreaded complications of hemolytic uremic syndrome (HUS) or thrombotic thrombocytopenic purpura (TTP) with antibiotics. Like the difficulty eradicating *Cyclospora* or *Cryptosporidium* with chlorination, EHEC reminds us yet again of our vulnerability to emerging infectious diseases, not to mention the threats of increasingly resistant organisms and the growing list of diseases like gastric and hepatic cancer, malnutrition and coronary artery disease now being linked to infections.

We now add to these threats the unspeakable horror of intentional use of infectious agents as weapons as noted in Richard Preston's latest book, *"The Cobra Event."*

2) Exploding population (our Malthusian thinking is dangerously backwards!) My next point about the importance of improved health for population control derives initially from personal experiences in Africa, Bangladesh and especially in Brazil.

In the course of two and one half years of prospective surveillance for diarrheal diseases in Pacatuba, near Fortaleza, in northeastern Brazil, one (4%) of 23 mothers in the better homes had a baby during the study period. In contrast, of the 32 mothers in the poorer homes, 17 (53%) had an additional child in the same period (P < 0.001).²⁶ In other words, our "Malthusian" thinking (albeit not from the insightful 18th century political essayist's latter writings)–that disease and poverty will ultimately control human population overgrowth—must now be seen as dangerously backwards in the modern world. With the voluntary ability to control family size, it is clear that it is not bad health but good health (along with education, women's roles, economic opportunity, etc.) that is consistently associated with control of population overgrowth.

This is not only true within rural villages in northeastern Brazil, but in virtually every country across the globe and within each industrialized country's history. We forget that both the infant mortality and the fertility rates in New York



FIGURE 4. Correlation of infant mortality and total fertility in selected countries and areas of world. Data are from 1995 as published in reference 27.

City in 1900 exceeded those found in Bangladesh and Nigeria today. While some like to blame the Pope, even Italy has a lower fertility rate than the United States, Japan, or Sweden (Figure 4).^{7,27}

Furthermore, there has been a consistent decrease in the period required for the "demographic transition;" the time over which infant mortality and fertility decline. This interval has progressively shortened from more than 60 years for western Europe from 1870 to the 1930s, to less than 12–20



FIGURE 5. Births and deaths in Bangladesh: transient impact of natural and political disasters.²⁸ (Reprinted from Mosley WH, Hossain M, 1973. Population: Background and Prospects. Chen LC, ed. *Disaster in Bangladesh: Health Crises in a Developing Nation*. New York: Oxford University Press: 8–17, with the permission of the publisher.)

years in rapidly developing countries such as Thailand, Botswana, Kenya, and Zimbabwe (1980–1990s).²⁶

The ineffectiveness of even record breaking natural or political disasters in controlling population overgrowth is evident from the demographic effects of the cyclone and war in Bangladesh in 1970–1971. The huge peak of devastating mortality, with more than a quarter million deaths in each of these disasters within a four-month period, was more than offset by a "postdisaster baby boom" (Figure 5).²⁸

The devastating impact of AIDS in areas of Uganda, with the highest rates in the world, reaches demographic importance only in the most localized parish areas—in part because orphaned children move away. At the district or national level, this only slightly slows the staggering 3.5% growth rates. Conversely, one can practically draw a map of the roads traveled from a three-dimensional graph of orphan rates in the Rakai and Masaka districts of Uganda, as reported by Low-Beer and others in *Nature* this year.²⁹

Finally, the dramatically greater effectiveness of improved health in reducing population overgrowth was demonstrated clearly in the Naraganwal and Jamkhed projects, as reported by Carl Taylor.³⁰ Prior to a primary health project, the birth rate was 40 per 1,000 and the infant mortality rate was 120 per 1,000 live births. In other words, of 1,000 people, there were 40 births and five deaths resulting in an increase of 35 children per year (a typical 3.5% growth rate). In contrast, after introduction of basic health measures (at a cost of <\$2 per capita per year, borne by the villagers themselves), the infant mortality rate decreased to only 20 per 1,000 with a reduction in birth rate from 40 to 23 per 1,000. This means that of 1,000 people, 23 children were born, one died; resulting in only 22 children, now much healthier, added to the population each year (for a striking 37% reduction in population growth with simple health improvements).³⁰

Thus, lest we leave population control to disastrous infec-

GUERRANT



FIGURE 6. Increasing percentage of the population residing in developing countries (**dark shading**). As shown in the lightly shaded portions of the bars, the percentage of the world's population residing in industrialized countries (United States, Canada, Europe, Australia, Japan, and the USSR) is steadily decreasing. Data are from reference 32.

tious diseases and famine or to a fascist removal of human dignity, we must work unceasingly for the improved health (and education and economic development) of all who share our planet—as this is the *only* way to see the population explosion brought under control. *Such a basic level of health with education and economic opportunity for all may well prove to be the greatest test of all for the survival of democracy in the world*.

Consider even the nuclear or biological warfare threats they much more likely lie in the hands of the enraged disadvantaged person who has nothing to lose than in the hands of the so-called "powerful" who stand to lose everything they have.

Consequent to the striking skew in population growth being among the poor, we in the United States comprise a shrinking minority of the world's population, soon to fall below 4%.³¹

Conversely, the percentage of the world's population living in developing countries increases from 75% of 4.4 billion in 1980 to 84% of 7.8 billion by 2020 (Figure 6).³² In fact, the only region in which a relative percentage increase of the world's population is projected, despite the dire consequences of AIDS and its staggering impact on the orphan rate, is sub-Saharan Africa (Figure 7).³³ Furthermore, the urban migration further skews this population distribution, to the extent that by the year 2015 it is projected that of the 10 largest cities in the world, all but Tokyo, Shanghai, and Beijing will reside in or border on the tropics (Figure 8).³⁴

If one includes all high income countries, the percent comes to only 18% of the world's population. Yet, this 18% consumes more than 60% of the global nonrenewable resources such as oil, while 82% in lower and middle income countries consumes only 39% of its oil equivalents at a nearly seven fold lower per capita level of 739 kilograms per year (Figure 9).²⁷

Perhaps most alarming is the destabilizing disparity between the rich and the poor (also assessed as the Gini co-



FIGURE 7. Projected changes in the relative distribution of populations in major regions of the world between 1990 and 2050. Only Africa shows a substantial relative increase (eight-fold) from the number in 1990. Data are from reference 33.



FIGURE 8. Current and projected populations of the 10 largest urban agglomerates in the world by the year 2015. Data are derived from reference 34.

efficient)²⁷, illustrated by the percentage share of income for the highest and lowest 20% segments of the population for four representative countries. While this difference is 4–9-fold for Bangladesh and the United States, respectively, it is a striking 15–32-fold for Honduras and Brazil (Figure 10).²⁷

Furthermore, as noted by the World Health Organization (WHO), poverty is increasing.³⁴ The number of extremely poor doubled between 1970 and 1990; one-fifth of the world's population now lives in extreme poverty, one-third of the children are undernourished, and half of the world's population lacks regular access to essential drugs.³⁴

What are the health threats? Mortality and DALYs. What then are the health threats on a global scale? Whether one examines the global mortality or Christopher Murray's DALY³⁵ calculations that include morbidity, infectious diseases account for 1–3 times the mortality and morbidity due to heart disease, cancer, and strokes combined (Table 3).^{5,19} Familiar to this audience, these are led by respiratory infections, diarrheal diseases, tuberculosis, malaria, measles, and others (Table 4).^{5,19,20,36,37} Stated differently, 12.2 million children less than five years of age die each year (that is, more than 33,000 children dying each day)! In developing countries, more than half of these childhood



FIGURE 9. Disparate global energy consumption by high-income countries HICs (Japan, Europe, United States, Canada, Australia, New Zealand, Singapore, Hong Kong, and Israel) contrasted with that of the low- and middle-income Countries (L/MICs). While 18% living in the HICs consumes 61% of the total oil equivalents as of 1995 (at a per capita level of 5,066 kg/c), 82% of the world's population living in the L/MICs consumes only 39% of global oil equivalents (at 739 kg/capita). Data are derived from reference 27.



FIGURE 10. Percentage share of income for the lowest and highest 20% segments of the population in four representative countries. The ratio of income for the highest to that of the lowest 20% segments range from four to 32 times in these example countries. Data are derived from reference 27.

deaths are also associated with malnutrition (Figure 11).^{32,38}

Of course this devastating mortality (and I would argue even greater, largely uncounted, morbidity) affects primarily the poor. Davidson Gwatkin has pointed out that while communicable diseases cause only 8% of deaths among the wealthy, they account for more than half (56%) of deaths among the poor (Figure 12).³⁹ Geographically, 89% of the global DALYs are in the lower and middle income regions of Asia, Africa, and Latin America.²⁰ The DALY rates by region show that Latin America, Asia, and sub-Saharan Africa tower over those in the higher income countries (Figure 13).²⁰

Thus, as Murray and others³⁸ largely acknowledge, huge challenges remain to address their "unfinished agenda": First, is the disproportionate effect on the poor, whose numbers are growing the fastest; second, socioeconomic development and effective antimicrobials are assumed; third, the impact of infectious diseases on ulcers, cancer, malnutrition and possibly coronary artery disease is overlooked; and, perhaps most important of all, no sequelae of childhood illnesses, helminths, or malnutrition are adequately quantified or even counted. For example, the DALY for diarrhea counts only the slight disability for a few days of overt illness, but misses the far more devastating but poorly quantified impact of repeated or persistent illnesses and enteric infections without overt diarrhea on long-term child and human development. When Bundy and others added these calculations for intestinal helminths, for example, their DALY impact more than doubled!^{40, 41}

Unless these challenges from tropical infectious diseases are addressed by our best science and resources, their growth in exploding populations threaten us all.

3) Erosion of humanity/leadership. The third, and some argue the most important threat, is the erosion of our humanity if we ignore the readily addressable health problems of the growing majority on our planet. By turning our backs, I would argue, we become something less than human.



FIGURE 11. Distribution of 12.2 million deaths estimated to occur among children less than five years old in developing countries. Data are derived from references 37 and 38. ARI = acute respiratory infections.

TABLE 3 Leading causes of global mortality and morbidity*

		Mortality	Morbidity (% DALYs)
1.	Infectious diseases	16.5 (32.0%)	36.4%
2.	Cancer	6.1 (11.8%)	5.9%
3.	Heart diseases	5.0 (9.7%)	3.1%
4.	Cerebrovascular disease	4.0 (7.8%)	3.2%
5.	Chronic lung disease	3.0 (5.8%)	3.5%

* Data are summarized from references 19 and 35. DALYs = disability-adjusted life years.

While this point was said by the Washington speech writers to be politically incorrect, its restatement as erosion of our "world leadership" was felt to be more palatable. So be it– I see our human dignity and our leadership as fundamentally the same!

This has been most eloquently stated by the Bengali writer, Rabindranath Tagore, who in 1893 wrote: "If in this world misery must exist, so be it; but let some little loophole, some glimpse of possibility at least, be left, which may serve the noble portion of humanity to hope and struggle unceasingly for its alleviation..."

Who then is the noble portion of humanity? Who and where are our leaders?

A perhaps extreme glance of the grim reality facing a growing majority of the poor is reflected in the Indian poem, circa 1970, which may be the result of what King and Elliott have called "entrapment."⁴²

Mother decide: who will go without today? Will it be Ram who is the strongest, And does not need it so much? Or Raj, who is the weakest, And will not need it so long? Or Sita, who is a girl anyway? Decide mother, and kill part of yourself.

Such unthinkable entrapment has had King struggling over the potential for increasing suffering if children survive. It led others to the inappropriate analogy of the developed world as a "life boat," leaving those outside in the developing world to drown. In fact, those who are struggling to survive are multiplying the fastest, as I have noted.

Clearly it becomes imperative to avoid "unthinkable entrapment." In subsequent writings, King suggests that the two ways to avoid unthinkable entrapment are to control population growth (which necessitates improved health and education) and enhance "connectedness" (that is, the ability to obtain products or migrate).⁴² Areas that have avoided this entrapment include Singapore and Thailand. Countries in which entrapment remains worrisome are those such as Nepal.

So, how are we doing at improving the health, population overgrowth and connectedness of the world's poor that threaten us all?

Very disturbing discrepancies between the American public's perceptions regarding U.S. foreign aid and the worsening realities have been documented by the University of Maryland Center for the Study of Policy Attitudes. The U.S. public believes that we are spending 15% of our Federal budget on foreign assistance (Figure 14), and feels that we should be spending at least 5-8%.^{43, 44} This genuine concern is reinforced by the way the public has eulogized and nearly idolized the selfless caring of Princess Diana and Mother Teresa this year.

However, the harsh reality is that we spend a shrinking percentage (now less than 1%) of our national budget (Figure 14)⁴⁵⁻⁴⁸—barely one tenth of 1% of our Gross National Product (GNP)—on foreign assistance, and only a small fraction of that goes towards health. This places the United States at its lowest percentage since 1950, and for the first time ever (in absolute amounts of foreign aid) behind Japan, France, and Germany (Figure 15).⁴⁴

Despite Ted Turner's high profile gesture, among the top 21 industrialized countries in foreign aid as percentage of GNP, the United States comes in last! (Figure 16).⁴⁴

Looking exclusively at government grants, as defined by the Organization for Econonmic Co-operation and Development (OECD), the U.S. percentage of the total amount going to developing countries from OECD member countries has progressively fallen from 32.6% to only 17.7% (Figure 17) reflecting a steady decline in our leadership in this area.⁴⁷

Where then do global health resources go? Of the \$1.7

Global mortality and DALYs lost from specific IDs, 1990*					
		Global mortality millions/year	% of total global mortality	% of total DALYs lost	
Acute respirat	ory infections	4.3	8.2	9.0	
Diarrheal dise	ase	3.1	5.9	7.3	
Tuberculosis		2.9	5.6	3.4	
Malaria		2.1	4.0	2.6	
Measles		1.2	2.2	2.5	
Hepatitis B		1.2	2.1	0.1	
HIV/AIDS		1.1	2.1	2.2	
Other STDs		Tetanus	Pertussis	Meningitis	
Schistosomias	is	Leishmaniasis	Yellow fever	Dengue/DHF	
Japanese ence	phalitis	Cholera	Polio	Chagas' disease	
Trachoma		Intestinal helminths	Other		
All IDs		16.5	32	36.4	
All deaths		51.6	100	100	

TABLE 4 Global mortality and DALYs lost from specific IDs, 1990*

* Data were complied from references 5, 19, 20, 36, and 37. DALYs = disability-adjusted life years; IDs = infectious diseases; STDs = sexually transmitted diseases; DHF = dengue hemorrhagic fever.



FIGURE 12. Percentage of deaths due to communicable (comm.) versus non-communicable diseases in the richest and poorest 20% portions of the world's population (pop). These observations were reported by Gwatkin.³⁹

trillion for global health (8% of the gross world product), 90% goes for the 15% of people living in high income countries (at \$1,500 per capita, per year), while 10% goes to the remaining 85% of the world's population at approximately \$41 per capita, per year.⁴ Parenthetically, 41% of all global health resources go for health expenditures of the 4% of the world's population living in the United States at \$3,291 per capita, per year.

Despite the exciting and important new initiatives and global leadership at the NIH, CDC and the World Bank, whose leaders are here today, the \$2.9 billion in expenditures (including the U.S. Agency for International Development, Foundation and Defense funds) for all of infectious diseases or international health constitute less than 0.3% of the U.S. health budget (0.04% of our GNP). Even adding World Bank lending and WHO expenditures, spending for international health totals only \$3.8 billion per year. This means that the impressive leadership at this afternoon's session represents a major portion of the total global external assistance for health of \$4.8 billion per year! However, these global totals come to less than \$3 per DALY for measles and other vaccine-preventable childhood infections, \$1.31 per DALY for malaria, and less than \$0.60 per DALY for enteric and respiratory infections²⁰ that kill more than 30,000 children each day and leave far more developmentally scarred for life.

These limitations exist, despite the improving bargain of



FIGURE 13. Total disability-adjusted life years per 1,000 population by region, as reported by Murray and Lopez.²⁰ EME = established market economies; FSE = formerly socialist economies of Europe; CHN = China; LAC = Latin America and the Caribbean; OAI = other Asia and islands; MEC = Middle Eastern Crescent; IND = India; SSA = sub-Saharan Africa.



FIGURE 14. Public opinion and reality regarding the percentage of the United States budget expended for Overseas Development Assistance (ODA) and defined as total ODA plus grants. While the public thought we spent 15% of our budget on foreign aid, 43,44 we actually spent a shrinking 0.98%. $^{45-48}$

buying health. The total U.S. investment of \$32 million for smallpox eradication is estimated to be returned to the United States every 26 days. Polio eradication will save \$500 million by the year 2000 and \$3 billion by 2015, and each dollar spent for measles, mumps, and rubella immunizations saves \$21, while each dollar spent for DPT immunizations saves \$29.⁴⁴ Furthermore, the major improvements in life expectancy can be accomplished with a fairly modest income. Chile has attained its current life expectancy of 75 years with a per capita income of only \$5,000; an income equivalent to that in the United States in 1900 when we achieved only 40 years of life expectancy with the same per capita income.⁴⁴ It is clear that we have fallen far behind where the American public thinks we are in showing the leadership that is so urgently needed in global health.

CONCLUSIONS

So, what are the solutions to the growing threats from health crises in the tropics? For this I turn to one of the great





FIGURE 15. Official development assistance in billions of dollars as recently reported by the Institutes of Medicine.⁴⁴ (Reprinted from Board on International Health, Institute of Medicine [IOM], 1997. *America's Vital Interest in Global Health: Protecting Our People, Enhancing Our Economy, and Advancing Our International Interests,* Washington, DC: National Academy Press, with permission of the publisher.)

FIGURE 16. Official development assistance as percentage of the Gross National Product by 21 top countries in which the United States comes in last. (Reprinted from Board on International Health, Institute of Medicine [IOM], 1997. *America's Vital Interest in Global Health: Protecting Our People, Enhancing Our Economy, and Advancing Our International Interests*, Washington, DC: National Academy Press, with permission of the publisher.)



FIGURE 17. Declining role of the United States in Government Grant totals provded to developing countries. These data from the Organization for Economic Co-operation and Development (OECD) are taken from reference 47.

founders of democracy and of the University of Virginia, Thomas Jefferson. To paraphrase a letter Jefferson wrote to William Jarvis in 1820: "The power of society belongs in the hands of the people. If the people should ever seem inadequately enlightened to exercise this power, the solution is not to remove the power from the people, but to educate them."⁴⁹

Toward this end, I propose that our Society develop an annual "report card" assessing tropical infectious disease risks, resources and opportunities, for we have far to go. I have presented this concept to Council and will complete an initial report.

In closing, some have lamented that our rudderless, postcold war society appears to have lost its bearings. Global health (now an achievable imperative for our survival) may well provide the missing compass. The opportunities are greater than ever before. Entire genomes are known. We dare not neglect to think creatively about new vaccines, simple but elegant diagnostics and therapeutics, and molecular approaches to prevention or control for the major health threats in the tropics because as the repository of expertise on tropical medicine, it is we, the members of this Society, who uniquely understand the urgency of these threats. Ours has become a pivotal role.

As the sun rises over the tropics, we may now see the dawning of an era when, perhaps for the first time in human evolution, we can begin to perceive the *survival advantage* of caring about the other person, the poor in the tropics. We have seen how emerging and re-emerging infections threaten us all; how the staggering mortality and even greater morbidity in the poorest areas led by tropical infectious diseases do not control, but are associated with exploding population overgrowth; and how growing disparity threatens us all. I suspect that only such a realization will move those in authority to make the necessary responses.

Because we work in tropical medicine, it is we who realize these threats and must play a pivotal role in this unprecedented window of growing awareness. The solutions to these children's problems (among the poor in the tropics) are the solutions to our problems. Of one thing I am sure: How they and the disadvantaged around the world fair is what will clearly determine the destiny of us all. Thank you.

At the request of the Council of the American Society of Tropical Medicine and Hygiene, this manuscript and the color slides from Dr. Guerrant's presentation are being made available on the ASTMH website at http://www.astmh.org>.

Acknowledgments: Much of the data analysis and presentation was done by Bronwyn L. Blackwood and Leah J. Barrett.

Financial support: This work was supported in part by the Abbott Award to Richard L. Guerrant by the Infectious Disease Society of America. In addition, National Institutes of Health (ICIDR Grant No. 2-U01-AI26512) and Rockefeller Foundation support have been critical to this work.

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REFERENCES

- Herwaldt BL, Ackers ML, 1997. Outbreak in 1996 of cyclosporiasis associated with imported raspberries. The Cyclospora Working Group [see comments]. *New Engl J Med 336:* 1548–1556.
- Committee on International Science, Engineering, and Technology (CISET), 1995. *Infectious Disease–A Global Health Threat*. Washington, DC, National Science and Technology Council (NSTC).
- Centers for Disease Control and Prevention (CDC), 1994. Addressing Emerging Infectious Disease Threats: A Prevention Strategy for the United States. Atlanta, GA: U.S. Department of Health & Human Services, Public Health Service.
- World Bank. World Development Report, 1993. Investing in Health. New York: Oxford University Press.
- Platt AE, 1996. Confronting Infectious Diseases. Brown LR, Flavin C, Starke L, eds. State of the World 1996: A Worldwatch Institute Report on Progress Toward a Sustainable Society. Chapter 7. New York: W.W. Norton & Company, 114–132.
- Guerrant RL, Guerrant DI, 1993. History of cholera and overview of gastrointestinal infections. *Curr Opin Infect Dis 6:* 37–40.
- 7. Guerrant RL, 1994. Lessons from diarrheal diseases: demog-

raphy to molecular pharmacology (review). J Infect Dis 169: 1206–1218.

- Lima AAM, Soares AM, Freire JE Jr, Guerrant RL, 1992. Cotransport of sodium with glutamine, alanine and glucose in the isolated rabbit ileal mucosa. *Braz J Med Biol Res* 25: 637–640.
- Lima AAM, Barboza MS Jr, Silva TMJ, McAuliffe I, Guerrant RL, 1997. Enteroaggregative E. coli Associated with Persistent Diarrhea: Pathophysiology and Treatment with Glutamine-Based Oral Rehydration and Nutrition Therapy (ORNT). Sixth Annual Meeting of the NIAID International Centers for Tropical Research (ICTDR), May 5–7, 1997. Bethesda, MD: National Institute of Allergy and Infectious Diseases. (Abstract).
- Lima AA, Fang G, Schorling JB, de Albuquerque L, McAuliffe JF, Moto S, Leite R, Guerrant RL, 1992. Persistent diarrhea in northeast Brazil: etiologies and interactions with malnutrition. *Acta Paediatr Scand 381 (suppl)* 39–44.
- Fang G, Lima AAM, Martins CC, Nataro JP, Guerrant RL, 1995. Etiology and epidemiology of persistent diarrhea in northeastern Brazil: a hospital-based prospective case control. J Pediatr Gastroenterol Nutr 21: 137–144.
- Koopmans MP, Goosen ES, Lima AA, McAuliffe IT, Nataro JP, Barrett LJ, Glass RI, Guerrant RL, 1997. Association of Torovirus with acute and persistent diarrhea in children. *Pediatr Infect Dis J 16:* 504–507.
- Guerrant RL, Kirchhoff LV, Shields DS, Nations MK, Leslie J, de Souza MA, Araujo JG, Correia LL, Saver KT, Mc-Clelland KE, Trowbridge FL, Hughes JM, 1983. Prospective study of diarrheal illnesses in northeastern Brazil: patterns of disease, nutritional impact, etiologies, and risk factors. J Infect Dis 148: 986–997.
- Schorling JB, Wanke CA, Schorling SK, McAuliffe JF, de Souza MA, Guerrant RL, 1990. A prospective study of persistent diarrhea among children in an urban Brazilian slum. *Am J Epidemiol 132*: 144–156.
- 15. Steiner TS, Lima AAM, Nataro JP, Guerrant RL, 1998. Enteroaggregative *Escherichia coli* produce intestinal inflammation and growth impairment and cause interleukin-8 release from intestinal epithelial cells. *J Infect Dis* 177: 88–96.
- Checkley W, Gilman RH, Epstein LD, Suarez M, Diaz JF, Cabrera L, Black RE, Sterling CL, 1997. Asymptomatic and symptomatic cryptosporidiosis: their acute effect on weight gain in Peruvian children. *Am J Epidemiol 145:* 156–163.
- Schorling JB, McAuliffe JF, de Souza MA, Guerrant RL, 1990. Malnutrition is associated with increased diarrhoea incidence and duration among children in an urban Brazilian slum. *Int J Epidemiol 19:* 728–735.
- Guerrant RL, Schorling JB, McAuliffe JF, de Souza MA, 1992. Diarrhea as a cause and effect of malnutrition: diarrhea prevents catch-up growth and malnutrition increases diarrhea frequency and duration. *Am J Trop Med Hyg* 47: 28–35.
- Murray CJL, Lopez AD, eds, 1997. The Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1900 and Projected to 2020. Cambridge, MA: Harvard University Press.
- Murray CJL, Lopez AD, eds, 1994. Global Comparative Assessments in the Health Sector: Disease Burden, Expenditures and Intervention Packages, Belgium, World Health Organization.
- Guerrant RL, Thielman NM, 1998. Emerging Enteric Protozoa: Cryptosporidium, Cyclospora, and Microsporidia. Scheld WM, Armstrong D, Hughes JM, eds. Emerging Infections I. Washington, DC: ASM Press, 233–245.
- 22. MacKenzie WR, Hoxie NJ, Proctor ME, Gradus MS, Blair KA, Peterson DE, Kazmierczak JJ, Addiss DG, Fox KR, Rose JB, Davis JP, 1994. A massive outbreak in Milwaukee of *Cryptosporidium* infection transmitted through the public water supply. *New Engl J Med 331*: 161–167.
- Vakil NB, Schwartz SM, Buggy BP, Brummitt CF, Kherellah M, Letzer DM, Gilson IH, Jones PG, 1996. Biliary cryptosporidiosis in HIV-infected people after the waterborne out-

break of cryptosporidiosis in Milwaukee. *New Engl J Med 334:* 19–23.

- 24. Morganthau T, 1997. E. coli Alert. Newsweek 130: 26-32.
- Watanabe H, Guerrant RL, 1997. Summary: Nagasaki Enterohemorrhagic *Escherichia coli* Meeting and Workshop. J Infect Dis 176: 247–249.
- Guerrant RL, 1994. Twelve messages from enteric infections for science and society. Am J Trop Med Hyg 51: 26–35.
- 27. World Bank, 1997. World Development Report 1997: The State in a Changing World. New York: Oxford University Press.
- Mosley WH, Hossain M, 1973. Population: Background and Prospects. Chen LC, ed. *Disaster in Bangladesh: Health Crises in a Developing Nation*. New York: Oxford University Press: 8–17.
- Low-Beer D, Stoneburner RL, Mukulu A, 1997. Empirical evidence for the severe but localized impact of AIDS on population structure (see comments). *Nature Med 3:* 553–557.
- Taylor CE, 1992. Surveillance for equity in primary health care: policy implications from international experience (review). *Int J Epidemiol 21*: 1043–1049.
- 31. United States Bureau of the Census. 1997.
- 32. Ad Hoc Committee on Health Research Relating to Future Intervention Options, 1996. *Investing in Health Research and Development*. Document TDR/Gen/96.1. Geneva: World Health Organization.
- Bos E, Vu MT, Massiah E, Bulatao RA, 1994. World Population Projections, Baltimore: The Johns Hopkins University Press.
- United Nations Center for Human Settlements (HABITAT), 1996. An Urbanizing World: Global Report on Human Settlements. Oxford, Oxford University Press.
- 35. Homedes N, 1995. *The Disability-Adjusted Life Year (DALY): Definition, Measurement and Potential Use.* Work Bank Human Capital Development and Operations Policy (HCO), Working Papers,
- 36. World Health Organization (WHO), The World Health Report 1996: Fighting Disease, Fostering Development. Geneva: World Health Organization.
- 37 LeDuc JW, Hughes JM, 1998. Surveillance for emerging infectious diseases. Guerrant RL, Walker DH, Weller PF, eds. *Tropical Infectious Diseases: Principles, Pathogens, and Practice.* Philadelphia: W. B. Saunders (in press).
- 38. Murray J, Adeyi GN, Graeff J, Fields R, Rasmuson M, Salgado R, Sanghvi T, 1997. Emphasis Behaviors in Maternal and Child Health: Focusing on Caretaker Behaviors to Develop Maternal and Child Health Program in Communities. Arlington, VA: Basic Support for Institutionalizing Child Survival (BASICS) Project, U.S. Agency for International Development.
- Gwatkin DR, 1997. Global burden of disease (letter; comment). Lancet 350: 141–145.
- Chan M-S, 1997. The global burden of intestinal nematode infections–fifty years on (review). *Parasitol Today 13:* 438– 443.
- 41. Bundy DAP, et al, 1997. *Health Priorities and Burden of Disease Analysis: Methods and Applications from Global, National and Sub-national Studies.* Cambridge, MA: Harvard University Press for the World Health Organization and the World Bank (in press).
- 42. King M, Elliott C, 1993. Legitimate double-think. *Lancet 341:* 669–672.
- 43. Kull S, 1995. Americans and Foreign Aid: A Study of American Public Attitudes. College Park, MD: Program on International Policy Attitudes, Center for the Study of Policy Attitudes and the Center for International and Security Studies, School of Public Affairs at the University of Maryland.
- 44. Board on International Health, Institute of Medicine (IOM), 1997. America's Vital Interest in Global Health: Protecting Our People, Enhancing Our Economy, and Advancing Our International Interests, Washington, DC: National Academy Press.
- 45. Organisation for Economic Co-operation and Development (OECD), 1975. *Geographical Distribution of Financial*

Flows to Aid Recipients: Disbursements, Commitments, Country Indicators. Paris: OECD.

- 46. Organisation for Economic Co-operation and Development (OECD), 1985. Geographical Distribution of Financial Flows to Aid Recipients: Disbursements, Commitments, Country Indicators. Paris: OECD.
- 47. Organisation for Economic Co-operation and Development (OECD), 1991–1995. Geographical Distribution of Financial Flows to Aid Recipients: Disbursements, Commitments, Country Indicators. Paris: OECD.
- Historical Table 1.1, 1997. Summary of Receipts, Outlays, and Surpluses or Deficits (-): 1789-2002. Washington, DC: Budget of the United States Government Fiscal Year 1998.
- 49. Jefferson, Thomas to William C. Jarvis, 1820. "I know no safe depositary of the ultimate powers of the society but the people themselves; and if we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them, but to inform their discretion by education. This is the true corrective of abuses of constitutional power.".