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A Comparison of the Burden of Foodborne and Waterborne Diseases in Three World Regions, 2008

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ABSTRACT

The World Health Organization (WHO) has estimated that 2.2 million deaths occur each year because of diarrheal diseases. Data from WHO show that diarrheal illnesses are a significant cause of mortality in children under five years old in six world regions; however, there are few comparative data on the burden of foodborne diseases, which are primarily diarrheal, among the general population in the WHO-defined regions. The focus of this research was to collect and analyze data on foodborne and waterborne outbreaks, available through public sources, to assess the disease burden across world regions. Researchers at the Center for Science in the Public Interest (CSPI) in the United States collected 416 foodborne and waterborne outbreak reports in English from six world regions during the calendar year 2008. Three regions provided adequate data for comparison; Africa was the region with the highest number of reports (128), followed by the Western Pacific region (118 reports) and Europe (97 reports). Comparisons of these three regions included seasonality of outbreaks, rates of identification of the cause (food, water, unspecified), and reported size of outbreaks by morbidity and mortality. Findings demonstrated that for many regions, valuable information on the incidence of foodborne and waterborne outbreaks can be gathered from the media, international organizations and other non-governmental sources.

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INTRODUCTION

Foodborne illnesses are prevalent in all parts of the world, and their toll on human health is enormous. They affect consumers and industries all over the world, in developed as well as developing countries; some industrialized countries have estimated that each year up to 30% of their population may become ill from biological hazards in the food supply *(14).* The World Health Organization (WHO) has identified many different types of food contaminants as major sources of disease, including *Salmonella*, *Campylobacter*, *Clostridium,* hepatitis A, Cholera, *Listeria*, enterohemorrhagic *E. coli*, metals, persistent organic pollutants, biologically derived toxins, pesticides, toxic chemicals and organisms causing transmissible spongiform encephalopathies (TSE)-type diseases (e.g., bovine spongiform encephalopathy) *(15).*

Some countries publish comprehensive estimates of their national burden of disease linked to foodborne pathogens, while others do not. For example, in the United States, the Centers for Disease Control and Prevention (CDC) estimated in 1999 that foodborne diseases cause 76 million illnesses and 5000 deaths annually *(7)*.

WHO has estimated that each year 2.2 million people, including 1.9 million children, die because of diarrheal diseases *(18).* This and similar partial estimates provide valuable information, but they do not quantify the global burden of disease from contaminated food and water. WHO therefore convened a panel of experts, the Foodborne Disease Burden Epidemiology Reference Group (FERG), to conduct a more comprehensive assessment. The research reported here was intended to complement the work of the FERG and provide the panel with useful information about the extent of informal reporting of foodborne diseases in different world regions.

Effective methods of disease surveillance can provide important information for assessing the burden of disease. This is admittedly a complicated task, as foodborne illnesses have many different symptoms, with both short- and long-term consequences. Although nausea and diarrhea are the most common symptoms, other consequences can include kidney and liver failure, brain and neural disorders, septicemia and death. For example, *Listeria monocytogenes* infection has a mortality rate of 20–30%, including miscarriages *(2).* Some illnesses have long-term complications, such as reactive arthritis and paralysis, which can affect 2–3% of those who are infected *(12, 13)*.

Moreover, in many countries, because of economic difficulties, inadequate medical care, and lack of health insurance, medical attention is not sought, making accurate reporting of food and waterborne diseases difficult. For example, according to the Jordan Burden of Illness Study in 2003, only two in five persons with diarrhea sought medical care *(6).*

Economic globalization has also increased the risk of outbreaks extending beyond national borders, underscoring the need for a comprehensive global assessment of the burden of food and waterborne illnesses. For example, in 2008, an outbreak caused by melamine contamination in infant formula caused sickness in 300,000, hospitalization of 52,000 and death in at least 6 infants in China; the outbreak, which extended to Hong Kong and Taiwan, sparked global recalls of products containing milk and milk ingredients from China *(16).*

In developing nations, foodborne diseases are a primary cause of malnutrition, which adversely affects the growth and disease resistance of infants and children, making them more vulnerable to a range of ailments such as respiratory infections that contribute to the downward spiral of further malnutrition and disease. Patients can also suffer from arrested physical and mental development, preventing them from reaching their full potential in society *(12).*

Food also plays a central role at the interface between human and animal diseases, because pathogens that evolve in animals can spread to humans through food. This commonly occurs today, as documented by disease outbreaks linked to *Salmonella*, *Campylobacter* and hemorrhagic strains of *E. coli* linked to both animal and plant food vehicles *(11)*. Human practices in raising animals as food sources can lead to the emergence and spread of new pathogens and the development of antibiotic resistance in common animal pathogens, making it harder to treat the diseases they cause *(4)*. Sometimes, emerging diseases begin at the animal level, e.g., highly pathogenic avian influenza and bovine spongiform encephalopathy, but are then transmitted through proximity to animals or through the food supply *(10)*.

An accurate assessment of foodborne diseases is also important in order to quantify their economic burden. Foodborne diseases can contribute to absenteeism from work or school and can lead to high medical, legal and other expenses. The costs to national governments can include increased costs of health care, outbreak investigations, food recalls, and loss of consumer confidence.

The best estimates of the economic costs of foodborne disease have come from developed countries. In the United States, for example, foodborne disease costs billions of dollars each year; government sources estimate the cost of human illnesses caused annually by seven foodborne pathogens at U.S. $5.6 to 9.4 billion, and a more recent estimate for the total burden of foodborne disease was $152 billion *(5, 8)*. The cost of human *Salmonella* infections in England and Wales in 1992 was estimated at U.S. $560 to 800 million, over 70% of which was directly associated with treatment and investigation of cases and sickness-related absences from work *(12).* The cost of the estimated 11,500 cases of food poisoning daily in Australia was calculated at AU $2.6 billion annually *(1)*. In the United Kingdom, care and treatment of people with the new variant of Creutzfeldt-Jacob disease (vCJD) would cost £50,000 per case. A £55,000 trust has been set up to care for up to 250 victims as part of the Government's no-fault compensation scheme *(9)*.

For the year 2008, researchers at the Center for Science in the Public Interest (CSPI) analyzed the reporting of foodborne and waterborne illness outbreaks in public sources (news articles, scientific publications, and announcements by governments or international organizations) in English from every world region except North America. It is acknowledged that disease outbreaks that were documented and analyzed constitute a small portion of the true burden of foodborne disease, which clearly is much larger and should be quantified in countries all over the world.

MATERIALS AND METHODS

Data collection

In October 2007, Safe Food International (SFI), a project of CSPI, launched a data aggregation project to track outbreak reports linked to contaminated

FIGURE 1. Regional reports by quarters, 2008

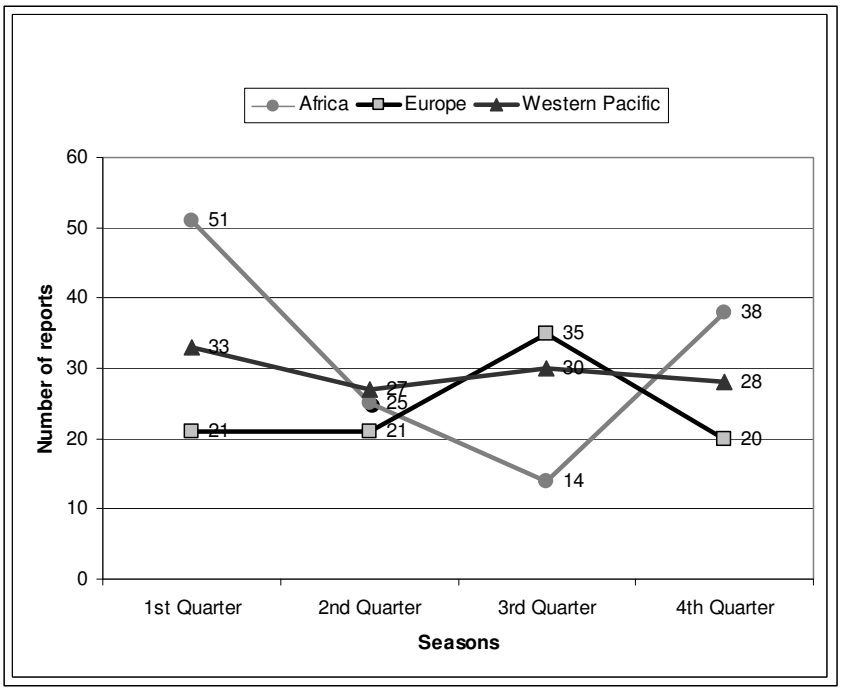
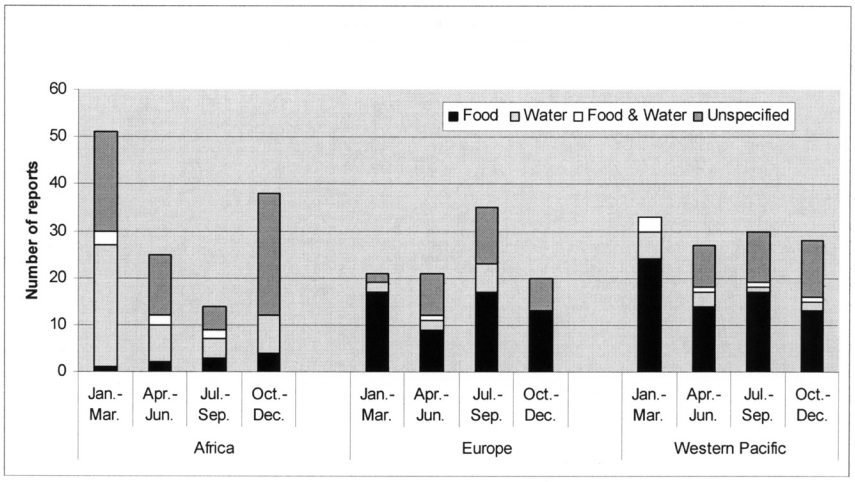


FIGURE 2. Reported vehicles by quarters, 2008



food and water, animal disease reports (limited to key food sources), plant disease reports, food safety studies, and food safety policies. The data collection was organized by subject matter and world regions.

The researchers adopted WHO's geographic division of national governments into seven world regions *(19)*: The Western Pacific Region (37 countries), the South East Asian Region (11 countries), the Eastern Mediterranean Region (24 countries), the African Region (46 countries), the European Region (52 countries), the Central and South American Region (28 countries), and the North American Region (3 countries). Because the researchers were situated in, and focus extensively on the food safety issues and policies in, the North American region, that region was not included in this study in order to neutralize any North American bias of the results.

The data were compiled from web-based sources, including news articles, scientific publications, and announcements from international organizations and government entities. Only documents written in or translated to English were included in the 2008 database. For several regions (Latin America, Middle East and Southeast Asia), the small number of reports found led the researchers to conclude that data collection in multiple languages was essential to assess the burden of disease. Therefore, those regions were not included in this analysis. Tests were conducted in French and Mandarin to determine the number of reports that might be captured using these additional languages. The tests involved one region (Africa) and several countries in the Western Pacific Region, mainly China.

The data were obtained by using internet data gathering tools such as Google Alerts, and by consulting news listservs such as ProMED-mail, an emerging diseases monitoring program of the International Society for Infectious Diseases, and FS-Net, developed by Professor Doug Powell at Kansas State University, which provide current food safety news. Information specific to one country or one region was also provided directly by the SFI member consumer organizations in different regions. These reports were included if they were supported by a reliable source of information (consumer organizations contributed a small number of reports, less than one percent).

Each report was assessed to determine whether it represented a new outbreak or provided updated information for an outbreak already reported in the database. Documents related to the same story were grouped together and counted as a single entry. For each report included in the database, the following information was recorded: The original source, the date, and the hyperlink to the webpage where the report was originally published. The reports were listed in the database chronologically and were sorted by categories and geographical location.

As with other studies of the burden of foodborne diseases, the outbreaks included in the SFI database represented only a small proportion of the actual disease outbreaks and illnesses related to food or water. The vast majority of foodborne illnesses are sporadic, and as a result they are not identified as an outbreak. In addition, many foodborne illness outbreaks are underreported, because of a number of factors, including their small size or long incubation period, geographic dispersion and location, lack of access to or use of medical care, and lack of a functioning surveillance system.

TABLE 1. Contaminant attribution

Africa (n = 128)

Contaminant	Number	Percentage
Cholera	105	82%
Gastroenteritis	2	9%
Contamination	2	2%
Schistosomiasis	2	2%
Hepatitis E	2	2%
Salmonella	1	1%
Toxins	1	1%
Rabies	1	1%
Typhoid	1	1%
Botulism	1	1%
Melamine	1	1%

Europe (n = 97)

Contaminant	Number	Percentage
Salmonella	20	21%
E. coli	16	16%
Gastroenteritis	12	12%
Norovirus	9	9%
Cryptosporidium	6	6%
Trichinellosis	5	5%
Botulism	4	4%
Contamination	4	4%
vCJD	4	4%
Hepatitis A	3	3%
Rotavirus	2	2%
Unspecified	2	2%
Bleach	1	1%
Dioxins	1	1%
Listeria	1	1%
Safety violation	1	1%
Adenovirus	1	1%
Hepatitis E	1	1%
Azaspiracid Shellfish Poisoning	1	1%
Cholera	1	1%
Dysentery	1	1%
Paraxysmal myoglobinuria	1	1%
Staphylococcus	1	1%
Brucellosis	1	1%
Ciguatera	1	1%
Clostridium botulinum	1	1%

Western Pacific (n = 118)

Contaminant	Number	Percentage
Gastroenteritis	30	25%
Cholera	21	18%
Contamination	16	14%
Salmonella	9	8%
Hepatitis A	6	5%
Melamine	5	4%
Norovirus	5	4%
E. coli	4	3%
Dysentery	2	2%
Listeria	2	2%
Toxins	2	2%
Pesticides	2	2%
Staphylococcus	2	2%
Vibrio	2	2%
Campylobacter	2	2%
Shigella	2	2%
Unspecified	2	2%
Cryptosporidium	2	2%
Bacillus	1	1%
Lectin	1	1%
Marine biotoxin	1	1%
Methanol	1	1%
Arsenic	1	1%
Clostridium	1	1%
Clenbuterol	1	1%
Typhoid	1	1%

Data analysis

Typically, a foodborne outbreak refers to a situation in which two or more people who have consumed the same contaminated food develop the same illness *(3)*. The definition of "outbreak" differs in this project, because the information included in the reports may not always specify the actual number of illnesses. In some report of government recalls or warnings of contaminated food or water, initiated after people became ill, the article reported on the government action, not on the number of illnesses. These reports were characterized as having a morbidity range of 0 to 1 case.

The majority of reported foodborne and waterborne illness outbreaks do not have complete outbreak information. Of all outbreaks included in the database, 38% had no known food or water attribution; for these, the outbreaks were categorized as "unspecified." Some outbreaks did not specify a pathogen but identified the illness as

FIGURE 3. Government action during reported outbreaks

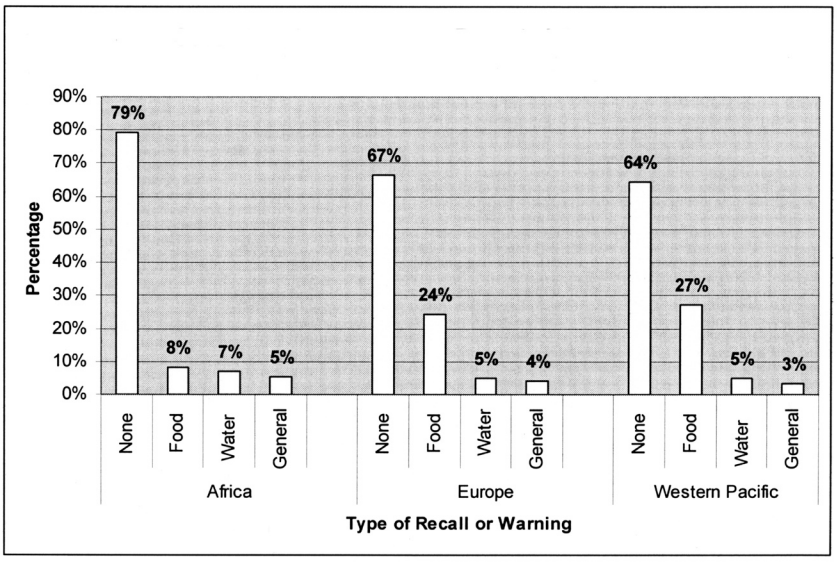
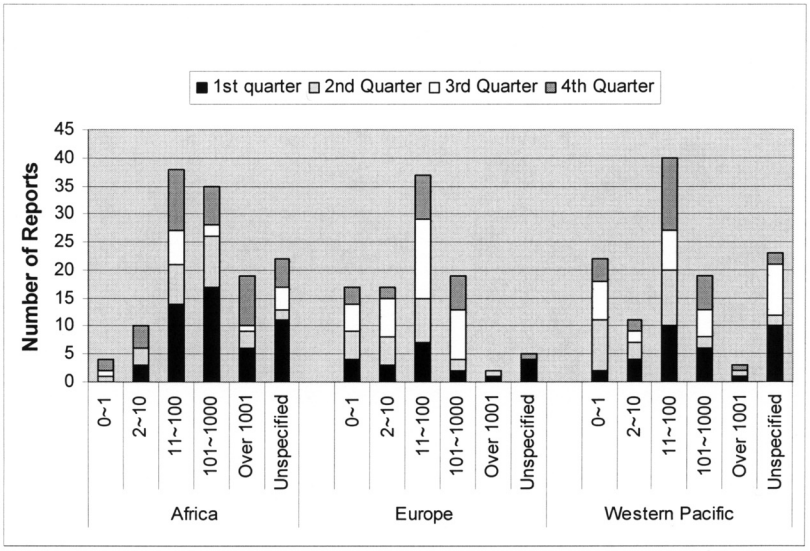


FIGURE 4. Morbidity by region, 2008



"food poisoning"; these cases were placed in the general "gastroenteritis" category. Because the vehicle and pathogen attribution were not well identified in many reports, they should be used cautiously, as the ability to verify either was limited in many countries and regions.

To analyze seasonal trends, reports were divided into quarters: The first quarter (January, February, March), the second (April, May, June), the third (July, August, September), and the fourth (October, November, December).

The research relied on the reports being available in English through the internet.For non-English speaking countries, this may result in a bias toward larger outbreaks or those with a more unique fact pattern, such as a unique food or disease agent. Taking into consideration the complete database, reporting was greatest in the regions with a larger number of English-speaking countries.

Three of the six regions (Africa, Western Pacific and Europe) had sufficient data in 2008 to be analyzed. Results analyzed from those three regions included seasonality of outbreaks, rates of identification of the cause (food, water, unspecified) of the outbreaks, size of outbreaks reported, and reported mortality rate.

RESULTS

Researchers collected 416 foodborne or waterborne outbreak reports from the regions studied during the calendar year 2008. The region with the highest reporting was Africa, with 128 reports. The Western Pacific region had 118 reports, followed by Europe with 97 reports, Southeast Asia with 35 reports, the Middle East with 28 reports and Latin America with 10 reports.

Europe

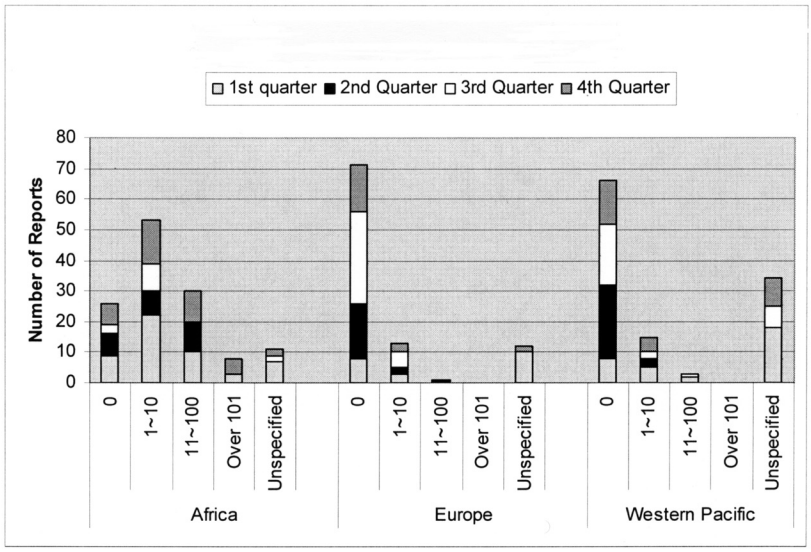
Europe is the most industrialized of the three geographical regions included in this study. The region is characterized by advanced public health sectors and highly developed communication systems that include formal (governmental) and informal (media) reporting systems. Nearly 100 reported outbreaks from this region for the year 2008 were analyzed.

The largest number of outbreaks (35) was reported in the third quarter, which consists of the warmest months in this region (Fig. 1). The numbers of reports were nearly identical (20–21) during the other three quarters. In the first, third, and fourth quarters, food was the most frequently identified vehicle of outbreaks. In contrast, in the second quarter, food and the "unspecified" category each comprised 43% of the vehicle of outbreaks (Fig. 2). Water was consistently the least frequently identified vehicle.

The reports identified a broad variety of pathogens, although *Salmonella* and *E. coli* were reported most frequently, followed by Norovirus in the fourth quarter. (Table 1). Occasionally, warnings were issued for specific food or water vehicles. In 34% of the total reports in the European region, the government took action by issuing a recall or warning in response to food contamination, with specific food recalls mentioned in nearly 20% of the total reports in this region (Fig. 3).

In every quarter, the majority of outbreaks reported in Europe affected 11–100 people, although several very large outbreaks were reported during the year. For example, an outbreak affecting 700 people was linked to consumption of chicken meat. The next most frequently reported size of outbreaks was in the 2–10 person range for the first and second quarters, and in the 101–1,000 range in the third and fourth quarters (Fig. 4).

FIGURE 5. Mortality by region, 2008



Deaths linked to the outbreak reports were less common in this region than in the others. Deaths were reported in 14% of the outbreak reports, and half of these deaths were linked to *Salmonella* (Fig. 5).

Africa

Africa reported the largest number of outbreaks among the three geographical regions included in this study, with a total of 128 reported in 2008. The region is unique in many ways, such as seasonality, vehicle, size of the outbreaks and number of illnesses and deaths associated with outbreaks. Because of its less developed public health sector, the role of the media in outbreak reporting becomes more relevant and important for assessing the public health impacts of contaminated food or water.

The largest number of outbreaks was reported in the first quarter (51), followed by the fourth (38), second (25) and third (14). In 2008, waterborne disease outbreaks that were diagnosed as cholera were more frequent, larger, and more severe in the end of the fourth and beginning of the first quarters, during the rainy season (Fig. 1).

Unlike the outbreaks in the other two regions included in this study, only a small percentage of reported outbreaks in Africa were specifically linked to food consumption. In the first quarter, water was identified as the dominant vehicle (more than 50%), while in the other quarters, most reports did not identify a vehicle (Fig. 2).

Vibrio cholerae was the most frequently reported pathogen in this region, identified in 71% to 86% of the reports, depending on the quarter. Contaminated food and water were the likely vehicles of exposure, though the exact route was frequently unspecified and probably not known. The lack of a specified vehicle may indicate that the surveillance system in this region was relatively ineffective in determining causation (Table 1).

A government-issued warning or recall was mentioned in 20% of the reports (Fig. 3). The size of the outbreaks reported from Africa was larger than in any of the other regions included in this study. In the first two quarters of the year, one-third of reported outbreaks had 101–1,000 illnesses. In the third quarter, 43% of the reported outbreaks had 11–100 illnesses, while outbreaks of 101–1,000 persons were reported in 14%. The final quarter (Oct., Nov., Dec.) had a unique distribution: 29% of the outbreaks were in the 11–100 range, 18% in the 101–1,000 range, and 24% over 1001 (Fig. 4).

In the final quarter of 2008, a very large cholera outbreak began in Zimbabwe and spread to surrounding countries as refugees crossed borders. Five other countries (Botswana, Mozambique, Malawi, South Africa and Zambia) reported outbreaks linked to the one that originated in Zimbabwe *(17)*. These outbreaks were counted as six separate outbreaks in that quarter, because of the number of countries involved, with morbidity estimates ranging from 8 to over 26,000.

The death rate associated with outbreaks in Africa was comparatively high. Mortality was reported in 70% of the outbreak reports, with mortality of 1–10 persons in 41% of outbreaks. In the final quarter, the number of outbreaks with mortality of over 100 persons rose to 42% (Fig. 5).

Note: The researchers analyzed outbreak reports collected in the first quarter of 2009 in both English and French for the African region and found that most outbreaks were reported in both languages. This resulted in part from the involvement of the WHO and other international non-governmental organizations that work extensively in the African region and publish their reports in multiple languages. For example, in March 2009, only two reports were carried in French exclusively and not accessed by our regular methods of information gathering.

Western Pacific

A total of 118 reports from the Western Pacific region in 2008 were analyzed. This region includes economically developed and developing countries. There was consistent reporting in English from Australia, New Zealand and a number of Asian nations in the region, including Japan and the Philippines.

Reported outbreaks did not show a seasonal trend in this region, which is not surprising because the region covers countries on both sides of the equator. Outbreak reports in the four quarters ranged from 33 to 27. The percent of cholera outbreaks increased over each successive quarter, from 9% in the first quarter to 19% in the second, 20% in the third, and 25% in the fourth (Fig. 1).

Food, the most common vehicle of the reported outbreaks, was implicated in the majority of reports from the Western Pacific region in each of the quarters. The next most reported vehicle was "unspecified" in three of the quarters (Fig. 2).

No specific pathogen dominated the reports. Reports used less specific terms, such as "contamination" and "gastroenteritis," with greater regularity. "Gastro-

enteritis" was the specified cause in 25% of the reports for the year, and cholera was specified in 18%. Reports documenting chemical contamination occurred more frequently in this region than in the other regions studied, being identified in 24% of the reports in the first quarter and 29% of those in the fourth quarter (Table 1).

Food recalls and warnings were issued in 36% of the outbreaks, which is slightly more frequently than in any other region included in this study. Interestingly, given the lack of seasonal variability in the reports from this region, warnings declined in the final quarter, from 39% in the first quarter, 38% in the second, and 39% in the third to 28% in the fourth quarter (Fig. 3).

Outbreaks in this region most commonly affected 11–100 persons, which was similar to data from the European region. However, both smaller and larger outbreaks were commonly reported. Very small (0 to 1 case) and large (101 to 1,000 cases) outbreaks each contributed 20% of the reports. Outbreaks affecting 11 to 100 persons were reported in one-third of the reports (Fig. 4).

Deaths were reported in 21% of the reports in the first quarter. Afterwards, mortality rates decreased to 11% and 10% of the reports in the second and third quarter, respectively, but increased to 18% in the fourth quarter. The mortality rate was lower than in Africa, as only a few reports mentioned deaths in the 11–100 range, and there were no reports of outbreaks with mortality of over 101 persons (Fig. 5).

Note: Outbreak reports collected from the Western Pacific region in the first quarter of 2009 (January to March) were analyzed in English and in Mandarin. The researchers found many additional outbreaks reported in Mandarin that were not covered in the English media. Between January and March 2009, 16 reports were carried in Mandarin exclusively and therefore were not accessed by our regular methods of information gathering.

DISCUSSION

The researchers tracked the reporting of foodborne and waterborne disease outbreaks through reports that were publicly available in the media and that were from international and non-governmental organizations. Such informal reporting systems are available in every region. This research provided preliminary evidence that informal reporting systems can provide valuable information that can be used to compare the burden of foodborne and waterborne diseases in different regions. The researchers analyzed public reports of foodborne and waterborne outbreaks in three regions: one with highly developed surveillance systems (Europe), one with less developed surveillance systems (Africa), and one with intermediate systems (the Western Pacific region).

Surveillance systems vary greatly from region to region. Several countries have sophisticated surveillance systems that can support formal estimates of the burden of foodborne disease, while many others have rudimentary or developing systems. For further research, it would be valuable to compare informal reporting results with the formal estimates available in some countries.

Seasonality was more evident in both Europe and Africa than in the Western Pacific region. In Africa, the pattern of cholera outbreaks seemed to correlate strongly with the rainy season in the end of the fourth quarter and the beginning of the first. In Europe, the surveillance system provided more specific identification of pathogens causing the outbreaks, allowing observation of seasonality, such as the increase in Norovirus reports in the winter and fall months of the fourth quarter. In the Western Pacific region, seasonal trends were difficult to observe and identification of pathogens was relatively unspecific, necessitating the use of more general categories such as "contamination" and "gastroenteritis."

With respect to vehicle attribution, it was observed that the outbreaks linked to food were more common in Europe and the Western Pacific region than in Africa, which reported more waterborne outbreaks than the other two regions. Outbreaks with an unspecified vehicle were reported in every region, although the proportion varied greatly by season in each region.

The pathogens identified varied widely between regions. Despite having the highest number of outbreak reports, Africa had the least diversity among the pathogens reported, as 82% of the reports identified the cause as "cholera" *(Vibrio cholerae)*. The consistency of this narrow finding led the researchers to postulate that use of the term "cholera" may not be the result of a laboratory finding, but rather may indicate a non-specific category of diarrheal diseases. Europe identified *Salmonella*, *E. coli* and Norovirus most frequently and overall identified a much greater variety of pathogens in its reports. The Western Pacific region had no specific pathogen that dominated the reports, and its reports used nonspecific terms, e.g., "contamination." Also, that region reported more chemical contamination problems than either of the other two regions.

Food recalls and warnings were issued by governments in a minority of the outbreaks reported. The region with the greatest number of such consumer alerts (recalls and warnings) was the Western Pacific region, where recalls or warnings were reported in approximately 36% of the outbreaks. Europe issued alerts in approximately 34% of the outbreaks, and alerts were least frequent (20%) in the outbreaks reported from the African region.

The most frequently reported range of illnesses was 11–100 persons for each region during most of the seasons. Africa was an exception for the first two quarters, when the most frequent range was 101–1000 persons. This may indicate that surveillance was more efficient in Europe and Western Pacific than in Africa, because these regions were better able to issue recalls and warnings and publicize outbreaks before more than 100 persons became ill.

The rates of mortality showed the greatest differences between the regions. In Africa, mortality was reported in 70% of the outbreak reports, and the proportion of outbreaks with mortality of over 100 persons was very high, especially in the fourth quarter (42%). The European region had lower mortality rates, perhaps as a consequence of less potent pathogens circulating in the region or better outbreak surveillance systems that ensured more rapid control of outbreaks.

CONCLUSION

At the level of international governance, there is increasing focus on infectious diseases, especially those at the interface of humans, animals and the ecosystem, under the One World, One Health Strategic Framework. This framework was developed by the Food and Agriculture Organization (FAO) of

the United Nations, the World Organization for Animal Health (OIE), the World Health Organization (WHO), the United Nations Children's Fund, and the World Bank, responding to recommendations that emerged from national governments *(11)*.

As the WHO Foodborne Disease Burden Epidemiology Reference Group (FERG) states, foodborne diseases place both a public health and an economic burden on countries *(20)*. Understanding waterborne and foodborne disease trends by region and country is necessary to focus resources on actual disease problems and identify locally important diseases that could become a threat to global health. While improving capacity in disease surveillance at the local, national, regional, and international level is a long-term objective, developing tools to analyze informal and public reporting of foodborne illness and promote information sharing can facilitate important public health protection. Available information streams should be utilized to develop baselines that could help estimate the regional burden of foodborne illness. They may also prove essential in more rapid identification and assessment of infectious disease agents and other emerging public health problems.

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