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ABSTRACT

Accurate estimates of disease burden are the foundation of sound public health policy. To better quantify the morbidity and mortality associated with foodborne diseases in the United States, we compiled and analyzed information from a wide variety of surveillance systems, including data from the recently developed Foodborne Diseases Active Surveillance Network. Overall, foodborne diseases cause 76 million illnesses, 350,792 hospitalizations and 4,981 deaths in the United States each year. Known pathogens account for 17 million foodborne illness, 67,614 hospitalizations and 1,854 deaths. Three pathogens, *Salmonella*, *Listeria*, and *Toxoplasma*, are responsible for 15% of deaths caused by foodborne transmission of known pathogens. A large proportion of foodborne illness is caused by agents which have not yet been identified.

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IV. Overall Burden of Foodborne Illness

To determine the total burden of foodborne illness, we summed the burden of illness attributable to foodborne gastroenteritis caused by known pathogens and unknown agents, yielding an estimate of 76 million illnesses, 345,910 hospitalizations, and 4,103 deaths due foodborne gastroenteritis (Figure 1). Adding to these figures the burden associated with non-gastrointestinal illness caused by *Listeria*, *Toxoplasma*, and Hepatitis A (Table 5), we arrived at a final national estimate of 76 million illnesses, 340,790 hospitalizations, and 4,981 deaths each year.

DISCUSSION

Previous estimates of foodborne illness in the United States have varied widely. Since 1985, different authors have estimated the annual burden of foodborne illness at 24-81 million illnesses (1), 6.5 million illnesses with 9,000 deaths (3), 12.5 million illnesses with 11 deaths (4), and 33 million illnesses (5) nationwide. Although often overlooked, part of the disparity among these figures stems from differences in the entity being estimated. For example, the estimate of 6.5 million illnesses derived by Bennett et al. refers only to those illnesses caused by known infectious agents, whereas the estimate of 33 million illnesses by the Council for Agricultural Science and Technology (6) refers to gastrointestinal illnesses caused by all agents, known and unknown, infectious and noninfectious.

Our estimates of the burden of foodborne illness differ from previously published figures in several respects. For known pathogens, our estimate of 12.5 million illnesses is nearly threefold higher than the previous estimate

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of 6 million illnesses per year derived by Bennett et al. (3). Most of this difference is due to our inclusion of foodborne illness caused by Norwalk-like viruses. Similarly, for foodborne illness of all etiologies, our estimate of 76 million cases is considerably higher than the 33 million cases estimated in the CAST report (5). Notably, the CAST estimate assumes that 35% of all gastroenteritis cases resulted from foodborne transmission, a percentage that is similar to the one developed here. The disparity between these two estimates reflects differences in the estimated frequency of acute gastroenteritis overall: 99 million cases annually for the CAST estimate, 211 million for our estimate.

In contrast to our figures for total illnesses, our mortality estimates are generally lower than previous studies. We estimated that foodborne illness causes 4,981 deaths annually (1,854 deaths due to known infectious agents and 3,127 deaths of unknown etiology), a total that is slightly over half of the 9,000 deaths estimated by Bennett et al. (3). This previous estimate included 2,100 deaths due to campylobacteriosis, 1,200 deaths due to staphylococcal food poisoning, and 1,000 deaths due to trichinosis; our total for all three of these diseases is 4,000 deaths. Our estimated case-fatality rates for several other diseases are also lower than those used in the Bennett report, either because better data are available, or perhaps because treatment has improved.

Differences between our estimates and previously published figures are generally the result of better information and new analyses rather than real changes in disease frequency over time. For example, *E. coli* O157:H7 was previously estimated to cause 10,000 to 20,000 illnesses annually. This

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estimate was based principally on studies of patients visiting a physician for diarrhea. Recent FoodNet data have allowed a more detailed estimation of mild illnesses not resulting in physician consultation. Our estimate of nearly 74,000 illnesses each year incorporates these milder illnesses and should not be misconstrued as demonstrating a sudden surge in *E. coli* O157:H7 infections.

With respect to the overall frequency of diarrheal illness, differences in methodology make it difficult to compare recent FoodNet data with earlier data from the Tecumseh and Cleveland studies. Nevertheless, markers of disease severity suggest that episodes of diarrheal illness reported in the FoodNet and the Tecumseh studies were comparable with regard to duration, activity restriction and the presence of fever (H. Besser, manuscript in preparation). Age-adjusted rates of diarrheal illness were somewhat higher in the FoodNet survey population, but the rate of diarrheal illness with vomiting, arguably a more robust measure of gastrointestinal illness, was slightly lower (Table 2). While it is difficult to conclude with certainty that rates of diarrheal illness have increased since the late 1960's when the Tecumseh study was conducted, there is no evidence to suggest that they have decreased significantly. Consequently, our continued reliance on data from the Tecumseh study is unlikely to have falsely elevated our estimates of gastrointestinal illness.

The pathogen-specific estimates developed here harbor several notable findings. Norwalk-like viruses (NLV) account for over 75% of all cases of foodborne illnesses and 42% of related hospitalizations, but only 8% of fatalities. *Campylobacter* and *Salmonella* are other important causes of hospitalization, and *Listeria*, *Salmonella*, and *Toxoplasma* are the leading

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causes of mortality. It should be noted that a large number of deaths due to toxoplasmosis occur among patients infected with the human immunodeficiency virus (HIV). In this respect, advances in HIV treatment are likely to have greater impact on mortality due to toxoplasmosis than are efforts to prevent toxoplasmosis infection.

Our analysis has several limitations. First, with the exception of a few pathogens (see appendix), we have not estimated the burden of chronic sequela, although this may be an important part of the overall burden. Second, because of a paucity of surveillance information, we did not have specific estimates for some known, occasionally foodborne pathogens (*Plesiomonas*, *Aeromonas*, or *Edwardsiella*), nor did we develop specific estimates for known noninfectious agents such as mushroom or marine biotoxins, metals and other inorganic toxins. Many of these agents cause gastroenteritis and are therefore captured in our overall estimate of gastrointestinal illness. Third, differences in surveillance information prevented us from using the same method for estimating the burden of all bacterial, parasitic, viral pathogens. Fourth, few data are available on the relative frequency of foodborne transmission for individual pathogens, and well documented estimates for the degree of underreporting are not available for most pathogens. We were therefore forced to rely on multipliers derived for *Salmonella* other diseases. Fifth, the generation of mortality estimates is based on somewhat arbitrary assumptions, although we believe our assumptions to be reasonable or even conservative, future research may refine these assumptions and allow for more precise estimates. Finally, because a very large number of illnesses are attributed to Norwalk-like viruses (NLV), the data for these agents have a

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major effect on our overall estimates. For example, if the actual number of cases of NLV infections due to foodborne transmission is 30% rather than 40%, our overall estimate would decrease from 76 million cases per year to 62 million cases per year.

Addressing these limitations will require continued and refined active surveillance activities. Beginning in 1998, the FoodNet population survey was modified to capture cases of vomiting not associated with diarrhea, and further adjustment to capture concomitant respiratory symptoms should enhance the utility of the FoodNet survey data. With additional clinical diagnostic capacity, surveillance efforts should be able to estimate the degree of underreporting for additional diseases, and to refine estimates of the proportion of specific diseases that are transmitted through food. Heightened surveillance for acute, noninfectious foodborne diseases such as mushroom poisoning and other illnesses caused by toxins could further improve estimates of the burden of foodborne illness. Emergency department-based surveillance systems (30) or poison control center-based surveillance may provide a way of obtaining this type of information. Finally, our estimates suggest that a substantial proportion of foodborne illness is of unknown or unrecognized etiology. Expanded efforts are needed to identify new causes of enteric illness and to define the public health significance of known agents (e.g., enterococci, *E. coli*) whose role as pathogens in this country is currently uncertain.

Figure 1. Estimated frequency of foodborne gastroenteritis in the United States, 1997

