Public Health and Food Safety: a Historical Association

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Synopsis

Since the initial passage in 1906 of the first Pure Food and Drug Act and the Meat Inspection Act, public health, as measured by mortality trends, has greatly improved. These acts have been amended several times, and other laws dealing with safety of foods and drinks have been enacted. Food- and beverage-transmitted infectious diseases that were so devastating after the Civil War have been controlled. Nutritional deficiencies such as pellagra are almost nonexistent. Mass episodes of poisoning of food by chemical contaminants that have plagued some other countries have not occurred in the United States. Other factors such as refrigeration and improved transportation have helped, but it is probable that food safety regulatory activities have contributed to the saving of the 1.8 million Americans who would die each year if the public health advances since 1900 had not been made. Effective use of information was a key factor in the improvement in public health. Now, as then, effective information systems are needed.

FOOD SAFETY has been regulated at the national level under the authority of two laws enacted in 1906: the Pure Food and Drug Act and the Meat Inspection Act. At that time both laws were implemented by the U.S. Department of Agriculture.

The Pure Food and Drug Act was amended several times and in 1938 became the Food, Drug, and Cosmetic (FD&C) Act. The FD&C Act now is enforced by the Food and Drug Administration, an agency of the Public Health Service. Other laws dealing with the safety of such commodities as milk and water have been enacted by Federal, State, and local governments. Emphasis in this paper has been placed on food safety as regulated under the FD&C Act.

In this study I examined historical information for (*a*) evidence supporting the widespread belief that activities regulating food safety have benefited public health and, more importantly, (*b*) accounts of experiences from which we can learn to protect the public's health better. In particular, I examined mortality data collected since 1900 for trends and the relationship of those trends to major national events in the United States. Following that analysis, I inspected in more detail the mortality data for specific types of diseases related to food safety.

Background

The state of public health is measured by morbidity and mortality, that is, the rates at which illnesses and deaths occur in the population. I have chosen to report on mortality data because they have been more completely recorded and are more readily available than morbidity data.

History of mortality data. The amount of mortality data is limited for the years before 1906, when the food safety laws were enacted. The reasons for this paucity relate as much to political philosophy as to the state of biomedical science. Records of populations in European countries originally were maintained for purposes of collecting taxes and raising armies. Records of common people were kept in churches, especially state churches, but only church rites—baptism and burial—were recorded rather than births and deaths. As the civil power of state churches declined, and concern over epidemics such as cholera increased, national governments took over the recording of vital statistics.

In England the national government assumed that responsibility in 1837. In the United States, where no state church ever was formed, the Federal Government has never had authority over recording of vital statistics. The Federal Government receives mortality data from the States.

Soon after local and State governments were established, they began to record vital statistics. There are three major purposes for recording births and deaths: to obtain knowledge of the movement of the population, to protect the lives and health of people, and to protect the rights of individual persons and the community in legal matters, for example, inheritance, pension claims, and foul play (*1*).

The key event in the development of mortality data is the issuance and registration of a death certificate by the State government. Starting in 1880, States were admitted gradually to a national death registration system. Information on death certificates was made available to the Bureau of the Census, which issued, beginning in 1900, annual national reports of deaths. In 1946 vital statistics reporting functions were transferred to the Public Health Service and are now performed by the National Center for Health Statistics (NCHS). The death registration system became complete when Alaska was admitted in 1960. The dates when States were admitted into the system are shown in the box.

Recorded on the death certificate were cause of death and other information about the decedent, including age, race, and sex, together with the place of death and the place of usual residence. Then, the causes of death were classified and given numeric codes according to rules of the International Classification of Diseases (*2*). Because of changing conditions and improvements in medical diagnoses, the International Classification of Diseases (ICD) has been updated about every 10 years. The period during which each revision of the ICD was used to code mortality in the United States follows.

Revision	*Period*	*Revision*	*Period*
first	1900–09	sixth	1949–57
second	1910–20	seventh	1958–67
third	1921–29	eighth	1968–78
fourth	1930–38	ninth	1979–present
fifth	1939–48		

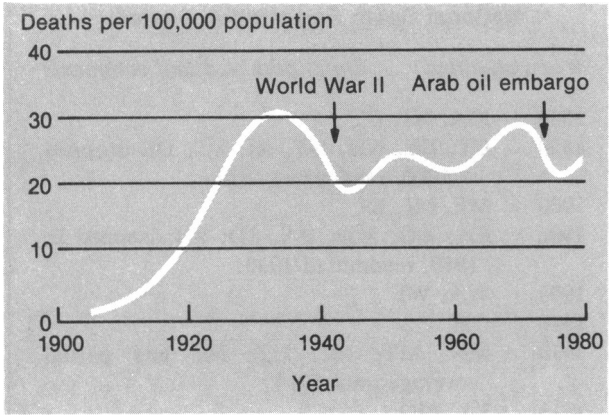
Strengths and limitations of mortality data. Although the U.S. vital statistics system was built with much effort, some limitations exist. There is not always a one-to-one correspondence of codes from one revision of the ICD to the next.

Dates When States Were Admitted to the National Death Registration System

When admitted	*States admitted and comments*
1880	MA, NJ, DC
1890	CT, DE, NH, NY, RI, VT; DE dropped in 1900, readmitted 1919.
1900	ME, MI, IN
1906	CA, CO, MD, PA, SD; SD dropped in 1910, readmitted 1930.
1908	WA, WI
1909	OH
1910	MN, MT, NC, UT; NC had partial coverage until 1916.
1911	KY, MO
1913	VA
1914	KS
1916	NC, SC
1917	TN
1918	IL, LA, OR
1919	DE, FL, MS
1920	NE
1922	GA, ID, WY; GA dropped in 1925, readmitted 1928.
1923	IA
1924	ND
1925	AL, WV
1926	AZ
1927	AR
1928	GA, OK
1929	NV, NM
1930	SD
1933	TX
1959	HI; HI and AK data were received before this date but were compiled in tables separate from the data on other States.
1960	AK

Time-trend analysis of death rates requires determination of equivalent ICD codes over different revisions. No complete set of equivalent codes covers all causes of death over all ICD revisions, but some subsets of equivalent codes have been created, principally by the NCHS (*3*). The standard for a State's mortality data being entered into the death registration system was registration in the State of 90 percent of the deaths that occurred. It is assumed that registration has approached 100 percent in recent years; this percentage has not been verified. The quality of mortality data depends on the care with which the cause of death and other information about the decedent were determined and recorded on the death certificate.

Figure 1. Death rates for motor vehicle accidents, 1900-1980



Quality control procedures in coding are followed, and their effectiveness has been evaluated (*4*), but some inaccuracies and improbable data still exist.

No data set is perfect in all aspects. An example is the 1980 census. It is the most complete census ever taken in the United States, yet there have been several challenges to its accuracy. Nonetheless, the data were finalized, and important decisions were based on them. Census data are not perfect, but they are the best that are available. Similarly, even though national mortality data have limitations, they are the largest, most available, and best resource for evaluating the national public health.

The mortality data I used were extracted from the annual reports and special reports (*5*) of vital statistics published by the NCHS and its predecessor agencies. Population counts were taken from the national decennial census and intercensal estimates of population. Annual death rates were computed by dividing the number of deaths during the year by the population count for that year.

Findings

Public health has improved since 1906, as indicated by increased life span and decreased death rates for several specific diseases. Food- and drink-related diseases have greatly diminished as causes of death.

Life span. Increases in the average life span have been steady since 1906. But the span had been increasing unevenly for at least the previous two centuries. The major factor was a decline in child mortality. In London in the 1600s, 60 percent of the children died before age 16; by the late 1700s, the mortality of children by age 20 had decreased to 50 percent (*6*). In 1865 in Massachusetts, mortality before age 20 was about 28 percent (*7*).

It often has been assumed that control of infectious diseases brought about the decrease in deaths among children. But Matossian's (*6*) opinion is that at least in England and Western Europe an improvement in food safety—specifically, awareness of mycotoxins—might have contributed significantly to the decrease. An example is ergot. Its significance in the United States is suggested by a theory linking ergotism to the unusual behavior among women who were tried—and some were burned at the stake—as witches in early Salem, MA (*8*). If these assumptions are correct, namely, if contaminated foods caused many of the illnesses and deaths during the United States' early history, millions of lives had been affected. At least some deaths would have been prevented if there had been adequate food safety laws.

Before the present century, the decline of death rates was not steady even among infants; there were periods of retrogression such as during and after the Civil War. Epidemics of enteric diseases were part of the legacy of the Civil War in which more men died of diseases than were killed in battle. Soldiers returning home from that war brought the diseases with them. (Concern over outbreaks of enteric diseases helped lead to the public health reforms of the late 1800s and early 1900s that included the food safety laws.) Infants are especially susceptible to the dehydration caused by enteric diseases, and the infant mortality in Massachusetts—from 125 deaths per 1,000 live births in 1855 to 175 deaths per 1,000 live births in 1870—illustrates the retrogression accompanying the Civil War. No war, economic depression, or other event since the post-Civil War period has been followed by any marked reversal in the steady decline of infant mortality (*7*).

The annual overall death rates were somewhat erratic during the period 1900–1906, but subsequently they fell rapidly except during the influenza pandemic of 1918. No other event of this century has increased death rates with the abruptness and magnitude of that pandemic. There was no sharp increase in death rates during or following World War II or the Korean or Vietnam conflicts as had occurred after both the Civil War and World War I. Apparently, public health measures had advanced sufficiently to control serious epidemics associated with mobilization of large numbers of men and their exposure to field conditions.

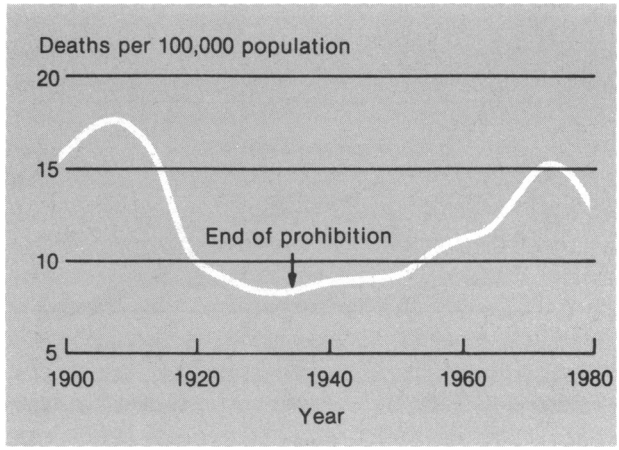
A more detailed analysis of deaths classified by race, sex, and age shows that decreases have not occurred at the same rate in all groups. The death rates for nonwhites have been higher than those for whites since 1900, but they generally have declined more rapidly than those for whites. This is especially so for nonwhite females. Rates for females have been lower than those for males every year since 1900, and in recent years the survival advantage of females has expanded. Though some progress has been made for chronic diseases of the older adult groups, death rates for children have improved more.

Cause-specific death rates. Analyses of trends for selected causes of death illustrate the relationship of public health to major events. Motor vehicles were so uncommon at the turn of the century that the 1900 edition of the ICD included no code for motor vehicle accidents. As motor vehicles became widely available, the rate of deaths from motor vehicle accidents rose steeply. Rates fell during the gasoline rationing of World War II but rose again after that war. Rates then declined with the 55 miles per hour speed limit that was imposed as a result of the Arab oil embargo (fig. 1).

Diabetes has been a leading cause of death throughout the 20th century. It was hoped that the discovery of insulin in 1922 would result in the control of this disease. Unfortunately, the overall death rate from diabetes actually rose in the decade that followed. However, as has happened after the introduction of control measures for several other diseases, the younger age groups benefited most, and their death rates from diabetes declined at the same time that the rates for older age groups were increasing, following the introduction of insulin. These statistics should be viewed with caution. For diabetes, and perhaps other causes of death, reported death rates are affected by several factors including changes in recognition of the disease, procedures for recording causes of death, and classification of causes. Some analysts believe that since the introduction of insulin the true mortality trend for diabetes has been downward rather than upward (*9*).

Cirrhosis of the liver is another example which shows that public health is intertwined in the ebb and flow of events. Death rates from cirrhosis fell markedly after the passage of various laws to restrict the availability of alcohol in the period before and during World War I and following ratification of the 18th constitutional amendment in 1919, which initiated national prohibition. After

Figure 2. Death rates for cirrhosis of the liver, 1900-1980



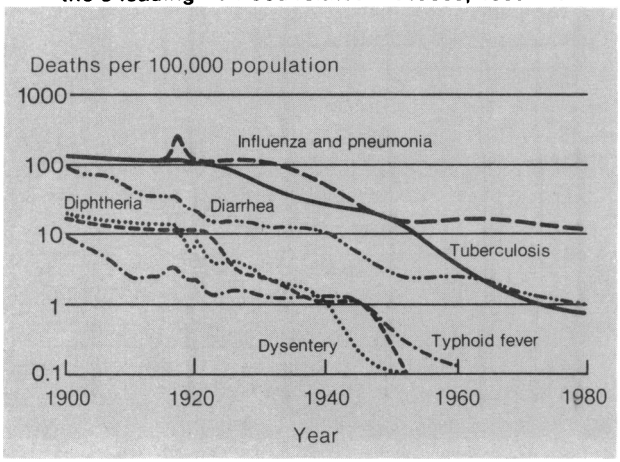
the repeal of the 18th amendment in 1933, rates gradually rose again (fig 2).

Poliomyelitis epidemics had occurred periodically for decades in the United States. The death rates were not as high as those caused by many other diseases, but almost everyone had family members or acquaintances who had been crippled by the disease. The nation itself had a President, Franklin D. Roosevelt, who was so afflicted. After the development and widespread use of polio vaccine in 1955, the death rate plummeted. The relationship between the event and the trend is unmistakable.

Foodborne infectious diseases. One of the clearest indications that public health has improved in the United States is the rapid decline of deaths caused by infectious diseases transmitted through food or beverages. Trends for death rates for the three leading infectious diseases of 1900 that are mainly food-related were compared with those of the three leading diseases that are transmitted mainly by human contact. The food-related diseases are diarrhea, typhoid fever, and dysentery; the nonfood-related diseases are tuberculosis, influenza and pneumonia, and diphtheria (fig. 3).

Death rates for all six causes have fallen almost continuously, except for influenza and pneumonia during the 1918 pandemic. In the first decade after 1906, death rates for the food-related diseases declined faster than those for the nonfood-related diseases. In fact, death rates for influenza and pneumonia increased 10 percent, and rates for tuberculosis declined only about half as rapidly as those for the food-related diseases. Thus, the major food-related diseases that had been of such concern during and after the Civil War were being

Figure 3. Death rates for the 3 leading food-related and the 3 leading nonfood-related diseases, 1900-1980



controlled more rapidly than some of the leading nonfood-related diseases. However, after diphtheria vaccine became widely used, the death rate for this disease dropped faster than that for dysentery or diarrhea.

One problem in interpreting trends is that some diseases have changed over time. The changing types of influenza viruses are well known. The pattern for diarrhea, in particular, has changed. In the early part of the 20th century, various strains of *Salmonella*, *Shigella*, and other organisms probably were involved in most diarrheal outbreaks, but the etiology often was not determined. There was a strong seasonal distribution; annual outbreaks reached a peak in late summer, and rates were lowest in midwinter. The summer peak disappeared in the 1940s. Diarrhea, which had been a major cause of death among infants, gradually subsided as a fatal threat in the general community, but its occurrence remains high in the lower socioeconomic classes of people.

The age distribution also has changed. Most deaths from diarrhea reported in 1906 were of children under 1 year. The rates were much lower during the midyears of life, but the rate in people aged 85 years and older rose to 18 percent of that in infants. In childhood most deaths occurred after the first 2 months of life. In 1930, during an outbreak of infant diarrhea in San Antonio, TX, only 8 percent of the deaths occurred in infants under 2 months. By 1978, 75 percent of the deaths from diarrhea among children under 1 year occurred in the first 2 months of life. Similarly, the death rate for diarrhea among people 85 years and older was 56 percent of that among infants.

Much of the regulatory activity under the Meat Inspection Act since 1906 has been directed at controlling *Trichina* and other types of parasitic infestations of meat. Deaths from these causes have become rare; there were 13 deaths reported for *Trichina* in 1913 compared with none in 1978.

Nutritional diseases. Nutritional deficiencies contributed measurably to death rates for the first four decades of this century. Some deaths were attributed to beriberi, and young children sometimes died of scurvy or rickets. But the greatest number of deaths was caused by pellagra, a deficiency of niacin and other B vitamins.

As indicated in the national mortality reports of the Bureau of the Census, cases of pellagra were concentrated in the rural South. In 1930 the death rate for pellagra recorded in the death registration system was 5.3 per 100,000 population. Two-thirds of all deaths from pellagra were reported from six southern States. Few deaths from pellagra were reported before 1906 in the death registration system for States in the urban Northeast. However, reports of pellagra-related deaths increased as interest in the disease heightened and as southern States were admitted to the death registration system. Death rates were higher among nonwhites. Women of childbearing years, aged 14 to 50 years, had higher death rates than men of that age group, but after age 50 the rates for women were generally similar to those for men. Improvement did not occur until the cause was identified, in the late 1920s, as being a nutritional deficiency. However, pellagra and the other deficiency diseases were not fully controlled until after the economic improvement of World War II and the enrichment of certain foods, such as cereals.

Some diseases that are caused by nutritional deficiencies are still reported in mortality statistics; they occur more often in data on the very young and very old. A diet-related diagnosis that started to appear in mortality statistics after World War II is obesity. Overnutrition seems to be replacing undernutrition as a health risk. However, this change does not indicate that nutrient intake is adequate for the entire population. Each year since annual reporting started in 1900, a few dozen people have died of starvation in the United States. Nutrient imbalances are still suspected of having a negative effect on public health. Efforts are being made to address problems such as iron deficiency in women of childbearing age.

Chemical contamination of food. Poisoning from food was coded for 1,779 deaths in the death registration system in 1910; deaths in that category

decreased to 15 in 1978. However, it cannot be determined what portion of those deaths may have been caused by chemicals rather than by microbial toxins. As the Office of Technology Assessment of the U.S. Congress concluded (*10*), there have been no mass poisoning episodes among human beings in the United States due to chemical contamination of food. Some other countries have not been so fortunate. For example, seed wheat treated with methyl mercury was eaten by human beings and caused several deaths in Iraq (*11*), as did table oil adulterated with hexachlorobenzene and consumed in Turkey (*12*). One of the best known outbreaks of poisoning by chemically contaminated food is that of mercury-contaminated fish in the area of Minamata Bay, Japan (*13*).

Other food-related diseases. The decrease in cardiovascular death rates has been a major contributor to the increase in life expectancy of the older age groups. Despite much scientific effort over the past few decades to determine the relationship between diet and cardiovascular disease, there is no universal agreement on the role of diet in cardiovascular disease. The mortality pattern for neoplasia is complex; however, there are indications that some dietary factors may have a role in its etiology (*14*). Several other diseases associated with diet—goiters, deficiency anemias, milk sickness—have been brought under control to the point where reports of deaths from them are uncommon in national mortality data.

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Discussion

Public health has improved markedly since passage of the food safety laws. Some of the greatest gains have been in reduced mortality from infectious diseases transmitted through foods and beverages and from nutritional deficiencies. The central question is whether those gains can be attributed to food safety measures. If all the theoretically possible outcomes are considered, food safety regulatory activities may or may not have had an effect on public health, the magnitude of the effect may or may not be measurable, and the effect may be negative or positive. (Occasionally a well-intentioned public health measure can have negative effects, as was tragically illustrated by the outbreak in 1955 of poliomyelitis that was caused by faulty vaccine.)

Various kinds of evidence may be cited to address the question concerning the relationship between food safety regulations and public health:

1. *time sequence.* Improvements in public health, especially decreases in reported death rates from food-transmitted diseases, followed the enactment of the food safety laws.
2. *consistency of the relationship in different groups of people.* Food-related diseases are higher among people of lower socioeconomic status in the United States who do not get full benefit of the food safety laws.
3. *consistency of the relationship for different diseases.* Many kinds of food-related diseases have been controlled since 1906.
4. *absence of deleterious effects.* There has been no indication that food safety regulatory activities have had any detrimental effect on public health.

It is recognized that these types of evidence come from descriptive epidemiology and do not allow the greater degree of certainty of conclusions that would come from analytical epidemiology procedures such as case-control studies. However, the conclusion still can be reached that food safety regulatory activities have probably contributed to improved public health.

In a broader sense, evaluation of public health data raises general points that can be applied to food safety activities, as well as to other health improvement activities:

- Health problems were defined and control measures were begun on the basis of the best information at hand, even though that information was not perfect. Efforts were then started to get improved information to support better decisions in the future.

'If certainty had been a requirement for implementing the health reforms of the late 1800s and early 1900s, hundreds of millions of lives would have been lost. If the death rate of 1900 had not been reduced, an additional 1.8 million Americans would die each year. This number is about that of the population of West Virginia, and such loss would be particularly tragic since more than half the additional deaths each year would be of children under 5 years.'

- Control programs were based on demonstration of actual public health benefits rather than on theoretical ones. In some instances, control of the disease was accomplished before the theoretical basis of the disease was known, as in cholera.
- The effects of some events on the public's health could be seen only upon detailed examination of data.
- Control programs did not benefit all groups of people equally. Efforts were addressed to problems that seemed most likely to yield results.

The common threads running through these points relate to the importance of good information and practical disease-control procedures.

Development of an adequate vital statistics system was a key factor in the public health reform activities of the late 1800s and early 1900s. (Vital statistics, for example, have been called the mother of modern sanitation, and sanitation was the major factor in reducing death rates, especially among infants and young children.) Now, as then, valid information and effective use of that information is important to support disease control. That function in FDA is served by the Epidemiology Information System (EIS)—a system of food safety information, data sources, and analytical capabilities in FDA's Center for Food Safety and Applied Nutrition—so that the agency can carry out its mission to ensure the safety of foods. The EIS contains both bibliographic information and original data on population counts and demographic characteristics, food intakes, food contaminants, and health outcomes such as mortality.

One difficulty in interpreting public health trends and apportioning credit for producing benefits is that many kinds of activities in government, academia, and the private sector have contributed—improved sanitation, better food preservation, improved economic conditions, and improved nutrition are examples. Some of the factors that provided a more varied diet and foods that were better preserved were well in place long before the FD&C Act, such as refrigeration and faster transportation by rail. Basically these improvements came about because of economics and the pleasure people derived from eating certain foods.

An example is the post-Civil War cattle drives from Texas to railhead towns in Kansas. Economic advantage to the ranchers, railroads, and meatpackers motivated them to move beef from southwestern ranges to northeastern dinner tables. There is no indication that concern for better nutrition played a role in the decision. Similarly, the growth of the citrus and fresh vegetable industries in Florida, California, and other sunbelt areas was driven largely by economics. In fact, the impetus for national safety inspections of food was not generated by public health concerns in this country. Federal meat inspection was first made available at the request of meat packers whose products needed Government endorsement before they would be accepted for import into certain foreign countries.

"The Jungle" was not written out of concern for public health; Upton Sinclair wrote it as an appeal for socialism, which he believed to be the answer to the economic and social problems of the lower class. In describing the pitiable circumstances of a poor immigrant family, he also described the filth in meat-packing plants. The ensuing outcry from the public, together with some reformation work, was influential in getting food safety laws passed.

But of greater importance than apportioning credit for improvements in public health is the protecting of gains that have been realized from improved public health. Courses of action for doing so should be based on the best information and the best evidence available when decisions must be made about the kinds of controls to use. If certainty had been a requirement for implementing the health reforms of the late 1800s and early 1900s, hundreds of millions of lives would have been lost. If the death rate of 1900 had not been reduced, an additional 1.8 million Americans

would die each year. This number is about that of the population of West Virginia, and such loss would be particularly tragic since more than half the additional deaths each year would be of children under 5 years. Even in the unlikely event that public health cannot be improved in the future, food safety regulatory activities would be justified on the basis of preventing a return to the conditions of the past.

A number of problems remain. Death rates fell little in the 1950s and 1960s. The lack of a continued decrease in mortality is largely attributable to high death rates for cardiovascular diseases. In addition, infant mortality reached a plateau during that time, as did the rates for influenza and pneumonia and for diarrhea. Greater life expectancy for males, especially nonwhite males, has taken place at a much slower pace than for females.

The complexity and cost of health regulations have grown in recent years. Basic sanitation was the major force for improvement in public health in the first half of this century; but in this second half, more effort has gone into regulatory activities based on theory. The theory has not always been adequately verified. Human volunteers were used in the early days of the predecessor agency to the FDA to test the toxicity of some food additives, but now toxicity testing is performed in animals and other model systems. Primary liver cancer associated with consumption of aflatoxin by humans has been called the most promising chance to verify laboratory testing and mathematical modeling, but the number of cases among humans used in the verification attempt was so low that misclassification of a few cases would completely alter the conclusions (*15*).

However, neither acquisition of data on humans nor analytical capabilities have been maintained. Only half of the death certificates for 1972 were coded. UPGRADE, an interagency data base and analytical system in the health- and environment-related areas, has disappeared because of lack of funds. The National Center for Health Statistics continues each year to state in reporting vital statistics that completeness of death registration is unknown, that is, we are unsure of the number of people who die. Human health data sources and analytical capabilities still need to be improved.

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