Food Safety Research Consortium
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Food Attribution Data and Methodologies in the Foodborne Illness Risk Ranking Model

Background

The attribution of foodborne illnesses from specific pathogens to specific foods is a critical component of the Foodborne Illness Risk Ranking Model (FIRRM), an analytical tool jointly developed by Resources for the Future and the Department of Epidemiology and Preventive Medicine of the University of Maryland School of Medicine, as a project of the Food Safety Research Consortium (FSRC). This document describes the methodologies used for food attribution within FIRRM, including the overall approach, assumptions, data sources, problems encountered, and opportunities and needs for future research. For more information about the model, please see the Methodology Primer.

Within FIRRM, the incidence of foodborne illness and the valuation of associated health outcomes are calculated by pathogen. These incidence and valuation estimates are then attributed to food categories according to the estimated percentage of the illnesses caused by each pathogen due to each food. This multiplication results in estimates of incidence and valuation by pathogen-food combination.

Obtaining adequate food attribution percentages, however, is problematic. It was one of the greatest challenges in creating the model, and remains the area most in need of further research and better data.

The model includes three approaches for estimating food attribution percentages, each of which has its strengths, weaknesses, and data gaps, and none of which is fully sufficient on its own. The three methods are: (1) the use of outbreak data in which cases of illness were traced back to originating food, (2) a risk assessment approach based on food contamination data, food consumption data, and algorithms for estimating resulting illnesses, and (3) an expert elicitation in which authorities on food safety were surveyed for their estimates of food attribution percentages. Thus, the model includes one top-down approach based on surveillance data, one bottom-up approach based on microbiological data, and one approach based on best judgments.

Food Categories

FIRRM uses food categories based heavily on those categories developed and used by the Center for Science in the Public Interest (CSPI), primarily in their regularly updated Outbreak Alerts. There are two tiers of food categories, the major food categories (e.g. Seafood), and the food sub-categories (e.g. Finfish), as shown in Table 1.

This category scheme was selected largely because the food attribution outbreak data used in the model comes from CSPI and uses these food categories. There is no standard set of food categories used across the food safety spectrum, though the various regulatory agencies do have their own categorization schemes. The Centers for Disease Control and Prevention (CDC) are currently developing a set of food categories specifically for foodborne illness, but are finding the task complex and difficult (Tauxe 2003).

FIRRM includes some additional categories beyond those developed by CSPI. Specifically, it includes the “Multi-Source” major food category and the various “Combo” sub-categories. These categories were created due to outbreak data in which multiple food items were implicated. The “Multi-Source” category differs from “Multi-ingredient” in that the latter tracks non-meat dishes composed of multiple items (such as casseroles or sandwiches), whereas the former is for cases in which cross-contamination led to multiple items being contaminated (such as both mashed potatoes and beef). The “Combo” sub-categories are for outbreaks in which two dishes from the same major food category were implicated, and thus further sub-categorization was impossible. The “Multi-Source” category and the “Combo” sub-categories are only used for the outbreak method of food attribution. One further note is that the “Multi-ingredient” category is for dishes composed primarily of non-meat ingredients; there are sub-categories within the major meat categories to capture meat dishes.

Table 1: Food Categories used in the Foodborne Illness Risk Ranking Model

Major category	Sub-category
Seafood	Finfish
	Molluscan Shellfish
	Other Seafood
	Seafood Dishes
	Seafood Combo
Eggs	Eggs
	Egg Dishes
	Eggs Combo
Produce	Fruits
	Vegetables
	Produce Dishes
	Produce Combo
Beverages	Juices
	Other Beverages
	Beverage Combo
Dairy	Milk
	Cheese
	Ice Cream
	Other Dairy
	Dairy Combo
Multi-Ingredient	Salads
	Rice/Beans/Stuffing/Hot Pasta Dishes
	Sandwiches
	Sauces/Dressings/Oils
	Other Foods
	Multi-Ingredient Combo

Major category	Sub-category
Breads and Bakery	Breads
	Bakery
	Breads and Bakery Combo
Game	Game
Beef	Ground Beef
	Other Beef
	Beef Dishes
Poultry	Chicken
	Turkey
	Other Poultry
	Chicken Dishes
	Turkey Dishes
Pork	Ham
	Other Pork
	Pork Dishes
Luncheon/ Other Meats	Luncheon Meats
	Other Meats
	Other Meat Dishes
Multi-Source	USDA
	FDA
	Both USDA/FDA
Unattributable	Unattributable and Other

Outbreak Method

The outbreak method of food attribution is based on CSPI’s compilation of data on outbreaks of foodborne illness. For purposes of this model, analysis was limited to data from the CSPI database for which both the pathogen and food were isolated, and in which the cases from each outbreak could be sorted into one of the food categories described previously. This data is based primarily on CDC data, but also includes outbreaks not reported to CDC for which CSPI was able to obtain data. Of the 2,472 outbreaks listed in the September 2002 Outbreak Alert, 300 or 12.1% were not from CDC sources (DeWaal and Barlow 2002). For the 28 pathogens included in FIRRM, it includes 1,977 outbreaks and 83,619 cases of foodborne illness.

The number of cases due to each pathogen-food combination is divided by the total number of cases of that pathogen to obtain attribution percentages for each pathogen-food combination. The model includes settings to further specify how to use the CSPI database. The user can specify the minimum outbreaks per pathogen required to use that data, so that pathogens with minimal coverage in the CSPI database are not attributed to food categories at all. One such pathogen is Toxoplasma gondii, which has only one outbreak in the CSPI database, which, if used for rankings, would attribute 100% of toxoplasmosis cases and deaths to game.

For the purpose of food attribution, use of outbreak data has limitations. Outbreaks, by definition, reflect unusual occurrences and/or breakdowns in standard prevention approaches. As such, they may not be representative of "standard" transmission patterns for specific pathogens. The intensity with which an outbreak is investigated may be dependent on its size or the presence of some unusual feature: i.e., an outbreak involving 100 persons, particularly if it involves an unusual vehicle, is more likely to be investigated than one involving three persons in which a "standard" vehicle is suspected. The completeness of investigations is also highly dependent on the interest (and time availability) of local health department investigators, and the diagnostic capabilities of the local laboratories.

Risk Assessment Method

In addition to the top-down approach of surveillance data, FIRRM includes a bottom-up approach to food attribution. Based on food consumption data and food-pathogen contamination data, this method estimates per capita illnesses for each pathogen-food combination using risk assessment methods. For this method to be completely represented within FIRRM, it would require individual risk assessments for each pathogen-food combination, a task well beyond the scope of this project.

FIRRM includes two risk assessment approaches. It includes the FDA/USDA/CDC risk assessments for Listeria and one shorthand method developed specifically for the model that utilizes contamination and consumption data and risk factors to estimate illnesses.

Risk assessments are very complex and resource-intensive, and they require knowledgeable modelers to use available pathogen-specific food contamination data and dose-response functions to estimate the risk of illness due to consumption of one serving of that food. This is multiplied by estimates of the annual per capita servings consumed to estimate the number of illnesses. There are often different dose-response functions and consumption patterns for different ages of consumers, and proper risk assessments incorporate these important age variations.

For food attribution purposes, it is critical to have risk assessments for each food category for a particular pathogen, and it is imperative that these risk assessments be performed by the same procedures and methods in order that they are comparable. One rare, such set of risk assessments exists for *Listeria monocytogenes*, a result of a cross-agency project of the FDA's Center for Food Safety and Applied Nutrition (CFSAN), the USDA's Food Safety and Inspection Service (FSIS), and CDC (CFSAN, FSIS, CDC 2001). This set of Listeria risk assessments includes 20 ready-to-eat foods, including seafood, produce, dairy, meats, and deli salads. It excludes foods usually cooked, such as most seafoods and meats, and low-risk foods such as grains, eggs, soft drinks, and prepared foods.

FIRRM uses the results of these risk assessments to develop food attribution percentages. For these 20 foods, servings per year by age category were multiplied by estimated cases of Listeria per serving by age category to obtain estimated cases of Listeria per year by age category. These results were summed across age categories, classified into five major food categories within FIRRM, and divided by the total cases to obtain percentages. When this method of food attribution is selected, rankings can only be performed for Listeria.

The shorthand method of food attribution by means of contamination and consumption data was developed to approximate the risk assessment approach for all pathogens and foods. Basically, this method estimates annual per capita illnesses for each pathogen-food combination by multiplying the average amount of each food consumed per person per year by the likelihood that any given serving of that food will be contaminated enough with that pathogen to result in illness; attribution percentages are obtained by dividing the resulting estimates for each pathogen-food combination by the sum of all estimates for each pathogen.

Annual per capita consumption of food is defined in the model by an upper and lower bound, where the upper bound is defined by "food disappearance" data from the USDA's Economic Research Service food consumption data system, and the lower bound is defined by "dietary recall" data from the USDA's Continuing Survey of Food Intakes by Individuals (CSFII). Contamination data comes from a literature search. Consumption by food, in kg/year, is multiplied by pathogen contamination data from the literature, in organisms/kg, to obtain estimates of consumed organisms/year for food pathogen combinations. To approximate consumer behavior, such as cooking the food or using proper handling behavior, we developed a risky behavior multiplier for specific foods, based largely on CFSAN data (2002). Despite these incredible simplifications of the risk assessment method, intended merely to give a rough estimate, there were too many data gaps in these four areas to utilize this method in the model. It is included in the model to show the approach, but rankings cannot be performed using the FSRC shorthand risk assessment method of food attribution.

Expert Elicitation Method

The third method of food attribution uses the results of an expert elicitation of experienced food safety and public health scientists, and people with extensive food safety policy experience. The purpose of this elicitation was two-fold. One was to see if there is any evidence that expert judgment differs from CDC outbreak data, given the potential limitations in outbreak data noted above. There is little systematic data collection attributing food-borne illness caused by specific pathogens to consumption of specific foods. In this kind of situation, past research on expert elicitation approaches indicates that expert judgment would provide a reasonably reliable basis for this estimation (Morgan and Henrion 1990). A survey study was developed based on the methodological results of this research.

A list of scientists, public health officials, and food safety policy experts with nationally recognized expertise in food safety that would indicate a knowledge of food attribution was compiled and peer reviewed with leading national food safety scientists. A survey was developed, pretested, and mailed to 94 possible respondents. Phone calls were made to follow up on the mailing and ask whether the respondents felt they could complete the survey. Twenty-two of these declined the invitation, most of whom self identified as not feeling that they had the appropriate background to fill out the survey, 54 respondents said they would complete the survey, and 18 have not yet been reached by phone. We have currently received 23 responses, and expect more in upcoming weeks.

The survey asked for background information on professional experience, and for a self-evaluation of one's level of expertise with the model's pathogens and food groups. This information will be used in analysis of responses. A questionnaire was included for each of the model's 11 pathogens. Each respondent was asked to identify whether a food from a specific category was likely to be a source of illness caused by a specific pathogen. For food categories where the answer to this question was yes, the respondent was asked to give their best estimate and an upper and lower bound on the percent of U.S. cases of foodborne illness caused by this pathogen in a typical year that was associated with consumption of food in this category. In a follow up question, the respondent was asked to identify information relied on in food attribution for a particular pathogen.

While the initial responses from the completed surveys have been entered into the model and can be used in the rankings, further analysis of this data will occur as more surveys are returned in upcoming weeks.

References

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