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Policy Options on Reduction of Foodborne Diseases

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Abstract This study explores policy options that can reduce prevalence of foodborne diseases. Using FoodNet surveillance data from 1997-2004, hazard risk index of mortality (HRI) was calculated and the relationship between age, gender and ethnicity were explored and used to develop policy options. The results show there were significant association between risk of mortality from *Salmonella* outbreaks and children (*rho* = .851**, p = .007) and statistically significant (p<0.01); *Listeria* outbreaks and ages (20-30 (*rho* = .752, p = .032); 50-60 (*rho* = .727, p = .041)); and men (*rho* =.812*, p = .014). Finally, there were strong associations between HRI and Hispanics, (*rho* = 1.00) for *Listeria* compared to all other ethnic groups and for *E. coli* and the Asian ethnicity (*rho* = .707, p = .050). The conclusion of this paper is that public education and awareness of foodborne diseases is not adequate. Because there were statistically significant (p<0.05) association between HRI and age, gender and ethnicity, policy options should include food safety education, with emphasis to the ethnic groups, daycare/nursing homes workers, young and old. Consumption of raw or undercooked animal/seafood should be discouraged. Conclusively, public education on food safety and awareness of foodborne pathogens should be the responsibility of the government, health-care givers, parents and teachers.

Keywords Policy options, Foodborne diseases, Association between hazard risk of mortality and age, Gender

1. Introduction

Most foodborne diseases (FBD) are sporadic and occur as isolated cases. In public health practice, a foodborne disease outbreak is defined as the occurrence of at least two cases of similar illness, resulting from the consumption of common food [1]. Foodborne disease has emerged as an important issue of growing public health concern and economic problem in many countries [2]. The ultimate goal of all food safety programs is to stop contaminated food products from reaching the consumer. Surveillance for foodborne diseases is conducted to delineate the occurrence and burden of important public health concern [3]. To further show the urgency of foodborne diseases, a recent reported estimate by Jones [4] suggests that about 30% of all newly globally emerging infections included pathogens commonly transmitted through food. The government has established several types of surveillance programs in reporting cases of foodborne disease in the US, including consumer complaints, notifiable disease surveillance, outbreak reports and detection of enteric diseases transmitted through food [5]. Food stuff in the US is considered to be one of the safest worldwide because of the different reporting or surveillance programs. Furthermore, FoodNet surveillance is enhanced and focused on a handful of enteric foodborne pathogens. It is considered to be active surveillance, because FoodNet investigators are in regular contact with the area laboratories in the catchment area in 10 states namely: California, Colorado, Connecticut, Georgia, Maryland, Minnesota, New Mexico, New York, Oregon and Tennessee.

Although the surveillance of foodborne diseases is commendable, it is not robust enough. It is further complicated by several other factors, which pose serious challenges to the public health. The challenges include underreporting and under-diagnosis [6], frequent contamination of raw food supply [7], expansion of global transportation and supply of perishable goods or foods from different parts of the world [8], consumers lack of awareness in safe food handling and preparations [7, 9, 10], consumers' high risk behavior and desires for new taste and food experiences, continuous exposure of consumers to emerging foodborne pathogens and new vehicles of transmission of foodborne pathogens and increasing number of population at risk [11, 12]. It has been suggested that there are three major forms of protection against foodborne diseases. Ensuring food safety should be a three prong approach, in which the government, industry and the consumer play specific roles in ensuring a safe food supply. The role of the government include public health; encouraging the food industry including farmers by providing safe food handling training and guidance, to undertake voluntary measures to promote

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food safety.

In addition, the industries are expected to produce food under Good Manufacturing Practices (GMP), establish and employ The Hazard Analysis and Critical Control Point (HACCP) system; and voluntarily establish necessary system for safety assurance of their products by adopting appropriate protocols and new technology for quick detection of pathogens in food. Immediate product recall and removal from shelves should be enacted in cases of accidental contamination. Educating all food handlers from "farm to table" or "boat to throat" [8] will improve the hygienic quality of raw food supply. Tauxe [3] reported that the food industry in the United States had more microbiological food safety challenges now more than before. The importance of food safety assurance should be conveyed to the directors and managers as well as the workers for the safety of their product [13]. Prompt response and detection of an outbreak may limit the negative impact on public health by improving confidence in food supply and preventing future outbreaks [14]. Moreover, individuals should have access to precise information about the food they consume [13]. Therefore, the main objective of this paper is to explore policy options that can reduce the prevalence of foodborne diseases.

2. Materials and Methods

2.1. Surveillance Data

Secondary data of foodborne disease outbreaks were obtained from 1997 to 2004 from the Foodborne Diseases Active Surveillance Network (FoodNet) [15]. FoodNet is an active population-based surveillance system. Foodborne diseases reported cases under surveillance per 100,000 individuals in the population for each bacteria pathogen (*Campylobacter, Escherichia coli, Salmonella*, *Listeria, Shigella*, *Yersinia* and *Vibrio),* based on age, gender, ethnicity and mortality were used to develop Hazard Risk Index.

2.2. Hazard Risk Index (HRI) Development

Hazard risk index of mortality due to foodborne diseases was developed for each of the seven bacterial pathogens for 1997-2004 as described by [16]. Briefly, HRI was calculated as the number of foodborne disease cases from the FoodNet active surveillance data minus the foodborne disease mortality; divided by the number of cases.

2.3. Statistical Analysis

SPSS [17] (Statistical Package for the Social Sciences) was used to obtain descriptive analysis of the data. Descriptive analysis of the independent variable characteristics used to develop the hazard risk index (HRI) was demographic characteristics of foodborne disease cases including age; gender; ethnicity; and mortality rate. The Spearman *rho* correlation coefficient was used to determine the strength of the association between (HRI) of foodborne pathogens as dependent variable and the set of independent (age, gender and ethnicity) variables.

3. Results and Discussion

Overall, from the analysis of the surveillance data retrieved from FoodNet, there is a continuous increase in prevalence of foodborne disease cases. Bacterial foodborne pathogens of major health concern are *Escherichia coli, Campylobacter* spp., *Salmonella* spp., *Shigella* spp., and *Yersinia* spp. [18]. Pathogens such as *Salmonella* spp., *Escherichia coli, Yersinia* spp. and *Shigella* spp. all have positive correlation with hazard risk index of mortality for children 1-<10 years old as shown in Table 1.

Globally, diarrhea is one of the major causes of morbidity and mortality in children particularly in the developing countries [19]. In US, there are estimated 25 million episodes of diarrheal illness in children less than 5 year old [18]. According to Zimmerman [21], there are 200,000 children diarrheal related illness hospital admissions every year accounting for 4% of all admissions. Since their immune systems are still developing, infants and children are more prone to foodborne disease [22]. Also, foodborne diseases can spread faster, once they emerge.

Previous studies have reports that the numbers of cases of salmonellosis are relatively higher for children than for other demographic groups [23]. In addition, infants and young children are most vulnerable to gastrointestinal infection and prolonged diarrhea which often results in increased prevalence of developmental disorders and increased mortality [24].

Other Age distribution 20-<30 had positive correlation with *E. coli, Shigella, Vibrio* and significant for *Listeria monocytogenes*. Also, HRI and age 30-<40 had positive correlation with *E. coli, Salmonella, Shigella and Yersinia*.

Listeria monocytogenes and the 50-60 age distribution showed strong and significant positive association with hazard risk index (*rho* = .727*, p = .05). Older adults are increasing demographics in the United States and considered to be particularly vulnerable to foodborne diseases. As reported by the US census bureau in 2000 there were estimated 35 million individuals over 65 years old and the number is estimated to grow to 71 million by year 2030 [25]. Furthermore, as reported by Ailes, [26], hospitalization rates for persons 60+ were highest for infections caused by *Listeria* species, *E. coli, Yersinia* species, *Vibrio* species, *Salmonella* species, *Shigella* species and *Campylobacter* species.

Several underlining factors are contributory to the vulnerabilities of older adults to foodborne diseases. Such factors include aging immune system, chronic diseases, risk of malnutrition, dementia and limited physical activity [27].

Table 1. Spearman rho Correlation Coefficient of 7 bacterial pathogens under active surveillance for foodborne diseases

Variables	*CM*[a]	*E. coli*	*LM*[b]	*Salmonella*	*Shigella*	*Yersinia*	*Vibrio*
	Spearman *rho* Correlations Coefficient $p = 0.05$						
HRI[c]	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Age							
0-<1	-.689	.228	.103	-.200	-.086	-.181	-.094
1-<10	-.091	.500	-.244	.851**	.284	.491	-.805*
10-<20	-.663	.167	-.205	-.050	-.086	.098	-.599
20-<30	-.078	.216	.752*	-.050	.099	-.012	.181
30-<40	-.443	.548	-.097	.050	.222	.360	-.143
40-<50	-.574	.071	.149	-.050	.161	-.115	-.790*
50-<60	-.417	-.119	.727*	-.150	.037	-.364	-.773*
60+	-.417	-.071	.157	-.150	-.185	-.329	-.731*
Gender							
Male	-.509	.429	.812*	-.100	.161	-.236	-.667
Female	-.509	.190	.220	-.150	-.086	-.072	-.810*
Ethnicity							
White	-.730*	.262	.261	.050	.099	-.361	-.833*
Black	-.091	.381	.250	.200	.037	-.515	-.874**
Hispanic		-1.00	1.00		1.00	1.00	-1.00
Asian	.313	.707	.161	.350	-.259	.479	-.503
Nat. Am	-.439	-.103	.462	.252	.043	-.064	-.247
Others			1.00		-1.00		-1.00
Unkwn	.391	.253	.539	-.300	-.124	.061	-.204

Source: Table 1 (Ajayi et al., 2014 FPT. In Press). Data used to compute the Spearman rho were extracted from CDC FoodNet from 1997 to 2004. *CM*[a] =*Campylobacter*; *LM*[b] =*Listeria monocytogenes*; Nat. Am=Native American; Unkwn=Unknown
HRI[c] = Hazard risk index of mortality; *, **Correlation is significant at the .05 and .01 levels (2-tailed)

Male have positive association with HRI (*rho* = .812*, p = .05) for *Listeria, E. coli* and *Shigella.* Female, show weaker association with HRI for *Listeria, E. coli* compared to male. For ethnicity, for example, Hispanics (*rho* = 1.00) and Native Americans had positive association with 3 pathogens; the Whites, Blacks with 4 pathogens while Asians had positive association with 5 pathogens as shown in Table 1.

Policy options

It has been established by the CDC that foodborne disease outbreak can present in varying degrees of severity including vomiting, diarrhea, cramps, gastrointestinal symptoms, deeper tissue invasion and death [28, 29]. Some factors such as age, gender, ethnicity and immunity are known to influence the severity of symptoms [28, 29]. Policy options should therefore be tailored to meet specific groups of individuals based on these variables.

Age

According to this study, children from infancy to age 10 are most vulnerable to infections and at high risk of mortality from *Salmonella, E. coli, Yersinia and Shigella* foodborne pathogens. It is generally agreed that a lot foodborne disease occur from home and since children cannot exercise any food safety control, because their meals are usually prepared by others, parents, older siblings and child care providers should have a basic knowledge of safe food preparation. Furthermore, care givers should wash their hands after changing diapers and prior to preparing food or bottles, along with good food sanitation and handling practices could help to prevent or limit the spread of foodborne illness in children.

Young adults are risk takers and information about the potential hazards in food and the different food vehicles must be conveyed through various multi-media outlets.

From the analysis of the surveillance data, it is conclusive that food safety policies should be established for older adults. Because there is a strong association between hazard risk index and age distribution for *Listeria* species, particularly for the elderly in this study as well as other studies (Table 2). In response to these earlier findings, the US Food and Drug Administration Food Code established guidelines in 1997 for nursing homes. Some of the guidelines include not serving raw seed sprouts, prepackaged juices or beverages bearing warning labels regarding lack of pasteurization, or foods containing raw or partially cooked eggs, fish, and meat [30]. However, cross contamination of raw with ready to eat foods such as (soft cheeses, cold smoked fish, cold deli salads, luncheon meats, and cold hot dogs) continues to be problematic [27], since processed meats has been identified as food that carried the highest risk for listeriosis [31]. In addition, to further strengthen the guideline, not serving or consuming these risky foods to older people is a viable policy option. Furthermore, food safety education is more effective, if it targets changing the behaviors most likely to result in

illness. Although this could be challenging, because according to Gettings and Kiernan [32] seniors believe the food handling behaviors they practice most consistently were not causing them to become ill. More food handling and safety education will be beneficial, in order to change perception and encourage less risky food-handling behavior and consumption of raw foods.

Gender

According to Yang [7], men are reported to be high risk takers in food handling and preparation issues. From this analysis, they are at high risk of illness and mortality from *Listeria, E. coli, Shigella,* and *Yersinia* while the risks to women are reduced. Information and announcements given by men about the effects of hazards in foods to their male counterparts could lead to better compliance.

Ethnicity

Hispanics are vulnerable and at high level of risk for foodborne infections from *Listeria, Shigella* and *Yersinia*, possibly because of ready-to-eat meals. Asians are at high risk for *E. coli, Yersinia, Salmonella Listeria* and *Yersinia* from the analysis of this study. Information about foodborne diseases should be ethnic friendly.

Several studies have reported that the majority of US consumers claimed to be aware of the hazard of *Salmonella* (94%) and *E. coli* (90%) in food, but in contrast, only about one third of them were aware of *Listeria* (32%) and 7% were aware of *Campylobacter* [33, 34]. Most consumers that claimed awareness of *Listeria* were unable to identify possible food vehicle [34]. It is therefore possible that consumers are unaware of the presence or effects of these pathogens in food and should be educated particularly the males should be focused on as a policy option.

Individuals who purchase and prepare meals for the family assume larger responsibility, since personal hygiene such as hand washing; cross-contamination of raw and cooked foods; consumption of raw, undercooked foods; and improper holding and cooling temperatures during storage of foods are critical actions that can be corrected and important means to reducing foodborne Illness [35, 36]. More vigilance is required for the medical teams who treat diarrheal diseases, to be on the lookout for foodborne pathogens. Creating effective national surveillance for an emerging pathogen depends on developing new clinical, and laboratory practices and changing policies in many jurisdictions.

Even though the process can be slow, as reported by Allos [37], the cycle of public health prevention begins with the critical first step of surveillance.

In this study, attempts were made to compile and compare the information on foodborne disease and the effect on public health system. While it is encouraging, only a percentage of the population is actively surveyed for foodborne diseases and there continues to be an increase in foodborne outbreaks. Furthermore, one of the problems with surveillance is underreporting of foodborne diseases because the symptoms of gastroenteritis are self- limiting, therefore exact number of foodborne diseases are difficult to obtain. As a policy option, surveillance needs to expand to a more representative population size and include other foodborne pathogens. Exploration of other policy options is discussed in Table 2 below.

Table 2. Foodborne pathogens and exploration of policy implications

Pathogen	Variable	Analysis	Interpretation (outcome of the analysis)	Policy Options
Campylobacter	● Age 1-<10 ● White	-.689 -.730*	● Strong ● Stat. significant As HRI increases, the rate of mortality reduces for age and race	● Improve education and awareness of food safety. ● Avoid consuming raw/ undercooked poultry.
E. coli	● Hispanics ● Asian	-1.00 .707	● Risk of mortality is reduced for Hispanics, but moderately strong for Asians.	● Awareness and education of *E. coli* FBD should be targeted to the Asian populations
Listeria	● Age 20-30 ● Age 50-60 ● Male ● Hispanics	.752* .727* .812* 1.00	● As HRI increases, the risk of mortality is strong and statistically significant	● Avoid eating RTE or drinking raw milk products during pregnancy, elderly. ● Food safety awareness is crucial for the old, males and child bearing Hispanics
Salmonella	● Age 1-10	.851**	● Stat. significant risk of mortality for this age group	● Education should be targeted at Teachers, parents and children
Shigella	● Hispanics	1.00	● Strong association with HRI	● Further studies needed to investigate the increased risk of mortality for the Hispanics.
Yersinia	● Hispanics ● Asian ● Black	1.00 .479 -.515	● Strong and significant association with HRI for Hispanics, moderate for Asian, but inverse for black	● Chitterling is considered a high risk food for *Yersinia.* The population at risk need to be educated and made aware of *Yersinia* infection
Vibrio	● Age 20-30	.181	● Association is weak, but positive HRI	● Education and awareness about consuming uncooked seafood

*, **Correlation is significant at the .05 and .01 levels (2-tailed)

For each of the foodborne pathogen under active or passive surveillance, information on food vehicle association should be given to all consuming public particularly vulnerable (young, old, pregnant and immune-compromised) individuals.

Target groups based on gender, age, ethnicity should be educated as to their risk index with specific foodborne pathogen, and information could be presented in multi-lingual platform.

4. Conclusions

Ensuring food safety should be a three prong approach, in which the government, industry and the consumer play specific roles in ensuring safe food supply. The goal of this paper is to explore policy options that can reduce the prevalence of foodborne diseases. The need to strengthen food safety education programmes for the prevention of foodborne diseases is increasingly being recognized by different countries [38]. Using secondary data from FoodNet surveillance on foodborne disease, this study finds that there were significant association between risk of mortality from *Salmonella* outbreaks and children (*rho* = .851**, p = .007) and statistically significant (p<0.01); *Listeria* outbreaks and ages (20-30 (*rho* = .752, p = .032); 50-60 (*rho* = .727, p = .041)); and men (*rho* =.812*, p = .014). There were also associations between HRI and ethnicity. Furthermore, policy options should include food safety education, with emphasis to the ethnic groups, daycare/nursing homes workers, young and old. Consumption of raw and un-cleaned plant foods or undercooked animal/seafood should be discouraged. Therefore, the conclusion of this paper is that public education and awareness of foodborne diseases is not adequate. There should be frequent and consistent public service announcements via the media outlets; schools; food stamp/Women Infants and Children (WIC) programmes; senior centers; nursing homes; and health care givers about foodborne diseases. Personnel from food safety programs should engage and teach school age children about the importance of proper hand washing, proper food handling and cooking technique. Reduction in the number of foodborne disease cases translate to reduction in absenteeism from school and market place.

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