JOINT ESCOP/ECOP
FOOD SAFETY TASK FORCE

Identifying Potential Contributions
of the
Land Grant Universities
for the
Implementation of the

Preliminary National
Food Safety Strategic Plan

A COMPREHENSIVE REPORT

June 2000

INTRODUCTION

With the recent preparation of the national "Preliminary Food Safety Strategic Plan" (January 2000) opportunity now exists for the major players to organize a national effort with the objective of significantly reducing the occurrence and impacts of food borne hazards.

To address this opportunity to contribute to the Strategic Plan's implementation the Experiment Station Committee on Organization and Policy (ESCOP) and the Extension Committee on Organization and Policy (ECOP) of the National Association of State Universities and Land-Grant Colleges (NASULGC) formed a joint ECOP/ESCOP Food Safety Task Force. The charge to the Task Force was to:

1. Provide comments on the preliminary plan; and,
2. Prepare assessments and recommendations on the contributions that the Land Grant Universities (LGUs) could make to the strategic plan's implementation.

The Food Safety Task Force (see Appendix 1 for the membership) elected to conduct its assessments as teams of specialists looking at:

1) Categorical issues of implementation;
2) Our institutional capacities to respond;
3) The existing knowledge gaps, and
4) Actions that could be recommended to the LGU System to move the Strategic Plan forward.

All of this was done electronically and by conference calls.

We recognize that several partners, both within the public sector as well as in the private sector, are logical choices for the LGUs to work with in collaboration. However, we feel strongly that our traditional federal partner, the Cooperative State Research, Education and Extension Service (CSREES) should be our primary partner for the needed activities in teaching, Extension, and research. To this end we seek their support.

The Task Force first set about preparing comments for consideration and submission by ESCOP and ECOP leadership during the Public Comment period. Those comments have now been submitted. The Task Force then turned its attention to the second part of its assignment.

The categories that were established by the Task Force for the assessments were:

- Science;
- Education; and,
- Communication and Coordination.

For the categorical topic of **Science,** the Task Force reviewed: disease vectors (as microorganisms, toxins, pesticides, and allergens); emerging problems; detection; interventions and controls; and risk analysis and communication research. For the categorical topic of **Education,** the Task Force elected to address formal degree programs, life long learning (including consumers, the general public, and high risk groups), regulatory needs in education, industry education and training, and web-based educational opportunities. For the topics of **Communication and Coordination,** the teams evaluated risk communication, agency-to-agency and partner-to-partner communications, scientific databases, and publications.

SCIENCE

DISEASE VECTORS

Food borne hazards can take many forms, including microorganisms (bacteria, fungi, viruses, parasitic protozoa, and helminths), toxins, pesticide residues, and allergens. In the following section we will briefly describe the current state of knowledge on food borne disease vectors, followed by assessments of the LGUs' collective capacities. Gaps in each topic area are also discussed

MICROORGANISMS: To completely understand the etiology of human disease caused by food borne microorganisms and to develop effective measures for control, research must be carried out on several fronts. Only a few of the specific sources of microorganisms associated with food borne disease have been identified. To enhance control, important information is needed on pre-harvest and post-harvest contamination sources of food borne pathogens, and the strain-specific mechanisms of pathogenesis. It is also imperative to determine the precise significance of the presence of various levels of pathogens in a food, and their relationship with natural, nonpathogenic contaminants. This information is essential for establishing infectious doses and the influence of storage or handling on final food contamination levels. Until this information is known, we have no scientific basis for developing microbial food hazard specifications or food safety standards, which are necessary for completing risk analyses, and establishing food safety objectives.

Environmental characteristics and behavior in foods of food borne microbial pathogens are important pieces of information and are probably the most extensively researched areas. The influence of pre-harvest handling of raw food sources on subsequent survival and growth of pathogens on foods, especially those consumed fresh or raw, is extremely important. This is particularly relevant today, given the increase in consumption of fresh (i.e., unprocessed) foods.

Significant research has been carried out over the years on the effects of post-harvest processing control methods and storage on survival and growth of food borne pathogens. Unfortunately, with no organized direction for this research the results are often inconsistent in the methods used, the conditions examined, and pathogens analyzed. For example, knowledge on chemical food antimicrobials (i.e., compounds being increasingly examined as primary pathogen control agents) is very inconsistent due to lack of targeted and coordinated research. In addition, little is known concerning the interactive effect of physical and chemical control methods on food borne pathogens, or on the interaction of various groups of microorganisms in foods.

Information on the effect of consumer handling of foods on growth and survival of food borne pathogens is woefully inadequate. This leads to food safety experts giving consumers generalized recommendations that are often too extreme to be adopted, and as a consequence, may lead to a failure of targeted groups to adopt desired behavior modifications.

Finally, not enough is known about human disease targets and factors that influence the ability of microorganisms to cause disease (including infectious dose and virulence). The latter is especially important, as very little research has been done to identify the effect of processing factors on virulence of pathogenic microorganisms.

LGU Capacity: Most of the research on pathogenic microorganisms in foods has been done in laboratories at LGUs, the Centers for Disease Control and Prevention (CDC), Food and Drug Administration (FDA) and the USDA's Agricultural Research Service (ARS). These organizations have contributed much to our knowledge of the sources and characteristics of microorganisms; on the effects of pre-harvest and post-harvest control methods; and on the overall control of many of the food borne pathogenic microorganisms. Because these organizations have vast experience with microorganisms, their sources, the products, and processes used for their control, it is important that they lead the way in developing and carrying out future research designed to control these pathogens. The LGUs are also unique in their ability to study food borne pathogenic microorganisms; literally from the farm to the table because their research faculty deals with all areas of food production, processing and delivery to the consumer.

Knowledge Gaps: While there is considerable information available concerning the occurrence and control of bacteria in foods, much less is known about other microorganisms and the newly emerging pathogens. Even for most traditional food borne bacterial pathogens, there are major gaps in our knowledge. These gaps include needed information on:

- Specific sources of food borne pathogenic microorganisms;
- The level or number of pathogenic microorganisms on foods;
- The significance of the relationships of pathogenic microorganisms with natural, nonpathogenic contaminants on foods;
- The interaction of pre-harvest handling or processing procedures on subsequent post-harvest survival or growth of pathogens (e.g., resistance development);
- Systematic information on the effect on pathogens of many commonly used post-process control measures (e.g., food antimicrobials; newer processing techniques)

- Effects of consumer handling methods on growth and survival of food borne pathogens; and,
- The influence of pre- and post-harvest handling techniques on pathogen virulence.

Federal funding agencies should give strong consideration to coordinated funding of research projects in areas where food safety information gaps have been identified. The results of such research should provide valuable knowledge that will serve as the basis for the development of food safety education and outreach programs, especially for previously under-served groups.

TOXINS: Foods contain numerous substances that have the potential to be hazardous under certain exposure circumstances. Each year, several hundred episodes of food borne disease of chemical etiology are reported to the CDC. Undoubtedly, many more such toxin-induced incidents likely occur but are never reported.

Food can contain potentially hazardous substances arising from a variety of sources. One of the major sources would be naturally occurring toxicants. Many examples exist of naturally occurring toxicants ranging from carcinogens to the neurotoxins responsible for paralytic shellfish poisoning and ciguatera poisoning, to a host of different toxicants present in the many species of poisonous mushrooms. Some organisms naturally contain sufficient levels of hazardous chemicals that are not considered safe to eat. The poisonous mushrooms are an example.

A source of food borne toxicants arises from environmental pollution caused by industrial chemicals. A primary example would be polychlorinated biphenyls that find, on occasion, their way from environmental spills into certain foods.

Another potential source of food borne toxicants is the various agricultural chemicals, including pesticides. Pesticides are covered in another section of this document.

Food additives represent a source of food borne chemicals that sometimes engender toxicological concerns. However, food additives are continuously evaluated and regulated, and usually do not represent food hazards when used according to good manufacturing practices.

Finally, accidental contamination of foods can occur in food service facilities or homes. Many of the heavy metal intoxications reported to CDC are the result of inappropriate storage of acidic foods and beverages in containers that leach heavy metals, such as lead, into the products.

Consumers wish to avoid foods that might contain hazardous levels of various toxicants. The safety evaluations conducted on food additives and agricultural chemicals are designed to protect consumers from any potential hazards associated with their use in foods. The LGUs have a limited role in the evaluation of the safety of chemicals intentionally added to foods because that is the responsibility of the private sector companies that commercialize those uses. However, LGUs can and do play an important role in assessing exposure to such intentionally added chemicals and the adherence to good manufacturing practices. LGUs can also play a role in identifying new hazards that may be associated with intentionally added chemicals, especially chemical interactions. Thus, the major role of the LGUs in food toxicology is the evaluation of the hazards potentially posed by naturally occurring substances in foods. Foods contain uncounted numbers of naturally occurring chemicals, the majority of which are safe under most circumstances of exposure. However, safety evaluations have been conducted on only a fraction of those naturally occurring chemicals. Much research remains to be done with development of analytical methods for exposure assessment, dose-response studies in experimental animals to determine potential hazards, and metabolic studies to determine the suitability of animal models to evaluate the risk to humans.

Several emerging areas should focus more attention on food toxicology. Food allergens are highlighted in another section are one example.

Another concern is the increasing popularity of dietary supplements and nutraceuticals (defined herein as any substance that may be considered a food or part of a food that provides medical or health benefits, including the prevention and treatment of disease). There is a concern that these products are increasing exposure to naturally occurring chemicals. In many cases, the safety of these products, especially those with chemicals at elevated doses, has not been carefully assessed. Assessment is often complicated the need for unique analytical methodology to identify and characterize the components of such materials.

Finally, the advent of genetically modified foods mandates that the safety of such foods be compared to their conventional counterparts. In many cases, limited information is available on the types and amounts of potentially hazardous, naturally occurring chemicals in the conventional counterparts, which makes such comparisons very difficult.

LGU Capacity: With respect to research, LGUs currently have limited, but critical, institutional resources in food toxicology. Only a few LGUs have food toxicologists and many of those scientists are focused on pesticide residues and toxicity. Accordingly, a dearth of research is being conducted on naturally occurring toxicants. Research funding has been limited for food toxicology, which further contributes to the lack of institutional capacity. With the recent emergence of issues related to dietary supplements, nutraceuticals, and genetically modified foods, the resources at LGUs to handle the increased research needs seem grossly inadequate. The federal government similarly lacks resources in this area, so the contribution of the LGUs is critical.

Cooperative Extension offers an excellent national capacity to train food and food service industry personnel and consumers on issues relating to food toxicology. However, the amount of training that currently occurs in this particular food safety area would be categorized as very modest.

Perhaps one of the best roles for the LGUs would be to include instruction on food toxicology in courses on food science and technology. However, only a few LGUs offer such instruction at the current time.

Knowledge Gaps: The area of food toxicology is vastly under-served with respect to research, teaching, and Extension. Critical gaps in information and dissemination of information abound.

In research, the LGUs should play an increased role in hazard identification, especially with respect to naturally occurring chemicals in foods. This research should involve the identification of potentially hazardous chemicals through research on appropriate experimental animals and *in vitro* models. This research should also involve the development of appropriate methods that are needed for the detection of potentially hazardous chemicals in foods. The LGUs should conduct research on the dose-response relationships especially with respect to naturally occurring chemicals to determine which chemicals represent the greatest hazards. Research on exposure assessment is also needed to help characterize the risk. The LGUs might also conduct research on methods to lessen the hazard through processing and other approaches.

Certainly, increased institutional focus is needed on the safety assessment of dietary supplements and nutraceuticals, since consumer exposure to these substances is increasing rapidly. The private sector is not required to conduct safety assessments on these materials but the risks posed by these substances, especially to certain population groups, may be significant in some cases. And, the LGUs must get involved in the safety assessment of foods produced through agricultural biotechnology. The scientific reputation of the LGUs will add credibility to the research results.

In Cooperative Extension, training is needed for Extension specialists, food and food service industry professionals, and others. Nationally, many more training sessions are needed to begin to do an effective job with this immense task.

In teaching, the addition of food toxicology into the curriculum of food safety courses should be adopted on a much wider scale.

PESTICIDES: Pesticides are commonly used in the U.S. and worldwide to protect agricultural products from damage caused by pests such as insects, plant diseases, and fungi. Pesticide use frequently allows agricultural producers to increase their crop yields and extend their production seasons. Epidemiological studies have indicated that human diets including ample consumption of fruits, vegetables and grains can significantly reduce one's risk of heart disease, certain types of cancer, and many chronic diseases. Pesticides serve as important tools to ensure that a wide variety and abundance of these agricultural products are available to consumers at affordable prices.

Pesticides also pose potential risks to consumers due to the presence of pesticide residues in foods. In a few instances, pesticide residues in foods have been linked with actual cases of human poisoning; residues of the insecticide aldicarb illegally used on watermelons, for example, were implicated as the cause of more than 1,000 illnesses in the Western U.S. and Canada in 1985. More commonly, food safety concerns regarding pesticides have focused upon theoretical risks of developing long-term chronic health effects such as cancer. Such concerns remain highly controversial, as present epidemiological methods are incapable of establishing such correlations.

Recent interest has focused upon the potential risks of infants and children from pesticides in the food supply. Physiologically, according to a 1993 landmark report of the National Academy of Sciences (NAS), infants and children cannot be considered to be merely small adults. In some cases, they may be more sensitive to the effects of pesticides than their adult counterparts (even after adjusting for body weight differences), and their exposures to pesticides are commonly greater because they consume more food per kilogram of body weight than do adults.

The Food Quality Protection Act (FQPA) was passed unanimously by Congress and signed into law in 1996. Major provisions of FQPA are derived from recommendations of the 1993 NAS report. These include the consideration of the:

- Potential susceptibility of specific population subgroups, such as children to pesticides;
- Aggregate exposure to pesticides in drinking water and in the residential setting, in addition to pesticide residues on/in foods; and,
- Cumulative risks from exposure to all members of a family of pesticides possessing a common toxicological mechanism of action.

The more stringent requirements of FQPA are likely to result in the elimination of many pesticide uses that were not previously considered to pose any significant dietary risk. The organophosphate and carbamate insecticides, for example, represent families of pesticides that account for approximately 70 percent of all agricultural insecticide use in the U.S. The cumulative risk provision of FQPA is likely to render the dietary risks from these families of insecticides as excessive and several uses of these chemicals may be eliminated.

FQPA requires the U.S. Environmental Protection Agency (EPA) to use sophisticated risk assessment methods to justify their regulatory actions. Unfortunately, such methods are still in the process of development. As a result EPA faces statutory deadlines for making some regulatory decisions in the absence of appropriate risk assessment methods. Methodologies must be developed to generate and incorporate data concerning factors such as pesticide use practices, food consumption, residue levels, and post-harvest effects (for example, washing, cooking, processing).

In the event that risk assessment methods prescribed by FQPA indicate that elimination of specific uses of pesticides is warranted, the loss of such uses could have significant impacts upon subsequent agricultural practices. Risk management decisions need to consider the potential impacts of the use of alternative pesticides (if available) on food production, food safety, worker health, environmental effects, and impacts upon existing integrated pest management (IPM) practices.

LGU Capacity: LGUs have not been traditionally strong in terms of pesticide food safety research. While there is some expertise with respect to pesticide residue analysis, most food safety researchers in food science and/or nutrition departments have focused on pathogenic microorganisms or mycotoxins in food while those in the fields of toxicology and crop sciences frequently concentrate on pesticide environmental fate, ecotoxicology, and worker safety. The practice of dietary pesticide risk assessment is still in its scientific infancy and efforts of LGU scientists are needed to improve the process, validate critical assumptions, and guide EPA's risk assessment and implementation efforts *vis-à-vis* FQPA.

With respect to research/outreach activities, Cooperative Extension possesses considerable expertise in pesticide use and pest management activities. Many LGUs are active in USDA's National Pesticide Impact and Assessment Program (NAPIAP). This program has coordinated the development of crop profiles. The crop profiles are critical documents that identify realistic pest management practices, the availability of pesticide alternatives, and the potential impacts resulting from the elimination of specific pesticide uses on agricultural productivity and/or pest management practices. Such efforts were initiated rapidly in anticipation of significant restrictions on pesticides through EPA's FQPA implementation. Extension personnel need to continue to develop and improve crop profiles to allow the information to become both uniform and comprehensive. Information gleaned from the crop profiles can effectively guide EPA in both its risk assessment and risk management practices.

Instruction concerning pesticide residues in food is relatively limited in the LGU system as most food safety attention has primarily focused upon microbiological contamination of foods. Systems for pesticide regulation and risk assessment in the U.S. and throughout the world are complicated and require greater understanding among researchers, instructors, producers, regulators, legislators, and the consuming public to protect the public health and to ensure optimal decision making. Educators also need to expand their efforts to include risk communication as a companion to risk assessment and risk management.

Knowledge Gaps: Under FQPA, the EPA is instructed to make its risk assessments on the basis of reliable and available data. In many cases, such data does not exist and EPA may rely upon more conservative assumptions that may overstate exposure and could lead to inappropriate regulatory decisions. A large gap exists in the scientific understanding of the impacts of various post-harvest treatments such as washing, peeling, cooking, and processing foods. Limited evidence suggests that such treatments may dramatically change residue levels. In most cases, residue levels are reduced significantly while in other cases residues may concentrate or be converted to other chemical constituents possessing unique toxicological properties that could influence risks.

Pesticide use practices need to be defined more clearly. Presently, there is no national uniformity concerning how pesticide use is reported. An improved understanding of pesticide use practices could provide a logical starting point to improve the assessment of risk and to anticipate potential changes in risks resulting from elimination of specific pesticide products.

The development of sophisticated computerized models to estimate pesticide exposure and risk has traditionally been undertaken by proprietary consulting organizations, to the exclusion of the academic community. Significant efforts are underway to develop publicly funded state-of-the-art software available in the public domain capable of aggregate and cumulative pesticide risk assessment. Such software could provide tremendous benefits to academicians involved in risk assessment activities as both a research and an outreach tool.

The influence of pesticide use on levels of naturally occurring toxins is not well understood at present. While it has been theorized that pesticide use could improve food safety by limiting production of plant toxins through stress minimization or by reducing fungal populations capable of producing mycotoxins (such as aflatoxins and fumonisins), very little direct evidence exists. A small number of studies have also suggested that pesticide use could increase natural toxin levels.

While science provides the basis for many of the regulatory decisions concerning pesticides and food safety, a variety of political, philosophical, and economic factors also influence the decisions. Scientists need to gain a greater understanding of risk communication theory and apply it to their own work as an aid in ensuring that their research and outreach efforts are most optimally utilized in food safety decision-making processes.

ALLERGENS: Food allergies and sensitivities affect approximately 2-2.5% of all U.S. consumers. True food allergies mediated by allergen-specific IgE antibodies are the most serious health issue in this category. Symptoms can range from mild to transitory to severe, life-threatening manifestations. It is estimated that 100-200 Americans die each year from inadvertent ingestion of allergenic foods. Infants and young children experience food allergies more frequently (4-8% prevalence) than do adults.

Eight foods or food groups (peanuts, soybeans, tree nuts, cows' milk, eggs, fish, crustacea, and wheat) account for more than 90% of all food allergies on a worldwide basis. However, more than 160 other foods have been implicated in the remaining 10% of true food allergies. Basically, any food that contains protein (since most allergens are proteins) can elicit an allergic reaction at least on rare occasions.

Celiac disease is another form of food sensitivity that affects perhaps 1 in every 2000 Americans. Celiac disease is associated with intolerance to the ingestion of wheat, rye, and barley. Celiac disease affects the absorptive function of the small intestine and is associated with intestinal symptoms and symptoms associated with nutritional deficits created by the malabsorption effect. Individuals with celiac disease are also at increased risk of several chronic illnesses including lymphoma.

Various non-immunological food intolerances also occur. Some, such as lactose intolerance, are very well understood. Lactose intolerance afflicts a large number of Americans, although symptoms are comparatively mild. Others, such as sulfite-induced asthma, are well documented to exist but are poorly understood. And, in other cases, the cause-and-effect relationship between a specific food or food ingredient and a particular set of symptoms in susceptible individuals has not been firmly established.

Individuals with food allergies and sensitivities must avoid the foods or food ingredients to which they are sensitive. But, especially, in the case of true food allergies, exposure to even trace amounts of the offending food can elicit severe adverse reactions. Thus, residual allergens existing in other products from use of shared processing or preparation equipment, inadequate cleaning practices, and other issues can be sufficient to trigger allergic reactions.

Better methods are needed for the detection of potentially hazardous residues of allergenic foods and the food industry needs to design and implement better quality control procedures to avoid the transfer of allergenic residues into products where they do not belong. In addition, the entrance of genetically modified foods into the marketplace has created concern among some about the possibility that novel allergens may be genetically inserted into these foods.

Allergy assessment must be an important part of the safety assessment process for genetically modified foods. But, by the same token, biotechnology also offers the promise that allergens might be removed from commonly allergenic foods. With food sensitivities, further exploration of cause-and-effect relationships and mechanisms are needed.

LGU Capacity: With respect to research, the LGUs currently have limited but critical important resources to deal with food allergies and sensitivities. Despite the recent emergence of food allergies and sensitivities as important public health issues, few scientists at LGUs are currently conducting research in this area. However, food scientists, food analysts, and protein biochemists have the skills needed to address many of the most important issues. Since some LGUs also have medical schools and dietetic programs, the opportunity exists for the development of collaborations on the important clinical issues related to food allergies and sensitivities. Moreover, this entire research area is vastly under-served, especially in comparison to the amount of suffering experienced by the sensitive segment of the population.

Cooperative Extension offers an excellent national capacity to train food and food service industry personnel and consumers on issues relating to food allergies and sensitivities. However, the amount of training that currently occurs in this particular food safety area would be categorized by most experts as very modest.

Perhaps one of the best roles for LGUs would be to increase food allergies and sensitivities instruction using an integrated approach into the curriculum in fields such as food science and technology, nutritional science and dietetics. However, to date, little such instruction occurs within the LGU System.

Knowledge Gaps: Methods are needed for the detection of potentially hazardous residues of allergenic foods that might contaminate other foods. Immunoassay methods show promise and have been developed for peanuts, eggs, milk, and wheat. But many more such methods are needed.

Clinical research is needed to determine the threshold doses required to elicit allergic reactions in the sensitive segment of the population. And surveys are needed to determine the extent of contamination of the food supply with unexpected allergenic food residues. Research is also needed to develop effective cleaning practices that the food industry can implement to avoid transfer of allergens with shared equipment. The effect of food processing on allergens should also be assessed.

Many food ingredients are derived from allergenic sources, and the allergenicity of these ingredients must be determined. Only a few of the many allergenic food proteins have been purified and characterized. Clearly, more basic research of this type is needed.

Nationally, many more food allergy-training sessions are needed to do an effective job with this immense task. Cooperative Extension has the opportunity and challenge to offer food allergy management training to Extension agents/educators, food and food service industry professionals and workers, school food service workers and nursing staff, to name a few. To successfully fulfill this task, Cooperative Extension faculty must be fully knowledgeable in the interrelationships among food technology, food science, and dietetics.

In teaching, the addition of information on food allergies and sensitivities into food safety courses should be adopted on a much wider scale.

EMERGING PROBLEMS

A number of "new," "emerging," "re-emerging" or "evolving" pathogenic microorganisms have been associated with documented food borne illness episodes in the past 20 years, and the number of these events seems to be increasing. These agents may be classified as biotic and environmental. Some recently emerged, and now commonly encountered biological problems are: *Listeria monocytogenes*, C*ampylobacter jejuni*, *Escherichia coli* O157:H7 and other enterohemorrhagic *E. coli* serotypes, *Salmonella* serotypes Enteritidis and Typhimurium DT 104, *Cyptosporidium parvum*, *Cyclospora cayetanensis,* and certain viral agents. Many factors no doubt relate to the emergence and subsequent recognition and persistence of food borne problems. These include increased virulence of microorganisms, changes in social attitudes and eating habits, changes in food production and distribution systems, an increase in the number of immune-compromised individuals, and improved pathogen detection systems.

Intensified research and testing in recent years have indicated continuous adaptation and development of resistance by pathogenic bacteria to antibiotics and to the traditional food preservation barriers of low pH, heat, cold temperatures, dry or low water activity environments, and chemical additives. Microbial pathogens are the major cause of food safety problems in terms of outbreaks, cases, and deaths.

Furthermore, there is evidence of strains of pathogens with enhanced ability for survival in their hosts, low infective doses, and increased virulence, sometimes after exposure to common environmental stresses. These findings indicate that the microbial ecology of our food supply is undergoing changes that go along with the modernization, taking place in our food processing and distribution industries, and the multifaceted transformation of our society with new and complex demands for foods.

Environmental factors associated with variations in geographic location and climate, as well as natural stresses may induce biological changes and lead to new or enhanced virulence. Food-related factors that may encourage pathogen emergence, increased resistance or enhanced virulence include:

- Changes in food production and harvesting practices;
- Modifications in food processing operations;
- New marketing practices;
- Modern food preparation methods; and,
- Development of new food products to address consumer preferences and lifestyles.

As the number of pathogenic microorganisms documented as being transmitted through food has increased, so has the number of foods being involved in food borne illness. A variety of food items, which were not previously associated with confirmed food borne illness episodes, have been linked with transmission of microbial food borne illness in recent years. It is a fact that only a small portion of food borne illness episodes are reported and investigated annually, and that in less than 50% of those cases reported is the cause identified. Still-to-be discovered causes might be responsible for a portion of the remaining unresolved cases, currently classified as "caused by unknown agents". Additionally, only a small fraction of these microbes are culturable with existing methodology.

The above points indicate the challenges that need to be addressed, and they emphasize the need for control of known, emerging and unknown causes of food borne illness in order to enhance the safety of our food.

LGU Capacity: The LGUs have traditionally been leaders in food safety research that has generated new scientific knowledge and trained scientists to deal with known and newly recognized or emerging causes of food safety problems. Therefore, it is imperative that this resource in knowledge, expertise and laboratory infrastructure to become a major part of the efforts to generate and share scientific knowledge dealing with emerging food safety issues and concerns. In cooperation with the CDC, FDA, and the ARS, LGU scientists can be major contributors to the generation of knowledge needed to control emerging food borne illness agents.

Knowledge Gaps: Emerging agents of food borne illness need concerted research efforts to examine various aspects necessary for their control. Research dealing with emerging food safety problems should address the problem of pathogen identification, detection methodology, sources and ecology, properties, microbial resistance issues, and procedures for control.

Knowledge of emerging pathogen ecology throughout the food chain can be instrumental in determining risk factors and niches, and in developing intervention strategies for their control. Pathogen control procedures are needed to assure food safety by preventing, reducing, inhibiting, inactivating, or eliminating pathogens. Use of predictive models can allow determination of the contribution of traditional, novel, physical, chemical and biological methods to control pathogens. Studies should address various aspects, including microbial detection, adhesion, penetration, removal, biofilms, inactivation, resistance, injury, inhibition, competition, culturability, superdormancy, mechanisms, and microbial and environmental interactions.

One concern that needs to be addressed is the observation that pathogenic bacteria develop resistance to antibiotics and to traditional preservative barriers such as low pH, cold, heat, water activity, disinfectants, and preservatives. Furthermore, the application of microbial control methods should be evaluated in association with their influence on practicality of application, quality and acceptability of treated foods, economics of application, and risks associated with potential subsequent contamination or product abuse.

Setting specific research targets and objectives should be based on the application of quantitative risk assessment to determine intervention points with major impact on food safety enhancement.

DETECTION

The ability to monitor food processing environments and foods for the presence of disease-causing organisms is a central tenet of protecting public health and well being. Successful microbial analysis of foods is needed in a comprehensive food safety assurance approach. However, standard methods for bacterial detection, identification, and enumeration are sufficiently expensive, tedious, and time-consuming that large-scale monitoring of the food supply and processing environments for the presence of pathogens is currently technically impossible. Standard methods rely on the ability of organisms present in foods to grow on specially prepared media in the laboratory. Confirmation of the presence of a specific organism may take several days. Clearly, the need to wait for results under these analytical time frames impedes timely and appropriate distribution of highly perishable foods. Current food protection strategies thus must rely upon representative sampling and analyses of very small quantities of food substances as well as on the ability to monitor the prevention or elimination of product contamination (e.g., Hazard Analysis Critical Control Point programs).

Newly emerging analytical technologies, such as those based on immunocapture of pathogens in complex matrices or rapid detection of specific genetic “signature” sequences present only in bacterial pathogens, for example, are gaining acceptance in testing laboratories, and show considerable promise for more rapid detection of possible pathogens. Successful development of effective new pathogen detection strategies will require research that is integrated across multiple scientific disciplines and that involves both public and private stakeholders. To gain widespread adoption, these new tools must be rapid, reliable, sensitive, specific, and affordable. Furthermore, there is a need for research on sampling methods and schemes, and on sample preparation protocols, for microbial detection to be an effective contributor in the effort to reduce food safety risks.

LGU Capacity: Considerable research is already ongoing in the field of rapid pathogen detection. However, despite the existence of a large number of scientific publications describing rapid detection and subtyping methods, very few of these new methods are actually commercialized or adopted by the food industry. Effective partnerships with the private sector are needed to produce new and improved detection methods, which can and will actually be used by the food industry and laboratories.

The LGU System is already established throughout every state in the U.S. Information delivery mechanisms include workshops, training programs, and written information on the latest technical innovations in various scientific fields. These programs and materials could be designed to specifically target food testing laboratories and small- to medium-sized food processing operations with limited technical resources. Strategies will be needed to bridge the interface between the physical and biological sciences for successful development of pathogen detection technologies.

Knowledge Gaps: To ensure the safety of foods, an ideal food monitoring strategy should provide nearly instantaneous feedback on the presence of harmful organisms, within the limitations of sampling protocols. This needs to be done with a statistically significant quantity of a given food substance at an early-enough point in the food system (environment or product) to prevent distribution of potentially hazardous foods. This type of strategy would require “real-time” detection capabilities based on the development of appropriate biosensors.

Many scientists across the U.S. are working toward developing strategies that could contribute to the development of biosensors and to other rapid detection strategies (e.g., Polymerase Chain Reaction-based detection strategies), but these (typically individual) research projects lack integrated national or even regional or local coordination. The result is the establishment and propagation of competing rather than cooperative research programs. Furthermore, effective food industry/government/research scientist partnerships must evolve to ensure that research findings become available for application and commercialization. This step is essential for development of affordable strategies for rapid food hazard detection.

INTERVENTIONS AND CONTROLS

Better control of the introduction of food borne hazards during pre-harvest production could reduce or minimize the need for additional steps that would otherwise have to be applied to post-harvest processing to achieve food safety preservation and safety. The food processing industry, with considerable knowledge input from the LGUs, has developed control measures designed to detect and reduce food borne hazards, while new chemical and physical methods are being evaluated constantly. Thus, it is reasoned, pre-harvest controls combined with post-harvest strategies are the most effective approach to food safety assurances through intervention and control.

The challenge for intervention and control does not end with pre-harvest or initial post-harvest processing efforts. Recontamination and/or residual hazard amplification in products that are considered safe after processing (i.e., ready-to-eat**?** and warm-and-eat foods) can occur during storage, transport, marketing, and final preparation. Additional challenges come when one considers minimally processed foods that are consumed without any further treatment. Intervention strategies and controls must be deployed and encouraged beyond the initial processing. However, for intervention and control strategies to be most effective they must target critical points ranging from production to consumption.

LGU Capacity: The LGU System has today the capacity to develop and test hazard control and intervention strategies in model systems. While mostly in limited cases, the LGUs can run tests under commercial production and processing environments. Obviously the use of hazardous agents for testing in commercial settings poses significant health, regulatory, environmental, and economic obstacles. Strategies that can be used to resolve these obstacles include the use of non-hazardous indicator agents (a.k.a. surrogate hazards) and mathematical modeling based on laboratory or pilot plant data. Although both approaches provide valuable data, in some cases validation under commercial conditions with the actual hazard may be essential. This is because information on validated technology collected under real world conditions is more quickly adopted by industry, and more acceptable to regulatory agencies and consumers.

Concurrent agreement by all stakeholders significantly speeds information and technology transfer. With the continuing emergence of new hazards and/or evolution of known hazards, testing and technology transfer must be facilitated. Historically, most food safety concerns have been largely confined to hazards that are common to the food supply. The picture becomes considerably more complicated if a non-typical or emerging hazard is introduced either accidentally or intentionally. We must therefore expand our capabilities to address potential emerging hazards and validate intervention strategies and controls for all foods and for all reasonable circumstances.

Knowledge Gaps: Even though the LGUs have adequate capacity to evaluate hazards and their control in model systems, there are additional needs. The LGU System needs to have the expanded capability to evaluate intervention strategies and controls for actual hazards under commercial-scale conditions. As mentioned above, this will expedite information and technology transfer.

RISK ANALYSIS AND COMMUNICATION RESEARCH

The national Food Safety Strategic Plan identified risk assessment, risk management, and risk communication as a framework for science-based and coordinated regulation, inspection, enforcement, research, and education programs. These components are considered to be critical for the success of the strategic plan. To implement the plan, three issues should be addressed:

- Effective Risk Assessment and Implementation;
- Risk Management Tools and Financing; and,
- Science-based Risk Communication.

Effective Risk Assessment and Implementation: The major risk assessment challenge facing the transition from the traditional **qualitative visual inspection** to a **preventative system** like HACCP is its effective implementation. It is necessary to ensure proper HACCP validation, implementation, and operation. Although the effort is already underway, there is a need for much more effective implementation of hazard control strategies. The emphasis is currently on biological risk assessment**.** But there is also a need for well-coordinated biological, behavioral, and economic risk assessments.

Risk Management Tools and Financing: The major issues in the science of risk management are to identify the least-cost alternative with the greatest marginal impact for reducing risk, and to determine the cost-risk trade-off for who is liable to pay for food safety hazards. Although much research has been accomplished to compare least-cost regulatory strategies, very little has been accomplished at the industrial firm level. This creates a major implementation conflict, and the likelihood for hazardous behavior.

Science-based Risk Communication: Experts are correct in noting a need for additional scientific research on food safety risk communication. The areas in need of attention are:

- Risk communication science relies too strongly upon psychometric approaches that assume a stimulus-response model of risk education-behavior. Risk communication science needs to draw upon social science research on the diffusion of innovations to understand how risk perceptions are socially constructed through interactions of consumers, scientists, industry representatives, the media, and food safety opinion leaders.

- Scant research exists on the process of consumer risk perception formation. Improved understanding of consumer risk perceptions requires longitudinal research on the factors that affect perceptions over time.

- Food production and processing will become increasingly technological and complex. Therefore, research is needed on discovering general patterns of consumer risk decision-making that might be expected to occur over time.

LGU Capacity: Microbial testing for evaluation of hazards and methods for their control are significant components of risk assessment. Scientists at LGUs can undertake studies to provide data necessary for valid risk assessment and management efforts.

The Extension and research faculty need to continue activities in all of these areas are available at the LGUs, but effective coordination and organization are required.

Knowledge Gaps: Effective risk assessment development teams should incorporate behavioral science researchers who would add to our understanding of the human factors that influence decision making for a safe food system. As well, we need to establish formal linkages between the LGUs and government agencies with complementary expertise.

Also, coordinated and continuous funding for food safety teaching, research and Extension efforts is essential for success. There is also a need to generate and make available supporting food safety data for all three functions (i.e., teaching, research, and Extension), on a continuous basis

EDUCATION

A comprehensive and seamless food safety program must provide food safety education to a variety of audiences. This should include (but should not be limited to):

- Degree seeking students;
- Consumers (youth and adults, including those groups at high risk for developing food borne illness, such as young children, pregnant women, older adults, and immune-compromised individuals);
- Food processors;
- Retail and institutional food handlers;
- Food transportation workers;
- Teachers and health professionals;
- Veterinarians; and,
- Food producers.

A major challenge is to create training and educational programs that address the food-related risks relevant to each audience. Research is an important element in identifying critical components of training and education programs and targeting those programs to the appropriate audiences at all stages along the food chain.

FORMAL DEGREE PROGRAMS

We believe that there are four issues that need to be considered in the assessment of undergraduate and graduate course offerings in food safety. These four major considerations are:

- The content and scope of traditional and non-traditional programs;
- The potential job market for graduates;
- Models to finance these programs; and,
- The institutional teaching capacity that is available.

*Content and Scope***:** Degree programs for both traditional and non-traditional students must cover food safety issues from farm to table. No one academic department can cover this spectrum. Teaching faculty that span disciplines must come together across college lines to put an effective food-safety course offering together.

Developing distance education degree programs might be more fitting for non-traditional students (current employees, those in the military, etc.) The challenges are whether or not they can conveniently do laboratory classes

Job Market: Non-traditional students have an advantage when entering the job market because they most likely will have had work experience in food safety. For traditional students, this has been a major issue. This raises the question…. How big is the job market, and should all of the LGUs engage in degree program offerings? This question needs to be answered before we 'over-invest' in food safety curriculum development.

*Models to Finance Degree Programs***:** Challenge grants might be offered to 'jump start' degree programs for institutions that can pull faculty from all disciplines to collaborate in food safety curriculum development. To be effective, all food safety aspects from farm-to-table should be covered.

Teaching capacity that is available: Institutions that are willing to contribute to the education of food safety specialists must have the existing capacity, or the resolve to add the faculty that can support a comprehensive food safety degree program.

ADULT EDUCATION

FOOD PROCESSORS: Processors of all sizes need to be made aware of their role in food safety and how they can prevent food contamination through educational programs. This might best be done by the LGUs and other public institutions and government agencies through public-private sector partnerships, and through train-the-trainer programs designed specifically for industry.

CONSUMERS: Despite educational efforts, food borne illness remains prevalent throughout the United States. Food handlers at each stage of the food chain lack knowledge of food safety risks and related safe food handling practices. The consumer is expected to make informed decisions about food choices and handle and maintain food in a safe and responsible manner. But without the knowledge of food safety practices and proper food-handling procedures, food borne illness cannot be significantly reduced. To assist the consumer, there must be improved consumer education about food safety. Food safety education programs should be developed to reach individuals at each stage in the food chain, from field to fork.

RETAIL AND INSTITUTIONAL FOOD HANDLERS: Food service workers, food managers, retail and other institutional food handlers must be made aware of how they can prevent food contamination and reduce pathogen growth. HACCP can help define where education and training must be provided. No doubt a strong emphasis on teaching food handlers how to develop and implement HACCP plans will be needed. Those responsible for the transportation of food are often unaware that mishandling of food during shipment can result in contamination, and this gap also needs to be addressed through education.

EDUCATORS, HEALTH PROFESSIONALS, SCIENTISTS: Health professionals and physicians need specific knowledge about causes and effects of food borne illness to more effectively detect and treat illnesses. Producers of animals used in human food production and veterinarians treating such animals must be made aware of food safety aspects of drugs and drug residues. Professional societies, such as the American Society for Microbiology, the American Dietetic Association, the Institute of Food Technologists, and the International Association for Food Protection could play a valuable role in bringing scientists from different areas together to provide a multidisciplinary approach to food safety issues. Collaborations among scientists from the areas of clinical microbiology, food microbiology, animal health and production, microbial ecology, and epidemiology might be effective means for addressing a number of food safety issues.

LGU Capacity: LGU faculty have a firmly-established track record for developing and implementing food safety training and education programs for a variety of audiences, from producers to consumers. The grassroots Extension network, available through the LGUs, has enabled LGU researchers and educators to rapidly identify emerging issues in food safety and their potential impacts on various audiences across the U.S. and its territories.

The LGUs have food safety teaching, research and Extension faculty, libraries, and laboratory facilities to meet these degree program challenges on many campuses. But there is at present no formal study of the actual teaching, research, or Extension capacity within the LGUs that was known to the Task Force.

Funding from a variety of sources, including competitive grant funding, has enabled Extension faculty to help these diverse audiences translate research-based food safety information into sound, practical behaviors that reduce the risk of food borne illness across the food chain. Traditionally, Extension has placed a special emphasis on providing:

1) HACCP education and training to food processors, food service workers and other retail and institutional food handlers;
2) Train-the-trainer educational programs that prepare teachers, health professionals, and other ‘multipliers’ to develop and implement food safety education programs in their respective settings; and,
3) Consumer education that focuses on the needs of under-served or hard-to-reach audiences or other groups at high risk for developing food borne illness and other food and health-related illnesses.

Knowledge Gaps: For each of the respective audiences listed above, research is needed to determine what factors influence food safety behaviors. Additional research is also needed to determine key behaviors that put consumers and other food handlers at risk for developing food borne illnesses. Once these key behaviors are identified, research is needed to determine the most appropriate educational methodologies for transferring food safety messages to the various food safety audiences, and how to successfully motivate behavioral changes consistent with recommended food handling practices.

A state-of-the-art national information network is needed to provide for the rapid flow of information among all those who make food safety decisions and influence food safety policies, from consumers, to regulators, to government officials. To this point, the LGUs are uniquely positioned to rapidly disseminate information to local communities, health departments, departments of education, schools, and other organizations where time-sensitive food safety information is crucial. Since 1991 educational materials and resources in food safety have been developed by the LGUs using plans of work and competitive grant funds available to LGU faculty . The LGUs should now evaluate the materials and educational resources that have been produced, and identify state-of-the-art, science-based food safety courses and materials that are effective for the various food safety audiences across the food continuum.

The LGUs have an effective means of technology transfer through the use of Extension specialists and agents. The LGUs have Extension agents or educators trained in many different specialty areas who can target a particular segment of the food chain. However, one area lacking capacity is food science. The LGUs need to hire agents or educators in the field who are trained in food science. These individuals would then be able to coordinate food safety training.

Effective networks among the major food safety players are missing. This is a detriment to teaching, research, and Extension. But the consequences for classroom teaching are perhaps more significant. Without teaching-capacity-planning it is likely that either too many or too few food safety specialists will be ready for our future needs. Developing a network of food safety players should foster more communication and facilitate planning for human resource capacity needs.

Extension should develop specialized training for food and related industry personnel so that they can become more familiar with this important area of food safety.

COMMUNICATIONS AND COORDINATION

The sharing of information within the LGU System of food safety is an important activity that needs to be facilitated in ways to support the implementation of the Food Safety Strategic Plan. Various types of information communication and coordination are considered in this section.

RISK COMMUNICATION

The transfer of knowledge in food safety practices often entails communication of the risks associated with certain practices. Understanding human behavior (e.g., psychological, sociological, cultural) and perceptions is critically important to changing risky behavior. Access by teachers and faculty to educational information on food safety topics, and the coordination of educational activities is critical to the success of any national effort to reduce food borne hazards through education.

According to annual Food Marketing Institute surveys, public confidence in the safety of the food supply vacillates. These shifting views may be linked to perceptions of current food safety risks. Widely publicized food borne illness outbreaks tend to undermine public confidence in food safety. Yet, these are teachable moments for food safety education. Education in safe food handling can give the public a sense of control. This, in turn, can help consumers accept responsibility for their role in keeping food safe.

Studies have shown that food safety knowledge isn't necessarily correlated with safe food handling behavior. Risk perceptions may be an intervening variable. Consumer perceptions are often based on qualitative aspects of risk (the so-called outrage effect) rather than on quantitative hazards. Scientists often fail to recognize this. Food safety risk communication must take both objective and subjective factors into consideration.

Consumers require additional education about emerging food production and processing technologies. And of equal importance, they require more education on the nature of science - its strengths and limitations. Scientists, on the other hand, require additional education on techniques for communicating risks to consumers and others.

Risk communication involves more than dissemination of scientific results. It entails exchange of information among scientists, consumers, industry representatives, and the media. The impact of this interaction on risk perceptions needs to be investigated.

LGU Capacity: The LGUs have a long history of public education in food safety, consumerism, and family behavior. Networks of county Cooperative Extension offices place Extension faculty in close proximity with their clientele. As an unbiased information resource, Extension faculty can earn the trust of their clientele.

Information Technology (IT) now makes it possible to rapidly disseminate food safety updates to all county Extension staff whom in turn can reach the public. Inter-state communication among Extension Services broadens the resource base.

Cooperative Extension can represent all of the steps of the food chain from producer to processor to consumer. Thus, food safety risk communication can be integrated into a holistic approach. Extension faculty excel at translating research into applied knowledge. In addition, they have the ability to design and conduct program evaluation studies that document impact of risk communication and food safety education.

Knowledge Gaps: A greater understanding is needed about the factors that influence consumer perceptions and decision-making practices *vis-à-vis* food safety. An improved understanding requires longitudinal research on the factors that affect perceptions over time.

Resources (funding and qualified staff) are needed to support educational campaigns that require print and broadcast media strategies for effective dissemination of safe food handling messages.

INTERAGENCY AND PARTNER-TO-PARTNER COMMUNICATIONS

Six agencies in the federal government have primary responsibility for food safety. Two of those agencies, the FDA and the CDC, are under the Department of Health and Human Services. Three agencies are under the Department of Agriculture – the Food Safety and Inspection Service, ARS, and CSREES. The sixth agency is the U.S. EPA.

It is imperative that these agencies work together with partners in academia, industry, professional organizations, and others to identify the greatest public health risks related to food safety, and design strategies to reduce these risks. This is because federal agencies must work more closely together to respond in a coordinated fashion to food borne illness outbreaks and other food-related emergencies. Changes in regulatory policy must be communicated quickly and accurately to all agencies, and messages shared with audiences targeted by those agencies must be simple, accurate, and consistent.

Appropriate participation by representatives of state and local agencies charged with responding to food borne illness outbreaks is needed, and more effective ways for involving the appropriate state agencies must be found. Food service workers, food managers, retail and other institutional food handlers must be made aware of how they can respond to food borne illness outbreaks and other food-related emergencies. It is the LGU partner who most often conveys this information to the various target audiences.

LGU Capacity: Enhanced coordination will enable contributing agencies and partners to assess and catalogue available federal, state, and local resources for food safety education and outreach, and to share those resources with various audiences. The grass-roots Cooperative Extension network, available through the LGUs, makes our institutions uniquely capable of transferring food safety information directly to communities across the U.S. and its territories. Interagency coordination and partner-to-partner communication can be enhanced by IT networks supported by the LGU System. This could become a crucial component of the government-wide information system available at http://www.foodsafety.gov This is one mechanism by which communication can be enhanced among all cooperating partners -- federal, state, and local

Knowledge Gaps: There is currently a need to strengthen the infrastructure for support and coordination among federal, state, and local food safety cooperators. This support and coordination can help to strengthen food borne-disease surveillance programs and enhance interagency/partner-to-partner food borne outbreak response. Support and coordination can also enhance the ability of food safety cooperators to assess and catalogue available federal, state, and local resources for food safety education and outreach. What is needed is a communications plan to provide for the rapid flow of information among all those who make food safety decisions and influence food safety policies ranging from consumers, to regulators, to government officials.

SCIENTIFIC DATABASES

It has become a formidable task to keep up the ever-expanding food safety information resources, even within a narrow area of specialization. The President's Council on Food Safety has placed a strong emphasis on the development of a food safety system based on sound science and risk assessment. Fortunately, as the rate of growth of the scientific literature has accelerated, so have computing and networking capabilities. The development and management of appropriate scientific databases are absolutely essential to a food safety system based on sound science and risk analysis.

Scientific databases don't manage themselves, and are not inherently user-friendly. Those collecting new data must be able to easily input this information into these databases, while those using these data for risk assessment purposes must be able to easily find the information they need. Additionally, existing data in the published literature needs to be gathered, organized and placed in these databases, while high quality unpublished data needs to be identified, peer-reviewed and also entered into these databases. Finally, a mechanism for identifying data gaps in the database, and targeting future research should be in place.

LGU Capacity: As indicated in the section on publications below, libraries have recently begun to serve as clearinghouses for information (including databases), but design and management of these databases to capture the appropriate level of scientific detail needed for risk assessment is beyond the ability of most library scientists. It is also important to note that "one stop shopping" is essential since the development of databases for risk assessment is quite labor intensive and duplication of effort must be avoided.

The LGU food safety scientists, including both researchers and Extension faculty, have the ability to provide the scientific oversight needed to design and manage these food safety scientific databases. As database users who will provide new and previously published data, and who will use existing information, they can also offer a critical "user's-eye view" needed for successful database implementation.

As noted in the section on publications below, the members of professional food science and food safety societies represent another resource that should be used to expand the content and strengthen the utility of food safety scientific databases. Also, federal and state food safety regulatory agencies, food trade associations, and other special interest groups all share an interest in the development of high-quality food safety scientific databases as potential information creators and users.

Knowledge Gaps: There is a very real absence of high quality scientific databases that are needed for food safety risk assessment. The Food Safety Risk Analysis Clearinghouse is operated through the Joint Institute for Food Safety and Applied Nutrition (JIFSAN) (which is a collaborative venture between the University of Maryland at College Park and the U.S. Food and Drug Administration). While this resource offers some support (see http://www.foodriskclearinghouse.umd.edu/databases-ed1.htm) it is primarily at this time a pointer to existing databases for microbial risk assessment. Databases for allergens are presently absent, but are planned for future offerings. What is needed is the rapid development of at least prototype databases for microbial and allergen risk assessments. Unless this deficiency is addressed directly the scientific underpinning for the Food Safety Strategic Plan will be significantly weakened. JIFSAN might be an excellent partner for fulfilling this need.

Mechanisms for the exchange of food safety data suitable for risk assessment between federal, state, and local government agencies is at present non-existent. Meanwhile, high quality, unpublished data from multiple public and private sources represents an untapped informational resource that should be captured in a database for optimal food safety risk assessments.

Thus, a national food safety scientific database is needed to:

1. Store new food safety data;
2. Allow mining of suitable information from previously published literature;
3. Collect and peer-review high-quality unpublished data;
4. Allow easy use of stored data by risk assessors; and,
5. Assist in the identification of data gaps and research needs.

Facilitating the development of a national food safety scientific database could be a role for the LGUs. Likely partners include are the CDC, the Food and Drug Administration (FDA), FSIS and ARS, among others.

PUBLICATIONS

The publication of food safety information will be critical to the successful implementation of the Food Safety Strategic Plan. These publications will be of various types, including, *inter alia,* popular and professional printed materials, taped and broadcast information (video, radio and TV), educational materials (e.g., formal classroom publications, consumer informational materials, and Extension education 'fact sheets'), product labels, and Internet-exchanged information. Much of this publication activity is already underway, and no doubt much more will be needed in this area.

The transfer of food safety information to the intended user should be well coordinated. There needs to be assurances that the message is valid, consistent with other sources, and accessible to the target audience. Some dependable clearinghouse system is required to efficiently transfer the best available information from one resource to another. As one example, consider the translation of scholarly food safety reports in professional journals to consumer-information publications. We see the coordination and interpretation of multiple sources of useful and valuable food safety information as a programmatic complexity that is in need of considerable organizational attention.

LGU Capacity: Libraries have traditionally served as warehouses for publications, and more recently have served as clearinghouses for information (e.g., published bibliographies, organizing databases, creating centers for specific technologies). However, the translation of factual information into general publications seems beyond the capacity of most libraries. Moreover, without adequate coordination, those efforts would most likely become needlessly duplicated. Cooperative Extension offers an excellent national capacity to gather and interpret food safety information. And, the LGUs' cadre of agricultural communicators represents an additional capacity that could be used to translate factual food safety information into more popular publications.

The professional societies (i.e., those that are related to the food sciences) represent, through their memberships, yet another capacity that could be employed to enhance the value and impact of food safety publications. Also, federal and state agencies mandated to regulate and/or support food safety programs, agricultural and food industries, trade groups, and special interest groups all share interests in food safety assurances, and issue publications as well. And each of these represents unique capacity for the publication of food safety information.

Knowledge Gaps: There is an apparent communications gap that exists through the absence of a national network of food safety information resources. This gap is serious, and in need of attention. Without an effective solution, constrained resources for food safety publications will not be sufficient to meet the intentions of the Food Safety Strategic Plan, as valuable information will not be adequately interpreted and shared with logical partners and collaborators.

The exchange of food safety publications (broadly defined) between federal, state, and local government agencies is not, at present, optimum. Moreover, the vast amount of information from multiple sources (public and private) represents an informational resource that must be brought to the focus of the Food Safety Strategic Plan. A national communications network is needed to make use of available and emerging food safety information.

Facilitating this collaborative network could be a role for the LGUs, along with some other partners. Some likely partners are CDC, FDA, FSIS, and NIH, among others. This partnership in food safety publications should focus on filling the current publication gap by supporting a central coordinating resource. This resource should additionally contribute to food safety information validation and the fostering of a rapid response system for information deployment in the event of a severe food safety outbreak. Jointly sponsored bibliographies, inter-linked web pages, and summary documents might also be the responsibility of this gap-filling network.

RECOMMENDATIONS

SCIENCE

It is recommended that the LGUs:

- Along with the food industry, and including our traditional partners at USDA and FDA, and with input from our public and private stakeholders, develop specific research agendas to address:

    1. The knowledge gaps concerning characteristics of certain food borne hazards;
    2. The sources of these hazards; and,
    3. Existing and potential pre- and post-harvest hazard control measures from production through consumption.

- Support studies on:

    1. The sources, ecology and extent of microbial contamination in foods;
    2. The mechanisms of pathogenesis, especially recognizing that these mechanisms may be strain-specific;
    3. Interaction of pre- and post-harvest factors and processes on microbial survival and resistance development, as well as changes in virulence due to exposure to stress;
    4. Procedures to control microbial pathogens and their interaction with the natural spoilage microbial flora; and,
    5. Effect of consumer handling practices on the incidence of food related illness.

- For emerging agents of food borne illness, there is a need to:

    1. Resolve problems with pathogen identification;

2. Devise improved detection methodologies;
3. Locate the sources and ecology of these agents; and,
4. Determine their properties, *vis-a-vis* resistance and control.

[Note: Specifically, there is a need to support studies on microbial adhesion, penetration, removal, biofilms, inactivation, resistance, injury, inhibition, competition, culturability, superdormancy, mechanisms, and microbial and environmental interactions.]

- Establish a national "clearinghouse" for a research database of food safety projects and information.

- Establish significant national collections of food borne pathogens, made readily available to research scientists to support the development of new detection strategies.

- Continue research aimed at identifying sensitive production and processing steps where food safety hazards are most likely to occur.

- Collaborate with the key federal agencies to fill the voids in biological, behavioral, and economic food safety risk assessment.

- Create an artificial intelligence center for food safety risk assessment in LGUs. [Note: This center should develop computer models for predicting potential outbreaks and effective intervention strategies.]

- Begin immediately to plan and implement a national review and evaluation of research investigating the determinants of food safety behaviors, and find out how to motivate behavioral change that is consistent with recommended food safety practices.

- Work to develop new intervention and control strategies that are refined and employed from production to consumption.

- Partner with ARS and the food industry to increase intervention strategy and control testing capabilities under commercial-like conditions.

- Seek more funding for needed critical research and education in the areas of:

    1) Pathogen detection, interventions and control methods;
    2) Food allergies and sensitivities, especially for collaborative research between clinical medicine, dietetics, and agricultural scientists;
    3) Food toxicology, particularly as it relates to naturally occurring toxicants and to the safety assessment of pesticides, dietary supplements, nutraceuticals, and foods produced through new technologies; and,
    4) Risk analysis and communication methodologies.

EDUCATION

It is recommended that the LGUs:

- Establish formal linkages between colleges and government agencies that have necessary expertise to support educational offerings.
- Determine more about future job markets, so the output of food safety graduates matches the anticipated employment opportunities to prevent production of surplus capacity.
- Encourage formal collaboration between LGUs, government agencies, and the industry to design effective degree-credit programs.
- Begin immediately to collaborate with the FDA [http://www.foodsafety.gov]to enhance connectivity and expand access to food safety information from government, industry, and university sources.
- Work with other Federal agencies (such as FDA and FSIS) to develop a strategy for helping communities respond to food borne illness outbreaks and other food safety emergencies.
- Hire Extension field staff trained in food science or dietetics, to assist in food safety training.
- Incorporate instruction on food toxicology into the curriculum of the LGUs in areas such as food science and technology.
- Have centers that continuously collect and manage risk assessment data, complementary to those of the CDC.
- Establish formal linkages between the government, the food production industry, the processing and packaging industry, consumer groups, and LGUs.
- Hold conference and workshops to discuss future directions, as viewed by all food safety players.
- Maintain through Extension a train-the-trainer approach so that the power of its vast human resources can be focused on critical issues such as the training of food service workers and school staffs. [Note: This is being done at many LGUs, and needs to be continued and/or expanded.]

COMMUNICATIONS AND COORDINATION

It is recommended that the LGUs:

- Identify and remove barriers to collaborative research: within universities and across universities; between industry and academia; and between government and industry.

- Initiate research collaborations with behavioral scientists to identify barriers to adoption of safe food handling practices by consumers.

- Facilitate the creation of public/private partnerships at the state level to promote communication of food safety risks.

- Become the leading entity to provide a nationwide consumer education campaign based on consumer risk perceptions.

- Partner, along with other government agencies, with the media to effectively disseminate food safety risk communication messages to the public.

- Conduct, along with the six cooperating federal agencies, an accurate assessment of available federal, state, and local resources for food safety education and outreach.

- Take the lead, along with the six cooperating federal agencies, in developing a coordinated communications plan for food borne outbreak response that has, as its primary focus, the dissemination of accurate and timely outbreak information to states and local communities.

- Join the current CDC and FSIS-sponsored Food borne Diseases Active Surveillance Network (FoodNet), to assist in the more rapid identification, and better monitoring of food borne hazards.

- Contact other federal agencies (e.g., the Department of Defense) who may also be interested in the research on intentional introduction of food borne hazards.

- Take the lead in conducting an assessment of state and local resources and ensure that the information is transferred to cooperating agencies and other food safety partners.

- Begin immediately to form activities (i.e., programs and projects) that integrate all forms of research and Extension publications from the LGU System. Participation should, of course, be open to all sectors. Logical partners would be the USDA's Agricultural Research Service (ARS), the CDC, FDA, and NIH.

- Be prepared to advocate for adequate funding for the National Agricultural Library to establish a "Foods Safety Resource Center", and to contribute to its clearinghouse activities.

- Support the establishment of a national scientific food safety database, with special emphasis on storage of data on microbial pathogens and allergens needed for risk assessment. This database should support those doing food safety:

    1. Research in ways to easily store new food safety data; and,
    2. Risk assessment in ways to quickly and easily extract information from the database.
    3. Information "mining" from previously published literature and for the collection and peer-review of high-quality unpublished data for incorporation into the database; and,
    4. To identify food safety data gaps and research needs.

    [Note: This might best be done as an initiative of JIFSAN, with LGU support.]

CONCLUSIONS

The challenges of implementing the national Food Safety Strategic Plan are many. But the LGUs have enormous capacity to contribute to the effort. We also have opportunities to partner with many others in the public and private sectors, to get the job done. The likely impacts of investing efforts in food safety teaching, research, and Extension are considerable. And although there are many tasks to be done, much of the work is very suitable to the purposes and mission of the LGUs. What is needed is a set of plans to;

- Direct the science into concerted, priority areas;
- Focus our educational efforts into topics of importance to the plan's objectives; and ,
- Organize our information and communications to be most effective.

The institutional capacities identified in this report point to the opportunity to contribute as a major partner in the implementation of the Food Safety Strategic Plan. The institutional gaps we have identified should be addressed in ways that will help us build on our strengths, and not suffer from our institutional weaknesses. And, the recommendations contained in this report are intended to support a strong commitment from the LGUs' for implementing the national Food Safety Strategic Plan's objectives.

We are seeking support from our broader community for moving forward with this food safety activity.

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APPENDIX 1

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