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Food Safety in Cambodia: Current Programs and Opportunities

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Acronyms

Abbreviations	Description
ADB	Asian Development Bank
AFD	Agence Française de Développement
BOD	Burden of Disease
BTC	Belgium Technical Cooperation
CDC	Communicable Disease Control Department
CE SAIN	Center of Excellence on Sustainable Agricultural Intensification and Nutrition
CFU	Colony Forming Unit
DFAT	Department of Foreign Assistance and Trade
DfID	Department for International Development
EIDs	Emerging Infectious Diseases
FAO	Food and Agriculture Organization
FMD	Foot and Mouth Disease
FORT	Food Disease Outbreak and Investigation Response Team
GDCE	General Department of Customs and Excise
GMS	Greater Mekong Subregion
HIV	Human Immunodeficiency Virus
IHR	International Health Regulations
ILRI	International Livestock Research Institute
ITC	Institute of Technology Cambodia
KOICA	Korean Office for International Cooperation and Assistance
LEFS	Laboratory of Environment and Food Safety
MAFF	Ministry of Agriculture, Forestry, and Fisheries
MOC	Ministry of Commerce
MOH	Ministry of Health
MOIH	Ministry of Industry and Handicraft
MOT	Ministry of Tourism
PE	Phthalate Esters
RRT	Rapid Response Teams
RUA	Royal Agriculture University
SARS	Severe Acute Respiratory Syndrome

SFFF	Safe Food, Fair Food
SPS	Sanitary and Phytosanitary
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USFDA	United States Food and Drug Administration
WB	World Bank
WHO	World Health Organization

Introduction

Up to 8% of deaths of Cambodians under the age of five are due to diarrhea. This percentage increases significantly when deaths due to premature births, birth asphyxia, and other peri-partum deaths are excluded from totals (Conseil Sante 2016). While the burden of disease (BOD) in adults in the Greater Mekong Subregion (GMS) countries has shifted to non-communicable diseases, the BOD in children is still predominantly comprised of diarrheal diseases. In most cases, Cambodians are more vulnerable than other GMS countries due to the rate of poverty, percent of the rural population, etc. The incidence of acute diarrhea in Cambodia, however, is considered quite high across all socio-economic groups, ranging from 11% among the wealthiest and 18% among the least wealthy quintiles of the population, indicating that determinants of diarrheal disease extend beyond poverty.

Diarrheal diseases occur primarily through the consumption of contaminated water or food. In the case of Cambodia, the etiological agents responsible for most cases of diarrhea are unknown. This is especially true for diseases outside of reportable infectious diseases and waterborne diseases, such as cholera. Likewise, comprehensive data regarding etiological agents responsible for (what are traditionally considered) foodborne diseases are still scarce in Cambodia. This being stated, officially recognized foodborne disease outbreaks have occurred throughout the country (Inrasothythep 2019). These are usually large outbreaks with associated fatalities. In these instances, the Cambodian government has been able to identify the causes of disease. For example, from 2014-2019, Cambodia officially reported 135 foodborne disease outbreaks, resulting in 5,825 individual cases and 81 deaths (Mekong Institute 2019). Recent high-profile, larger-scale outbreaks have involved methanol poisoning (homemade rice wine; Anon. 2016), parasitic infections (pork; Kunthear 2017), noodles (*Bacillus* and/or *Staphylococcus*; Kimsean et al. 2016), a 2015 outbreak at a large conference affecting 800 attendees (herbicide poisoning and/or poor hygiene; Dara 2015, Sotheary et al. 2015), a 2017 outbreak at a school affecting 200 individuals (contaminated rice; Suy 2017), and a 2018 disease outbreak involving pesticide-contaminated water that resulted in at least 120 cases and 10 deaths.

It is important to note that these data represent only confirmed cases. More accurate estimations of the true incidence of foodborne disease usually come from modeling. Such modeling studies are not available for Cambodia, but conditions in the country would indicate that, as in other countries, the number of foodborne disease outbreaks and individual cases is likely several orders of magnitude higher than what is reported due to limits in surveillance, diagnostics, and epidemiology. For reference, Laos, Myanmar, and Vietnam reported 949, 6,864, and 5,664 incidents of “food poisoning,” respectively, for 2016 alone (Sante 2016). Troeger et al. (2018) recently reported that the disease burden of diarrhea in Cambodia as

determined by disability-adjusted life years, which combines mortality and morbidity, is much higher than that estimated by the Global Burden of Disease.

There is a clear lack of data on etiological agents for acute diarrheal diseases. There are less data concerning chronic exposure to foodborne pathogens and foodborne illness that may not result in hospitalization. Malnutrition and associated effects such as stunting are significant challenges in Cambodia, and it is currently unclear how foodborne disease contributes to these challenges (e.g., gastric dysfunction, impaired absorption of macro and micronutrients, etc.). When unresolved, these types of foodborne illnesses also contribute significantly to the diarrhea-associated BOD. Taken together, these observations highlight a need to close major data gaps, follow informed policies, link food sector stakeholders, and enhance food safety communication throughout the country. The following is a landscape review of food safety efforts in Cambodia with the aim of describing the current status of food safety governance, surveillance, research, partnerships, and opportunities.

Cambodian Government Agencies Involved in Food Safety

Currently, food safety efforts in Cambodia are largely dictated by the Food Safety Law of 1997, the Law on Cambodia Standards of 2011, and the Law on Management of Quality and Safety of Products and Service of 2018, among others. Numerous sub-decrees have also been adopted describing how different regulations or standards are to be implemented. The country does have a newly drafted Food Safety Law, which was developed with assistance from the UN's FAO. The first draft of the law was introduced in 2015, and it has undergone iterative reviews and revisions, primarily through the Council of Ministers. Its approval is expected in the coming months.

At the federal level, food safety is managed by six Cambodian ministries: Ministry of Health; Ministry of Agriculture, Forestry and Fisheries; Ministry of Tourism; Ministry of Commerce; Ministry of Industry and Handicraft; and Ministry of Economy and Finance. These six ministries have different food safety responsibilities or jurisdictions. For example, Camcontrol (Ministry of Commerce) has a broad mandate for food safety inspection of exported goods as well as local markets. The Food Safety Bureau (Ministry of Health) focuses on restaurants and similar food service establishments. The division of food safety responsibilities is described schematically in Figure 1.

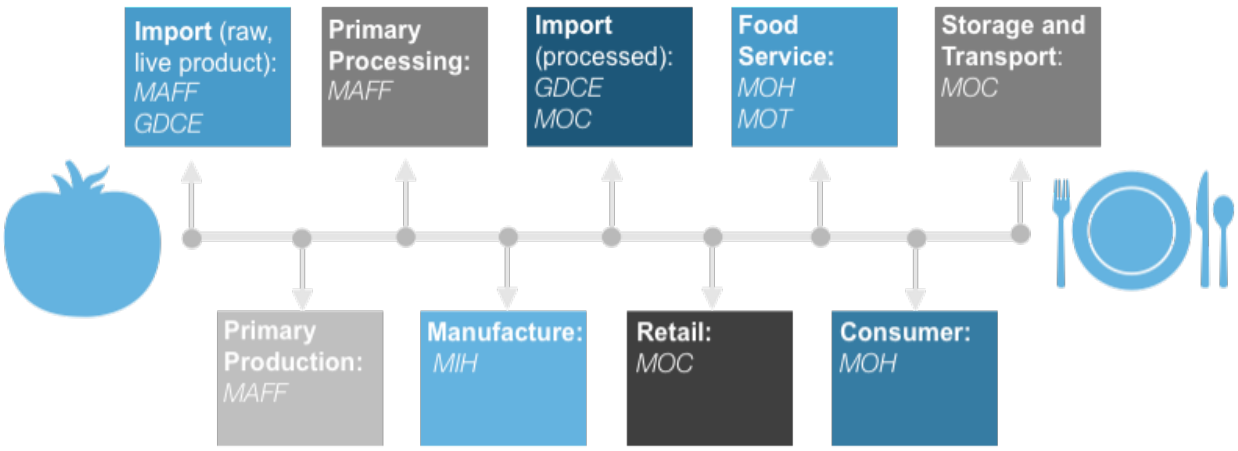

Figure 1. Cambodian Ministries Involved in Food Safety and Their Responsibilities. *MAFF = Ministry of Agriculture, Forestry and Fisheries; GDCE = General Department of Customs and Excise; MOIH: Ministry of Industry and Handicraft; MOH = Ministry of Health; MOC = Ministry of Commerce; MOT = Ministry of Tourism. Adapted from Inrasothythep N, 2017.*

The six ministries, while having different responsibilities, coordinate many of their efforts as seen in the Food Disease Outbreak and Investigation Response Team (FORT), spanning across different agencies. In addition to FORT, the six ministries have formed a Food Safety Technical Working Group, with representation from each ministry. More recently, this technical working group joined with a national task force on risk assessment to form the National Food Safety Task Force. The Cambodian government has also developed Rapid Response Teams (RRTs) to better identify and address outbreaks at the provincial level (RRTs have the capacity to respond to incidents within 24 hours of initial reporting [Conseil Sante 2016]). The level to which these RRTs focus on foodborne disease outbreaks is unclear for reasons detailed below. Similarly, Cambodia has developed several innovative reporting systems, including toll-free reporting systems, which have allowed the country to identify smaller outbreaks. While yearly incidence data are available, the MOH Communicable Disease Control Department (CDC) also releases weekly incidence reports through their CamEWARN program (CamEWARN 2020). Additionally, many of the ministries have well-equipped laboratories, including the BSL-2 referral laboratory of the National Institute of Public Health. Regional, provincial, and district labs also exist, but the functionality of these laboratories is not detailed here.

In addition to ministries, the Institut Pasteur du Cambodge, located in Phnom Penh and affiliated with the Ministry of Health, has several food safety initiatives as part of their Laboratory of Environment and Food Safety (LEFS). The mission of the LEFS is to "*assist all food operators to detect, control and prevent foodborne from farm to table and to provide quality and healthy foods*." The lab offers a variety of services and trainings (Institut Pasteur du Cambodge 2018) for both private and public sectors and also conducts independent research in food safety (discussed in more detail in sections below).

While dividing food safety responsibilities among different government agencies is not uncommon (e.g., USFDA vs. USDA), there is a general consensus that Cambodian food safety efforts may sometimes be disjointed due to a lack of clarity and/or overlap in responsibilities of each ministry. Additionally, while one ministry may be responsible for a certain stage of production, this responsibility may be further subdivided into different departments within the ministry itself, commonly based on the commodity (e.g., animal products, vegetables or grains, fish, etc.; Parsons 2008). Thus, some food safety efforts may be uncoordinated in certain cases and duplicative in others (e.g., different ministries may have different protocols and standards for testing similar products or samples).

To date, national food safety initiatives have focused largely on chemical contamination of food products, namely production-related chemicals including pesticides. This is reflected in education programs and the general language of government officials. There have been measured changes in behavior coinciding with this focus, from production practices to consumers' preferences (markets have grown for “organic” foods or foods with some process verification regarding pesticide use). The result, however, may be that Cambodian consumers think of food safety in terms of chemical contamination to the exclusion of other potential issues, namely contamination with pathogenic bacteria. Informal conversations with various officials and experts in Cambodia did indicate that more emphasis should be placed on microbial contaminants at governmental, production, and consumer-awareness levels.

Cambodian Health Security

Although somewhat dated, the Asian Development Bank (ADB) completed a health security analysis of Cambodia, Vietnam, Laos, and Myanmar. The report was completed as “project preparatory assistance” to accompany a request from the ADB for support of the Greater Mekong Subregion (GMS) Health Security Project. Among other objectives, the report provided assessments of preparedness to prevent and respond to infectious disease outbreaks. The report is focused largely on emerging or re-emerging infectious diseases (EIDS), most of which are reportable (e.g., HIV, malaria, cholera, etc.) and fall outside of what are traditionally considered foodborne diseases. Pertinent to food safety, however, the report details capacities in each country to meet International Health Regulations (IHR), which are WHO-developed standards for controlling infectious diseases. IHRs covers several aspects of infectious disease prevention and response, from laws/legislation to infrastructure and various key resources (human and physical).

Cambodia’s assessment results and those of Laos, Myanmar, and Vietnam are presented in Table 1. Cambodia received a 67 (of 100) in the category of food safety; however, the authors indicate that IHR standards/requirements for food safety are much less stringent than other

categories. In many food safety-allied categories (e.g., response, risk communication, laboratories), Cambodia received lower scores.

In general, the authors conclude that many of the GMS countries studied have outbreak response networks but need to enhance them to include reporting from the village level. Likewise, each country has built laboratories but often need to focus on integrating each of the labs (within each country) in terms of standards, biosafety, and technical skills of personnel. Laboratories also lack resources, in terms of supplies and reagents necessary to conduct thorough diagnostics. Each country studied has developed surveillance systems. Again, however, these systems may focus largely on reportable diseases or those classified as emerging or re-emerging diseases. It is likely that self-limiting foodborne illnesses or diseases may fall outside the scope of most systems. For purposes of FSIL, this would translate to a lack of clarity as to the etiological agents for most foodborne illnesses or diseases that may be chronic, or at least do not result in hospitalization.

Table 1. International Health Regulations (IHR) Assessment of Core Capacities in Cambodia, Laos, Myanmar, and Viet Nam. (adapted from Sante 2016)

	Score				
Core Capacity	**Cambodia**	**Laos**	**Myanmar**	**Viet Nam**	**Average**
Legislation	50	60	60	100	68
Coordination	55	89	94	100	85
Surveillance	80	81	73	88	81
Response	48	58	67	89	66
Preparedness	60*	71	48	95	69
Risk communication	42	62	40	100	61
Human resources	40*	44	43	100	57
Laboratory	40	78	77	100	74
Ports of entry	76	61	56	100	73
Zoonosis	78	69	92	100	85
Food safety	67	80	46	100	73
Chemical	30*	41	39	88	50
Radiological	30*	47	47	100	56
Total score	53	66	60	96	69

**Expert estimate only (not derived from questionnaire data)*

Food Safety-Allied Programs

Various groups have invested in different types of SPS-related training and development in Cambodia, including USAID. In the early 2000s, most of these efforts focused on infrastructure, including the development of laws or standards and/or human capital development to enact standards (e.g., training of inspectors, etc.). However, these programs have focused mainly on

more globally-focused and coordinated initiatives, such as efforts to minimize the spread of highly pathogenic avian influenza, SARS, FMD, etc. (Ignacio, 2007; Sante 2016). From 2005-2013, Cambodia received close to 17M USD for SPS-related programming, with 0.6M USD devoted to food safety, 1.8M USD devoted to animal health, and 14.1M USD devoted to avian flu (Parsons 2008). Table 2 describes several of large EID or food safety-related aid programs.

Table 2. Major or Relevant Infectious Disease-Focused Aid Projects in Cambodia. (parts adapted from Conseil Sante 2016; N/A indicates information is not available)

Aid/Development Organization	Project Name	Time Period	Funding (M, USD)
ADB, DFAT, DfID	Second GMS Communicable Diseases Control Project and Extension	2015-2017	14.0
USAID and partners	Global Health Security Agenda	2016-present	N/A
AFD, BTC, DFAT, DfID, KOICA, UNFPA, UNICEF, WB	Health Sector Support Program Phase II	2009-2016	150
DFAT, Korea, WB WHO	Health Sector Support Program Phase III Systems Strengthening Program/Support for Health Sector Reform	2016-2020 N/A	N/A N/A
Feed the Future Innovation Lab for Livestock Systems	Safe Food, Fair Food	2017-2021	0.85
Feed the Future Innovation Lab for Horticulture	Building Safe Vegetable Value Chains in Cambodia; Investigating Integrated Vegetable-Livestock Systems in Cambodia; Creating a Market Niche for 'Food-Safe' Vegetables in Cambodia and Vietnam	2016-2019	0.48
	Multidimensional Trade-Off Analysis of Integrated Horticulture Livestock Farming Systems in Cambodia	2017-2019	0.75

While these efforts have definitely led to the development of improved standards and responses, food safety in Cambodia is still hampered by the lack of effective inspection (number of inspectors, practices, etc.), surveillance, diagnostics, enforcement of standards, coordination among different government actors, and consumer awareness (Tum 2008; Inrasothythep 2019). Like other countries in the region, Cambodia also has limited “surge capacity” or capacity to effectively treat large numbers of patients in the event of large, life-threatening outbreaks (Sante 2016).

Food Safety Research Programs

Agriculture research in Cambodia, in many respects, has focused on production, and research programs examining food safety outside of chemical hazards are still comparatively new. Several universities have new or active research programs focused on food safety, including Royal Agriculture University (RUA), Institute of Technology of Cambodia, and University of Battambang, among others. As in most countries, food safety often comes under the purview of the department or faculty of veterinary medicine as "food safety" has traditionally been concerned with animal-sourced foods. There is inter-departmental cross-over at RUA, which is fostered by the recent research projects of the Feed the Future Sustainable Intensification Innovation Lab and the Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN), which is based at RUA. The Institute of Technology Cambodia (ITC) also has active research programs in food safety (outside of veterinary science) primarily through its Faculty of Chemical Engineering and Food Technology. Examples of current ITC studies include assessing the safety of fermented foods and characterizing antibiotic resistance in *Enterococcus* sp.

The International Livestock Research Institute coordinates the Safe Food, Fair Food (SFFF) program in Cambodia, which is currently at its mid-point (September 2017-March 2021). The project is part of the Feed the Future Innovation Lab for Livestock Systems and coordinated by Emory University, the International Livestock Research Institute (ILRI), Cambodia's National Animal Health and Production Research Institute, and the Centre for Livestock and Agriculture Development. SFFF has sponsored and/or conducted research to establish some baseline measurements of contamination rates, focusing on animal-sourced foods. The studies have been small in scope, but they are beginning to provide indicators of pathogen loads and types (including antibiotic resistance phenotypes) found in various animal-sourced foods. SFFF has also been involved in bringing together various governmental organizations, allowing for the formation of a Food Safety Technical Working Group.

The Feed the Future Innovation Lab for Horticulture has also conducted various research and engagement programs in Cambodia focused on food safety. These efforts have involved (among others) U.C. Davis, Kansas State University, RUA (Phnom Penh), and the Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN), which is located on the RUA campus. Details of those studies are included below. Their projects have focused on integrated livestock/vegetable production systems, developing value chains for safely produced vegetables, and creating market opportunities for "safe food." Finally, as mentioned previously, the Institut Pasteur du Cambodge conducts food safety research through its Laboratory of Environment and Food Safety (LEFS). The laboratory is focused mainly on diagnostics but

devotes a significant amount of its efforts toward food safety research (e.g., 2018 Street Food Project).

Current Research

The following is not a complete review of the Cambodia-related food safety research literature. Rather, it aims to provide an idea of research directions of different groups with recent examples. Schwan et al. (2018; unpublished data) examined foodborne pathogen contamination rates in informal vegetable markets in Cambodia and isolated *Salmonella* from 75% and 25% of food contact surfaces and non-food contact surfaces, respectively. Correspondingly, vegetables exposed to FCS were more frequently contaminated with *Salmonella*. In a similar study, Desiree et al., (2019) measured *Salmonella enterica*, generic *E. coli*, and coliforms in vegetables in retail. The authors reported high *Salmonella enterica* contamination rates on vegetables being sold in informal markets, with prevalence rates on lettuce samples collected in the wet seasons reaching 55.8%. Importantly, the concentrations of *Salmonella* found on the different samples were uniformly high (highest: 5.70 log10 CFU/g in lettuce; lowest: 4.23 log CFU/g in cucumbers).

Chrun et al. (2017) measured contamination rates in fermented foods collected at retail (open air markets). Samples (n = 68) frequently contained different types of bacteria, including generic coliforms, *E. coli*, *Bacillus*, *Listeria* sp., and pathogenic *Enterococcus*, among others. Similar studies with raw vegetables showed comparable results (Phoeurk et al., 2019). Osbjer et al. (2016) compared *Campylobacter* (*C. jejuni* and *C. coli*) strains in both humans and livestock in rural Cambodian communities. *Campylobacter* was isolated more frequently in children (18%) vs. adults (7%). *Campylobacter* carriage rates in livestock approached 75% (pigs). The authors also identified several risk factors for human exposure to *Campylobacter* via livestock, including home-slaughtering and the presence of animals in sleeping or food preparation areas, among others. Similar results are described in other studies conducted in Cambodia or surrounding GMS countries (Nguyen et al. 2017).

Untreated wastewater is frequently used in the irrigation of various crops in Cambodia. This is highly problematic in the cases of foods like water spinach (Hold 2010). Equally problematic is the impact on fish, which comprises 37% of protein intake in Cambodian diets (Vilain 2016). Cheng et al. (2016) sampled common foods sold through informal markets in Kampong Cham, Kratie, and Kandal provinces to determine consumers' daily intake levels of phthalate esters (plasticizers). PEs were detected in most foods tested, but the highest estimated exposures were from rice consumption. All estimated average daily intake levels, however, were below tolerable daily intake levels established by the US FDA and the European Food Safety Authority. The use of untreated wastewater in food production poses microbial risks as well. As an

example, close to 20% of Cambodians are seropositive for Hepatitis E (Yamada et al., 2015), which is largely transmitted via feces-contaminated water.

Several groups have examined antibiotic resistance phenotypes in pathogenic bacteria isolated from live animals, animal-sourced foods, and a variety of vegetables. While most of these studies have lower sample numbers, when aggregated, it is clear that the various pathogenic bacteria isolated from food products in Cambodia regularly exhibit resistance (multi-resistance in most cases) to a broad spectrum of antibiotics, including extended spectrum beta-lactams (Nadimpalli et al., 2019). Thus, it is safe to assume that Cambodians are regularly exposed to antibiotic-resistant bacteria through food.

Roesel et al. (2018) recently completed a study to better understand consumer awareness of the impacts of foodborne disease in Cambodia and barriers to consumers accessing safer foods in Cambodia. Participants (n = 66) identified more than 600 consequences of unsafe food with consequences such as "getting sick," "decrease in living standard," and "paying for treatment" most common. The strongest barriers to accessing safe food according to participants were cost and "getting shops to sell safer food."

Gaps and Opportunities

Etiological Agents

In several large foodborne disease outbreaks in Cambodia, the cause(s) were identified. Little is known regarding causes of smaller outbreaks and less is known regarding individual cases of foodborne disease. While the frequency of diarrheal diseases is high, there is little known regarding specific pathogens causing such diseases. There is a growing number of studies characterizing pathogens that can be recovered from different food products, but most studies have focused on specific pathogens (e.g., *Salmonella*, *Campylobacter*). Those studies, by design, are narrow and identify several pathogens that Cambodians are likely exposed to through food. They do not, however, necessarily identify causative agents for foodborne disease throughout the country (e.g., a food item may contain *Salmonella*, but illness could be caused by the myriad of other potential foodborne pathogens, including viruses, which may also be present but not targeted in the study).

Foodborne Pathogen Transmission

Food safety research in Cambodia is still in its infancy and there are few longitudinal studies or studies that examine contamination of food products over time. Most studies are "snap-shots," which are informative and can be aggregated to give a better idea of contamination; however, the studies are still limited. Likewise, to date, most studies have examined only single parts of what are often complex production chains (e.g., meat at retail). Thus, it is difficult to fully

understand transmission routes and to identify critical points in the production chain that could be targeted to maximize reductions in contamination.

Antibiotic Resistance

Studies conducted thus far in Cambodia have found antibiotic-resistant bacteria in all foods tested. In most cases, multi-drug resistant bacteria were isolated, as were bacteria resistant to later-generation drugs or therapies. Thus, Cambodians may be regularly exposed to antibiotic-resistant bacteria through food preparation and consumption in addition to the growing misuse of antibiotics (Caron et al., 2018). There is a general feeling that antibiotics are overused or misused at different production levels, primarily in food animal production (Om and McLaws 2016). Thus, limiting exposure to antibiotic resistant bacteria will likely require a multi-factorial effort beginning with food animal health and husbandry outreach and extending to consumer education. As such, effective programming will require collaboration across several ministries and agencies.

Perception of Food Safety

Foodborne diseases are preventable, but prevention requires resources. Often there is less political will for prevention programs, as there may not be a clear or measurable outcome, as opposed to a response to an existing outbreak. In Cambodia, food safety efforts have focused largely on chemical contamination, and it is likely that consumer perception of food safety may also center on chemical contamination. Thus, it will likely take effective outreach and engagement programs to better introduce the role of microbial pathogens in diarrheal diseases (outside of cholera). Otherwise, it may be difficult to gain support for programs addressing challenges not recognized by consumers and beyond.

Informal Markets

As in many other countries, businesses or producers with the most awareness of food safety practices are those with large export businesses or multinational companies (Parsons 2008; personal observation). The overwhelming majority of food consumed by Cambodians, however, is purchased from informal markets. Informal markets are complex, fluid, and non-uniform. In Cambodia, informal markets have only loose regulations, and sanitation in these markets is weak (Wiwanitkit and Wasana 2015; personal observation 2019). In smaller or more rural versions of these markets, there may be no oversight. Thus, reducing foodborne disease in Cambodia will require a significant focus on food obtained through informal markets.

Innovative Interventions

The development of effective food safety interventions is hampered by a lack of data on etiological agents and transmission routes. However, there are hundreds of different

interventions shown to be effective elsewhere that are likely to be as effective in Cambodia. Currently, however, there is very little research focused on assessing the impact or efficacy of food safety interventions in reducing foodborne disease or increasing the adoption of food safety practices in Cambodia. Likewise, there is little research focused on the development of interventions specifically designed for the Cambodian context. Beyond "bench" science, there is also a need to better understand "willingness-to-adopt" and other economic considerations of different interventions. Finally, there is a need to develop and test the efficacy of different intervention-focused outreach and education programs.

Integration of Food Safety into Existing Infectious Disease Programs

There is significant enthusiasm for addressing food safety across ministries, universities, and other research centers (personal observation 2019). There are several well-functioning individual programs with excellent human resources as well as physical resources. Aggregating this experience for collaborative projects would likely accelerate various food safety outreach and research programs. Cambodia has significantly improved its health security capacities (surveillance, diagnostics, response, etc.). These efforts have focused largely on reportable infectious diseases (cholera, highly pathogenic avian influenza, HIV, etc.). There are likely significant opportunities to further integrate food safety programming into this existing infrastructure, which could also accelerate food safety outreach and research programs. CE SAIN, specifically, and its human capacity, networks, and numerous agricultural technology parks, offers unique opportunities for collaboration in all areas, from research to outreach.

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