Livestock Production and Foodborne Diseases from Food Animals in Thailand

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ABSTRACT. Thailand is a developing nation dependent on agriculture. Due to lack of modern public health practices, she suffers from the consequences of foodborne illnesses. The number of foodborne infection cases has nearly doubled in the past 10 years. Salmonella and Campylobacter pose the greatest risk of bacterial contaminants, mostly from pigs and chickens, and this paper will review livestock production systems and foodborne diseases from cases stemming from these sources. Due to the complexity of the livestock production systems, collection of data to date has been sporadic, but it is clear that controls are needed in slaughterhouse processing methods, and more communication between agencies and surrounding regions is paramount for proper surveillance to have any significant effect.

KEY WORDS: Campylobacter, food animal, foodborne diseases, Salmonella, Thailand.

Public health is an issue that affects everyone, whether one lives in a developed or developing country. Matters of concern are more serious in developing nations, of course, and one problem that people face is the risk of foodborne infections. The majority of diarrhea cases in developing countries are thought to be due to foodborne contaminants, and the results can often lead to death. Moreover, there is a huge number of existing and new causative agents of such infections in the world, and every country or region has its own particular problems–social, cultural, political, or economic–and types of microbial threats.

Consumers and workers represent a large number of people directly affected by the food processing systems that ultimately play a significant role in the chain of events leading to the risk of foodborne contamination. Surveillance for potential bacterial pathogens must span the entire range of possible contamination sources from the production of food animals at the farms to consumption at the table, if we are to understand and control problems with foodborne infections in Thailand.

This paper, thus, provides a review on both ends of this range as they pertain to Thailand, especially for the major contaminants Salmonella and Campylobacter.

FROM FARM TO CONSUMPTION

Livestock production systems: Pigs, chickens, cattle, and aquatic animals including fish and shrimp are commonly produced and consumed in Thailand. Dairy products are produced domestically in low quantity compared to the amount imported from other countries. However, chickens, pork products, and aquatic animals are the major exported food commodities apart from rice. There are approximately 7 million pigs and 250 million chickens at any given time on Thai farms. Export pigs and chickens are raised mostly in the central part of the country, while those farms used for local consumption are scattered throughout the country [37].

The majority of pigs in Thailand are raised on industrialized farms with either an open or a closed housing system, and there are small numbers of backyard pig raisers mostly residing in mountain areas. The closed houses are literally wrapped with plastic sheets with an evaporative cooling system to control temperature and humidity. Generally, breeder farms, which produce only piglets, supply weaned pigs to fattening farms that produce pigs destined for slaughterhouse. Piglets are weaned at 18–21 days of age, and the sows are moved to the mating unit on the same day. The sows are managed in a 2-week system. Seven days prior to delivery, the sows are moved to cleaned and disinfected farrowing units, where they are treated with antibiotics for 2 days after delivery to prevent and reduce stress.

All-in-all-out system, in which all pigs enter and leave from the facility together at the same time, is applied in mating, farrowing, and nursery units. Animals raised under the same management system are considered to have a similar disease status [40]. Therefore, any production compartments can claim freedom of disease for the animals produced regardless of where the animals actually are.

The poultry industry in Thailand can be divided into three sectors [37] (Fig. 1). Sector 1 includes export poultry producers with integrated production units from feed mill to highly sophisticated farms and slaughterhouses. Sector 2 consists of commercial producers with sophisticated farms, but they process their chickens through local slaughterhouses. The third sector includes small holders whose chickens are held live at the market. In addition, there are backyard type producers who consume most of their chickens themselves. There is also a special poultry population called fighting cocks, which are kept as pets and used in a gambling sport. These cocks travel with the owners to various fighting rings and subsequently provide a unique route to transmit diseases. Other poultry species such as ducks...
and quails have been present in low proportions, and they have almost completely disappeared since the outbreak of avian influenza.

With 70% of the poultry population raised for export, Thailand has the most sophisticated poultry industry among its neighboring countries. Before the outbreak of avian influenza, Thailand exported close to 40 billion baht worth of chickens [15]. The export value dropped to 200 million during the outbreak of avian influenza but recovered to some extent afterward. Avian influenza forced the export of pig products, but their export value is relatively low compared to that of chickens (Table 1).

During the past 5 years, livestock farming in Thailand, particularly on pig and chicken farms, has been inspected by the department of livestock and certified to meet the standards of practice required by law. The criteria for certification also include microbial standards for feed and water used on farms. However, there are no specific criteria for Campylobacter [13].

Slaughtering system: The majority of pig slaughterhouses use a traditional slaughtering process whereby the animal is killed by cardiac puncture, and this is followed by scalding (to remove hair and soften skin) usually with hot water. The carcasses are then cut and eviscerated on the floor. There is no temperature control at any point. Some slaughterhouses may transport cut carcasses to the market in open-air trucks with no refrigeration. There are some modern pig slaughtering plants which process pigs mostly for export. In these modern facilities, the carcasses are hung for cutting, evisceration, and freezing before being cut into smaller pieces and then packed for transport to domestic supermarkets and exporting purposes.

Chickens raised for local consumption are processed in traditional slaughterhouses operated by meat vendors. Chicken carcasses are usually chilled in a large tank of cold water, which unfortunately provides an opportunity for cross-contamination from any infected birds. However, in contrast to pig slaughtering, evisceration of chickens is usually done at the market. There is no temperature control at any point of the processing. The production system for export chickens differs from those destined for local consumption, particularly at the slaughterhouse. Once the broilers are grown to market size, they are processed through industrialized slaughterhouses with a high level of hygiene which meets the international standards for processing plants [14] (Fig. 1).

Foodborne diseases: Despite efforts to improve standards of food hygiene in Thailand [10], from 1996 to 2004 the incidence of foodborne diseases increased from 137 to 248 cases/100,000 people then declined slightly to 217 cases/100,000 people in 2006 (Fig. 2), which was much higher than the incidence of avian influenza during the same period of time (0.01 case/100,000) [25]. Although avian influenza may be a more severe disease, foodborne diseases affect many more people. The most commonly isolated etiologic agents from patients with foodborne illness in Thailand are rotavirus, Salmonella and Campylobacter [11, 17, 41].

It has been suggested that the increase of foodborne disease, particularly in industrialized countries, may be the result of changes in the livestock industry as well as changes in consumer lifestyle or eating habits, an increase in traveling, greater virulence of pathogens, changing population demography, and improved diagnostic capacity [6, 20–22]. The higher incidence of foodborne disease in Thailand is probably the result of a combination of these factors; however, there is not enough information regarding the impact of each of them in order to understand their individual significance and allow measures to be taken to reduce the number of cases. Therefore, there is still a wide gap of knowledge to be filled regarding foodborne diseases to effectively improve public health conditions.

**EPIDEMIOLOGY OF SELECTED FOODBORNE BACTERIA**

*Salmonella*: Salmonella is a Gram negative bacterium in

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**Table 1.** Total amount of pig and chicken products exported from Thailand in 2002–2006 (million baht) [15]

<table>
<thead>
<tr>
<th>Year</th>
<th>Pigs</th>
<th>Chickens</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>None exported</td>
<td>39,744.8</td>
</tr>
<tr>
<td>2003</td>
<td>39.5</td>
<td>762.4</td>
</tr>
<tr>
<td>2004</td>
<td>130.1</td>
<td>243.4</td>
</tr>
<tr>
<td>2005</td>
<td>1,644.6</td>
<td>31,574.8</td>
</tr>
<tr>
<td>2006</td>
<td>1,782.6</td>
<td>32,216.0</td>
</tr>
</tbody>
</table>
the family Enterobacteriaceae, which also includes E. coli, Proteus and several other species. Epidemiologically, we may divide Salmonella into 2 groups: 1) typhoidal Salmonella including S. Typhi and S. Paratyphi, which only infect humans, and 2) non-typhoidal Salmonella including S. Enteritidis and S. Bongori, which infect animals and may be transmitted to humans via food [35]. Humans are commonly infected with Salmonella through consumption of contaminated food. The incubation period of foodborne salmonellosis ranges from 6 to 48 hr, and the clinical signs include fever, headache, nausea, vomiting, abdominal pain, and diarrhea, which are common among gastrointestinal infections. Some serotypes of Salmonella such as S. Enteritidis serovar Typhimurium or Enteritidis may invade the bloodstream and cause septicemia. Although the incidence of foodborne disease in Thailand has increased steadily during the past 10 years, the proportion of Salmonella infections has been quite unchanging despite some fluctuation [25] (Fig. 3).

The significance of Salmonella spp. as foodborne pathogens has been documented in Thailand. Pre-slaughter pigs and chickens have been incriminated as the major sources of Salmonella contaminations of chicken carcasses and pork products at later stages in the food processing chain [2, 24, 34, 36, 39]. In 2006, Padungtod and Kaneene [30] reported that the prevalence of Salmonella isolation from pre-slaughter pigs (6%) and chickens (4%) was at a low level in Thailand. However, serological testing of the pigs yielded a much higher sero-prevalence (60%) [16, 33], suggesting that pigs may be exposed to Salmonella during the raising period, but that they may not shed the bacteria at the farms. However, when pork and chicken meat samples were collected from the same area during the same period of time, the prevalence of Salmonella contamination in both pork and chicken meat increased significantly [30]. An early report of Salmonella contamination showed that 22 serovars of Salmonella including S. Enteritidis (28%) were isolated from 72% of chicken meat at retail markets [8, 9]. In Thailand, a survey [27] of raw meat preparations showed up to 56% Salmonella contamination in Nham (raw pork sausage) and 19% contamination in Laabdib (raw minced meat salad). Recently, a foodborne salmonellosis outbreak was associated with vegetable consumption [26].

Apart from molecular assays, we use traditional serotyping methods to indicate the relationship between Salmonella isolated from different sources. From 1990 to 1993, the prevalence of S. Enteritidis in humans and animals increased from 1.3% to 17.0% and 0.3% to 15.9%, respectively [38]. In Thailand, S. Rissen and S. Weltevreden can be commonly found in food animals, meat, and patients with diarrhea (Table 2). Another study by the WHO National Salmonella and Shigella Centre in Bangkok reported that S. Weltevreden and S. Enteritidis are found in humans and frozen foods of animal origin [5]. These observations sug-
gested that food animals may be an important source of salmonellosis in Thailand. However, a study in Thai children less than 5 years old found no significant association between consumption of chicken, pork, or milk with Salmonella infections [17, 30].

Since food animals have been implicated as sources of Salmonella for human infection, studies have been conducted to determine factors associated with Salmonella contamination along the pork production chain. A 2007 study in pre-slaughtered pigs in Thailand [15] showed that infected pigs were more likely to come from medium-sized farms having a department of livestock development certificate, using effective micro-organisms as feed additives, having slurry waste management and having fewer numbers of pigs per pen. No results from the pig slaughterhouses and the markets are available yet.

In the chicken production chain, there have been no reports of risk factor studies on poultry farms in Thailand. A study in nearby Vietnam reported significant factors associated with Salmonella contamination at chicken slaughterhouses; such factors at the production level included use of intensive farming and at slaughterhouse level small sized operation, less frequent cleaning of working areas and use of unchlorinated water [42].

An additional issue of concern in foodborne bacterial infections is antimicrobial resistance [21, 22]. One study in Vietnam and Thailand [23] reported a higher proportion of Salmonella isolated in Thailand with resistance to antimicrobial agents used for treatment of gastrointestinal infection, with 28% and 59% of isolates resistant to ampicillin and tetracycline, respectively. Resistance to new agents such as ciprofloxacin (0.5%) and azithromycin (5%) has already been found in Thailand [23]. It has been suggested that antimicrobial agents used in livestock production may contribute to the increase of resistant bacteria, which may subsequently infect humans [1]. A study of standard farms where veterinarians control antimicrobial use and non-standard farms where farmers freely administer antimicrobial agents showed that Salmonella isolated from non-standard farms were resistant to more types of antimicrobial agents than those isolated from standard farms [5]. However, when we examined the resistance to newer agents such as ciprofloxacin, no resistance was found in food animals, while resistance was common among food animals and humans for traditional drugs such as tetracycline [23]. This observation suggested that resistance mediated by transferable genetic elements was shared between humans and animals, but resistance mediated by mutation of the chromosome (such as resistance to fluoroquinolone, resulting from gyrA gene mutation) may be the result of drugs used in humans.

Tetracycline resistance is mediated by a mobile resistance gene usually clustered together in an integron capable of horizontal transfer [3, 19]. Detection of the integrase gene in the bacteria indicates the presence of an integron element which may carry an antimicrobial resistance gene. A recent study in Thailand identified this integrase gene in 95% of Salmonella isolated from food animals with resistance to oxacillin, erythromycin, tetracycline, and trimethoprim-sulfamethoxazole [31]. Therefore, it is possible that resistance to these agents may result from antimicrobials used in food animals and then become transferred to humans, or vice versa.

Campylobacter: Campylobacter is a Gram negative spiral rod bacterium. Most Campylobacter grow at 37°C, but some also grow at 42°C, which is a normal body temperature of chickens. C. Jejuni and C. Coli are two common species of Campylobacter that cause foodborne gastroenteritis in humans. These two species do not cause discernible disease in any food animals; therefore, infected food animals may be processed through the food production chain and pose a threat to the consumer undetected. Other species of Campylobacter including C. Fetus and C. Venerealis can cause reproductive disease in cattle and pigs [18]. Campylobacter spp. have been found in chicken meat, unpasteurized milk, untreated water, and in the intestinal tracts of

### Table 2. Serotypes of Salmonella identified in Thailand [5]

<table>
<thead>
<tr>
<th>Pig</th>
<th>Pork</th>
<th>Chicken</th>
<th>Chicken meat</th>
<th>Human</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rissen</td>
<td>Weltevreden</td>
<td>Emek</td>
<td>Weltevreden</td>
<td>Weltevreden</td>
</tr>
<tr>
<td>Derby</td>
<td>Anatum</td>
<td>Enteritidis</td>
<td>Hardar</td>
<td>Rissen</td>
</tr>
</tbody>
</table>

Anatum Enteritidis Hardar Stanley Enteritidis Anatum

Fig. 4. Proportion of species infected with Campylobacter in Thailand [29].
animals including cats, dogs, poultry, wild birds, swine, cattle, rodents, and monkeys [18].

The prevalence of *Campylobacter* in pre-slaughter pigs and chickens in Thailand was estimated to be 73% and 64%, respectively, but its presence on pork and chicken meat sold at markets was found to be lower at 23% and 47%, respectively [29]. The smaller percentages of contamination in meats suggested that pigs and chickens could be hygienically processed from the slaughterhouse to the market throughout.

Various molecular techniques may be employed to study the relationship between bacteria isolated from different sources. When a single-strand conformation polymorphism (SSCP) was applied to *Campylobacter* isolated from food animals and diarrhea patients in Thailand, the results showed that a large proportion of *Campylobacter* share similar nucleotide sequence profiles, suggesting a clonal spread among humans and food animals [29]. However, whether food animals in Thailand are important sources of *Campylobacter* infection in humans is not completely understood. Padungtod and Kaneene [29] showed that children less than 5 years old with diarrhea were more likely to consume chickens than those not infected. But, when they examined the species of *Campylobacter* in humans and food animals (Fig. 4), *C. Jejuni* was found in dairy cows and humans [7]. While *C. Coli* was the usual bacterial isolate in pigs and chickens, its presence was rare in humans. Therefore, dairy products, not pigs or chickens, might be more important sources of *Campylobacter* infection in humans in Thailand.

*Campylobacter* with resistance to various antimicrobial agents has been reported in several countries [28]. Macrolides (such as erythromycin or azithromycin) and fluoroquinolones (such as ciprofloxacin) are drugs of choice for the treatment of campylobacteriosis in humans. In Thailand, a high proportion of resistance to ciprofloxacin (77%) was found in *Campylobacter* together with some resistance to azithromycin (6%). On the other hand, a low level of fluoroquinolone resistance (7%) and no azithromycin resistance was found in Vietnam [23]. Since most fluoroquinolone resistance in *C. Jejuni* in Thailand was mediated by mutation in the *gyrA* gene [32], which can not transfer horizontally, it is likely that *Campylobacter* develops resistance in food animals during the raising period on farms, and subsequently infects humans. However, for other antimicrobial agents with mobile resistance genes, *Campylobacter* may develop resistance in food animals and transfer the resistance gene to other human pathogens similar to *Salmonella* [4, 12].

PRESENT FOOD SAFETY MANAGEMENT AND SURVEILLANCE SYSTEM

Surveillance is an ongoing systematic collection, collation, analysis, and interpretation of data; it also comprises the dissemination of information to those who need to know so that action may be taken. Surveillance systems generally involve field collection of disease occurrence data, which are then reported to the central authority. This authority may then produce a descriptive report of the disease information and determine factors associated with the disease occurrence, then design disease prevention and control schemes. After the disease prevention and control schemes are applied in the field, the impact on disease occurrence may be evaluated by the collection of further disease occurrence information, thus repeating such processes.

In Thailand, there are several agencies responsible for surveillance and control of foodborne disease at various stages of food production. The Department of Livestock Development (DLD) is responsible for the production of clean food animals on farms [13]. Local government authorities are responsible for the local slaughterhouses that process food animals for domestic consumption [14]. The Department of Health is responsible for the hygiene of the fresh markets where fresh food is sold. Aside from these tasks, which serve to inform the government and commercial institution, it is important that consumers should also be educated to protect themselves from harmful food consumption.

The Ministry of Public Health (MOPH) oversees the national human disease surveillance system [25]. There are 68 diseases under its surveillance system, including several gastrointestinal diseases, food poisoning, and enteric fever. Disease occurrence information from health centers, community hospitals, general hospitals, and regional hospitals is reported to the provincial public health office, which coordinates with the Bureau of Epidemiology in the MOPH to provide descriptions of disease occurrences through weekly, monthly, and annual reports. The provincial public health office also coordinates with the regional offices of disease prevention and control and with the department of medical science to conduct outbreak investigations when outbreaks occur. There are 76 provincial public health offices, 12 regional offices of disease prevention and control, and 13 departments of medical science laboratories around the country [25].

The DLD also oversees the national animal disease surveillance system operated through livestock officers and volunteers in the villages. Recently, the DLD began to enforce standard farm practices for food animal production. In brief, these practices comply with the good agricultural practice requirements. The DLD provides laboratory diagnosis of animal diseases through 9 regional laboratories; training for meat inspectors employed by the local government authority to perform meat inspection in the local slaughterhouse; and inspection for export slaughterhouses. The animal disease surveillance results can be found at their website (available only in Thai) [15].

In conclusion, Thailand suffers from the consequences of foodborne illness as we have described in this paper. *Salmonella* and *Campylobacter* pose the greatest risk of bacterial contaminants, mostly from pigs and chickens. These bacteria also develop antimicrobial resistance and harbor the potential to transfer such resistance genes to humans and other pathogenic bacteria.
We may employ a risk analysis framework to evaluate the impact and manage the risk of diseases from these bacteria in Thailand. Due to the complexity of the livestock production systems, collection of data to date has been sporadic, but it is clear that controls are needed in slaughterhouse processing methods.

Apart from risk assessment and surveillance, basic research can provide a scientific basis for improving the existing surveillance system and quality of food safety regulations in Thailand. For example, improving diagnostic capabilities by developing a more sensitive or more rapid assay for determination of bacterial contamination may allow the central authority to better regulate foods sold on the market.

As mentioned earlier, increasing numbers of human foodborne disease cases could be due to several factors. The surveillance system in Thailand has been put in place only recently, and consumers’ awareness level of understanding the hazard in food may still be very low. Only recently, reports on foodborne illness have appeared on the mass media such as newspapers and television programs. In Laos, Cambodia, and Vietnam, it is not certain whether food safety regulation has been in place. Therefore, improving consumers’ education level and practicing food safety regulation should help to reduce the incidence of foodborne disease not only in Thailand but also its neighboring countries. More active communication and actual collaboration between local and international agencies in surrounding regions are paramount to providing any significant effect on global food safety issues in this part of the world.

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REFERENCES


