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Investigation of the food value chain of ready-to-eat chicken and the associated risk for staphylococcal food poisoning in Tshwane Metropole, South Africa

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ABSTRACT

The objective of the study was to better understand the informal markets for ready-to-eat (RTE) chicken in Tshwane Metropole, Gauteng Province, South Africa, and in particular the links between the formal and informal sector. As part of this, we assessed the risk of a common food poisoning (staphylococcal) through consumption of RTE chicken sold by informal vendors. We used participatory risk assessment, a novel approach to understanding food safety in data scarce environments to collect information. Structured interviews and focus group discussions with informal vendors ($n = 237$) were conducted to understand poultry value chains for informal RTE chicken, business operation and hygiene practices. Samples ($n = 100$) of RTE were collected from informal vendors in six major taxi ranks. *Staphylococcus aureus* counts were determined using 3M™ Petrifilm™ plates. Data collected in this present study plus information obtained from reviewing of literature, were used to develop a stochastic risk model. The number of colonies which were too numerous to count (TNTC) was artificially modeled.

A mapping of the informal food value chain revealed that there are four possible value chains and that chicken spilled over from formal to informal markets. The prevalence of *S. aureus* in RTE chicken samples (44%; 90% CI: 36.1%–52.2%) was high. The mean *S. aureus* counts in the ready to eat chicken was $10^{3.6}$ (90%CI: $10^{3.3}$–$10^{3.9}$), and the risk of purchasing chicken of unsatisfactory quality ($>10^3$ cfu/g) was 32.9% (90%CI: 25.5%–40.4%). The probability of food poisoning due to consumption of RTE chicken contaminated with staphylococcal enterotoxin was estimated to be 1.3% (90% CI: 0%–2.7%). Sensitivity analysis showed that the probability of *S. aureus* having the enterotoxin gene was the most sensitive parameter for food poisoning. This was followed by *S. aureus* concentration in RTE chicken and lastly the prevalence of *S. aureus* in ready-to-eat chicken.

This study demonstrates the existence of a strong link between formal and the informal market. In view of the low risk observed, the relevant authorities in Tshwane should continue to support the informal sale of RTE chicken. However, there is still a need for provision of hygiene training to reduce the concentration levels of *S. aureus* on the RTE chicken, and to promote the sale of safer affordable source of protein for the large urban poor population in South Africa. This will also help secure the opportunities for employment associated with the trade.

1. Introduction

The great majority of poor people in developing countries obtain food from informal or "wet markets" but these are often neglected by food safety authorities and little is known about their impacts on public health (Grace et al., 2008; Grace, Makita, Kang'ethe, & Bonfoh, 2010). In South Africa, the first comprehensive study into the safety of street vended foods was conducted at a major taxi rank

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in Johannesburg central business district (Masupye & von Holy, 1999). This has been followed by a few other studies, with the most recent study conducted in Bloemfontein, Free State Province (International Union of Microbiological Societies, International Committee on Food Microbiology and Hygiene (IUM-ICFMH) and South Africa, 2005; Lues, Rasephei, Venter, & Theron, 2006). Some of these studies have suggested opportunities for improving safety of street vended foods (von Holy & Makhoane, 2006), and other studies indicate the importance and the benefits associated with the informal sector (Steyn, Labadaries, & Nel, 2011).

Food that is contaminated, irrespective of whether it has unacceptable levels of pathogens or chemical contaminants or other hazards, poses health risks to consumers and economic burdens on individual communities and nations (KZN-DOH, 2001; Mensah, Mwamakamba, Mohamed, & Nsue-Milang, 2012); but quantifying these burdens is essential for rational resource allocation. Previous studies done in South Africa which focused on detecting the presence of hazards could not predict the risk to human health. However, quantitative risk assessment (QRA) can predict health risk along with margins of uncertainty. This information is important to decision makers in developing countries who have to allocate scarce resources across competing health priorities. The application of QRA has been limited in Africa because of the high requirements of data and skilled personnel. In the past decade, participatory risk assessment has been developed as a method that integrates participatory techniques, long used in rural and urban development, with conventional risk assessment (Grace et al., 2008, 2010). Although participatory risk assessment has been applied to several food safety problems in Africa (Appiah, 2010; Grace et al., 2008, 2010), this is the first study on its use in South Africa to address a key hazard of informally marketed food.

Staphylococcal food poisoning (SFP) is one of the most common food-borne diseases that affects hundreds of thousands of people each year worldwide (Asao et al., 2003; Hazariwala et al., 2002; Hennekinne, De Buyser, & Dragacci, 2012; Ji-Yeon et al., 2013). According to the Centers of Disease Control and Prevention (CDC), USA, 240, 000 illnesses with 1000 hospitalizations and 6 deaths associated with staphylococcal food poisoning occur annually (Tallent, DeGrasse, Wang, Mattis, & Kranz, 2013). The role of poultry in SFP has been recognized, and in one study 6.8% of the 236 outbreaks were associated with poultry (Hennekinne et al., 2012; Ji-Yeon et al., 2013).

The cause of SFP is staphylococcal enterotoxins produced by enterotoxigenic strains of coagulase-positive staphylococci (CPS), among which *Staphylococcus aureus* is the main cause with other species such *Staphylococcus intermedius* very occasionally implicated (Hennekinne et al., 2012). While there is evidence for coagulase negative strains being enterotoxigenic, only CPS have been evidenced in food poisoning incidence. In view of this, the present study considers CPS *S. aureus* the main causative agent described in SFPOs (Hennekinne et al., 2012).

In milk *S. aureus* starts producing SE when the population density reaches about $10^{6.5}$ cfu/ml (Fujikawa & Morozumi, 2006). However in low a_w conditions, such as in salted RTE chicken, *S. aureus* accumulate low molecular weight compounds called compatible solutes, which stimulate not only growth but also toxin synthesis (Qi & Miller, 2000). In food, a slightly lower population density of 10^6 CFU/g of *S. aureus* is able to produce sufficient amounts of SEs to cause SFP (Min et al., 2013), but SFP is in many cases confirmed by recovery of at least 10^5 *S. aureus* from food remnants (Hennekinne et al., 2012). Therefore, the present study considers that SFP from consumption of RTE chicken occurs when the chicken is contaminated with *S. aureus* with its concentration higher than 10^5 cfu/g.

The motivation for this study is based on following facts: there is a paucity of data on street foods in South Africa, and to our knowledge, there is no study that has looked at the links between the formal and informal food sectors. Furthermore, quantitative microbial risk assessment (QMRA) of the risk of SFP through consumption of RTE sold by informal traders in Tshwane, South Africa has not been conducted.

2. Material and methods

2.1. Study sites

The study was conducted in Tshwane Metropole with a population of 2,345,908. The Metropole includes Pretoria, the capital city of South Africa.

2.2. Study design

Participatory risk assessment (Grace et al., 2008) was applied in the present study following the procedure of the Codex Alimentarius Commission system framework (CAC (Codex Alimentarius Commission), 2010). Participatory methods are well suited where there is a need to improve understanding of issues and yet data is scarce. Methods that can be employed in such situations include interviews and focus group discussions, visualizations, matrix scoring and proportional piling (Catley & Berhanu, 2003).

2.3. Sampling strategy

Past studies on informal markets in South Africa show that informal food vendors tend to concentrate in and around taxi ranks and railway stations (Lues et al., 2006). In view of this, taxi ranks and railway stations with higher vendor concentration were targeted. Given that the location and population of vendors is continually fluctuating in these informal markets, it was difficult to design a formal sampling frame. Therefore six larger clusters were purposively selected out of a possible 13 markets identified in the Tshwane Metropolitan. The markets that were sampled in this study include; Marabastad, Mabopane, Soshanguve, Belle Ombre/Prinsloo, Mamelodi and Sausville (Fig. 1). With the exception of Belle Ombre that serves a nearby railway and a bus station as well as a taxi rank, the rest are located at taxi ranks. Where the railway stations and taxi ranks are in close proximity to each other, the market is more closely related with the taxi rank. In that case one informal market serves both the railway station and the taxi rank.

While the markets/taxi ranks formed clusters, the units of concern were the vendors selling RTE chicken. All vendors encountered in each of the selected clusters/markets were invited to participate in the study. Verbal and written consent was obtained from each vendor prior to purchase of RTE chicken samples for microbial analysis. Sampling was conducted in April and May 2011 and in total, 100 samples were collected from six markets. The sample size was determined basing on the expected prevalence and the available budget.

2.4. Enumeration of bacteria

Enumeration of *S. aureus* was performed on 3M™ Petrifilm™ Staph Express Count Plate (3M, st. Paul. Mn, USA), which uses a selective and differential medium for *S. aureus* (Merck, 2007), chromogenic modified Baird–Parker medium, following instructions by the manufacturer. When the numbers of colonies on a plate was greater than 150, the count was recorded as too numerous to count (TNTC). In cases where background flora (colonies with non-red-violet color i.e. black colonies or blue-green colonies) were encountered on the plates, as recommended by the manufacturer, 3M Petrifilm Staph Express Discs (3M, st. Paul.