

Salmonella contamination and food safety practices along the pork value chain in a rural east African setting.

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Background

Non-typhoidal salmonellosis is one of the most prevalent food-borne zoonotic diseases globally with a disproportionately higher burden observed in Africa and other low-and- middle-income countries (LMICs). Pigs are considered as some of the most significant sources of infection as their nature as asymptomatic non-Typhoidal *Salmonella* (NTS) carriers hampers our ability to prevent infected pigs from entering the food chain. A recent study isolated NTS from 12.7% of slaughter pigs in rural western Kenya, highlighting pork as a potentially significant source of human salmonellosis in this region, and emphasizing the need for the development of targeted intervention strategies. This study, therefore, aimed to assess how this risk changes at various stages of production from slaughter to retail, as well as to understand associated food safety practices in this setting that may influence NTS contamination in pork products.

Materials and Methods

We conducted cross-sectional surveys at each stage of the pork value chain from slaughter to retail; this entailed the collection of biological samples and data on food safety practices using observation checklists and structured questionnaires. We sampled 144 carcasses from 14 slaughterhouses; 113 meat carriers from as many meat transporters; 255 raw pork samples, 104 cooked pork samples, and 81 side-salad samples from 130 retailers. *Salmonella* were selectively isolated by culture using the standard protocol outlined by the International Organisation for Standardization (ISO 6579:2002) and further confirmed as *Salmonella* spp. using the matrix-assisted laser desorption-ionization time of flight mass spectrometry (MALDI-TOF MS) technique. Proportions and means with 95% confidence intervals were then used to statistically summarize data on *Salmonella* prevalence and food safety practices within each stage.

Results

Salmonella prevalence on pig carcasses, meat carriers and raw pork samples was 18.1 % (12.3 – 25.5%), 23.9% (16.6 – 33.0%), and 28.0% (22.6 – 34.2%) respectively. Further, we found that 46.4% (37.5 – 55.5%) of the raw pork retail outlets included in the study had at least one raw pork sample that was contaminated with *Salmonella* spp. during the study duration. We isolated *Salmonella* spp. from only 1.9% (0.3 – 7.5%) of the cooked pork samples and 8.6% (3.8 – 17.5%) of the raw vegetable side-salad samples. When we considered what would have been a ‘meal’ comprising the side-salad together with a portion of cooked pork, the prevalence per meal was 10% (4.7 – 19.3%) - higher than that from either of the samples separately.

At slaughter, all the pigs observed in the study were decapitated and dehaired on the floor, where carcasses came into contact with blood and fecal matter from other pigs. Additionally, there was accidental leakage of intestinal contents onto 51.1% (42.3 – 59.8%) of the carcasses, and direct contact between carcasses was recorded in 12.3% (6.6 – 21.4%) of our observations. Core carcass temperature before dispatch from the slaughterhouses ranged from 32.5oC to 43.4oC, averaging 38.6oC (38.2 – 39.0oC). These carcasses were then transported in mostly

woven plastic sacks (56.0 %, 95% CI 46.1 – 65.4%) and metallic boxes (29.4 %, 95% CI 21.2 – 39.0%) in ambient temperatures averaging 24.5 oC to retail outlets that were located on average 13.0 (11.6 – 14.5) minutes away.

At the raw pork retail outlets, approximately 84% of the retailers indicated that they frequently jointly purchased a live pig with one or more retailers to be shared among their butcheries, sold raw pork to another retailer, or purchased pork from another retailer for sale at their own outlet. All retailers in this study used tree stumps as pork chopping surfaces (100%; 95% CI 96 – 100%) that they used for an average of 17.6 (95% CI, 11.2 – 24.1) months before replacement with another. Only 20.5% (95% CI, 13.8 – 29.2%) of the retailers indicated that they frequently used soap and water to clean these surfaces - 90.6% (83.4 – 95.0%) of them indicated that they mostly scraped the tree stumps with a knife. The retailers displayed pork on sale for an average duration of 43.8 (40.8 – 46.8) hours- 62.8% (53.2 – 71.6%) at room temperature conditions, 19.5% (12.9 – 28.2%) in deep freezers and 18.6% (12.1 – 27.2%) in refrigerators. We additionally recorded the presence of flies in 74.3% (65.1 – 81.9%) of the retail outlets.

Cooked pork retailers prepared their pork for an average duration of 8.7 (7.3 – 10.1) minutes. The average core maximum cooking temperatures recorded were 185°C (179.0 – 191.0) for all the cooked pork samples included in this study. Approximately 41% of the outlets where a raw vegetable side-salad was sampled had a raw pork sample that was contaminated with *Salmonella*. Although handwash water was available in 83.5% (73.9 – 90.2%) and handwash soap available in 57.1% (46.3 – 67.3%) of the cooked pork outlets that served 'kachumbari', only 9.2% (4.3 – 17.8%) of the food handlers washed their hands after handling raw pork – even then, they did not use soap. It is worth noting, however, that this survey was conducted in 2019, before the COVID-19 pandemic.

Conclusion

In this study we observed that *Salmonella* prevalence progressively increased from slaughter, peaked at raw pork retail, and moderately reduced at the cooked pork consumption retail stage – the presence of *Salmonella* on the raw vegetable side salads, however, still poses a significant risk to cooked pork consumers. Detailing the hygiene practices at every node provides an opportunity to design interventions aimed at reducing the likelihood of a consumer purchasing a contaminated pork portion. The results of this study can be used to guide practical risk reduction measures and be used in risk assessment and intervention models along this and other similar meat value chains.