Assessment of safety risks associated with handling chicken as based on practices and knowledge of a group of South African consumers

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Highlights

- Only 38% of consumers were rated as following good practices when handling chicken
- Only 28% of consumers were rated as having good knowledge about chicken safety
- Consumers followed unsafe practices during chicken purchasing, thawing; and hand washing
- Knowledge gaps identified pertaining to chicken refrigeration and safety judgement
- Food safety authorities, chicken processors and retailers need to educate consumers on chicken safety risks

ABSTRACT

Chicken meat has been identified as one of the most important food vehicles of pathogens, particularly *Salmonella* spp. and *Campylobacter* spp. Consumer food safety knowledge and behaviour can substantially contribute to the prevention of foodborne illness. The main objective of this study was to assess the practices and knowledge of a group of South African consumers with respect to handling raw chicken meat, and the associated safety risks with the aim of reducing the risk of foodborne illness at the consumer level. Data were collected through a web-based cross-sectional survey (n = 863). Results showed that a substantial proportion of consumers do not handle raw chicken correctly during purchasing (55%) and thawing (44%); and do not wash their hands correctly before (31%) and after (36%) handling raw chicken. With regard to knowledge on factors affecting the safety of chicken meat, 48% of the respondents believed that refrigeration prevents the growth of bacteria in raw chicken, 93% did not know the maximum safe temperature for refrigerating raw chicken, 26% would refreeze raw chicken once thawed and 45% indicated that chicken that looks and smells fresh could not make them sick. Although the majority of consumers (at least 85%) indicated concerns about the safety risks associated with chicken meat, only 38% were rated as following good practices and 28% as having good knowledge about factors affecting the safety of chicken meat. Overall, consumers aged 40 years and older reported following more safe chicken handling practices and had more knowledge thereof than consumers below 40 years. The findings reflect safety risks related to consumers' knowledge and practices when handling chicken meat and highlight the need for consumer education. Development of safe chicken handling guidelines to prevent temperature abuse of chicken meat, transmission of pathogenic bacteria and cross-contamination are needed.

Keywords: Chicken meat, Consumer practices, Consumer knowledge, Safety risks, South Africa

1. Introduction

In South Africa, there is great reliance on poultry meat as the main source of animal protein (Ncube, 2018). According to the South African Poultry Association (SAPA), 2.2 million tonnes of poultry meat were consumed in South Africa in 2016, of which approximately 98% was chicken meat (SAPA, 2017). In fact, over the past decade more chicken meat has been consumed than beef, pork, mutton and goat combined (SAPA, 2017). Unfortunately, raw chicken meat is recognised as an important reservoir for *Campylobacter* spp. and *Salmonella* spp., which are human pathogens (WHO/FAO, 2009). The prevalence of these bacterial pathogens in raw chicken meat both at processing and retail level in South Africa has been reported (Bartkowiak-Higgo, Veary, Venter, & Bosman, 2006; Mabote, Mbewe, & Ateba, 2011; Olobatoke & Mulugeta, 2015; Van Nierop et al., 2005; Zishiri, Mkhize, & Mukaratirwa, 2016). Even though data on the epidemiology of salmonellosis and campylobacteriosis specifically due to contaminated chicken is scarce, the health risk is considered to be significant (WHO/FAO, 2009).

In general, foodborne illnesses are an important public health challenge globally (WHO, 2015a). The South African National Institute for Communicable Diseases (NICD) defines a foodborne disease outbreak as a food poisoning incident involving two or more people epidemiologically linked to a common food or beverage source (NICD, 2012). In 2016, 85 foodborne disease outbreaks were reported to the NICD. In total, 2096 people were affected, leading to 1651 hospital visits, 139 hospitalisations and 12 deaths (NICD, 2018a). The devastating listeriosis outbreak which occurred recently in South Africa, whereby 218 deaths were reported, further highlights the need for good food safety practices (NICD, 2018b). It is generally accepted that the actual prevalence and incidence of foodborne illness is markedly higher than the documented data mainly due to under-reporting and limited surveillance capacity, especially in developing countries (Jahan, 2012).

The emergence of foodborne illness has been mostly attributed to a contaminated food supply, mishandling of products at manufacture and food service facilities (Käferstein, 2003). Consumers' limited knowledge concerning microbial food hazards, unsafe food handling at home and risky consumption behaviours also adds to the incidence of foodborne illness (Käferstein, 2003). Food handlers, including those in charge of food preparation in the home, are considered the last and most critical 'line of defence' for preventing the occurrence of foodborne illness (Murray et al., 2017). In 2015, the World Health Organisation (WHO) launched a campaign urging governments to improve food safety by educating the general public on proper food handling, storage and preparation practices (WHO, 2015b). Raising consumer food safety awareness, particularly targeting foods that are widely consumed and those identified as major vehicles of pathogens, could prevent or minimise food poisoning cases.

Previous studies in developed countries have gained insight into consumers' level of food safety practices and knowledge on poultry meat and identified gaps that may pose health risks (Bearth, Cousin, & Siegrist, 2014; Bruhn, 2014; Donelan, Chambers, Chambers IV, Godwin, & Cates, 2016; Koppel et al., 2015; Kosa, Cates, Bradley, Chambers IV, & Godwin, 2015). In South Africa, research on food handlers' practices and knowledge relating to food safety has largely focused on ready-to-eat street-vended food and street vendors (Asiegbu, Lebelo, & Tabit, 2016; Campbell, 2011; Hill, Mchiza, Puoane, & Steyn, 2018; Kok & Balkaran, 2014; Lues, Rasephei, Venter, & Theron, 2006; Mjoka & Selepe, 2017), and food service personnel in delicatessen sections of retail outlets (Human & Lues, 2012; Van Tonder, Lues, & Theron, 2007), academic institutions (Sibanyoni, Tshabalala, & Tabit, 2017) and fast food outlets (Murwira, Nemathaga, & Amosu, 2015). Consequently, information on consumers' level of food safety practices and knowledge on chicken meat is limited. Therefore, the objective of this study was to assess the practices and knowledge levels of a subset of South African

consumers with respect to the handling of raw chicken meat and to identify safety risks, consumers' concerns and areas requiring intervention to prevent or limit risks. The aim of this study was to reduce the risk of foodborne illness at the consumer level.

2. Materials and methods

2.1. Questionnaire design

A structured questionnaire was designed by modifying questions from existing surveys by Bearth et al. (2014), Jevšnik, Hlebec, and Raspor (2008), Koppel et al. (2015) and Kosa et al. (2015). Ten consumers, recruited via convenience sampling, were asked to verbalise their understanding of questions and response options to determine if these were as intended (Haeger, Lambert, Kinzie, & Gieser, 2012). The questionnaire was revised accordingly. The online questionnaire was reviewed to determine ease of selection of response options and logic of branched questions. An online pilot test to verify the functionality of the questionnaire and estimate the survey completion time was then conducted with 94 participants. The questionnaire was finalised on the basis of the pilot study results. The final questionnaire obtained information on (i) consumers' self-reported practices when handling raw chicken from retail to the home, (ii) consumers' knowledge of factors affecting the safety of raw chicken, (iii) consumers' concerns about safety risks linked to handling chicken meat in and out of the home and (iv) consumers' socio-demographic characteristics (age, gender and education level).

2.2. Large-scale survey

Respondent recruitment and questionnaire administration for the large-scale survey was conducted through online lead generation (Egentic Asia Pacific Pte Ltd, Bukit Merah, Singapore). The survey was advertised on publicly accessible websites by inviting consumers to participate voluntarily. The consumers consented by agreeing to participate anonymously in

the survey. Respondents were directed to the survey generated on Compusense® Cloud (Compusense Inc., Guelph, ON., Canada). Approval of the research protocol was granted by the ethics committee of the Faculty of Natural and Agricultural Sciences, University of Pretoria, South Africa (EC161205-087).

2.3. Respondents' socio-demographic characteristics

The screening criteria required that respondents should be at least 18 years of age, responsible for buying raw chicken meat and preparing meals in their households. Respondents who did not meet all the criteria were eliminated from the survey. A total of 863 participants met the eligibility criteria and completed the survey. Among the surveyed consumers, 71% were women (Table 1). The largest group of respondents were in the age range of 18 - 29 years, and 99% of the respondents were educated to high school or tertiary level.

Table 1. Socio-demographic characteristics of survey respondents (*n* = 863)

Demographic segmentation	Number of respondents, *n* (%)
Gender	
Male	247 (28)
Female	612 (71)
Not disclosed	4 (1)
Age (yr)	
18 - 29	360 (42)
30 - 39	183 (21)
40 - 49	137 (16)
50 - 59	114 (13)
60 and older	69 (8)
Education level	
Primary school	4 (1)
High school	386 (44)
Tertiary	473 (55)

2.4. Statistical analysis

Consumers' responses to questions on chicken handling practices were grouped into two (those following recommended practices and those following risky practices). The two proportions were then compared using the chi-square test. Consumers' answers to questions on factors affecting the safety of chicken meat were also grouped into two (correct and incorrect answers), and the two proportions subsequently compared using the chi-square test. Chi-square test was also employed to compare the proportions of consumers who usually consider safety risks linked to handling chicken meat in and out of the home with those who do not.

Depending on their chicken handling practices and knowledge about factors affecting the safety of chicken meat, respondents were categorised using a scoring and categorisation system following a modification of the method described by Gizaw, Gebrehiwot, and Teka (2014). Six questions on chicken handling practices (practices questions 1 - 7, excluding question 3; see Appendix A) and 5 questions on chicken safety knowledge (knowledge questions 8 -12) were included in the analysis. A score of one (1) was awarded for each correct response and a score of zero (0) was given for incorrect responses. Scores for practices and knowledge questions were summed separately. Scores for each respondent were converted to percentages. Respondents were then grouped into three categories based on their practices and knowledge about handling chicken meat: 'poor' (0 - 59%), 'moderate' (60 - 79%) and 'good' (80 - 100%).

Spearman's correlation coefficient was calculated between consumers' practices percentage scores and knowledge percentage scores. In order to determine the effect of socio-demographic factors on consumers' practices and knowledge scores for handling chicken meat, the Mann-Whitney U test (for gender and education level) and the Kruskal-Wallis H test (for age) were employed. Multiple linear regression analysis was used to model the associations of socio-demographic factors with consumers' practices percentage scores and knowledge percentage scores, respectively. During multiple linear regression analysis, indicator variables

were developed, whereby the categorical predictor variables (age, gender and education level) were coded with values of 0 and 1 indicating the 'absence' and 'presence' of a characteristic, respectively (Bower, 2013). The categories 'male', 'high school' and '18 - 29 years' were used as reference categories for gender, education level and age, respectively. The analyses were carried out using SPSS software (version 20.0, IBM SPSS Statistics Inc., Armonk, NY, USA) at 95% confidence level.

3. Results and discussion

3.1. Consumers' self-reported practices for handling raw chicken from retail to the home

Consumers' practices for handling raw chicken are presented in Table S1 (see supplementary information). Responses in bold are the recommended practices.

3.1.1. Purchasing and period prior to home storage

During grocery shopping, a significant proportion of the respondents (55%) did not follow the recommended practice of selecting raw chicken when they are about to check out (χ^2 = 10.02, p = 0.002) (Table S1). A similar study by Jevsnik et al. (2008) revealed that, when shopping, 90% of Slovenian consumers also did not select raw meat when they were about to check out. Not following this practice could lead to temperature abuse of the chicken product and increase the potential for pathogenic bacterial growth, if present. Regarding this practice, it is highly probable that most consumers could be influenced more by where the chicken products are located in the retail store than concern for safety. In a standard supermarket layout, meat products are usually situated across the rear and away from the entrance or exit (Aloysius & Binu, 2013). However, no information on the layout of supermarkets as frequented by respondents in this study was collected.

After purchasing chicken meat, 95% of the respondents reported taking on average at most 2 hours before refrigerating or freezing raw chicken at home (χ^2 = 695.97, p < 0.001). This

included travel time from the retailer to home. This result is comparable with a survey reporting that about 93% of Irish consumers freeze or refrigerate raw meat within 2 hours after purchasing (Kennedy et al., 2005). Interrupting the chicken meat cold chain for extended periods could increase the risk of proliferation of pathogenic microorganisms to unacceptable levels, posing a health risk to consumers (Alonso-Hernando, Alonso-Calleja, & Capita, 2013). As per the South African Department of Agriculture, Forestry and Fisheries (DAFF) food preparation guidelines, the meat cold chain should not be broken for over 2 hours (DAFF, 2002).

3.1.2. Home storage

At home, a large majority of the consumers surveyed (86%) store raw chicken in the freezer (χ^2 = 441.12, p < 0.001) (Table S1). The rest (14%) keep it in the refrigerator. Both these practices are acceptable for domestic storage of raw chicken. It is well established that freezing (below -10 to -12 °C) has an inhibitory effect on the growth of both pathogenic and spoilage microorganisms and has the advantage of extended storage time (Coorey et al., 2018). As opposed to freezing, refrigeration of raw chicken for extended periods can pose a risk as bacteria can still grow but at a slow rate, especially at temperatures above 4 °C (Koutsoumanis & Taoukis, 2005; Tuncer & Sireli, 2008). It is challenging to investigate the ideal maximum refrigeration period for raw meat because the microbial load of meat differs widely on purchasing (Coorey et al., 2018). Nonetheless, the United States Department of Agriculture (USDA) recommends refrigeration of raw poultry for a maximum of 2 days at 4 °C or below (USDA-FSIS, 2014). In this survey, a significant proportion of the respondents (81%) reported refrigerating chicken meat for at most 2 days before cooking (χ^2 = 316.65, p < 0.001). However, 15% of the respondents indicated that they refrigerate chicken meat for more than 2 days and up to 7 days (Table S1). Following this practice could cause microbial pathogen growth in chicken meat thereby putting consumers at risk of food poisoning.

3.1.3. Thawing methods

Since a large majority (86%) of the consumers in this study freeze raw chicken after purchasing, it was important to ascertain their thawing practices prior to cooking. For domestic thawing, using the refrigerator, thawing under running cold water or in cold water that is changed regularly, or thawing in a microwave as part of the cooking process, is recommended in the South African Food Preparation and Home Food Safety guidelines (DAFF, 2002). In this study, 44% of the respondents reported risky practices, that is, either thawing raw chicken on the kitchen countertop (24%), in hot water (13%) or cooking it whilst still frozen (7%) (χ^2 = 12.78, $p < 0.001$) (Table S1). Thawing at ambient temperature or in hot water might expose the chicken meat to temperatures enhancing microbial growth, whilst cooking meat without thawing might result in undercooking of the innermost portions (FACS, 2016). According to Roccato et al. (2015), thawing raw chicken meat overnight at room temperature caused significant increases in *Salmonella* Typhimurium numbers in comparison with thawing overnight in the refrigerator. Research on other meat species (fish) demonstrated that refrigerator and cold-water thawing, in comparison with ambient temperature and microwave thawing, resulted in meat with the lowest total aerobic mesophilic bacterial counts (Ersoy, Aksan, & Özeren, 2008; Javadian, Rezaei, Soltani, Kazemian, & Pourgholam, 2013). Consequently, the recommendation to thaw raw chicken meat in a refrigerator or in cold water is pertinent to minimise the growth of both pathogenic and spoilage microorganisms.

3.1.4. Hand washing

In this study, 31% of the respondents reported not washing their hands with soap and water before handling raw chicken. After handling raw chicken, 36% of the respondents reported not washing their hands using soap and water. Several other studies, both observational and self-reporting, have also revealed that most consumers fail to comply with the hand hygiene guideline of washing hands with soap and water before and after handling raw chicken during

food preparation (Bruhn, 2014; Donelan et al., 2016; Jevšnik et al., 2008). Hand washing has been recognised as an important but easily overlooked public health practice that may considerably mitigate the transmission of pathogens to food and the risk of diarrheal diseases (Ejemot-Nwadiaro, Ehiri, Arikpo, Meremikwu, & Critchley, 2015). The South African Department of Health (DoH) hand washing guidelines to the general public recommend firstly wetting hands with clean running water, lathering hands with soap and then thoroughly rubbing the palms, back of hands, in-between fingers, thumbs, wrists and nails before rinsing with clean water and finally drying using a clean cloth or by air (Department of Health, 2016). Even though antibacterial soaps are the most effective, Toshima et al. (2001) and Burton et al. (2011) demonstrated that using plain soap and water is viable as it could remove more than 91% of bacteria of potential faecal origin from hands. Non-conformance by consumers to this hygienic practice could lead to cross-contamination, especially when consumers touch other utensils, kitchen surfaces or prepare other foods after handling raw chicken without first washing their hands with soap and water (Bruhn, 2014).

3.2. Consumers' knowledge of factors affecting the safety of chicken meat

Consumers' knowledge about the recommended safe storage and preparation practices related to chicken meat was determined (Figure 1 and 2). About half of the respondents (45%) were unaware that sensory indicators of raw chicken freshness (appearance and smell) are not accurate indicators of safety ($\chi^2 = 7.23$, $p = 0.007$). Unlike with spoilage bacteria, the growth of foodborne pathogens to hazardous levels in meat is impossible to detect through sensory assessment of meat freshness (Henson & Northen, 2000). Hence consumers should be made aware of the need to be constantly vigilant when handling and preparing chicken meat to avoid the risk of infections.

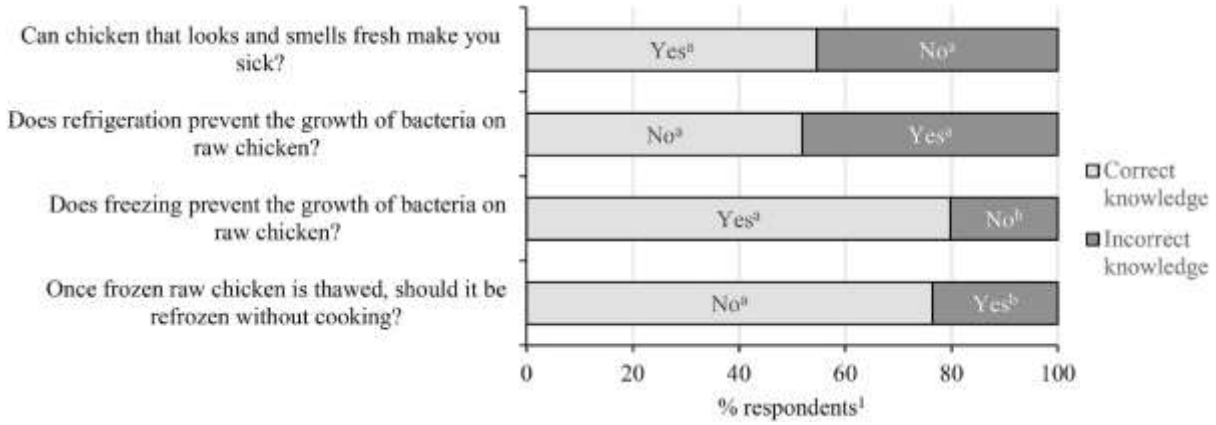

Fig. 1. Consumers' knowledge about factors affecting the safety of chicken meat. [1]Consumers' responses to dichotomous questions (Yes/No). Responses with different superscripts were significantly different (chi-square test, $p < 0.05$, $n = 863$).

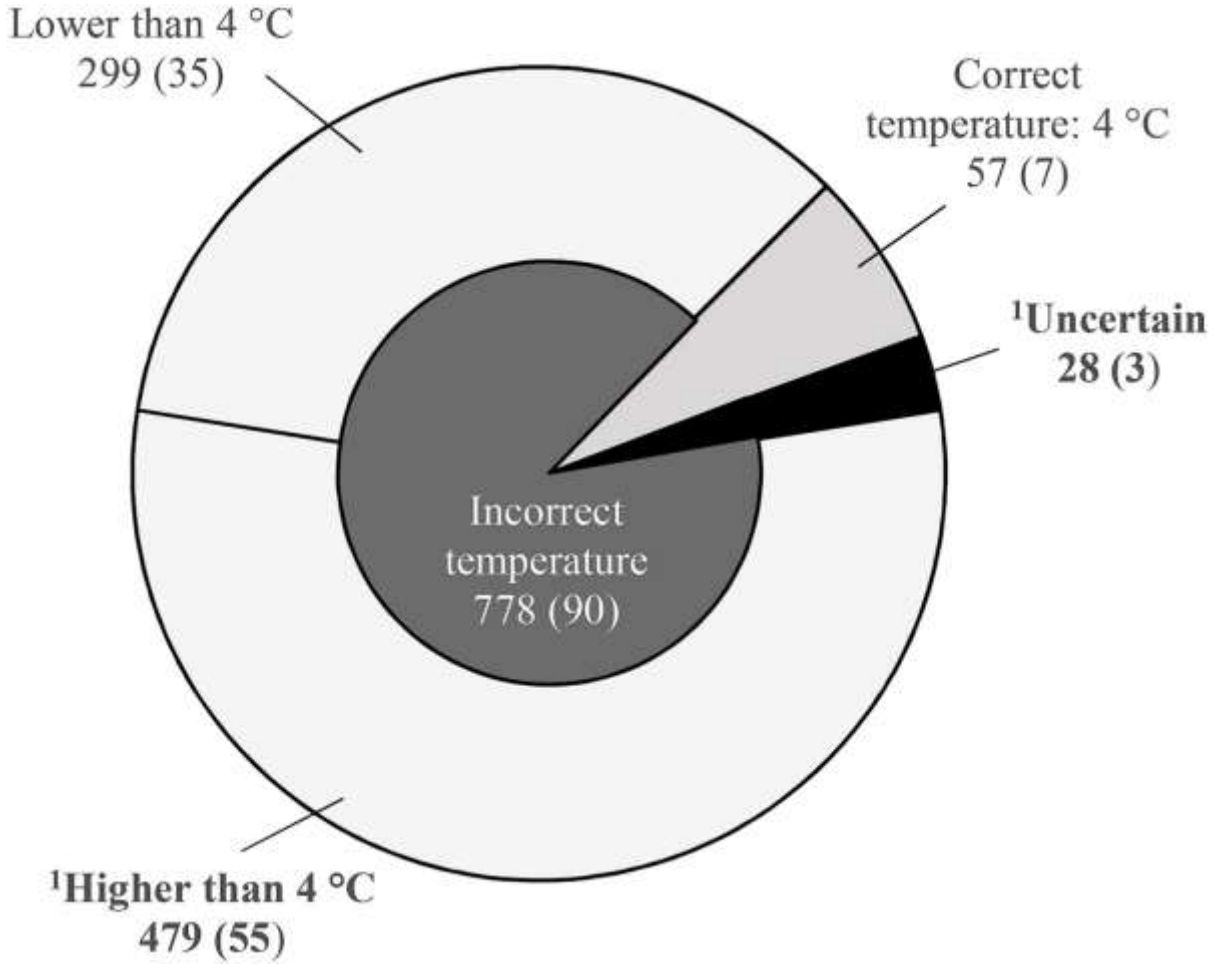

Fig. 2. Comparison of the number of respondents (% in brackets) who gave the correct maximum refrigeration temperature for raw chicken (4 °C) with those who did not ($n = 863$). [1]Number of respondents at risk of unsafe chicken meat appear in bold.

A significant proportion of the respondents (93%) did not know the ideal refrigeration temperature for raw chicken (χ^2 = 388.46, p < 0.001) (Figure 2). Of these, 55% reported temperatures higher than 4 °C as suitable (ranging from 5 - 45 °C), and 3% indicated that they were uncertain. The recommended temperature by the South African Food Advisory Consumer Service (FACS) is 4 °C (FACS, 2016). In the current study, the temperature of domestic refrigerators was not determined. A literature review by James, Onarinde, and James (2017) concluded that the practical application of consumers' knowledge about refrigeration temperatures is limited because of the general lack of refrigerator thermometers in homes. Consequently, most consumers do not know the temperature in their own refrigerators. The authors recommended that refrigerator manufacturers should include built-in sensors that may help consumers know and monitor the temperature of their refrigerators in order to minimise bacterial growth in food during storage, and ultimately reduce the occurrence of foodborne diseases.

Besides their lack of knowledge of the ideal chicken meat refrigeration temperature, about half (48%) of the consumers were of the impression that bacteria in chicken meat become dormant during refrigeration storage (χ^2 = 1.26, p = 0.261). In a similar study, Bearth et al. (2014) found that 49% of Swiss consumers were also of the misconception that pathogenic bacteria in poultry meat cannot reproduce at refrigeration temperatures. The findings of the current study are concerning because consumers indicate a lack of knowledge related to temperatures that inhibit bacterial growth. This could lead to improper storage of chicken meat at home. Thus, consumers should be educated on the effect of refrigeration temperatures on bacterial growth in meat.

Regarding freezing of chicken meat, 80% of the respondents correctly indicated that freezing prevents the growth of bacteria in raw chicken meat. After thawing, 24% of the consumers reported that raw chicken meat should be refrozen if not cooked immediately (χ^2 =

239.89, $p < 0.001$). However, of the 24% that reported that thawed chicken meat should be refrozen if unused, almost all (92%) do not use a refrigerator for thawing. It is proposed that during thawing of foods, bacterial growth could be enhanced due to the increased moisture and nutrients available from the formed exudate (Leygonie, Britz, & Hoffman, 2012). A study by Rahman, Hossain, Rahman, Hashem, and Oh (2014) showed that beef samples thawed at 4 °C had the lowest bacterial load after each freeze-thaw cycle (a total of 3 cycles), in comparison with those thawed at room temperature and in cold water. This implies that the practice of refreezing meat after thawing at temperatures higher than 4 °C could potentially compromise its safety and increase the chances of foodborne illness.

3.3. Categorisation of consumers based on practices use and knowledge of factors affecting the safety of chicken meat

Respondents were categorised into three groups based on poor, moderate or good chicken meat handling practices and poor, moderate or good knowledge levels of factors affecting the safety of chicken meat (Table 2). Only 38% of the respondents were categorised as following good chicken meat handling practices and 28% as having good knowledge of factors affecting chicken meat safety. Most consumers followed moderate or poor practices (62%) and had moderate or poor knowledge levels (72%). These results are concerning because almost all of the surveyed consumers in this study were educated to high school or tertiary level. However, their limited awareness could be attributed to lack of emphasis on food safety in the South African basic education curriculum (Department of Basic Education, 2011, 2017). The findings suggest that a large majority of the surveyed consumers need education to improve their practices and knowledge on chicken meat safety to alleviate the risk of foodborne disease infections. Intervention is needed from the Inter-departmental Food Safety Coordinating Committee (IDFSCC) in South Africa to develop consumer education programmes to improve consumer awareness on food safety matters. The IDFSCC could be more effective in the

implementation of consumer food safety education programmes as it is a collaboration of three government departments: Department of Agriculture, Forestry and Fisheries (DAFF), Department of Health (DoH) and Department of Trade and Industry (DTI) (DAFF, DoH, & DTI, 2013). Chicken meat processors could also raise consumer awareness by including clear safe handling instructions on chicken meat product labels. Currently, the safety information on raw chicken products is inadequate and unstandardised, that is, the amount of information provided differs from one chicken brand to another and is completely absent on other brands. This is probably because South African labelling regulations do not mandate the inclusion of safe handling practices on poultry products (Department of Health, 2010). Disclosure of safety risks associated with poultry on product labels could improve consumer knowledge and practices. Additionally, retailers could assist consumers to be conscious of food safety through several ways, for example, providing food safety information in the supermarket during in-store advertising, in catalogues, in retailer-owned magazines and on grocery bags; and colour coding of grocery bags to prevent cross-contamination during grocery packing at check out (as it is in the case of colour-coded chopping boards).

Table 2. Categorisation of respondents according to their practices and knowledge of factors affecting the safety of chicken meat (n = 863)[1]

	Categorisation system			**Mean score (%)**
	Poor (0 - 59%)	Moderate (60 - 79%)	Good (80 - 100%)	
Chicken handling practices	310 (36)	228 (26)	325 (38)	**66 ± 22**
Chicken safety knowledge	349 (40)	273 (32)	241 (28)	**56 ± 22**

[1]Data is presented as n (%).

3.4. Effects of socio-demographic factors on consumers' practices and knowledge of factors affecting the safety of chicken meat

Socio-demographic factors possibly influencing consumers' practices and knowledge related to handling chicken meat were investigated (Table 3). In this study, women respondents reported following more safe practices than men (U = 62.01, p < 0.001), though their knowledge levels were similar (U = 70.70, p = 0.125). This may be due to the fact that in South Africa women prepare food in the home more often than men hence they have more practise and experience (Altman, Hart, & Jacobs, 2009). Furthermore, it was found that the education level of respondents had no impact on their chicken meat handling practices (U = 89.54, p = 0.621), but respondents with tertiary education were more knowledgeable about factors affecting the safety of chicken meat than those with high school education (U = 100.74, p = 0.007). The results suggest that there could be instances whereby consumers who are knowledgeable about the safety of chicken meat do not always conform to safe practices for handling chicken meat. In this study, consumers' knowledge about factors affecting the safety of chicken meat did not substantially impact their practices for handling chicken meat (Spearman's correlation $\rho = 0.23$, $p < 0.001$, results not shown). The phenomenon of consumers failing to put their knowledge into practice is usually attributed to psychological factors, most commonly optimistic bias and habit (Al-Sakkaf, 2013). A study by Bearth et al. (2014) reported that consumers did not realise that their behaviour at home could lead to contracting foodborne illness (optimistic bias) and acknowledged that they found it challenging to break their risky habits. In addition to educating consumers, publicising foodborne disease outbreaks bold and clear (scare tactics) might help consumers to better understand the aetiology and severity of food poisoning and motivate them to change their attitudes and habits and adopt safe food handling practices. An example whereby scare tactics have been effective is in the United States of America (USA). Since 2012, the Centres for Disease Control and Prevention (CDC)

Table 3. Effects of socio-demographic factors on consumers' practices and knowledge of factors affecting the safety of chicken meat

	Gender	Mean score (%) ± SD (n = 859)[1, 2]	Education level	Mean score (%) ± SD (n = 859)[1, 3]	Age (yr)	Mean score (%) ± SD (n = 863)[1]
Chicken handling practices	Male	60.9[a] ± 20.9	High school	66.6[a] ± 21.8	18 - 29	58.6[a] ± 21.2
	Female	67.5[b] ± 22.0	Tertiary	65.6[a] ± 22.0	30 - 39	65.9[b] ± 21.0
					40 - 49	72.3[c] ± 21.4
					50 - 59	75.3[c] ± 19.5
					60 and older	74.6[c] ± 21.1
Chicken safety knowledge	Male	54.3[a] ± 23.2	High school	53.5[a] ± 22.6	18 - 29	52.6[a] ± 23.2
	Female	56.8[a] ± 21.8	Tertiary	57.7[b] ± 22.2	30 - 39	53.9[a] ± 20.4
					40 - 49	59.1[b] ± 21.8
					50 - 59	60.9[b] ± 22.0
					60 and older	63.2[b] ± 21.6

[1]Means with different superscripts within columns, for each score category, were significantly different (Mann-Whitney U and Kruskal-Wallis H test, $p < 0.05$).

[2]Consumers who preferred not to disclose their gender (1%) were not included in the statistical analyses.

[3]Consumers with primary school education (1%) were not included in the statistical analyses.

has periodically launched anti-smoking campaigns featuring compelling real stories of former smokers living with smoking-related diseases and disabilities (CDC, 2018). The CDC estimates that during 2012 to 2015, approximately half a million smokers in the USA successfully quit smoking definitively as a result of the campaign.

With respect to age, it was found that the youngest group of respondents (18 - 29 years) reported more risky practices than the rest of the consumers ($p < 0.05$). Consumers in this age group (18 - 29 years) demonstrated that they were significantly less knowledgeable than respondents in the other age groups ($p < 0.05$), except those in the 30 - 39 years age group ($p > 0.05$). Models developed to determine the strength of socio-demographic factors to predict consumers' practices when handling chicken meat (Table 4) and knowledge about factors affecting the safety of chicken meat (Table 5) also revealed that the age of respondents better predicted both practices and knowledge than gender and education level, as evidenced by the larger predictor variable coefficients. Similar studies conducted in other countries, such as Slovenia and Turkey, also showed that food safety knowledge and safe practices tend to improve with consumer age (Jevšnik et al., 2008; Sanlier, 2009). In accordance with the findings in the present study, young adults particularly aged 18 - 29 years were identified as the most susceptible to foodborne illness, followed by those aged 30 - 39 years. Byrd-Bredbenner, Abbot, and Quick (2010) speculated that this could be due to changes in school curricula leading to marginalisation of life skills subjects. As a result, a large proportion of young adults could have limited knowledge and skills on the safe purchase, preparation and storage of food. Life skills subjects such as home economics should be a standard and compulsory part of the basic education curriculum. Home economics could be an important tool to impart essential food safety knowledge and skills to children and youths with possible long-term effects on individuals after their schooling has been completed. Another reason cited by the author was that more mothers have careers nowadays and hence have less time to spend

preparing meals at home together with their children. Children and teenagers could acquire food safety knowledge and learn safe practices for handling food as a result of frequently observing and assisting their parents (or family members) when preparing meals at home. The food safety skills learned could develop into life-long habits thereby preventing the incidence of foodborne illness. In order to increase food safety awareness among young adults, consumer educators could employ the internet, social media and relevant social pressure (Young & Waddell, 2016). These modes of food safety education could be more interesting to young adults than conventional methods such as print-based material and lectures.

Table 4. Multiple linear regression model for the association of socio-demographic factors with consumers' practices for handling chicken (n = 855)

Socio-demographic factors	Categories	Unstandardised coefficients	Standard error	t-statistic	p-value[2]
Constant		55.228	1.707	32.337	< 0.001
Gender	*Male*[1]	-	-	-	-
	Female	5.696	1.557	3.667	< 0.001
Education level	*High school*[1]	-	-	-	-
	Tertiary	-0.923	1.414	-0.652	0.515
Age (yr)	*18 - 29*[1]	-	-	-	-
	30 - 39	6.763	1.879	3.596	< 0.001
	40 - 49	12.482	2.069	6.036	< 0.001
	50 - 59	16.213	2.215	7.321	< 0.001
	60 and older	17.289	2.715	6.373	< 0.001

[1]Reference category. Dependent variable: percentage scores for consumer practices.
[2]Association significant at $p < 0.05$, $R^2 = 0.116$. Consumers who preferred not to disclose their gender (1%) and with primary education (1%) were not included in the statistical analysis.

Table 5. Multiple linear regression model for the association of socio-demographic factors with consumers' knowledge of factors affecting the safety of chicken meat (n = 855)

Socio-demographic factors	Categories	Unstandardised coefficients	Standard error	t-statistic	p-value[2]
Constant		49.310	1.825	27.024	< 0.001
Gender	*Male*[1]	-	-	-	-
	Female	2.104	1.665	1.263	0.207
Education level	*High school*[1]	-	-	-	-
	Tertiary	4.080	1.512	2.698	0.007
Age (yr)	*18 - 29*[1]	-	-	-	-
	30 - 39	0.931	2.009	0.463	0.643
	40 - 49	5.878	2.213	2.656	0.008
	50 - 59	8.517	2.368	3.596	< 0.001
	60 and older	10.917	2.903	3.761	< 0.001

[1]Reference category. Dependent variable: percentage scores for consumer knowledge.

[2]Association significant at $p < 0.05$, $R^2 = 0.042$. Consumers who preferred not to disclose their gender (1%) and with primary education (1%) were not included in the statistical analysis

3.5. Consumers' concerns about safety risks linked to handling chicken meat

Lastly, it was important to investigate whether consumers consider the safety of chicken meat in the first place (Figure 3). Basically, at least 85% of the respondents indicated that they think about the safety of chicken meat when shopping, during storage and preparation of chicken meat at home and when consuming chicken meat outside of their homes ($p < 0.05$). Furthermore, a large majority (82%) knew that their practices for handling chicken meat from retail to the home could impact its safety ($p < 0.05$). However, the respondents' concerns were inconsistent with their self-reported practices, discussed earlier in this paper. A possible explanation could be that the respondents were concerned about the safety of chicken meat but lack knowledge on safe handling practices, hence the need for consumer education. On a more

positive note, their concerns could also be an indication that they would be receptive to education about the safety of chicken meat.

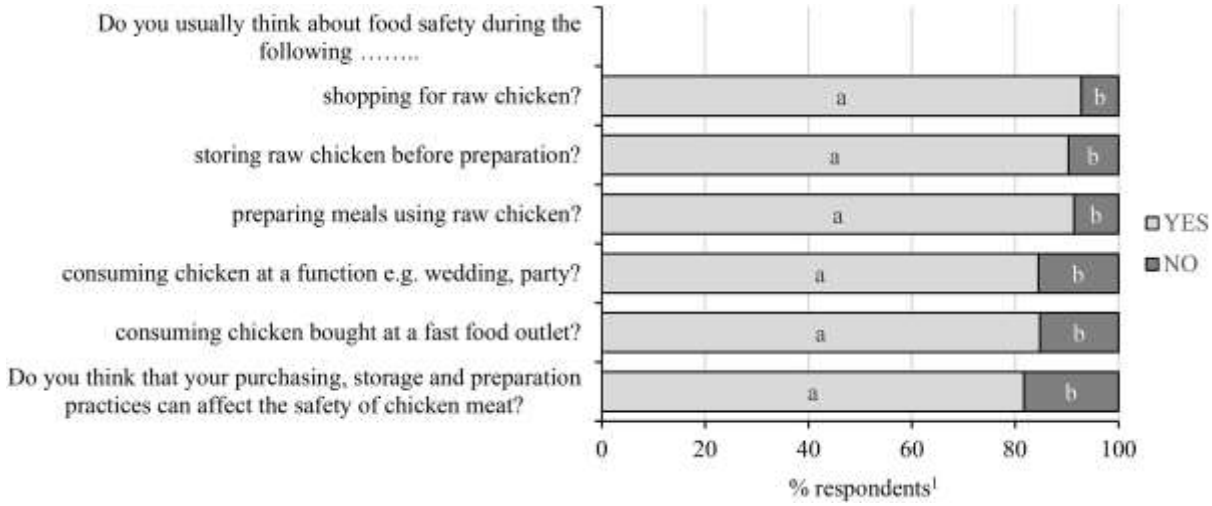

Fig. 3. Consumers' concerns over the safety of chicken meat. [1]Consumers' responses to dichotomous questions (Yes/No). Responses with different letters were significantly different (chi-square tests, $p < 0.05$, $n = 863$).

Incidences of foodborne illness implicating chicken meat have been reported in South Africa. For instance, 65 people reported ill after consuming contaminated chicken meat served in a lodge in Limpopo province in 2014 (Muvhali, Smith, Rakgantso, & Keddy, 2017). Similarly, 63 people were affected after eating contaminated chicken meat served at a hotel in Tshwane District in 2015 (NICD, 2015). A recent report by the NICD on foodborne disease outbreaks in South Africa revealed that there is generally great variability in the investigation and reporting of foodborne disease outbreaks throughout the country (NICD, 2018a). It was highlighted that food samples are not always collected and when collected, inappropriate testing methods are usually applied. Hence investigations towards establishing the sources of infections are often hindered (NICD, 2018a). There is, therefore, need to standardise and improve surveillance and reporting of foodborne disease outbreaks. In addition, the obtained

foodborne disease outbreak information, coupled with guidelines to prevent safety risks, could be publicised to increase consumer food safety awareness.

4. Research limitations

The sample of consumers surveyed in this study was biased towards consumers who use the internet and could read and understand English. Females and consumers in the young age group were more represented, so the results obtained in this study may not truly reflect the knowledge and chicken meat handling practices of males and older consumers. In addition, the consumer practices assessed in this study were self-reported and there could be inconsistencies with the actual behaviour due to social desirability bias, whereby the best practices for handling chicken meat could have been over-reported (Redmond & Griffith, 2003). Despite these limitations, the results obtained in this study are still useful as they revealed predominant misconceptions and non-compliance with safe practices by adult South African consumers who buy raw chicken meat and prepare it in their households.

5. Conclusions

This study investigates the safety risks associated with practices and knowledge of a subset of South African consumers related to handling raw chicken meat. Major gaps in practices and knowledge that could lead to temperature abuse of chicken meat, transmission of pathogenic bacteria and cross-contamination are identified. Based on these findings, there is potential for foodborne illness due to mishandling of chicken meat and a serious lack of knowledge about factors affecting the safety of raw chicken by a large proportion of consumers. Consumer practices and knowledge when handling chicken meat can be improved through educational interventions by the IDFSCC and non-governmental scientific organisations such as FACS, with emphasis on the basic science explaining the rationale behind recommended practices to

increase consumer understanding and motivation. The inclusion of specific food safety guidelines for consumers within the labelling regulations followed by poultry processors in South Africa (Foodstuffs, Cosmetics and Disinfectants Act) is also recommended. Furthermore, retailers can contribute in raising consumer awareness by providing food safety information during chicken product advertisement. For effectiveness, the employed risk communication strategies must be multifaceted in order to cater for consumers with different socio-demographic characteristics.

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