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Research Article

Assessing the Zoonotic Risk of Bovine Brucellosis Transmission in Gauteng Abattoirs

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Abstract

Abattoir workers could be exposed to bovine brucellosis when positive animals with known and unknown status are sent for slaughter. In veterinary science risk analysis consists of hazard characterisation, risk assessment, risk mitigation and risk communication. Occupational risk assessment is done by multiplying the likelihood by the magnitude or consequences of exposure. While the risk of zoonotic transmission during slaughter has been recognised, the likelihood of exposure at Gauteng abattoirs was not known.

The study estimated of the sero-prevalence of brucellosis in cattle in Gauteng. The risk of zoonotic transmission at different critical control points along the slaughter line was analysed using the risk matrix suggested for occupational health.

This was a cross-sectional study using mixed methods to include desk review. Sero-prevalence in cows was calculated from secondary data of 62 471 cows from mixed farming sectors from the Gauteng province. The blood samples were tested as they were collected over a period of 32 months. The proportion of cattle presented for slaughter without being tested for brucellosis was calculated from information from the abattoirs during the survey. Risk of occupational exposure was assessed using Hazard Analysis and Critical Control Point (HACCP) method.

Sero-prevalence in cows was calculated to be 1.12% (n = 700) from secondary data of 62 471 mixed cattle from both communal and commercial farming sectors. An average of 43 020 cows passed through the 21 abattoirs in Gauteng per month. Eighty percent (n = 34 416) of these animals are presented without being tested for brucellosis.

Keywords: Brucellosis; Risk Assessment; HACCP; CCP; Occupational Exposure

Introduction

The OIE lists bovine brucellosis *(Brucella abortus*) as a serious zoonosis. Brucellosis is an occupational and environmental hazard in abattoirs [10]. The Food and Agriculture Organisation of the United Nations (UNFAO)/Codex Alimentarius Commission (CAC)/ World Health Organisation (WHO) reports that it causes chronic disease and debility presenting as undulant fever, headache, malaise, profuse sweating, chills, wasting away and generalized pain [2,4,10,16,25]. This could be worse in those who are immunocompromised such as those who are malnourished or with HIV/ AIDs or both.

In the United States of America (USA) about 100 to 200 cases were reported annually, with Texas being worst hit[21]. Latin America is one of the most important reservoirs of human brucellosis. Most countries in the European Union are free from human Brucellosis, except for Turkey, Greece with Spain having the highest incidences of human Brucellosis worldwide [21,26,27,44]. The Mediterranean basin is endemic so are most countries in the Middle East with Saudi Arabia believed to be endemic and a reservoir for human brucellosis, it has a human sero-prevalence level estimated at 15%7 [10-14]. Pakistan has been found to have a prevalence of 21.7% in humans [1,21]. Seven countries of the former Soviet Union were placed in the top 25 countries with highest incidences of human Brucellosis [1,21]. Brucellosis is endemic in North Africa. Many countries do not have accurate incidence rates [21,30].

Human sero-prevalence in other parts of Sub-Saharan Africa are not known although most people in rural areas live with their livestock. Most people are of poor socio-economic status and depend on livestock for livelihood. There are poor surveillance systems on Brucellosis, vaccination programs are not efficient and effective and at times are non-existent. Control of Brucellosis involves the slaughter the livestock found positive which has a further negative impact on the socio-economic status of the susceptible population, such that for them it will be better to live with Brucellosis than to die from starvation [21,33]. Some work which was done in Tanzania revealed 5.52% incidence in slaughterhouse workers, 20% in nomads and 9% in abattoir workers in Sudan [21,33]. In Ghana 14% of the abattoir workers and 4,8% of the same group of population have been found to have antibodies to Brucellosis [2]. In Nigeria a sero-prevalence survey revealed a 24.1% prevalence in humans, among abattoir workers, butchers or meat handlers [4]. In South Africa a prevalence of 4% in the Northwest province [29]. Although brucellosis is endemic in South Africa, the policies do not make it compulsory for animals to be tested for brucellosis before slaughter [12,15].

Several authors have described risks of brucellosis in red meat abattoirs [2,4,6,10,11,33]. Inspections in abattoirs, both ante mortem and carcass inspection are a surveillance system for animal diseases and zoonosis at the same time ensuring safe and wholesome product fit for its intended use [25,28]. The veterinary services is central and primarily responsible for the ante- and pot-mortem inspections as they control and/or reduce biological hazards of animal and public health importance [35]. Abattoir workers get exposed at the slaughter floor when they slaughter brucellosis positive animals which were not tested. Legislation and regulations in South Africa are non-existent and fragmented with the risk of brucellosis as an occupational hazard not well covered [12,15,40]. The points along the slaughter process which are likely to be critical for exposure are at the holding pens (Havas 2011), bleeding and exsanguination [38,39], at the point of evisceration [8,14], and the handling and disposal of waste and condemned organs [7]. A risk- based approach has been suggested to prevent transmission of bovine brucellosis to workers in abattoirs. This should include a routine surveillance of live cattle and monitoring of the products throughout the food chain [10,28,41]. The risk in animals should be identified such that abattoirs should refuse to slaughter cattle with unknown brucellosis status. This might force the farmers to test their animals before sending them to the slaughter floor. In South Africa HACCP, HAS, HMP, GMP as shown in (Table 1) are risk-based approaches to meat hygiene and prevention of transfer of zoonosis to consumers and those who are at occupational risk. The emergence of risk-based approaches in collaboration with international standards has been highly influenced by the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures [42].

Approach	Definition	Reference #
HACCP	Hazard Analysis Critical Control Point. It is a system that identifies, evaluates and controls hazards that are significant for food safety.	[30-32]
HAS	Hygiene Assessment System, a nationally standardised evaluation system that quantifies the standard of hygiene management at abattoirs	[30-33]
HMP	Hygiene management programmes, are used to: (a) ensure that management programmes for each hazard is implemented; (b) establish critical limits for control points; (c) establish a monitoring or checking system for each control point; and (d) prepare written corrective actions that must be taken without hesitation when a deviation is detected and such corrective action must be specified.	[30-33]
GHP	Good hygiene practice.	[30,31,33]
CCP	Critical control point, this is a step at which control can be applied and is essential to prevent or eliminate or reduce food safety hazard to acceptable levels.	[30,33]
Hazard	A biological, chemical or physical agent in; or condition of; food with the potential to cause an adverse health effect. Those of animal origin can be grouped into several categories e.g. zoonosis resulting from clinical disease in animals; zoonosis resulting from asymptomatic infections in animals; and chemical sources.	[30,31,33]
Risk based	Containing any performance objective, performance criterion or process criterion developed according to risk analysis principles.	[1,28,29]

Table 1: Definitions and references for risk-based approach to food safety in abattoirs.

The flow diagram for an abattoir is essential to find CCPs, as detailed in figure 1.

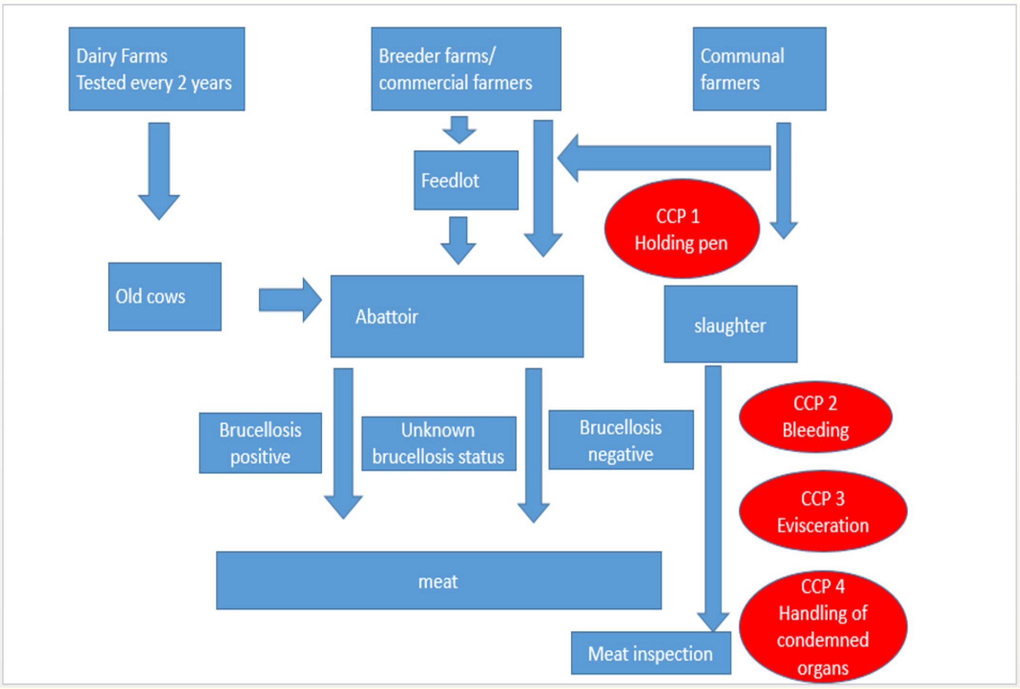

Figure 1: Slaughter Process.

Explanation of CCPs from figure 1

- **CCP1:** Arrival of animals with health attestation from the farmer. The OIE advocates for prevention of biological hazards in livestock before sending them to the abattoir by use of a public health policy. Animals presented for slaughter should come with a health attestation [36]. The current document used in South Africa does not give details on the brucellosis status of the farm (See Appendix 6). In South Africa the policy does not make it compulsory for animals to be tested for brucellosis before slaughter, it is therefore likely that there are many cattle arriving at the slaughter floor which are positive but with unknown brucellosis status [13,15].
- This study calculated the sero-prevalence of brucellosis on cattle farms in Gauteng from secondary data available to the Gauteng State Veterinary Services to estimate the risk of brucellosis. It also investigated if the health attestation and current legislation covered testing of brucellosis in cattle before being sent to an abattoir. It was not known if farms delivering cattle were tested for brucellosis. This information was derived from secondary data obtained from Gauteng Province Veterinary Services.
- **CCP2:** Slaughter and exsanguination Blood from positive animals poses a risk of infection to abattoir workers [35]. The risk to personnel who do not wear protective clothing when slaughtering cattle not tested for brucellosis, was estimated from the sero-prevalence in cattle tested in 2014-2016. To calculate the risk a structured questionnaire was used to determine the number of cattle slaughtered at each abattoir. Relative risk was estimated per abattoir according to secondary data obtained from previous audits.
- **CCP3:** Evisceration. As above
- **CCP4:** Offal disposal and waste management of hazardous waste specific for brucellosis. Hazardous organs from brucellosis positive cattle included the uterus of gravid cows, udders, testes of bulls, blood, hygromas and lymph nodes [1-4,8,10,11,24,25,33,41]. The way effluent was managed was important to reduce contamination of the environment, since *B. abortus* was known to survive in water for long periods [1]. A previous study done in red meat abattoirs in Gauteng showed that 75% were not compliant when handling condemned organs [38]. The risk of handling condemned material from cattle infected with brucellosis was related both to sero-prevalence in the general population and the level of compliance at the abattoir.-

Objectives

We established the sero-prevalence of bovine brucellosis in Gauteng cattle from routine surveillance secondary data from 2014 to November 2016. A calculation of the percentage of cattle presented to the abattoirs for slaughter without testing for brucellosis was done. Risk in the abattoir process was identified/allocated using the HACCP. A comparison of the slaughter of known Brucellosis positive cattle with those not tested for Brucellosis was done.

Method

A cross sectional study using mixed methods in the 21 of 22 beef abattoirs in Gauteng was done. All 21 registered abattoirs in Gauteng slaughtering cattle were included in the survey. All abattoirs slaughtering other species of livestock such as sheep, goats, pigs and chicken were not included in the study. The abattoirs (21) were divided into 4 categories depending on the number of animals they slaughtered per month, table 2.

Groups	Number cattle Slaughtered
A (6)	< 100
B (5)	100-999
C (6)	1000-5000
D (4)	5001 plus

Table 2: Abattoir groups.

Risk analysis

A risk analysis was carried out following the methods as outlined in table 3.

Risk Analysis	Data collection and analysis
Hazard identification	Brucellosis prevalence
Exposure	Slaughtering cattle with unknown Brucellosis status
Management	Policy and legislation changes
Communication	Training of vets, abattoir workers, farmers

Table 3: How risk assessment methods will be used in the study.

Hazard identification

The sero-prevalence rate of brucellosis was estimated using secondary data obtained from State Veterinary Services Gauteng Province from April 2014 to November 2016. Data from a total of 62 471 mixed dairy and beef cattle above 18 months from both communal and commercial farms was analysed to estimate sero-prevalence of brucellosis.

Exposure in the of the abattoirs

Twenty one of the 22 beef abattoirs in Gauteng, were used in the analysis. A cross sectional study of all the abattoirs was done using mixed methods

A self- administered questionnaire by a manager or representative of abattoir was used to get information on

- The numbers of cattle slaughtered per day and the different types slaughtered.
- The percentage of cattle, which came to the abattoir without being tested for brucellosis.
- Documents required from the farm on the health status of the animals.

In-depth interviews with key informants

These were carried out with key informants at the abattoirs. This enabled us to fill in the gaps of information on the questionnaires. The questionnaire was developed following the recommendations of the World Organization for Animal Health (OIE) Terrestrial Animal Health Code, in conjunction with the Food and Agriculture Organisation of the United Nations (UNFAO) and the World Health Organisation (WHO) policies and documents on protection of abattoir workers from Brucellosis and for estimating the risk of exposure to the disease [25,35,36].

The HACCP approach

A HACCP decision tree as illustrated in figure 2, was used to determine the critical control points (CCP).

Document review

The following documents were reviewed

- Brucellosis free certificates
- Health attestations

Data handling

Data was recorded on the questionnaire forms which were numbered A001 – A22. It was captured into EpiData 3.1, on a data capturing form as attached. Analysis was done using EpiData analysis.prototype.0.60.0.win.64. Data was analysed to assess the risk of transmission at each identified Critical Control Point in the abattoir, using HACCP methodology. STATA was used to compare the different beef abattoirs in order to get the general picture in the province.

The study was reviewed and approved by the Ethics Committee of the University of Pretoria, Faculty of Health Sciences, approval number 123/2017. Permission was given by the Gauteng Department of Agriculture and Rural Development (GDARD) to carry out the study. Verbal consent was given by the abattoir management to interview a key informant at each abattoir.

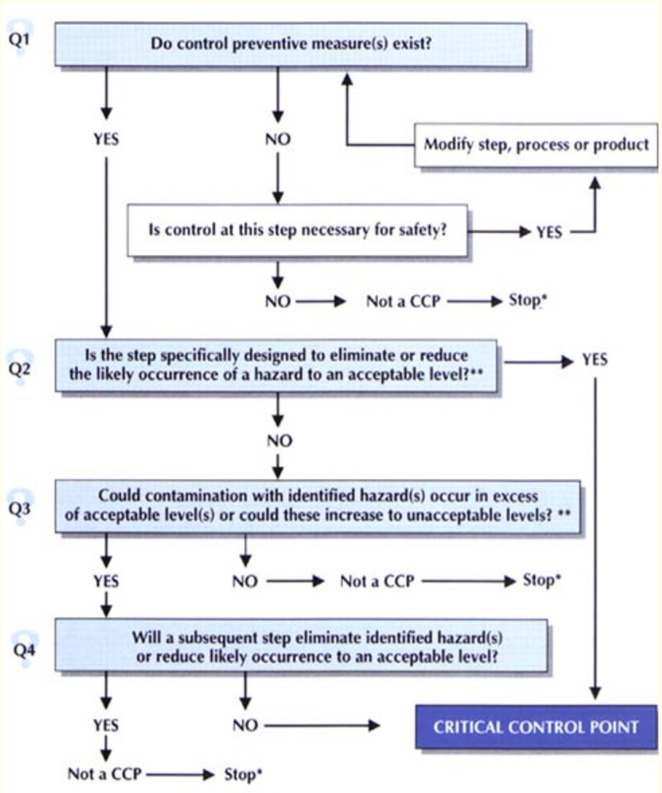

Figure 2: Red meat and abattoir association. HMS & HACCP for the abattoir industry. Learner's guide. Pretoria. December 2011. Page 175.

Results

Prevalence of brucellosis was found to be 1,12% (n = 700) in a total of 62 471 cattle from secondary data of cattle above 18 months from mixed farming sectors was found.

Twenty one of the 22 abattoirs participated in the study. The average number of animals slaughtered in the 21 abattoirs was 43 020 per month. The results of hazard identification are summarized in in table 4 below.

Only one abattoir in group C required that cattle for slaughter were presented with brucellosis (CA) free certificates. Another abattoir required that herds from which cattle were sent for slaughter had to be tested for brucellosis, but still accepted positive cattle. Altogether, only 4 abattoirs accepted cattle for slaughter from known positive herds. Of the 21 abattoirs, only 12 requested health attestations, which are a renowned legal requirement. Only 16 performed ante-mortem inspection, which is also a legal requirement.

Table 5 below shows the level of risk estimated during slaughter.

Hazard assessment/Risk estimation

Relative risk was estimated based on the number of cattle passing through the abattoirs and the brucellosis prevalence 1.12% obtained from secondary data [37]. Group A abattoirs were given a rela-

Group (n)	Average slaughtered /month	Abattoirs requiring brucellosis free certified animals. N	Suppliers testing for brucellosis n	Abattoirs requiring brucellosis tested animals. N	Abattoirs accepting positive. N	Health Attestation n	Ante-mortem examination n
A (6)	23	0	0	0	2	2	3
B (5)	406	0	0	0	0	3	4
C (6)	2 408	1	0	1	1	6	5
D (4)	6 600	0	0	1	1	3	4
Total	43 020	21					

Table 4: Hazard identification.

Group	Average slaughtered/month	Risk quantification		Relative risk
A	23	23 x 1.12 =	25.76	1
B	406	406 x 1.12 =	446.6	18,09
C	2408	2408 x 1.12 =	2696.96	104.7
D	6600	6600 x 1.12 =	7392	286,96

Table 5: Risk estimation.

tive risk of 1, group B were 18 times riskier than group A. Group C were 105 times riskier than group A with group D being 287 times riskier than group A.

Hazard identification/allocation using the HACCP in the abattoir.

The flow diagram in Figure 3, below shows the slaughter process. The stars are the critical control points, were control measures can be put in place to reduce risk of exposure of abattoir workers to brucellosis. CCP1 was the point of receiving cattle for slaughter from the farm, when the attestation form was supplied; CCP 2 presents the point of receiving the animals for slaughter from the farm; CCP 2 exposure in the lairage; CCP3 exposure during exsanguination; CCP 3 exposure during evisceration and CCP5 exposure during handling of offal and condemned material. Critical control point 1, was the most critical point to control and reduce potential risk of occupational exposure to brucellosis. If only brucellosis free animals were presented for slaughter, then the risk of occupational exposure of abattoir workers would be significantly reduced.

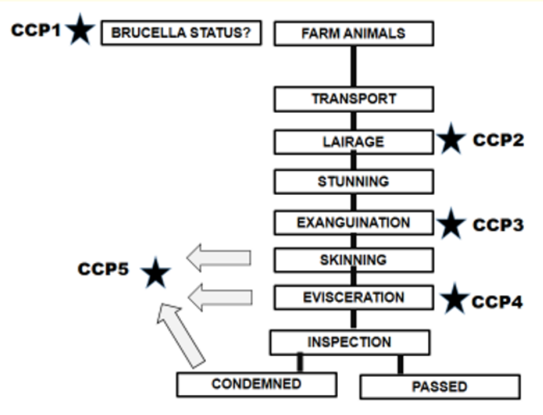

Figure 3: Flow diagram of abattoir process.

Discussion

The prevalence of 1.12% was evidence that the hazard was present and that there was potential risk of exposure to occupational brucellosis in the beef abattoirs. A total of 80% of the animals presented for slaughter at the abattoirs were not tested for brucellosis. There was evidence that most abattoirs did not require brucellosis tested or brucellosis free certified cattle and that none of their suppliers tested for brucellosis. This showed potential risk of exposure of abattoir workers to brucellosis. Most suppliers sending cattle to groups C and D did not require tested cattle as these were from their own feedlot farms and were assumed to be negative. Since these cattle were not being tested there was no evidence that they were negative. Although the potential of risk was high in all the groups of abattoirs it was worse in groups A and B as they accepted cattle not tested for brucellosis. The magnitude of risk and exposure to humans is proportional to the estimated prevalence of brucellosis in the animals presented to the abattoir especially those not tested for brucellosis [1,2,4,5,37]. The OIE advocates for the reduction of the hazard at the primary source. If the cattle are being presented from the farm without being tested it increases the potential of risk of exposure to occupational brucellosis [36,37].

The sero-prevalence of brucellosis in humans is proportional to the brucellosis prevalence in cattle [37].

Risk was estimated by multiplying the prevalence by the average number of cattle slaughtered per month. The estimated relative risk showed that the risk increased with the increase in the number of cattle slaughtered, with group D abattoirs having the highest risk and group A abattoirs having the lowest.

According to HACCP principles, at Control Point 1 where cattle are admitted to the lairages, the potential risk of occupational exposure to brucellosis would be almost zero or reduced if all cattle presented for slaughter had tested negative for brucellosis. Brucellosis positive cattle would then only be slaughtered in abattoirs equipped and designated to do so. This is supported by the recommendations from OIE, which advocates for the hazard to be controlled at the primary source before going to the abattoir [36]. Management systems for inspections at abattoirs should be based on international standards such as the Codex Alimentarius Code of Hygienic Practice for Meat (CHPM) [25,35,36]. The OIE and Codex Alimentarius have worked together closely in the development of international standards which have also been highly influenced by the World Trade Organization (WTO) Agreement on the application of sanitary and phytosanitary Measures [25,35]. Risk based approaches currently in use in South African abattoirs include HACCP, Hygiene Assessment System (HAS), Hygiene Management Programmes (HMP) and Good Management Practice (GMP) [17-20,35,36]. These are supposed to promote meat hygiene, as well as preventing of transfer of zoonosis to consumers and workers [35,36].

Although there were many abattoirs receiving health attestations, none of the health attestations included the brucellosis status of the cattle, which is an OIE requirement [35]. Cattle with brucellosis present as clinically normal and could come with a good health attestation yet they had brucellosis. Positive cattle from untested herds are known to pose a potential risk of occupational exposure to abattoir workers at the slaughter floor, as they show no ante-mortem or post-mortem signs of the disease [24,30,31-33]. A large proportion of abattoirs received cattle from the auction floor, A 33% (2) and B 40% (2). These did not have a health attestation, nor were they tested for brucellosis. This could increase the risk of occupational exposure to brucellosis at the abattoirs as these animals could be positive for brucellosis.

This research could have been affected by social desirability bias, as the research was done by a state veterinarian. The key informants at the abattoirs might have been giving the politically correct responses, which they thought the state veterinarian wanted to hear. This was evidenced by the discrepancies on the response to questionnaires and what was observed. An attempt was made to reduce the bias, by interviewing the veterinarians and technicians responsible for auditing the abattoirs as well as observing the slaughter process and reading documentation at abattoirs included in the study.

Conclusion

With a brucellosis sero-prevalence of 0.1% in Gauteng, there is a risk of occupational exposure to brucellosis in the Gauteng abattoirs. It is recommended that all slaughter cattle are sourced from tested herds. Standard operating procedures must be used for slaughtering of both untested and positive cattle. A full set of personal protective clothing should be provided to all the abattoir workers.

Recommendations

- That all animals coming for slaughter be tested for brucellosis or a penalty of R200 per animal to be paid if animals are not tested, which would be used to protect workers against potential exposure to brucellosis in the abattoirs.
- All abattoirs to comply with above or risk closure.
- Abattoirs slaughtering positive animals should provide documented SOPs, proper training and PPE to sufficiently protect the workers.
- Abattoirs slaughtering brucellosis positive animals should have documented SOPs on slaughter of CA positive animals to reduce risk of occupational exposure.
- There is need for training and awareness on the danger of CA to the abattoir floor workers.

Definitions

- **HACCP:** Hazard Analysis Critical Control Point. It is a system that identifies, evaluates and controls hazards that are significant for food safety [17-20,22,35].
- **HAS**: Hygiene Assessment System, a nationally standardised evaluation system that quantifies the standard of hygiene management at abattoirs [17-20,22,35].
- **GHP**: Good hygienic practice [17-20,22,25].
- **CCP**: Critical control point, it is a step at which control can be applied and is essential to prevent or eliminate or reduce food safety hazard to acceptable levels [17-20].
- **Hazard:** A biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect. Those of animal origin can be grouped into several categories e.g. zoonosis resulting from clinical disease in animals, zoonosis resulting from asymptomatic infections in animals, and chemical sources [17-20,22,25].
- **HMP**: Hygiene management programmes to;
  - Ensure that management programmes for each hazard are implemented;
  - Establish critical limits for control points;
  - Establish a monitoring or checking system for each control point; and
  - Prepare written corrective actions that must be taken without hesitation when a deviation is observed and such corrective action must specify [17-20].
- **GHP**: good hygienic practice [17-20].
- **CCP:** Critical control point, it is a step at which control can be applied and is essential to prevent or eliminate or reduce food safety hazard to acceptable levels [17-20].
- **Risk**: Likelihood of exposure to a hazard and the likely extend of the effect of that hazard and the resulting economic effect to an animal or human health [17-20].
- **Risk based**: Containing any performance objective, performance criterion or process criterion developed according to risk analysis principles [17-20,22,35,36].
- **Surveillance:** A systematic and continuous gathering, sorting out, and analysis of information related to animal health with the timely release of information to enable evidence based decisions with appropriate action being taken [35].
- **Hazard identification**: Process of identifying presence of brucellosis in cattle coming for slaughter especially those not tested [17-20].
- **Risk assessment**: The quantitative or qualitative estimation of the likelihood of harm from a hazard as well as economic effects of its presence, establishment and possibly its spread [17,20-25].

- **Risk management**: The process of selecting and implementing solutions, in order to reduce the magnitude of the risk [25].
- **Risk communication**: The interactive dissemination and exchange of information and opinions throughout the risk analysis process concerning the particular risk, the related factors and the risk perceptions among stakeholders [25].

Authors' Contribution

Nyasha Guzha-Chanetsa and Prof Cheryl ME McCrindle did the research and wrote up of the publication together.

Authors' Information

Nyasha Guzha-Chanetsa is a Chief state veterinarian with the Gauteng Department of Agriculture and Rural Development, Public Health and Export Facilitation. She is a holder of MPH, MSc Biotechnology and MBA. Currently working on her dissertation of the MPH programme. She has 25 years working experience as a veterinarian, 12 in the laboratory and 2.5 years with UNFAO as the Project Officer. Avian Influenza Expert.

Prof Cheryl McCrindle

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