

EVALUATING ENVIRONMENTAL HEALTH INVESTIGATIONS: LESSONS FROM THE 2017 LISTERIOSIS OUTBREAK LINKING TO 2024 CHEMICAL FOOD POISONING IN SOUTH AFRICA

Mokoatle MC*, and Mavundza SN

*Department of Environmental Health, Faculty of Health Sciences,
University of Johannesburg, South Africa*

Abstract: A total of 1060 laboratory-confirmed cases of listeriosis and 216 deaths were reported by National Institute of Communicable Diseases (NICD) in South Africa from January 2017 to July 2018. A ready-to-eat, processed meat product called polony was identified as the source of the outbreak. The World Health Organization (WHO) described this as the largest listeriosis outbreak that had ever been detected worldwide. This study aimed to examine the environmental health investigation methods on Listeriosis outbreak in South Africa during that period. The study identified factors to determine their association with the effectiveness of Listeriosis outbreak investigation. The study was conducted amongst 333 Environmental Health Practitioners (EHPs) at local government, who were directly involved in the outbreak in Gauteng, Western Cape and Kwazulu-Natal as the provinces that recorded the highest number of cases. Quantitative data was collected using a piloted online questionnaire with a set of close-ended and open-ended questions and was analyzed using Statistical Package for the Social Sciences (SPSS) software. The majority of participants, 316 (94.9%) were trained on outbreak investigation. About 298 (94.3%) of these participants trained in outbreak investigation participated in the 2017-2018 Listeriosis outbreak investigation. While participants reported challenges relating to location of cases to impact the effectiveness of outbreak investigation, other factors including improved human resources (50.8%), tools of trade and technology (30%) and legislative and policy framework (19.2%) were recommended for intervention to ensure effective outbreak investigations. These factors were also highlighted in the recent chemical food poisoning reports as areas of concern requiring urgent intervention. This as a result of the reported 22 children dying from chemical food poisoning-related illnesses since the beginning of 2024. Studies have investigated Listeriosis knowledge levels amongst consumers, analysed media messages on the outbreak and provided reviews on outbreak investigation reports and food systems governance in South Africa. This paper provides the perspective of EHPs knowledge and investigative methods during the outbreak and how these approaches link to the chemical food poisoning.

Keywords: Listeriosis, chemical food poisoning, Environmental Health Practitioners, outbreak investigation, listeria monocytogenes, food contamination

*Corresponding Author's Email: charlottem@uj.ac.za



1. Introduction

South Africa witnessed the world's largest Listeriosis outbreak, characterised by a progressive increase in cases of the disease between January 2017 and July 2018 where 1060 laboratory-confirmed cases of listeriosis were reported with a total of 216 death (National Institute of Communicable Diseases, 2018; Mphaga et al., 2024). Fast-forward to 2024, the country experienced chemical food poisoning-related illnesses resulting in 22 children death (Academy of Science South Africa, 2025). These two food safety encounters can be attributed to food contamination by microorganisms and/or chemicals which can occur at any stage during food production to consumption known as "farm to fork". Globally, these foodborne outbreaks remain a public health threat. The World Health Organization (WHO) Foodborne Disease Burden Epidemiology Reference Group (2015) reported the global burden of foodborne diseases to be comparable to those caused by major infectious diseases such as HIV/AIDS, Malaria and Tuberculosis. Shonhiwa et al. (2019) highlighted that vulnerable groups including infants and young children are most at risk of severe foodborne diseases. These was the case with the chemical food poisoning cases in South Africa, as it mainly affected children which were reported to have eaten snacks contaminated by hazardous organophosphate chemicals bought from tuck-shops mainly in the townships and rural areas. With the Listeriosis, eating food contaminated with high level of *L. monocytogenes* is the main route of infection (WHO, 2018; Halbedel et al., 2020). Food products most commonly identified as vehicles of *L. monocytogenes* transmission include unpasteurized milk and dairy products, soft cheese varieties, cooked ready-to-eat sausages and sliced meats, refrigerated smoked seafood, and refrigerated pâtés or meat spreads (Desai et al., 2019). In the South African Listeriosis outbreak, ready to eat processed meat products known as polonies were identified as the contaminated food source from an identified food production facility. These food production facilities are inspected and investigated by Environmental Health Practitioners (EHPs) to ensure compliance with food safety laws and to prevent foodborne outbreaks such as Listeriosis and the chemical food poisoning cases arising from such facilities. The mandate to safeguard the public and ensure compliance in these facilities is entrenched in Section 24 of the Constitution of the Republic of South Africa (1996) which state the right of all citizens to live in an environment that is not harmful to their health or well-being. Various organisations such as the WHO, Food and Agricultural Organisation (FAO) and Codex Alimentarius have been applying the policy of "zero tolerance" for *L. monocytogenes* in ready to eat processed foods to reduce the high risk of food contamination and, consequently, reducing the spread of infection to the public (Tchatchouang et al., 2020). The WHO also promotes the strengthening of food safety systems, good manufacturing practices and educating retailers and consumers on appropriate food handling to avoid food contamination (WHO, 2018). Furthermore, the South Africa Constitution (1996) list municipal health services including food control. The South African National Health Act (2003) provides for local government where EHPs are appointed, to ensure effective and equitable provision of municipal health services. As such EHPs play a crucial role in foodborne outbreak and illnesses investigations such as during the 2017 Listeriosis outbreak and the 2024 chemical food poisoning.

Varied methods are used in different countries for public health surveillance and investigations during outbreak, including physical inspection of facilities and potential sources; laboratory testing for pathogens identification and even patient evaluation. The Centre for Disease Control (2025) outlines that a foodborne outbreak investigation goes through several steps and that in reality investigations are dynamic, prompting several steps to take place at the same time, including finding cases, generation of hypotheses on potential sources, testing hypotheses, identifying the source of the outbreak and

controlling the outbreak. In South Africa, the overarching responsibilities of these outbreak investigations rest firmly on the EHPs and their knowledge of food safety and the basic components of conducting a foodborne illness investigation to prevent the spread of further illness and disease (Kearney et al., 2018). In the listeriosis outbreak in South Africa, the molecular epidemiology of the outbreak was investigated using whole-genome sequencing (WGS) analysis of the *L. monocytogenes* isolates performed in as real-time as possible (Smith et al., 2019) and EHPs conducted case investigations upon receipt of notifications requiring the much-needed investigative and reporting skill and food safety governance systems support during this outbreak. WGS has been explored elsewhere like the United State of America (Jackson et al., 2016) and Germany (Halbedel et al., 2020) proven to be effective, transforming listeriosis outbreak surveillance and response. Shonhiwa et al. 2019 conducted a review of secondary data from foodborne diseases outbreak reports and found great variability on how outbreaks are reported and investigated in South Africa. Other reviews focused on reflecting food systems structures and the need for intersectoral governance and policies to better the overall food safety systems especially in response to foodborne outbreaks (Hunter-Adams et al., 2018; Mphaga et al., 2024). Louw and van der Merve, 2020 explored Listeriosis knowledge levels amongst consumers in Gauteng, South Africa and found 47% claiming to know what Listeriosis is. Furthermore in 2022, a study analysed risk messages in the news media during the outbreak and found limited best practices messages featured in the risk message content which could be improved for future outbreaks (Lamprecht et al., 2022). While these studies have determined factors associated with knowledge amongst and communication with consumers on Listeriosis; laboratory activities on Whole-Genome sequencing analysis of isolates; food system governance, our study explored the factors that determine the effectiveness of Listeriosis outbreak investigations from an EHP 's perspective, whom are critical role players in outbreak response. This paper presents findings of the effectiveness of environmental health investigation methods used during the 2017-2018 Listeriosis outbreak in South Africa from a quantitative study of 333 EHPs. The paper further adds how these environmental health investigations methods may have been applicable to the recent chemical food poisoning cases the country, providing recommendations on what to improve for better outbreak response in the future.

2. Materials and Methods

2.1 Study setting and study population

The target population for this study was environmental health practitioners (EHPs) from Kwazulu-Natal, Gauteng and Western Cape. The listeriosis cases were more concentrated in the three provinces and accounted for 78% of all laboratory-confirmed cases as per the 2018 report of the National Institute for Communicable Diseases (NICD, 2018). South African Local Government Association (2018) reported that the total number of EHPs operational in the three provinces is 1017 with 417 in Gauteng, 284 in Kwazulu-Natal and 316 in Western Cape however not all EHPs were involved in the Listeriosis outbreak at that time.

2.2 Study design and sampling strategy

The study followed a survey approach which was best suited for this study due to its efficient and inexpensive means of collecting quantitative data (Sekaran & Bougie, 2013) A sample size of 333 EHPs was drawn from the three study provinces as a representative sample as determined using Centres for Diseases and Prevention Control (CDC) Epi Info 7. The sample size was determined by balancing both

the statistical and practical considerations (Bowling, 2009). Purposive sampling was used in this study to select environmental health practitioners who participated in the outbreak investigation allowing for a sampling strategy that permitted the selection on EHP participants in the three provinces irrespective of their gender, age and work experience.

2.3 Data Collection and Data Analysis

Data was collected using a self-administered electronic questionnaire with a standard set of close-ended and open-ended questions. The questionnaire was piloted in one province which is not part of the sample size to check for reliability. The feedback from the pilot study was used to improve the tool and its ability to collect relevant data and answer the research objectives. The questionnaire, participants information letter and consent form were distributed online and required 10 to 15 minutes to complete. This method is however not without its limitations of response bias where participants could have answered in a manner that presents them favourable and the online mode of completion lacking the researcher's ability to clarify questions. Upon completion questionnaires, the data was coded and entered into Microsoft Excel spreadsheet. Data was then imported into Statistical Package for Social Science (SPSS) software version 26 for analysis. Descriptive analysis was done to illustrate percentages and frequency distributions of variables and thus presented using tables, charts and graphs. The CDC program EPI INFO 7.2 was used to calculate the Crude odds ratios, as it helped to virtualize data. The statistical significance of relationships amongst the variables was determined using confidence intervals. The selected outbreak investigation variables were stratified by whether participants participated in the Listeriosis outbreak or not.

2.4 Ethical Approvals

The research protocol was approved by the University of Johannesburg, Faculty of Health Sciences Higher Degree Committee (MPH HDC-01-29-2020) and Faculty Research Ethics Committee (reference number: REC-475-2020). Furthermore, permission was obtained from the accounting officer of the municipalities in the three provinces.

3. Results and Discussion

Of the 333 EHPs who participated in the study, 310 (93%) were involved in the 2017 Listeriosis outbreak and 23 (6.9%) were not involved in that specific outbreak. The majority 179 (60%) were female, with only 154 (40%) males participating in the study. The participants were also asked for the number of years worked in the organisation and the number of years of experience in environmental health outbreak investigations, which both was categorised into three (3) groups namely: 0 to 5 years, 6 years to 10 years and 11 years and above. The distribution of participation in the three provinces was evenly distributed, with most of the participants 114 (34.2%) from Kwazulu-Natal Province, 109 (32.4%) participants were from the Western Cape Province and 110 (33.0%) from Gauteng province. Table 1 outlines the gender, employment years, the years of experience in environmental health outbreak investigations and provincial distribution of participants.

Table 1: Gender, employment years, years of experience and provincial distribution of participants

Variables	n (%)
Participation in the 2017 Listeriosis outbreak	
Yes	310 (93%)
No	23 (6.9%)
Gender	
Male	154 (40%)
Female	179 (60%)
Employment years of participants	
0-5 years	15 (4.5%)
6-10 years	88 (26.4%)
11 years and above	230 (69.0%)
Years of experience in environmental health outbreak investigation	
0-5 years	11 (3.3%)
6-10 years	93 (27.9%)
11 years and above	229 (68.7%)
Provincial distribution	
Kwazulu-Natal	114 (34.2%)
Western Cape	109 (32.4%)
Gauteng	110 (33.0%)

Figure 1 shows the number of participants that were trained on environmental health outbreak investigation at the time of study. The results show that the majority of the participants 316 (94.9%) were trained on outbreak investigation. Only 17 (5.1%) were not trained on outbreak investigation. As the WHO described this as the largest listeriosis outbreak that had ever been detected worldwide (Smith et al., 2019), the crucial knowledgeable investigative and preventative role of EHPs remained paramount during the outbreak and beyond.

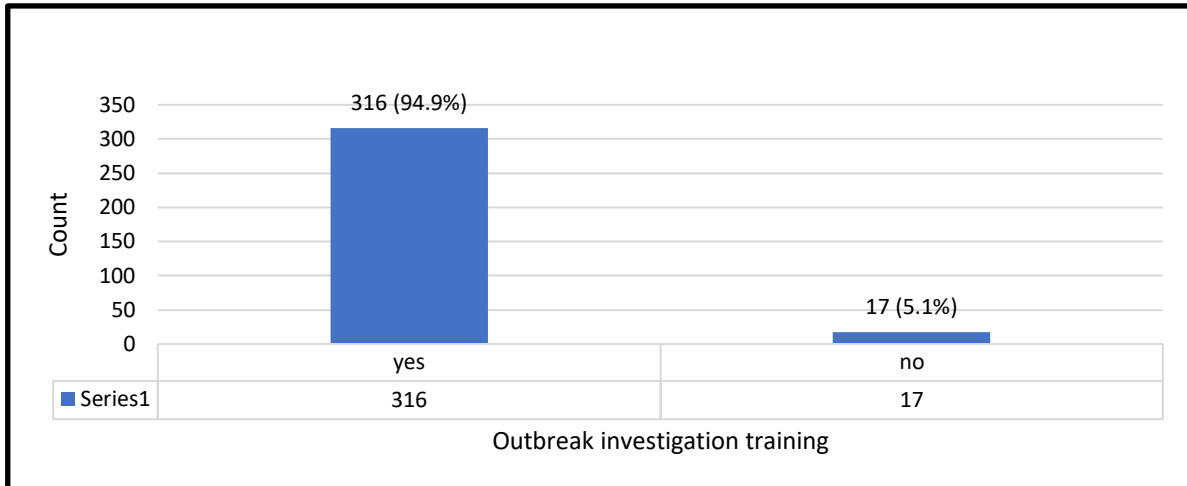


Figure 1: Distribution of EHPs training in outbreak investigation and response

Participants were further asked about the investigation methods during the Listeriosis outbreak, which were categorised as case investigation, laboratory test, WGS and others. Figure 2 depicts the distribution of the investigation methods reported to have been used during the outbreak and shows that most used investigation method was the case investigation used by 153 (46.1%) of the participants. Fewer participants 6 (1.8%) were using Whole Genome Sequencing (WGS).

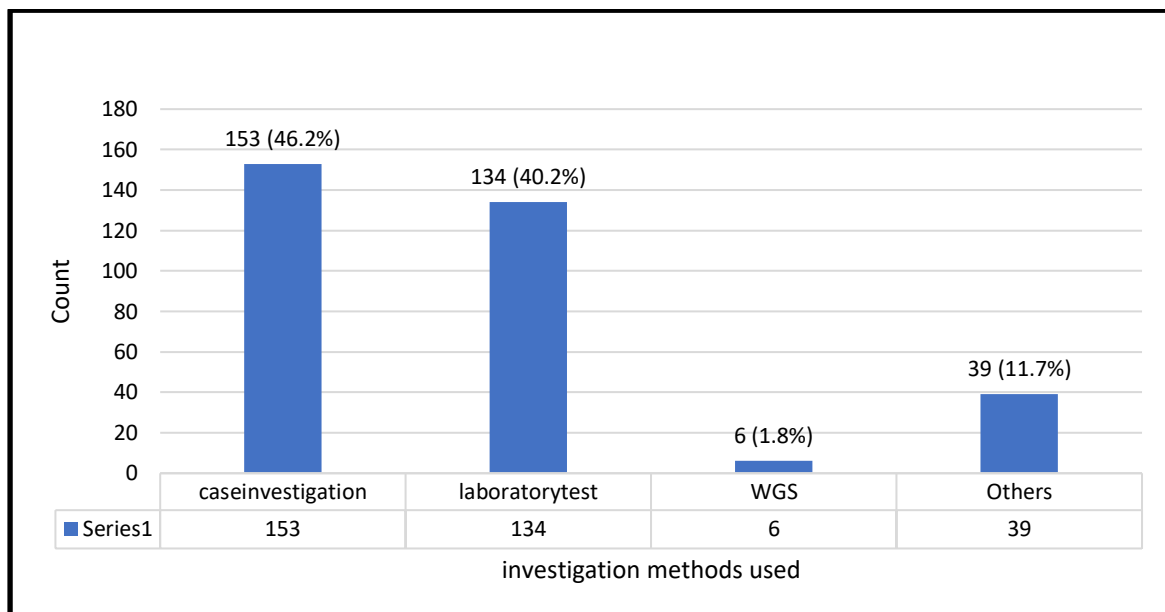


Figure 2: Distribution of outbreak investigation methods used

Notable there was a variation in the outbreak investigation methods used. Shonhiwa et al. (2019) also highlighted the inconsistencies in food borne diseases outbreak investigation and report writing at local/district levels, and the lack of epidemiological data hinders more detailed description of the

outbreaks. For example, the actual date of the outbreak is not always recorded; the place/location where the outbreak occurred is omitted in some reports; the age and gender of affected individuals were usually not recorded, and the total number and proportion of cases that developed disease following consumption of the implicated food is not always recorded in the reports.

Table 2 presents the distribution and Crude Odds ratios of Outbreak investigation information received by participants. All 15 (100%) of the participants with 5 years and less experience in environmental health outbreak investigation participated in the 2017-2018 outbreak and only 212 (92.2%) of those with 11 years and above experience participated in the outbreak training. The majority of 298 (94.3%) trained in outbreak investigation participated in the 2017-2018 Listeriosis outbreak investigation. The majority 288 (94.1%) of those who participated in the 2017-2018 Listeriosis outbreak believed that the outbreak investigation methods used were efficient. In the regression analysis, only those not trained on outbreak investigation were less likely not to participate in outbreak investigation (odds ratio (OR) 0.15, 95% CI (0.05 – 0.46)).

Table 2: Distribution and Crude Odds ratios of Outbreak investigation information received

Characteristics	Total		Participated in listeriosis outbreak		Not Participated in listeriosis outbreak		Crude Odds Ratio	95% CI*
	n	%	n	%	n	%		
Total	333	100%	310	93.1%	23	6.9%		
Years of experience in environmental health outbreak investigation								
0-5 years **	15	4.5%	15	100%	0	0.0%	0.88	0.11-7.25
6-10 years	88	26.4%	83	94.3%	5	5.7%	1.16	0.44 – 3.05
11 years and above	230	69.1%	212	92.2%	18	7.8%	Reference	Reference
Training								
Trained	316	94.1%	298	94.3%	18	5.7%	Reference	Reference
Not trained	17	5.9%	12	70.6%	5	29.4%	0.15	0.05 – 0.46
Outbreak Investigation methods used are efficient								
Yes	306	91.9%	288	94.1%	18	5.9%	Reference	Reference
No	27	8.1%	22	81.5%	5	18.5%	0.54	0.20 – 1.45

* CI is the 95% Confidence Intervals

** A 1 was imputed for zero “0”

Participants with 11 years and above experience in environmental health outbreak investigations were likely to participate in the Listeriosis outbreak investigation. The finding is plausible because taking part in investigations also gives practitioners important experience (Stehr-Green et al., 1983). One of the limitations of the study is that we did not include age as one of the socio-demographic graphic characteristics and as a result, we could determine correlation with what was found by (Goyder, 1986; Moore & Tarnai, 2002) that “younger people are more likely to participate than older people”.

In this study, those not trained on outbreak investigation were significantly more likely in crude analysis not to participate in Listeriosis outbreak investigation. This is expected considering the impact on training in responding to the health events as also confirmed by other studies. Rapid and effective emergency response to address health security challenges relies heavily on a competent and suitably trained local and international workforce (Parry et al., 2021).

Respondent also highlighted challenges experience during the outbreak investigations as stated in figure 3. The challenges reported included majority relating to locating of cases 134 (40.2%), address not provided 92 (27.6%), cases not available 60 (18%) and a minimal 47 (14.1%) relating to incorrect addresses of cases. Furthermore, participants were asked to give recommendations they thought would improve and strengthen listeriosis outbreak investigations. The majority of the participants 169 (50.8%) recommended human-resource-related interventions whilst tools and technology advancement were recommended by 100 (30%) of respondents and fewer 64 (19.2%) reported on policy and legislations interventions.

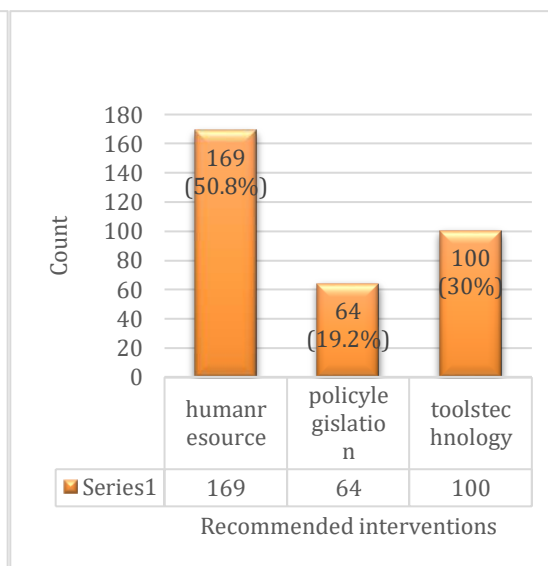
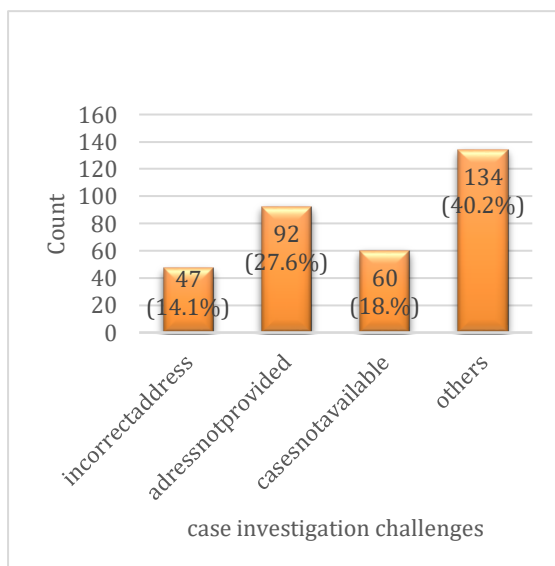


Figure 3: Reported challenges related to case investigation

Figure 4: Recommendations for improving outbreak investigation

Table 3 outlines All participants 6 (100%) using the WGS investigation method participated in the outbreak investigation. Only 33 (84.6%) of those using other methods participated in the 2017-2018

outbreak investigation. Those using other investigation methods are more likely not to participate in the Listeriosis outbreak investigation. An overwhelming majority 98 (98.0%) of those who recommended improved technology and tools as a required intervention to improve outbreak investigation participated in the 2017-2018 outbreak. In the regression analysis, those who recommended improved technology and tools as an intervention to improve outbreak investigations had an increased odds of 4.77 (OR= 4.77, 95% CI: 1.07–21.33) of participating in Listeriosis outbreak training compared to those who recommended an increase in human resources. Participants who used other methods of investigation were less likely not to participate in listeriosis outbreak (OR=0.30, 95% CI: 0.10 – 0.93).

Table 3: Distribution and Crude Odds ratios of Outbreak investigation methods used by respondents

Characteristics	Total		Participated in listeriosis outbreak		Not Participated in listeriosis outbreak		Crude Odds Ratio	95% CI
	n	%	n	%	n	%		
Total	333	100%	310	93.1%	23	6.9%		
Investigation methods used								
Case investigation	153	46.1%	145	94.8%	8	5.2%	Reference	Reference
Laboratory test	134	40.4%	125	93.3%	9	6.7%	0.77	0.29 – 2.05
WGS**	6	1.8%	6	100%	0	0.0%	0.33	0.04 - 3.09
Others	39	11.7%	33	84.6%	6	15.4%	0.30	0.10 – 0.93
Challenges								
Incorrect addresses	47	14.1%	42	89.4%	5	10.6%	0.53	0.17 – 1.72
Addresses not provided	92	27.6%	85	92.4%	7	7.6%	0.77	0.27 – 2.21
Cases not available	60	18.0%	57	95.0%	3	5.0%	1.21	0.31 – 4.72

Other challenges	134	40.2 %	126	94.0 %	8	6.0%	Reference	Reference	
Recommendations									
Improve human resource	169	50.8 %	154	91.1 %	15	8.9%	Reference	Reference	
Strengthen policy/legislation	64	19.2 %	58	90.6 %	6	9.4%	0.94	0.35 – 2.54	
Improved technology and tools	100	30%	98	98.0 %	2	2.0%	4.77	1.07 21.33	–
Improved technology and tools	100	30%	98	98.0 %	2	2.0%	4.77	1.07 21.33	–

* CI is the 95% Confidence Intervals

** A 1 was imputed for zero “0”

Mphaga et al., 2024 highlight the important role of EHPs in ensuring compliance with food safety laws in South Africa, however, indicating that the full implementation of this role is clouded by challenges such as lack of financial resources resulting in poor food safety oversight of small and medium enterprises. SA has three times fewer environmental health practitioners per 10,000 population than the ratio recommended by the World Health Organisation (WHO) and according to the President of South African Institute of Environmental Health (SAIEH) this is mainly due budget constraints in municipalities (Gous, 2018). With the current estimated ratio of 1 EHP: 30 000 population and in the wake of the world’s worst-ever Listeriosis outbreak in South Africa, questions are now being asked whether South Africa has enough practitioners for environmental health services including outbreak investigation. It seems that, at least in terms of the number of Environmental Health Practitioners, the country is far missing the mark (Gous, 2018) and such has been raised both in the findings of this study and in reports during the chemical food poisoning incidences.

4. Conclusion

Prior to 2017, an average of 60 to 80 laboratory-confirmed Listeriosis cases per year (approximately 1 per week), were reported in South Africa (Department of Health, 2018). The 2017 surge that resulted in the outbreak raised alarms for all stakeholders including environmental health. This prompted, globally, consideration in the shift in the execution of environmental health services. Similarly in South Africa, there is call for is a risk base approach to ensure that Environmental Health Practitioners (EHPs) can be able to identify risks, the cause of such risks, mitigation measures against the risks and a way to prevent

the risks from recurring and negatively impacting public and environmental health. Assaf (2025) highlighted that the South African government indicated stringent interventions following the deaths of the children due to food poisoning in order to curb the crisis by intensifying efforts to trace, test, and regulate food and chemical products. Additionally, as recommended by other studies multiple approaches should be considered when investigating *L. monocytogenes* clusters. Networks to facilitate the continuous exchange of human and food data between public health and food safety partners should be encouraged (Gaulin et al., 2014) to deal with any outbreak investigation and incidences such as the chemical food poisoning that resulted in death of children in South Africa. Furthermore, an improvement in tools and technologies across the environmental health workforce and workflow will significantly advance forecasting capabilities, enable involvement from multiple stakeholders (e.g., industry, government, and academia), and allow the field to develop a robust forecasting architecture. Such advances will improve public health response to outbreaks, mitigate economic losses, and save lives” (George et al., 2019). The paper brings forth valuable insights into environmental health outbreak investigations exploring the various strategies, highlighting challenges and recommendations that will enhance the EHPs effectiveness in managing future outbreak and the recent chemical food poisoning cases which remains a risk to the South African public health. It further gives opportunity for future research to also focus on tools and technologies for environmental health outbreak investigations efficacy in the African context and cross-country comparisons to better handle future outbreaks.

Acknowledgments

We acknowledge all the Environmental Health Practitioners from Gauteng, Kwazulu-Natal and Western Cape province who participated in the study and the accounting officers who granted permission for the study to take place.

Declaration of Interest Statement

The authors declare that they have no conflict of interests

Authors Disclosure

This article includes content that overlaps with research originally conducted as part of Mavundza Sekheto Nector’s master’s dissertation titled ‘An evaluation of the effectiveness of Environmental Health investigation methods during the 2017-2018 Listeriosis outbreak in South Africa’, submitted to the Faculty of Health Sciences, Department of Environmental Health, University of Johannesburg in 2022. The dissertation was supervised by Makhutsisa Charlotte Mokoalte. Portions of the data, analysis, and/or discussion have been revised, updated, and adapted for conference publication. The original dissertation is publicly available at: https://ujcontent.uj.ac.za/esploro/outputs/graduate/An-evaluation-of-the-effectiveness-of/9915708707691?institution=27UOJ_INST . The author affirms that this submission complies with ethical standards for secondary publication, and appropriate acknowledgement has been made of the original work.

References

- ASSAF. (2025). A Systems Approach to Curb Food-related Poisoning in South Africa. Retrieved from: <https://www.assaf.org.za/2025/02/05/a-systems-approach-to-curb-food-related-poisoning-in-south-africa/#:~:text=According%20to%20media%20reports%2C%20approximately,the%20crisis%20and%20these%20include>
- Bowling, A. (2009) Research Methods in Health: Investigating Health and Health Services. Retrieved from: https://www.researchgate.net/publication/32886258_Research_Methods_in_Health_Investigating_Health_and_Health_Services
- Centre for Disease Control. (2018). Steps in a Multistate Foodborne Outbreak Investigation. Retrieved from: <https://www.cdc.gov/foodborne-outbreaks/investigation-steps/index.html>
- Constitution of the Republic of South Africa. (1996). Act 108 of 1996.
- Department of Health, South Africa. (2018). Situation Report. Retrieved from: https://www.nicd.ac.za/wp-content/uploads/2018/07/Listeriosis-outbreak-situation-report-4July2018_fordistribution.pdf
- Desaia, A.N., Anyohac, A., Madoff, L.C. and Lassmann, B. (2019). Changing epidemiology of *Listeria monocytogenes* outbreaks, sporadic cases, and recalls globally: A review of ProMED reports from 1996 to 2018 International Journal of Infectious Diseases: 45 -53
- Gaulin, C., Gravel, G., Bekal, S., Currie, A., Ramsay, D & Roy, S. (2014). Challenges in listeriosis cluster and outbreak investigations, Province of Quebec, 1997-2011
- George, D.B, Taylor, W., Shaman, J., Rivers, J.C., Paul, B., O'Toole, T., Johansson, M.A., Hirschman, L., Biggerstaff, M., Asher, J & Reich, N.G. (2019). Technology to advance infectious disease forecasting for outbreak management. *Nature Communications*. Retrieved from: <https://doi.org/10.1038/s41467-019-11901-7> | 3
- Gous, N. (2018). South Africa doesn't meet world health standards for food inspectors. Retrieved from: <https://www.timeslive.co.za/news/south-africa/2018-03-07-south-africa-doesnt-meet-world-health-standards-for-food-inspectors/>
- Goyder, J. (1986). Surveys on Surveys: Limitations and Potentials: *Public Opinion Quarterly*, 50, 27-41.
- Halbedel S, Wilking H, Holzer A, Kleta S, Fischer MA, Lüth S, Pietzka A, Huhulescu S, Lachmann R, Krings A, Ruppitsch W, Leclercq A, Kamphausen R, Meincke M, Wagner-Wiening C, Contzen M, Kraemer IB, Al Dahouk S, Allerberger F, Stark K, Flieger A. 2020. Large nationwide outbreak of invasive listeriosis associated with blood sausage, Germany, 2018–2019. *Emerg Infect Dis* 26:1456–1464. Retrieved from: <https://doi.org/10.3201/eid2607.200225>
- Hunter-Adams, J., Battersby, J., & Oni, T. (2018). Fault lines in food system governance exposed: reflections from the listeria outbreak in South Africa. *Cities & Health*, 2(1), 17–21. Retrieved from: <https://doi.org/10.1080/23748834.2018.1508326>

Jackson KA, Stroika S, Katz LS et al. (2016). Use of whole genome sequencing and patient interviews to link a case of sporadic listeriosis to consumption of prepackaged lettuce. *J Food Prot*

Kearney, G.D., Knechtges, P.L. & Resnick, B.A. (2018). *Environmental Public Health: The Practitioner's Guide: American Journal of Public Health*. Available at <https://ajph.aphapublications.org/doi/10.2105/9780875532943ch13> (Accessed 11 February 2020)

Lamprecht, C., Guenther, L., & Joubert, M. (2022). 'Polony panic': News values and risk messages in news coverage of the South African listeriosis outbreak of 2017–2018. *Health, Risk & Society*, 24(1–2), 67–91. <https://doi.org/10.1080/13698575.2022.2033177>

Moore, D. L., & Tarnai, J. (2002). Evaluating nonresponse error in mail surveys. In: Groves, R. M., Dillman, D. A., Eltinge, J. L., and Little, R. J. A. (eds.), *Survey Nonresponse*, John Wiley & Sons, New York, pp. 197–211.

Mphaga, K.V., Moyo, D. & Rathebe, P.C. Unlocking food safety: a comprehensive review of South Africa's food control and safety landscape from an environmental health perspective. *BMC Public Health* 24, 2040 (2024). <https://doi.org/10.1186/s12889-024-19589-1>

National Health Act, 2003, Government Gazette, Vol 469, Capetown

National Institute of Communicable Diseases. (2018). Listeriosis outbreak situation report. Retrieved from: https://www.nicd.ac.za/wp-content/uploads/2018/07/Listeriosis-outbreak-situation-report-26July2018_fordistribution.pdf

Parry, A.E Kirk, M.D Durrheim, D.N, Olowokure, B., Colquhoun, S.M and Housen, T. (2021). Shaping applied epidemiology workforce training to strengthen emergency response: a global survey of applied epidemiologists, 2019–2020

Salga News. (2017). SALGA convene its National Executive Committee Lekgotla to reflect on the State of Local Government. Retrieved from: <https://www.salga.org.za/Salga%20News65.html>.

Sekaran, U. and Bougie, R. (2013) *Research Methods for Business: A Skill-Building Approach*. 6th Edition, Wiley, New York.

Shonhiwa, A.M., Ntshoe, G., Essel, V., Thomas, J and McCarthy, K. (2019). A review of foodborne diseases outbreaks reported to the outbreak response unit, national institute for communicable diseases, South Africa, 2013–2017. *International Journal of Infectious Diseases*. v 79, p73. Retrieved from: <https://doi.org/10.1016/j.ijid.2018.11.186>

Smith, A.M., Tau, N.P., Smouse, S.L., Allam, M., Ismail, A., Ramalwa, N.R., Disenyeng., B., Ngomane., M and Thomas, J. (2019). Outbreak of *Listeria monocytogenes* in South Africa, 2017–2018: Laboratory Activities and Experiences Associated with Whole-Genome Sequencing Analysis of Isolates. Retrieved from: <https://doi.org/10.1089/fpd.2018.2586>

Stehr-Green, J.K. Stehr-Green, P.A, Voetsch, A.C & Macdonald, P.D.M. (1983). *Introductions to outbreak investigations*. Jones & Bartlett Learning Books, 20

Tchatchouang, C.K, Fri, J, De Santi, M, Brandi, G, Schiavano, G.F, Amagliani, G and Ateba, C.N. (2020). Listeriosis Outbreak in South Africa: A Comparative Analysis with Previously Reported Cases Worldwide. *Microorganisms Journal*, 135

World Health Organization. (2008). Foodborne disease outbreak: Guidelines for investigation and control, WHO Press, Geneva, p. 146. Retrieved from: https://www.who.int/foodsafety/publications/foodborne_disease/outbreak_guidelines.pdf

World Health Organization. (2018). Listeriosis. Retrieved from: <https://www.who.int/news-room/fact-sheets/detail/listeriosis>

World Health Organization. Estimates of the Global Burden of Foodborne Diseases. Foodborne Diseases Burden Epidemiology Reference Group 2007–2015. Geneva: World Health Organization; 2015. Retrieved from: https://iris.who.int/bitstream/handle/10665/199350/9789241565165_eng.pdf

