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Research

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Retrospective analysis and the impact of improved meat inspection on organ condemnation at Kumasi Abattoir

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Abstract

Introduction: *Abattoirs play a crucial role in the global food supply chain, focusing on the safety and quality of meat products through stringent meat inspection processes. However, variations in organ condemnation rates and disease detection efficacy pose challenges to these processes, particularly in limited resource settings.* ***Methods:*** *this study focused on the Kumasi Abattoir, examining organ condemnation data over five years (2018-2023) and the impact of improved meat inspection on organ condemnation within four months (January to April 2024) when three veterinary doctors were introduced. Data obtained was subjected to descriptive statistics and paired t-test analysis.* ***Results:*** *the findings revealed fluctuating condemnation rates with the highest organ condemnation rate recorded in 2022 (n=151, 597 cases) and the least in 2019 (n=116, 613 cases). Cattle exhibited the highest organ condemnations (n=387, 348 cases) as compared to other animal species. Most of the condemnations were notably in the lungs (n=33, 1183 cases) and these were majorly abscessations. The introduction of veterinarians led to improved disease detection rates from an average of 7795 ± 2802.26 cases to 9432.25 ± 3390.91 cases.* ***Conclusion:*** *findings from this study emphasize the importance of investing in highly qualified personnel and robust meat inspection protocols. Enhancing disease surveillance systems, targeting interventions for livestock health, and enhancing meat inspection personnel with veterinary doctors will help ensure the production of safe meat and meat products and protect public health.*

Introduction

Abattoirs are important components of the worldwide food supply chain, serving a critical function in upholding the safety and quality of meat products [1,2]. According to Nastasijevic *et al.* [3], abattoir facilities serve as the main locations for cattle slaughter and processing and have the responsibility of following strict meat inspection processes to detect and remove organs and carcasses that could pose health hazards. The organ condemnation process, which is vital in these inspections, entails the rejection of organs that are unsuitable for human consumption due to diseases or contamination [4,5]. According to the report by European Food Safety Authority (EFSA) [6] and Stärk *et al.* [7], this crucial precaution of organ and meat inspection at the abattoirs aids in mitigating the transmission of zoonotic illnesses and ensures the protection of public health.

Although the organ condemnation process is important, it encounters several obstacles and discrepancies that might vary significantly between different locations and facilities [8]. These differences reveal substantial deficiencies in the efficacy and productivity of meat inspection procedures, frequently exacerbated by problems such as a lack of highly qualified personnel, antiquated methods, and inadequate data management [9,10]. These shortcomings have the potential to undermine both the safety of public health and the effectiveness of economic operations [9-11]. Studies conducted in many African nations, such as Nigeria [12-15] South Africa [16], Ethiopia [17,18], and Kenya [19] have revealed comparable difficulties, implying a general necessity for highly qualified meat inspection personnel throughout the continent. Nevertheless, there is a lack of in-depth research that examines condemnation rates and the underlying factors that affect them. This is particularly true for complete regional evaluations that take into account distinctive local circumstances and practices.

According to Frimpong *et al.* [20], the abattoir system in developed countries is quite different from that in limited-resource countries. While the abattoir system in developed countries provides services that are geared towards meat quality, most of the abattoir systems in limited-resource countries tend to lay much emphasis on quantity. In Ghana, meat inspection at the abattoir is often carried out by trained veterinary technicians and

environmental officers who may be limited in certain aspects of knowledge regarding meat inspection and disease detection. However, with time elapsing, due consideration for meat safety and quality has become an added objective of such establishments in Ghana.

One such establishment, Kumasi Abattoir serves as a prominent meat processing facility that handles a substantial number of livestock [20] and produces a large amount of data regarding organ condemnations. The data on organ condemnations is essential for discerning patterns and possible problems within meat inspection procedures. However, there have been few in-depth studies conducted to fully comprehend the elements that impact the rates of condemnation. Such research works include that of Shaibu *et al.* [21], Opoku *et al.* [22], and Emikpe *et al.* [23]. All these studies centered on specific organ condemnations hence the need to holistically assess the retrospective data on organ condemnation for the last five (5) years at the Kumasi Abattoir. This will help analyse both the patterns of condemnation and assess the effectiveness of the improved meat inspection introduced by the Hazard Analysis Critical Control Points (HACCP) Programme of the Food and Agriculture Organisation (FAO). This research has the potential to be used as a template for similar studies conducted throughout Africa, intending to strengthen the wider field of food safety and animal health management.

Methods

Study design: the research employed a retrospective observational study design, which involved examining past data to analyze trends in organ condemnation at the Kumasi Abattoir from 2018 to 2023. This approach allowed for a comprehensive assessment of historical data, providing insights into long-term patterns of organ condemnations. Additionally, a comparative analysis was conducted to evaluate the impact of improved meat inspection on organ condemnation rates. By comparing data from four (4) similar months before and after the implementation of improved meat inspection, the study aimed to assess the effectiveness of these interventions in disease detection and improving public health outcomes.

Study area: the study was conducted at the Kumasi Abattoir in the Ashanti Region of Ghana which was established in 1997 with support from the Government of Ghana and the Canadian International Development Agency. Regarding the abattoir, animals are sourced from farms within and outside Ghana, including regions like Yeji, Brong Ahafo, and neighboring countries such as Burkina Faso, Mali, and Niger as previously indicated by Frimpong *et al.* [20]. The abattoir premises include a cattle market, kraals for housing animals, a holding pen for cattle destined for slaughter, and a defunct waste treatment plant and abandoned fish pond nearby. The abattoir slaughters various animals like cattle, pigs, sheep, and goats for processing and distribution within Ghana. The geographical focus on the Kumasi Abattoir allowed for a targeted examination of organ condemnation and the impact of improvement in meat inspection.

Sampling: the study included all recorded cases of organ condemnation at the Kumasi Abattoir from 2019 to 2023, ensuring a comprehensive analysis of organ condemnation trends over the specified timeframe. By including data from multiple years, the study aimed to capture variations in organ condemnation rates over time and assess the effectiveness of interventions implemented during the study period.

Data collection: secondary data on organ condemnations, including details such as the type of organ condemned, reasons for condemnation, and the number of condemnations, were collected from the records maintained by the Kumasi Abattoir over the specified five-year period (2018-2023). These records provided a valuable source of information for assessing the frequency and nature of organ condemnations over time.

Additionally, 4 months (January to April 2024) of primary data on organ condemnations as a result of the introduction of three (3) veterinary doctors from the School of Veterinary Medicine, Kwame Nkrumah University of Science and Technology (SVM-KNUST) who were on the FAO HACCP Project to augment the existing six (6) meat inspection personnel at the Kumasi Abattoir was actively collected and analyzed to assess the extent of the impact of the meat inspection personnel improved on organ disease detection rates. The description of the qualifications of the meat inspection individuals is shown in Table 1 below.

Data analysis: data obtained were first recorded in Microsoft Excel Spreadsheet Version 19. Data analysis was performed using Statistical Package for Social Sciences (SPSS Version 27). Descriptive statistics were employed to analyze trends in organ condemnation rates over the study period. This involved summarizing and presenting key findings related to the frequency and distribution of organ condemnations by type and cause. The paired t-test analysis was carried out to compare the organ disease detection rates at meat inspection before and after the introduction of veterinary doctors as improvements in meat inspection personnel at the Kumasi Abattoir. Statistical analysis was tested at a 5% significance level or 95% confidence interval.

Results

Yearly distribution of disease cases: Table 2 presents a yearly distribution of disease cases per animal slaughtered across different livestock categories spanning from 2019 to 2023. Across the five years, a total of 662,364 organ disease cases were recorded. The data reveals fluctuations in disease incidence across the years and livestock types. Notably, in 2019, there were 68,195 disease cases reported in cattle, followed by a slight increase in 2020 to 81,834 cases, constituting the highest incidence recorded during the period. Sheep consistently exhibited lower disease incidence compared to cattle, with 34,098 cases in 2019, peaking at 43,327 in 2022. Conversely, goats demonstrated the lowest disease incidence among the considered livestock, with 13,639 cases reported in 2019, reaching 17,731 cases in 2022. Pigs, while showing the lowest absolute numbers of disease cases, also exhibited fluctuations, with 682 cases in 2019 and 737 cases in 2023.

Distribution of diseased organ cases per animal slaughtered: the presented data in Table 3 delineates the distribution of diseased organ cases per animal slaughtered across various livestock. Remarkably, the lungs emerged as a primary site of disease, with substantial incidence across all livestock species. Cattle exhibit the highest number of lung-related disease cases (193,674) followed by sheep with 96,837 cases, goats with 38,735 cases, and pigs with 1,937 cases. Similarly, the liver demonstrated significant disease incidence, with notable counts observed across all livestock categories. In cattle, 116,204 cases of liver-related disease were recorded, while sheep and goats exhibited 58,102 and 23,241 cases, respectively. Pigs, though with lower absolute numbers, also show liver-related disease cases, making a total of 1,162 cases. Across all livestock types, the heart showed notable disease incidences. Cattle present 38,735 cases, sheep with 7,747 cases, goats with 3,873 cases, and pigs with 387 cases. Cattle recorded 19,367 cases, sheep with 9,684 cases, goats with 3,873 cases, and pigs with 194 cases. Lymph nodes also presented noteworthy disease incidences across the livestock categories, albeit with lower absolute counts. Cattle exhibited 15,494 cases, sheep with 7,747 cases, goats with 3,099 cases, and pigs with 77 cases.

Organ-specific diseases identified at the Abattoir: Table 4 presents an overview of lung conditions observed in slaughtered animals across different species. Contagious bovine pleuropneumonia (CBPP) was only reported in cattle, with 19,367 cases recorded. Lung congestion was most prevalent in cattle with 5,810 cases, followed by sheep with 2,905, goats with 1,162, and pigs with

58. Lung abscesses were particularly prominent in cattle with 96,837 cases, followed by sheep with 60,039, goats with 24,016, and pigs with 1,201. Emphysema was more prevalent in cattle with 3,873 cases, followed by sheep with 1,937, goats with 775, and pigs with 39. Multiple abscesses were especially common in cattle with 38,735 cases, followed by sheep with 19,367, goats with 7,747, and pigs with 387. Pneumonia was most prevalent in cattle with 9,684 cases, followed by sheep with 4,842, goats with 1,937, and pigs with 97 cases. Tuberculosis was reported exclusively in cattle with 3,873 cases.

Table 4 further provides a comprehensive overview of liver conditions observed among different species of slaughtered animals at the Kumasi Abattoir. Fasciolosis was observed in all species with cattle exhibiting the highest incidence at 40,671 cases, followed by sheep with 20,336 cases, goats with 8,134 cases, and pigs with 407 cases. Liver abscesses were prevalent across all species, with cattle showing the highest incidence at 63,912 cases, followed by sheep with 31,956 cases, goats with 12,782 cases, and pigs with 639 cases. Liver cirrhosis was reported in all listed species, with cattle exhibiting the highest incidence at 23,241 cases, followed by sheep with 11,620 cases, goats with 4,648 cases, and pigs with 232 cases. Hepatitis was observed in all species, with varying frequencies. Cattle have 11,620 cases, sheep with 5,810 cases, goats with 2,324 cases, and pigs with 116 cases.

Table 4 also provides insights into the incidence of lymph node abscesses among different species of slaughtered animals, categorized by specific types of lymph nodes affected. Cattle exhibited the highest incidence of prescapular lymph nodes, with 2,324 cases, followed by sheep with 1,162 cases, goats with 465 cases, and pigs with 12 cases. Similar to prescapular abscesses, mediastinal lymph node abscesses were reported across all species. Cattle recorded the highest incidence at 3,099 cases, followed by sheep with 1,549 cases, goats with 620 cases, and pigs with 15 cases. Furthermore, cattle exhibited the highest incidence of bronchial lymph node at 9,296 cases, followed by sheep with 4,648 cases, goats with 1,859 cases, and pigs with 46 cases. While less common compared to other types, mesenteric lymph node abscesses were observed in all species. Cattle recorded 775 cases, sheep with 387 cases, goats with 155 cases, and pigs with 4 cases. Table 5 provides an overview of intestinal conditions observed in different species of slaughtered animals. Among the intestinal conditions listed, "Pimply gut" was recorded in sheep and goats but not in pigs. Sheep exhibit a higher prevalence of pimply gut compared to goats, with 872 cases reported in sheep and 349 cases reported in goats. Ascariasis was observed in all three species, albeit with varying frequencies. Sheep show 387 cases, goats with 155 cases, and pigs with 70 cases. Enteritis is also reported across all three species. Sheep exhibit 678 cases, goats with 271 cases, and pigs with 47 cases.

Impact of improvement in meat inspection on disease detection rates: the result shown in Figure 1 below presents the number of cases detected at the Kumasi Abattoir before and after personnel improved across 4 different months. In January, there were 11,449 cases before the improvement, which increased to 13,854 after the improvement. Similarly, February saw 8,396 cases before the improvement and 10,159 cases after the improvement. In March, the counts rose from 6,297 to 7,620, and in April, they increased from 5,038 to 6,096 after improvement. The paired t-test analysis shown in Table 6 demonstrated a statistically significant ($p=0.011$) increase in disease detection rates after the implementation of personnel-improved measures. Before the improvement, the mean number of detected cases was 7795 ± 2802.26. After the improvement, the mean detection rate notably increased to 9432.25 ± 3390.91. The derived t-value of 5.563, associated with a corresponding p-value of 0.011, underscores a significant disparity between the two conditions.

Discussion

This current study focused on a 5-year (2018-2023) retrospective analysis of organ condemnation and the impact of 4 months improved of meat inspection personnel on disease detection at Kumasi Abattoir in Ghana. Based on the retrospective data obtained, it was observed that the highest organ condemnation was recorded in the year 2022 (151,597 cases) which was 2 years post-COVID-19 and the least condemnation was recorded in 2019 (116,613 cases) which was the year before the outbreak of COVID-19. The observed fluctuations in disease incidence over the five years, with the highest condemnation recorded in 2022 and the lowest in 2019, underscore the complex interplay of factors shaping disease dynamics. These trends prompt reflection on potential drivers such as changes in environmental conditions, management practices, and the indirect effects of external factors like the COVID-19 pandemic [24,25]. The significant decrease in organ condemnation observed in 2019, preceding the pandemic, followed by an increase post-COVID-19 in 2022, suggests the need for further investigation into the pandemic's potential indirect impacts on animal health and disease transmission dynamics. Furthermore, the findings emphasize the critical role of robust meat inspection systems in safeguarding public health [26].

In terms of animal species and organ condemnation in this study, the cattle were the most affected with a majority of the organ condemnations (387,348 cases), and the pigs being the animal species with the least organ condemnations (3,873 cases) at the Kumasi Abattoir from 2019- 2023. This finding corroborates studies conducted by Adebowale *et al.* [27] at a municipal abattoir in Oyo State in Nigeria where cattle recorded the highest organ condemnations and pigs recorded the least organ condemnation. The disparity in organ condemnation rates among different animal species at the Kumasi Abattoir from 2019 to 2023 reflects several underlying factors. This can be attributed to the sheer higher volume of cattle processed at the facility, as well as their susceptibility to various diseases due to factors such as stress during transportation and potential exposure to infectious agents [20]. Moreover, the transportation of cattle from neighboring countries like Mali and Burkina Faso to Ghana for slaughter may increase their vulnerability to diseases, as stress during transit can compromise their immune systems, making them more susceptible to infections as indicated in other studies conducted by Frimpong *et al.* [20], Damtew *et al.* [28] and Bhatt *et al.* [29]. Conversely, the relatively low number of pig slaughterings at the Kumasi Abattoir as previously reported by Frimpong *et al.* [20], may contribute to their lower incidence of organ condemnations compared to cattle, sheep, and goats. The disparity in organ condemnation rates among different animal species underscores the need for targeted disease surveillance, management, and biosecurity measures tailored to the specific needs and vulnerabilities of each species slaughtered at the Kumasi Abattoir.

In terms of organs condemned, the lungs were the most affected in all animal species followed by the liver, heart, kidney, and lymph nodes while the intestines were the least affected organs. The consistent pattern of lung condemnation being the most prevalent across all animal species slaughtered at the Kumasi Abattoir highlights the significant burden of respiratory issues among these animals. The higher abscessations in the mediastinal and bronchial lymph nodes could indicate a deeper involvement of the respiratory system in these health issues. This highlights the importance of addressing respiratory health concerns in animal management practices and underscores the need for further investigation into the underlying causes contributing to these conditions.

The prominence of lung-related diseases, such as lung abscesses, underscores the importance of implementing strict surveillance measures to

monitor the health status of animals entering the abattoir. However, this finding was significantly different from the report by Mohammed *et al.* [30] who reported that tuberculosis was the major cause of lung condemnation in the Tamale abattoir. The differences could be a result of the differences in the disease pathogen dynamics in the different locations. Respiratory diseases not only pose a threat to animal welfare but also have implications for public health, as they can potentially lead to the contamination of meat products with pathogens harmful to humans [31-33]. Therefore, prioritizing stringent biosecurity protocols, including pre-slaughter health screenings and quarantine measures, can help mitigate the spread of respiratory diseases and ensure the safety of meat products intended for human consumption [34].

The findings regarding the heart, intestines, and lymph nodes reveal significant disease incidences across various livestock species slaughtered at the Kumasi Abattoir. However, it is noteworthy that comprehensive studies focusing on these specific organs have not been conducted in Ghana. The substantial disease incidences observed in these organs underscore the urgent need for further research into cardiomyopathies, lymphadenopathies, and intestinal problems at the abattoir. Cardiomyopathies, which affect the heart muscle, can lead to serious health implications in animals and potentially affect meat quality [35]. Similarly, lymphadenopathies, characterized by abnormal lymph node enlargement, may indicate underlying systemic infectious or inflammatory conditions that pose risks to both animal and human health [35]. Additionally, intestinal problems such as enteritis and ascariasis can compromise animal welfare and contribute to economic losses in livestock production.

The widespread condemnation of other vital organs such as the liver, heart, kidney, and lymph nodes further emphasizes the need for comprehensive disease surveillance and management strategies at the Kumasi Abattoir. The presence of diseases affecting multiple organ systems such as tuberculosis highlights the complex nature of health challenges faced by livestock populations [36]. Implementing holistic approaches, especially the One Health approach to animal health management, including vaccination programs, improved hygiene practices, and access to veterinary care, can help mitigate the prevalence of organ-related diseases and enhance the overall health and welfare of animals slaughtered at the abattoir as well as safeguarding the health of the public [37].

The findings of this study demonstrated a statistically significant increase in disease detection rates after the meat inspection personnel improved measures at the Kumasi Abattoir. The introduction of three (3) newly graduated veterinary doctors into the meat inspection personnel through the FAO HACCP Project at the Kumasi Abattoir represented a significant improvement compared to the previous staffing of veterinary technicians. This upgrade in personnel led to a notable improvement in disease detection rates and led to a more effective identification and reporting of diseased animals at the abattoir. Graduated veterinary doctors bring advanced training and expertise in animal health and pathology, which are critical for accurately diagnosing and identifying diseases in livestock [38,39]. Their deeper understanding of disease pathology, clinical signs, and epidemiology enables them to perform more thorough and accurate inspections compared to veterinary technicians [40]. By leveraging their specialized knowledge and skills, graduated veterinary doctors can contribute significantly to the early detection and control of infectious diseases in livestock populations, thereby reducing the risk of foodborne illnesses and safeguarding public health [41].

The observed increase in disease detection rates following the introduction of veterinary doctors further highlights the importance of investing in highly qualified personnel and implementing robust meat inspection protocols in

slaughterhouses and abattoirs [42]. This finding underscores the critical role of veterinary professionals in promoting animal health, food safety, and public health within the context of livestock production and food processing industries. By prioritizing the presence of trained veterinary professionals in meat inspection teams as highlighted in the Modified Meat Inspection Regulations, 2020 (L.I. 2405) by the Veterinary Council of Ghana [43], authorities can enhance the effectiveness of abattoir meat inspection, abattoir disease surveillance efforts, minimize the spread of infectious agents, and ensure the production of safe and wholesome meat products for consumers.

Conclusion

This study has provided valuable insights into the dynamics of organ condemnation and disease detection at the Kumasi Abattoir in Ghana over five years, from 2018 to 2023. The observed fluctuations in organ condemnation rates, with the highest recorded in 2022 and the lowest in 2019, highlight the complex interplay of factors influencing disease dynamics in livestock populations. Cattle recorded the highest organ condemnation rates among different animals slaughtered at the abattoir. The predominant condemnation of lungs across all animal species emphasizes the significant burden of respiratory issues and the importance of strict surveillance measures to monitor animal health. Additionally, the introduction of veterinary doctors led to a significant improvement in disease detection rates, underscoring the importance of investing in highly qualified personnel and robust meat inspection protocols to ensure the production of safe meat products and safeguard public health.

Based on the findings of this study it is recommended that the Kumasi Abattoir should enhance disease surveillance systems to monitor organ condemnation rates and disease trends, with a focus on targeted interventions for livestock health due to their higher organ condemnation rates. In addition, emphasis should be laid on control measures for respiratory diseases across all animal species. Furthermore, improvement in the meat inspection personnel through the employment of veterinary doctors is essential to improve disease detection, ensure the production of safe meat products, and protect public health at large.

What is known about this topic

- *Abattoirs are essential in meat production and their meat inspection activities help ensure meat safety and quality by removing hazardous organs and carcasses, thereby protecting public health;*
- *Organ condemnation rates and disease detection in abattoirs face challenges due to insufficient personnel, outdated methods, and poor data management, particularly in resource-limited settings;*
- *In African countries like Nigeria, South Africa, Ethiopia, and Kenya, meat inspection processes are deficient due to inadequate training and resources, highlighting the need for improvement across the continent.*

What this study adds

- *The study provides a comprehensive five-year analysis of organ condemnation rates at the Kumasi Abattoir, identifying trends and variations, especially among cattle;*
- *Introducing veterinary doctors significantly improved disease detection rates, emphasizing the need for qualified personnel to enhance meat inspection efficacy and public health;*
- *The study identifies the most frequently condemned organs and prevalent diseases, highlighting the importance of targeted interventions for respiratory health concerns and improved inspection protocols.*

Competing interests

The authors declare no competing interests.

Authors' contributions

All the authors have read and agreed to the final manuscript.

Tables and figure

Table 1: description of the qualification of meat inspection personnel

Table 2: yearly distribution of disease cases per animal slaughtered

Table 3: distribution of diseased organ cases per animal slaughtered

Table 4: lung, liver, and lymph node conditions for species of animals slaughtered

Table 5: intestinal conditions for species of animals slaughtered

Table 6: paired t-test comparison between the disease detection rates with personnel improved

Figure 1: four months of data on organ condemnations before and after improvement in meat inspection personnel at Kumasi Abattoir

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Table 1: description of the qualification of meat inspection personnel

Job description of meat inspection personnel	**Number**	**Qualification**
Veterinary technicians	4	Diploma/certificate in animal health and production
Veterinary doctors	3	Doctor of Veterinary Medicine (DVM)

Table 2: yearly distribution of disease cases per animal slaughtered

Year	**Cattle**	**Sheep**	**Goat**	**Pigs**	**Total**
2019	68195	34098	13639	682	116613
2020	81834	40917	16367	818	139936
2021	75015	37507	15003	750	128275
2022	88654	44327	17731	887	151597
2023	73651	36825	14730	737	125943
Total	387348	193674	77470	3873	662364

Table 3: distribution of diseased organ cases per animal slaughtered				
Organs	**Cattle**	**Sheep**	**Goat**	**Pigs**
Lungs	193674	96837	38735	1937
Liver	116204	58102	23241	1162
Heart	38735	19367	7747	387
Kidney	19367	9684	3873	194
Lymph nodes	15494	7747	3099	77
Intestines	3873	1937	775	116

Table 4: lung, liver, and lymph node conditions for species of animals slaughtered				
Lung conditions	**Cattle**	**Sheep**	**Goat**	**Pigs**
CBPP	19367	0	0	0
Congestion	5810	2905	1162	58
Abscess	96837	60039	24016	1201
Emphysema	3873	1937	775	39
Multiple abscesses	38735	19367	7747	387
Pneumonia	9684	4842	1937	97
Tuberculosis	3873	0	0	0
Liver Conditions	**Cattle**	**Sheep**	**Goat**	**Pigs**
Fasciolosis	40671	20336	8134	407
Abscess	63912	31956	12782	639
Cirrhosis	23241	11620	4648	232
Hepatitis	11620	5810	2324	116
Lymph nodes	Cattle	Sheep	Goat	Pigs
Prescapular lymph node abscess	2324	1162	465	12
Mediastinal lymph node abscess	3099	1549	620	15
Bronchial lymph node abscess	9296	4648	1859	46
Mesenteric lymph node abscess	775	387	155	4

Table 5: intestinal conditions for species of animals slaughtered			
Intestinal conditions	**Sheep**	**Goat**	**Pigs**
Pimply gut	872	349	0
Ascariasis	387	155	70
Enteritis	678	271	47

Table 6: paired t-test comparison between the disease detection rates with personnel improved				
Variable	**Average cases**	**Standard deviation**	**T-value**	**P-value**
Before personnel improved	7795	2802.26	5.563	0.011
After personnel improved	9432	3390.91		

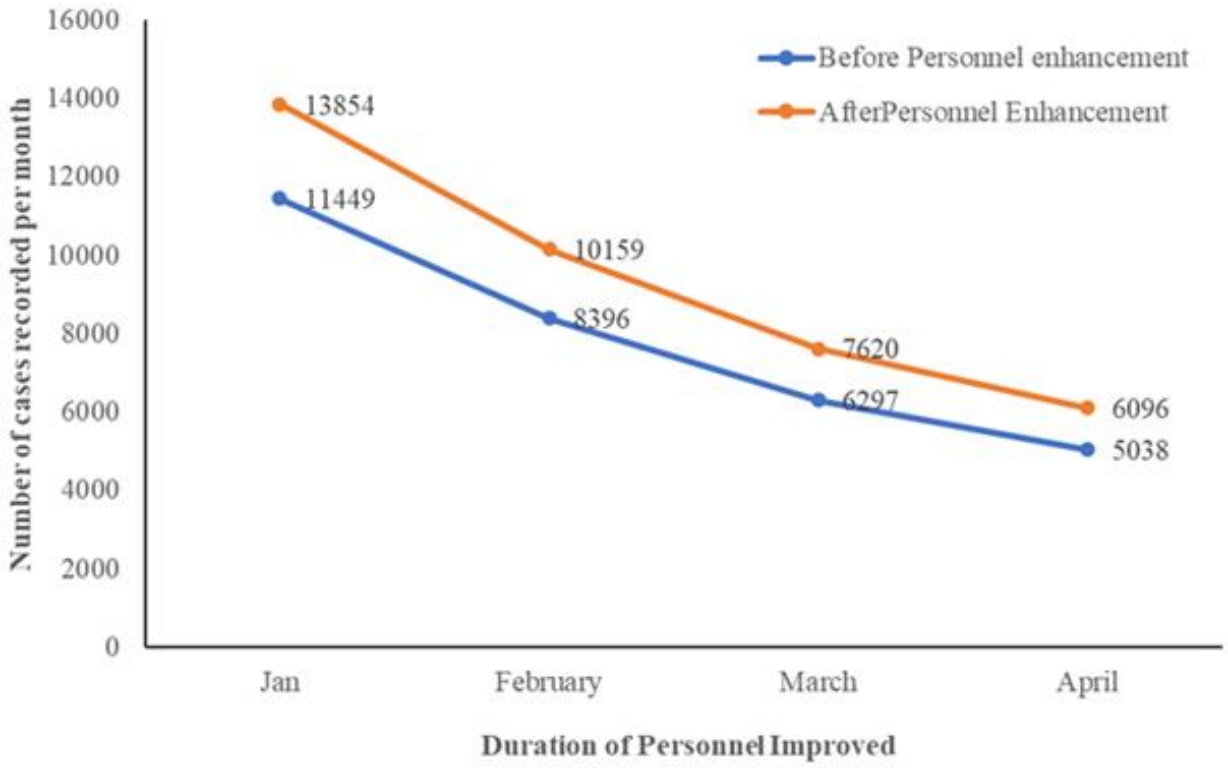

Figure 1: four months of data on organ condemnations before and after improvement in meat inspection personnel at Kumasi Abattoir