Original Article

Insight into Cattle Carcass Condemnation Due to Septicemia in Iran: Evidence From the Slaughterhouse in Mashhad City, Iran

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ABSTRACT

Background: Septicemia in cattle remains a significant concern in the meat production industry, often leading to carcass condemnation at slaughterhouses and economic losses while posing potential public health risks.

Objectives: This study aimed to assess the septicemia condemnation in the cattle population slaughtered in an industrial slaughterhouse in Iran.

Methods: The data used in the present study were sourced from an industrial slaughterhouse in Khorasan Razavi Province, Iran, covering all cattle slaughtered from January 1, 2018, to December 31, 2023. Data included slaughter date, sex, type of condemnation (total or partial), number of condemned carcasses, and organs condemned in partial cases. Global, total, and partial condemnation rates (PCR) were calculated based on post-mortem inspections (PMIs).

Results: Out of 474585 cattle slaughtered, 2588 carcasses were condemned due to septicemia, comprising 1501 total and 1087 partial condemnations. Female cattle exhibited higher susceptibility, with total condemnation rates (TCR) of 0.588% and PCR of 0.499%, compared to males, which had TCR of 0.099% and PCR of 0.004%. Seasonal analysis revealed that the highest condemnation rates occurred during the summer, with kidneys and heads being the most frequently condemned organs, accounting for 30.08% and 17.29% of partial condemnations, respectively. Annual analysis revealed fluctuating rates, peaking in 2022 without a declining trend.

Conclusion: These results highlight significant sex- and season-related differences in septicemia condemnation rates. Comparison with international studies underscores the need for improved management practices, veterinary supervision, and environmental controls to reduce condemnation rates, ensuring enhanced meat safety and public health.

Keywords: Carcass condemnation, Cattle, Mashhad, Septicemia, Slaughterhouse

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Introduction

Meat inspection is a process conducted in slaughterhouses to ensure the safety and quality of meat for human consumption. This process is generally followed in two steps: an ante-mortem inspection of the live animal, and a post-mortem inspection (PMI) of the slaughtered animal. During PMI, several diseases and conditions indicate that the product is condemned. In this regard, and in the absence of a distinctive list of condemnation titles in Iran, the European Union has identified 21 reasons for declaring meat unfit for consumption (Commission Regulation (EU), 2019). Septicemia is a condition in which pathogenic microorganisms, such as *Clostridium chauvoei*, *Salmonella*, *Bacillus anthracis*, *Pasteurella multocida*, *Mannheimia haemolytica*, and *Escherichia coli*, rapidly multiply in the blood, producing toxins.

As a consequence, the host's defense mechanisms are overwhelmed (Gracey et al., 1999). In this context, *Pasteurella multocida* and *Mannheimia haemolytica* are recognized as common bacterial pathogens that have been previously isolated from various livestock tissues in Iran (Gharibi et al., 2017; Karimi et al., 2024). Morbid changes in multiple tissues and organs, such as the liver, kidney, heart, spleen, and lymph nodes, are typically detected in PMI, along with other changes, including congestion of the carcass and alkalinity. Septicemic carcasses are unfit for human food because of the probability of the presence of foodborne microorganisms in the edible tissues or the weak organoleptic quality and limited shelf life of the carcass. As the guardian responsible for monitoring meat hygiene and safety, although the Iranian Veterinary Organization (IVO) has not yet provided specific guidelines for inspecting and judging septicemic carcasses, carcasses with prior generalized infections are traditionally condemned in Iranian slaughterhouses. However, in doubtful cases and due to the absence of detailed instructions, the meat inspectors make the final decision mainly based on their experiences. In this regard, besides condemnation (partial or total) and approval of the carcass, two other options—namely, "industrial" and "bulk consumption"—are also considered by inspectors in some slaughterhouses when making their final decision. Based on the degree of organoleptic changes and pH of the meat, carcasses with mild changes are subjected to heat treatment (industrial), and those with very mild changes are sold to restaurants or other mass ready-to-eat food producers (bulk consumption).

The PMI of livestock carcasses with ante-mortem general infection is the subject of numerous studies, many of which have been published recently, primarily from European countries (Laukkanen-Ninios et al., 2023; Petersen et al., 2022). However, data regarding the prevalence of various diseases and abnormalities, like septicemia, leading to condemnation during PMI, are lacking, and it seems that fewer than 15 surveys on these topics have been published in the last 30 years worldwide (Collineau et al., 2022). Based on a study published in 2008, for the years 2003 through 2007, 536257 (2.01%) of the total cattle slaughtered in the United States (26694317 cattle) were condemned during PMI (White & Moore, 2008). In this sense, septicemia, with 55721 cases (10.39%), was the third most common reason for condemnation during PMI. In another study conducted in Canada, septicemia and or toxemia were reported as the most common reason for cattle carcass condemnation in 207 abattoirs from 2001-2007 (Alton et al., 2010).

The analysis of condemnation rates at slaughterhouses is of great importance, not only for controlling product quality and safety but also for monitoring important issues such as animal health conditions and potentially improving animal management policies. As clearly indicated in the literature, the pattern of condemnation at slaughterhouses differs significantly in different countries and regions (Dupuy et al., 2014; Rezac et al., 2014; Vial & Reist, 2015; White & Moore, 2008), highlighting the importance of monitoring the ante-mortem and PMI data, particularly in regions with a lack of published information.

In this context, this study aimed to evaluate the septicemia condemnation in the cattle population slaughtered in an industrial slaughterhouse in Iran between 2018 and 2024.

Materials and Methods

Study area and animal population

The data used in the present study were sourced from an industrial municipal slaughterhouse in Iran, located in Khorasan Razavi Province in the eastern part of the country. All cattle slaughtered from January 1, 2018, to December 31, 2023, were included in this study.

Data collection

The slaughter records, particularly the PMI decisions and findings, were provided by the Office of Veterinary Inspection Service, which performed the formal ante-

mortem and PMI duties. In the present study, only data related to carcasses judged or identified as septicemic or suspected septicemic were considered and analyzed. In this concern, various data, including date of slaughter, sex, type of condemnation (partial or total), frequency of condemned carcasses, and condemnation organs (in case of partial condemnation), were used. The identification of carcasses with prior general infection was based on gross pathological changes in morphology, color, size, and consistency of the key organs and carcass as described by Gracey (1999). In cases of doubt, the meat inspectors make the final decision, mainly based on their experience.

Data analysis

Three condemnation rates, including global condemnation rate (GCR), total condemnation rate (TCR), and partial condemnation rate (PCR), were calculated using the Equations 1, 2, and 3 and expressed as a percentage:

1.

$$GCR = \frac{\text{Number of carcases partially or totally condemned}}{\text{Total no.of slaughtered animals}} \times 100$$

2.

$$TCR = \frac{\text{Number of carcases totally condemned}}{\text{Total no.of slaughtered animals}} \times 100$$

3.

$$PCR = \frac{\text{No.of carcases partially condemned}}{\text{Total no.of slaughtered animals}} \times 100$$

To examine the effect of three factors—sex of animal, year of slaughter, and season of slaughter —on the condemnation of septicemic carcasses, condemnation rates were calculated for these factors. All data, including fit and septicemic carcass information, were entered into an Excel spreadsheet (Microsoft Corporation, WA, USA) and used for calculating condemnation rates. Cross-tabulation was performed to evaluate the carcass condemnation using the data from the PMI. All statistics were performed using SPSS software, version 16 (SPSS Inc., USA).

Results

The following dataset (Table 1) provides an in-depth look into the slaughter and condemnation of cattle due to septicemia, a serious systemic infection, at the Mashhad Slaughterhouse, Iran, over 6 years. The data have been categorized by sex, year, and season, allowing for detailed insights into potential trends and contributing factors that affect slaughter statistics and condemnation decisions.

The data revealed significant differences in septicemia incidence and condemnation between male and female cattle. Female cattle accounted for 48.2% of the total slaughter but were disproportionately represented in septicemia-related condemnations, contributing to 89.8% of global condemnation cases. Additionally, 97.3% of partial condemnations involved female cattle.

Figure 1 also compares three key metrics (GCR, TCR, and PCR) between male and female cattle. The data highlight significant disparities between the sexes in terms of condemnation rates due to septicemia.

The GCR for female cattle (1.087) is substantially higher than that for male cattle (0.103), showing that female cattle are approximately 10.5 times more likely to be fully condemned.

In the case of TCR, female cattle once again show a higher rate (0.588) compared to males (0.099), indicating that while both sexes face some risk of septicemia, female cattle are approximately 6 times more likely to have their carcasses condemned, either partially or fully. The PCR reveals a significant difference between the sexes, with female cattle (0.499) experiencing partial condemnations more than 100 times more frequently than male cattle (0.004). This finding suggests that female cattle are more likely to have localized infections or lesions that require partial condemnation rather than full carcass rejection.

As shown in Table 1, the number of cattle slaughtered at the studied slaughterhouse fluctuated from 2018 to 2023, initially increasing up to 2021 before beginning a downward trend in subsequent years. The number of septicemia cases also fluctuated significantly over the 6 years, with the highest condemnation rates observed in 2022 (Table 1). A notable spike occurred this year, with 1312 global condemnation cases reported, representing 84.4% of septicemic cases, and more than half of these carcasses were partially condemned.

The analysis of cattle slaughter and condemnation data from the Mashhad Slaughterhouse (2018-2023) revealed significant trends (Figure 2). The GCR fluctuated over the years, with a notable peak in 2022 (1.617%). The lower rates in 2020 (0.116%) and 2021 (0.314%) suggest better control during those years. TCR followed a

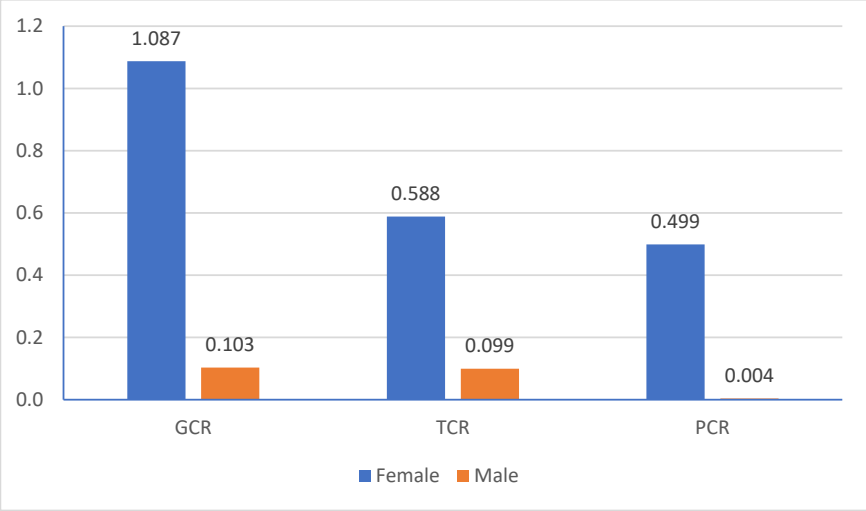

Figure 1. GCR, TCR, and PCR of cattle slaughtered in the Mashhad Slaughterhouse due to septicemia based on their sex (2018-2023)

similar pattern to GCR, with a marked increase in 2022 (0.655%). The PCR was notably high in 2022 (0.962%), indicating a significant proportion of carcasses were only partially affected by septicemia. The nearly zero PCR in other years (2020, 2021, and 2023) highlights 2022 as an outlier.

The slaughter data from the study slaughterhouse indicate that the number of cattle carcasses processed remained relatively consistent across winter, spring, and fall, with each season contributing approximately 24% of the total (Table 1). In contrast, summer stands out with a higher proportion of 27%, suggesting a potential seasonal factor influencing cattle health or slaughter rates during this period.

On the other hand, data indicate clear seasonal trends in the rates of cattle carcass condemnation due to septicemia (Table 1 and Figure 3). These trends are analyzed through GCR, TCR, and PCR (Figure 3), which show the relative proportions of condemned carcasses that were either fully or partially discarded.

Summer exhibited the highest condemnation rates across all categories, with a GCR of 0.992%, TCR of 0.378%, and PCR of 0.614%. The high PCR indicates that while a large proportion of carcasses were affected, many were only partially condemned, leaving other parts fit for consumption. Spring had moderate condemnation rates, with a GCR of 0.592%, a TCR of 0.299%, and a PCR of 0.292%, indicating a balanced mix of full and partial condemnations. Fall saw a decrease in condemnation rates compared to summer, with GCR, TCR, and PCR rates of 0.386%, 0.343%, and 0.043%, respectively. Winter had the lowest condemnation rates, with a GCR of 0.323% and TCR of 0.321%, and minimal partial condemnation (0.002%).

Figure 4 outlines the percentage of different organs condemned in the carcasses population, which were partially condemned due to septicemia during PMI at the Mashhad Slaughterhouse. The kidneys show the highest rate of condemnation, constituting 30.08% of all condemned organs due to septicemia. The head also displays a high condemnation rate at 17.29%. Lung, heart, and liver share an equal condemnation rate of 15.04%. The digestive tract has the lowest rate of condemnation (7.52%).

Discussion

The sharp difference detected between the TCR of female and male carcasses suggests that females are much more susceptible to severe cases of septicemia, leading to the condemnation of the entire carcass. This finding is consistent with other studies highlighting the increased vulnerability of female livestock to systemic infections, particularly in older breeding animals. Research from various regions, including North America (White & Moore, 2008), also suggests that female cattle, especially those used for reproduction, are more prone to health issues at the end of their productive lifecycle due to factors such as hormonal changes, reproductive stress, and older age at slaughter.

Table 1. Slaughter data and condemnation of septicemic cattle carcasses slaughtered at Mashhad Slaughterhouse from 2018 to 2023

Factor		No. (%)			
		Slaughter	Condemnation		
			Global	Total	Partial
Sex	Female	216014(48.2)	2349(89.8)	1271(84.3)	1078(97.3)
	Male	231571(51.7)	239(9.1)	230(15.3)	9(0.8)
Year	2018	65353(14.6)	628(33)	161(10.3)	467(22.7)
	2019	50231(11.2)	139(8.8)	131(8.3)	8(0.5)
	2020	85847(19.2)	125(6.6)	125(6.6)	-
	2021	108343(24.2)	384(22.5)	384(22.5)	-
	2022	78661(17.6)	1312(84.4)	555(34.2)	757(50.2)
	2023	59308(13.2)	275(18.2)	273(18.1)	2(0.1)
Season	Winter	110599(24.7)	357(13.7)	355(23.6)	2(0.2)
	Spring	108518(24.2)	642(24.6)	325(21.6)	317(28.6)
	Summer	120915(27)	1200(45.9)	457(30.3)	743(67.1)
	Fall	107715(24.1)	416(15.9)	370(24.6)	1(4.2)

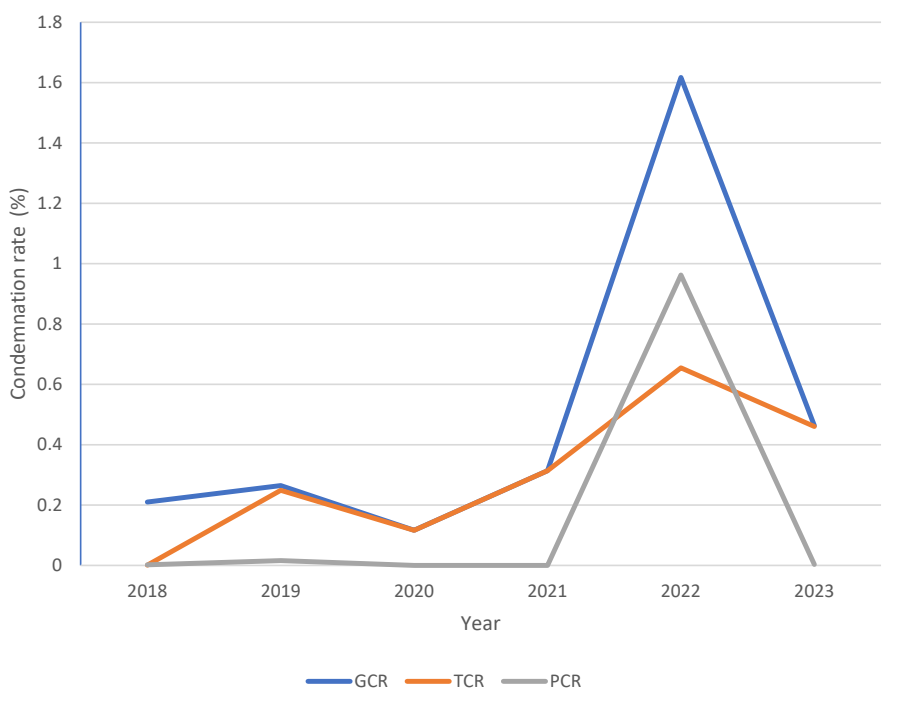

Figure 2. GCR, TCR, and PCR of cattle slaughtered at Mashhad Slaughterhouse due to septicemia (2018-2023)

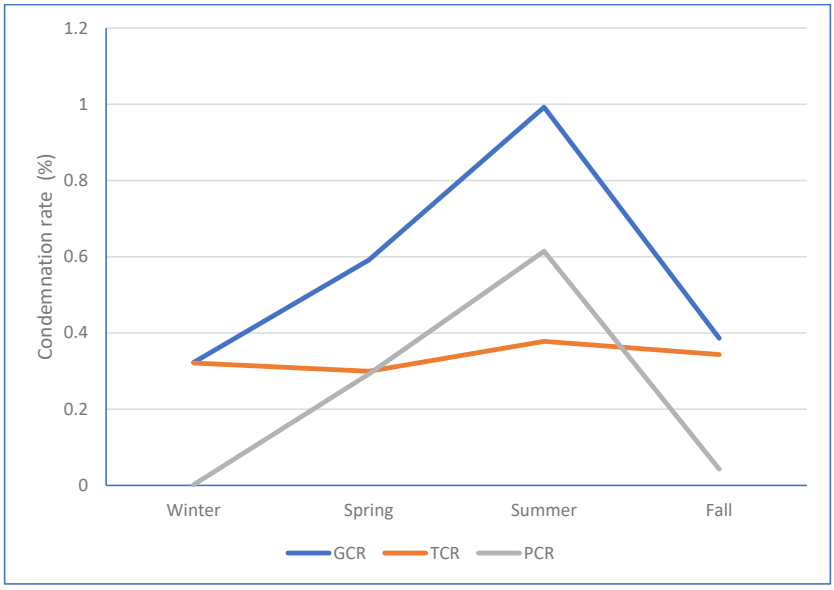

Figure 3. Seasonal trend of GCR, TCR, and PCR of cattle slaughtered at Mashhad Slaughterhouse due to septicemia (2018-2023)

The overall trend shows that female cattle are significantly more affected by septicemia-related condemnations compared to their male counterparts across all categories (global, total, and partial). Several factors might contribute to this disparity. The first factor is age differences. Female cattle, especially breeding animals, are generally slaughtered later in life, which increases their exposure to diseases and systemic infections (Allen & Browne, 2006). The second factor is physiological stress. Reproductive cycles, hormonal fluctuations, and the physical toll of pregnancy and lactation make female cattle more vulnerable to infections, particularly in the final stages of their productive life. To provide a more precise comparison of condemnation rates due to septicemia in cattle, we compared the GCR, TCR, and PCR from the Mashhad dataset with those from similar stud-

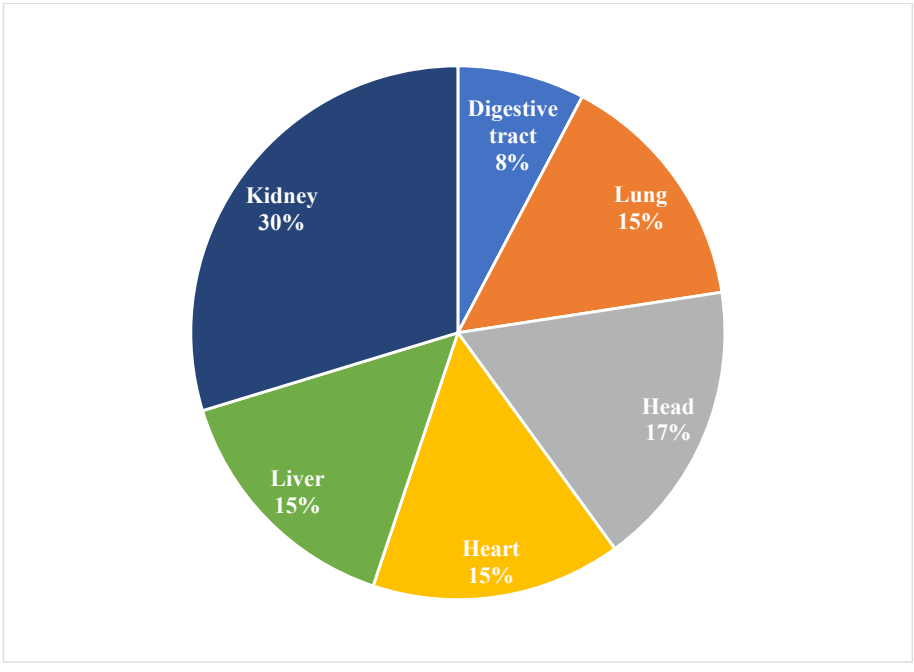

Figure 4. The percentage of organ condemnation due to septicemia in cattle slaughtered at the Mashhad Slaughterhouse (2018-2023)

ies in other countries. The influence of sex on overall condemnation rates was well demonstrated in previous studies (Collineau et al., 2022). In a study conducted in Canada between 2001 and 2007, overall condemnation rates were significantly higher in cows compared to other cattle slaughter classes (Alton et al., 2010). However, only in a survey conducted in the USA can condemnation rates due to septicemia be found. In this regard, the condemnation rate for females in Mashhad (0.588%) was nearly twice as high as the US rate for dairy cows (0.311%), and for males, the rate in Mashhad (0.099%) was almost double the rate observed for US beef cattle (0.058%). Several possible contributing factors, including animal health practices, environmental, and management differences, may explain these differences. First, the US cattle industry, particularly the dairy and beef sectors, has stringent health monitoring and veterinary intervention protocols, which can reduce the incidence of septicemia. Mashhad's higher rates might reflect gaps in these areas or differences in resource availability. Second, differences in climate, housing conditions, and access to veterinary care could also play a significant role in the observed variance in condemnation rates. Harsh environmental factors, such as extreme temperatures and limited access to disease-prevention strategies, may increase susceptibility to conditions like septicemia in cattle. This analysis suggests that improved veterinary care, management practices, and disease prevention strategies could reduce condemnation rates in Mashhad City, potentially aligning them more closely with those observed in other regions, such as the United States.

The spike detected in the GCR of 2022 indicates a possible health crisis or inadequate disease management during that year, which may have led to a higher prevalence of septicemia. A marked increase in TCR of this year also reflects a higher number of fully condemned carcasses, likely due to the severity of septicemia cases that year. The consistently lower rates in prior years suggest that 2022 was an anomaly, likely due to the outbreak of infectious diseases, which environmental or management factors may have exacerbated. Finally, the high PCR in 2022 indicates a significant proportion of carcasses were only partially affected by septicemia. This condition suggests that, although many cattle were infected, the disease may not have been severe enough to warrant full condemnation in most cases. The nearly zero PCR in other years (2020, 2021, and 2023) highlights 2022 as an outlier. Here also, the commendation rate due to septicemia was significantly higher than the relevant rates reported in the USA (White & Moore, 2008).

As mentioned, summer showed the highest condemnation rates across all categories. This finding suggests that the summer months are critical for managing septicemia upsurge, likely due to increased heat stress and related environmental factors. The high PCR of this season indicates that while a large proportion of carcasses were affected, many were only partially condemned, leaving other parts fit for consumption. The moderate condemnation rates observed in spring may indicate favorable environmental conditions, but potential management issues still permit septicemia cases. This seasonal drop in fall suggests a recovery period where cattle health improves, possibly due to cooler temperatures and reduced environmental stress. Finally, the low PCR recorded in winter indicates that nearly all condemned carcasses in winter were fully unfit for use; however, the overall lower rates may reflect better health management or reduced disease transmission during the colder months.

The seasonal condemnation pattern observed in the present study is consistent with research indicating that environmental stress, particularly heat stress, plays a critical role in exacerbating septicemia risks in cattle. Heat stress, particularly during the summer months, is one of the most critical factors contributing to the increased incidence of septicemia. As ambient temperatures rise, cattle struggle to maintain homeostasis, resulting in immune suppression and increased susceptibility to infections. Studies have shown that prolonged exposure to high temperatures compromises the cattle's immune system, reducing its ability to fight off infections that finally may lead to septicemia (Gupta et al., 2023; West, 2003) conduction, convection. Additionally, heat stress can cause physiological imbalances, dehydration, and changes in feeding behavior, further weakening the health of cattle (Gaughan et al., 2010). In addition to temperature, humidity, and other environmental factors such as overcrowding, ventilation, and sanitation in cattle housing, contribute to the spread of infections. High humidity levels can facilitate the growth and transmission of pathogens that cause septicemia, while poor ventilation increases the risk of respiratory infections that can develop into systemic infections (Mader et al., 2006). In environments where cattle are confined and exposed to these stressors, the likelihood of septicemia incidence rises sharply. However, as the humidity in Khorasan Razavi or other adjacent provinces is generally low, particularly in warm seasons, it seems that only poor ventilation or overcrowding may provide humid environments that trigger septicemia in the region. Environmental stress, whether caused by heat, transport, or overcrowding, leads to the release of cortisol, a stress hormone that suppresses immune function. Immunosuppressed cattle are more vulnerable to septicemia, particularly in conditions where bacterial loads

are high, such as during summer when pathogen proliferation is more pronounced (Carroll & Forsberg, 2007). Studies have shown that managing environmental stress through proper sheltering, cooling systems, and reducing transportation times can significantly lower the incidence of infections, which may lead to conditions like septicemia in cattle populations (St-Pierre et al., 2003).

The seasonal trend of carcass condemnation has been previously assessed in various studies across different countries (Scollo et al., 2017; Vial & Reist, 2014). Haredasht et al. stated that management and environmental parameters that vary seasonally (like market costs or land constraints), or the seasonal incidence of diseases or syndromes that lead to carcass condemnation, could be the reasons for the seasonal variation in the frequency of condemned carcasses (Haredasht et al., 2018). Moreover, they demonstrated that in California, emaciation, eosinophilic myositis, and malignant lymphoma were the only significant condemnation reasons presenting seasonality. On the other hand, Akkina and Estberg indicated that feedlot cattle condemnations due to septicemia showed some seasonal trends (Akkina & Estberg, 2019).

Septicemia is a severe systemic infection where bacteria and toxins spread through the bloodstream, affecting multiple organs. The kidneys showed the highest rate of condemnation. They are particularly vulnerable to septicemia because of their role in filtering blood. Infections can easily reach the kidneys via the bloodstream, leading to pyelonephritis or other forms of septic involvement, which necessitates their removal from circulation. The head, including structures such as lymph nodes, tongue, and masseter muscles, also displays a high condemnation rate. This finding could be attributed to the septicemia-induced spread of infections to areas such as the lymphatic system and nasal cavities, where bacterial proliferation is common during systemic infections. The lung, heart, and liver are vital organs commonly impacted by septicemia. Lungs can develop septic emboli or abscesses, particularly given their direct exposure to blood flow and their role in oxygen exchange. Heart involvement in septicemia often results in endocarditis or myocarditis, conditions that compromise the organ's functionality. The liver is also highly susceptible, as it plays a central role in detoxification and filtering blood, which may introduce infectious agents during septicemia. Although septicemia can affect gastrointestinal tissues, the relative protection from septic emboli compared to other more vascular organs might explain the lower condemnation rate. It should be noted that a proportion of condemned organs may be omitted due to other reasons, such as parasitic infection.

Conclusion

The findings of this study reveal significant trends in the total and PCR of cattle carcasses affected by septicemia at the Mashhad Slaughterhouse from 2018 to 2023. Findings indicated a significant impact of sex, season, and year on the condemnation of septicemic cattle carcasses. Specifically, females exhibited a higher TCR (0.588%) and PCR (0.499%) compared to males, who had a TCR of 0.099% and PCR of 0.004%. Additionally, seasonal variation influenced condemnation rates, with the highest rates observed during warmer months, likely due to factors such as heat stress. Yearly analysis revealed that condemnation rates fluctuated over the years, with a notable peak in 2022; however, no declining trend was observed.

In comparison with other countries, the TCRs due to septicemia in Iran are higher than those reported in countries with advanced veterinary health systems, like the USA, which often maintain TCRs below 0.3%. This discrepancy highlights a need for improvements in animal health management, including enhanced preventive healthcare practices and regular monitoring of livestock conditions. To reduce condemnation rates in the country, strengthening veterinary healthcare programs and implementing rigorous sanitation standards are essential. Training veterinary staff on early detection and control of septicemic conditions in livestock would also be beneficial. Adopting these measures could significantly reduce economic losses associated with septicemia-related condemnations and contribute to enhanced quality and safety in the national meat supply.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors' contributions

Conceptualization and supervision: Mohammadreza Rezaeigolestani and Amir Salari; Methodology: Soodeh Alidadi; Investigation and data collection: Mohammadmehdi Nikoosokhan and Majid Moosavi; Formal analy-

sis: Mohammadreza Rezaeigolestani; Data curation: Mohammadmehdi Nikoosokhan; Writing the original draft: Mohammadmehdi Nikoosokhan; Review and editing: All authors; Project administration: Mohammadmehdi Nikoosokhan; Funding acquisition and resources: Amir Salari and Mohammadreza Rezaeigolestani.

Conflict of interest

The authors declared no conflict of interest.

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