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Organizational Determinants of Zoonotic Disease Prevention in Facilities Handling Animal Products: Analysis of Waste Management and Vaccination Practices in the Democratic Republic of Congo

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Abstract

Zoonotic diseases represent a major public health challenge, particularly in resource-limited countries where health and environmental management systems are insufficiently structured. This study aims to analyze the organizational factors associated with the prevention of zoonotic diseases in facilities handling animal products in the Democratic Republic of Congo.

This was a cross-sectional analytical study conducted with 169 organizations (public markets, slaughterhouses, butcher shops, supermarkets, and delicatessens). Data were collected using a structured questionnaire focusing on waste management practices, the existence of regulations, and worker vaccination status. Statistical analysis included a descriptive approach, bivariate analysis (chi-square test), and binary logistic regression to identify independent determinants.

The results show that 57.4% of organizations do not have a formalized waste management procedure, 78.1% do not sort waste, and 82.8% do not treat liquid effluents. Bivariate analysis reveals significant associations between waste management and organizational variables ($p < 0.001$). Multivariate analysis identifies waste sorting (OR = 18.13), liquid effluent treatment (OR = 7.23), and regulatory compliance (OR = 3.96) as major independent determinants. The model demonstrates good predictive performance (AUC = 0.844).

In conclusion, the prevention of zoonotic diseases in the studied facilities depends heavily on the level of internal organization and the application of the regulatory framework. Strengthening waste management practices, particularly the sorting and treatment of effluents, as well as the effective application of health standards, is a priority. These results support the implementation of an integrated "One Health" approach to sustainably improve public health.

Keywords: Zoonoses; Waste management; Slaughterhouses; Markets; One Health; Democratic Republic of Congo; logistic regression

Introduction

Zoonotic diseases are a major public health challenge worldwide today, due to their high frequency and epidemic potential. It is estimated that approximately 60% of human infectious diseases originate in animals and that 75% of emerging diseases come from animals [1]. This situation is particularly concerning in low- and middle-income countries, where health

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surveillance and environmental management systems remain inadequately structured.

In sub-Saharan Africa, facilities handling animal products, particularly public markets, slaughterhouses, and butcher shops, constitute high-risk environments for zoonotic transmission. Inadequate sanitary controls in food value chains significantly increase the risks of exposure to pathogens [2].

Inadequate management of animal waste is a major factor in environmental contamination. Untreated slaughterhouse effluents represent a significant source of microbiological pollution in aquatic environments [3]. Furthermore, the lack of structured waste management systems, including sorting and treatment, is a key determinant of environmental degradation and health risks in developing countries [4].

Furthermore, poorly managed animal waste contributes to the spread of zoonotic agents and the development of antimicrobial resistance, thereby exacerbating threats to public health [5]. In this context, health governance and the effective enforcement of regulations appear to be essential levers for improving the prevention of zoonoses.

The "One Health" approach, which integrates human, animal, and environmental dimensions, is now recognized as a relevant strategy for sustainably reducing zoonotic risks [6]. However, in the Democratic Republic of Congo, empirical data on organizational practices in facilities handling animal products remain limited.

In this context, the present study adopts a cross-sectional analytical approach aimed at evaluating waste management and vaccination practices. It employs descriptive, bivariate, and multivariate logistic regression analysis to identify independent determinants of zoonotic disease prevention.

The results highlight deficiencies in organizational practices, including low levels of waste sorting, frequent lack of liquid effluent treatment, and limited enforcement of regulations. Multivariate analysis identifies waste sorting, liquid effluent treatment, and regulations as major determinants of zoonotic disease prevention.

Research Question

To what extent do organizational waste management practices and regulatory enforcement influence the prevention of zoonotic diseases in facilities handling animal products in the Democratic Republic of Congo?

Study Objectives

General objective

Analyze the organizational determinants associated with the prevention of zoonotic diseases in structures handling animal products, through the evaluation of waste management and vaccination practices in the Democratic Republic of Congo.

Specific objectives

1. Describe the characteristics of structures handling animal products (markets, slaughterhouses, butcher shops).
2. Evaluate solid and liquid waste management practices.
3. Determine the level of application of current health regulations.
4. Assess the vaccination coverage of exposed workers.
5. Identify the factors associated with the existence of a formalized waste management procedure.
6. Determine the independent predictors of zoonotic prevention by logistic regression.

Research Hypotheses

Main hypothesis

Structures applying structured organizational practices (waste sorting, effluent treatment, formalized regulations) exhibit a significantly higher level of prevention of zoonotic diseases.

Secondary hypotheses

H1: Waste sorting is positively associated with the existence of a formalized waste management procedure.

H2: The treatment of liquid waste is associated with better sanitary organization.

H3: The existence of an applied regulation increases the likelihood of having a written procedure.

H4: Vaccinating workers indirectly contributes to strengthening zoonotic prevention.

Methodology:

Type and framework of the study

This is an **analytical cross-sectional study** conducted in structures handling animal products (markets, slaughterhouses, butcher shops, supermarkets and delicatessens) in the Democratic Republic of Congo.

The study is part of a **One Health approach**, integrating the human, animal and environmental dimensions of zoonotic disease prevention.

Study population

The target population consisted of all structures involved in the handling, processing or marketing of products of animal origin.

Inclusion criteria

- Structures in operation at the time of the survey
- Agreeing to participate in the study

Exclusion criteria

- Closed or inaccessible structures
- Refusal to participate

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Sampling

In the absence of an exhaustive sampling frame, a **non-probability convenience sampling method** was used.

This method, although commonly used in operational contexts, exposes one to **selection bias**, limiting the generalization of results.

Sample size

A total of **169 structures** were included in the study.

The sample size is considered acceptable for an exploratory multivariate analysis, although no formal power calculation has been performed.

Data Collection

The data were collected using a **standardized structured questionnaire**, administered to managers or workers of the structures.

The questionnaire focused on:

- Waste management practices
- The existence of regulations
- The vaccination of workers

Since the data is self-reported, **information bias (social desirability bias)** is possible.

Variables Studied

Dependent variable

The main variable was:

Existence of a formalized waste management procedure

- Yes = 1
- No = 0

This variable is considered a proxy indicator of the organizational level of zoonotic prevention.

Independent Variables

The explanatory variables included:

- Type of structure
- Waste sorting (Yes/No)
- Liquid waste treatment (Yes/No)
- Existence of regulations (Yes/No)
- Vaccination of workers

All qualitative variables were coded as binary variables for analysis.

Statistical Analysis

The analysis was carried out in three stages:

Descriptive (monovariate) analysis

- Calculation of the number of employees (n)
- Calculation of proportions (%)
- Presentation in the form of a single merged table

Bivariate Analysis

The association between the dependent variable and the explanatory variables was assessed using:

Pearson's Chi-square test

Terms:

- Qualitative variables
- Comparison of proportions

Significance threshold:

- $p < 0.05$

Multivariate Analysis

The variables significant in bivariate analysis were introduced into a model of:

Binary logistic regression

This analysis allowed us to:

- To identify independent factors
- To estimate the adjusted Odds Ratio (OR)
- To control the effects of confusion

The results are presented with:

- OR adjusted
- 95% confidence intervals
- p-values

Model validation and performance

The performance of the logistic model was evaluated by:

✓ **Area under the ROC curve (AUC)**

- Interpretation:
- AUC > 0.8 → good discrimination

✓ **Youden's Index**

Allowing us to identify the optimal classification threshold.

✓ **Diagnostic indicators**

- Sensitivity
- Specificity
- Positive predictive value (PPV)
- Negative predictive value (NPV)
- Overall accuracy

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Verification of the model's assumptions

- No assumed collinearity between explanatory variables
- Independence of observations
- Log-linear relationship between variables and logit

Managing Biases

Several potential biases have been identified:

- **Selection bias:** related to convenience sampling
- **Information bias:** self-reported data
- **Confounding bias:** limited by multivariate analysis

Ethical considerations

- Voluntary participation
- Informed consent of participants
- Data confidentiality guaranteed

Results and Discussion

After describing the methodological framework and the variables studied, this section presents the main results of the analysis. It is structured around three complementary levels: a descriptive analysis of the characteristics of the structures surveyed, a bivariate analysis to identify associations between variables, and a multivariate analysis using logistic regression to determine the independent factors associated with the prevention of zoonotic diseases.

The objective is to highlight the level of organisation of waste management and vaccination practices, as well as their influence on the existence of a formalised waste management procedure, considered as a key indicator of zoonotic prevention.

Monovariate Analysis

Table 1: Descriptive (monovariate) analysis of variables (n = 169)

Variable	Modality	Number (n)	Percentage (%)
Type of structure	Public procurement	72	42.6
	Slaughterhouse	60	35.5
	Butcher's shop	21	12.4
	Supermarket	8	4.7
	Cold cuts	8	4.7
Waste procedure	No	97	57.4
	Yes	72	42.6
Waste sorting	No	132	78.1
	Yes	37	21.9
Liquid treatment	No	140	82.8
	Yes	29	17.2
Regulation	No	93	55.0
	Yes	76	45.0

The analysis shows that the majority of the structures surveyed are public markets (72 cases; 42.6%), followed by slaughterhouses (60 cases; 35.5%). Butcher shops account for 21 cases (12.4%), while supermarkets and delicatessens are poorly represented with 8 cases each (4.7%).

Regarding waste management, more than half of the facilities do not have a waste management procedure (97 cases; 57.4%), compared to 72 cases (42.6%) that do. Waste sorting is very rarely practiced, with 132 facilities (78.1%) not sorting at all, compared to only 37 (21.9%) that do.

Liquid waste management is also inadequate, as 140 facilities (82.8%) lack a treatment system, compared to 29 (17.2%) that do. Finally, more than half of the facilities are not subject to or do not comply with waste management regulations (93 cases; 55.0%), while 76 (45.0%) report complying with them.

These results highlight the predominance of public markets and slaughterhouses among the structures handling animal products. This configuration reflects the reality observed in many African countries, where marketing channels for animal products are largely informal [6]. A study conducted in Nigeria showed that traditional markets constitute critical points for zoonotic transmission due to the lack of sanitary controls and appropriate infrastructure [1].

The widespread absence of formalized waste management procedures observed in this study (57.4%) reflects a significant organizational weakness. Similar results have been reported in Ethiopia, where the majority of slaughterhouses operate without standardized waste management protocols, thus increasing health risks [2].

The low level of waste sorting (78.1% unsorted) observed in our study is also consistent with data from the African literature [7-9]. The lack of sorting is a major factor in environmental contamination and the spread of pathogens in urban markets [3].

Furthermore, the inadequacy of liquid waste treatment (82.8% untreated) highlights a high risk of water resource contamination [10-12]. Untreated slaughterhouse effluents contribute significantly to the microbiological contamination of surface waters, exposing populations to zoonotic diseases [4].

The absence or weak enforcement of regulations (55.0%) observed in this study highlights the limitations of health governance in highly informal contexts [13]. Insufficient regulatory control in meat value chains is associated with increased health risks for consumers [5].

Overall, these results confirm that the weaknesses observed in waste management, effluent treatment, and regulatory enforcement are not specific to the Democratic Republic of Congo, but are part of a broader problem

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affecting several African countries. They highlight the need to strengthen health governance systems and adopt integrated approaches such as the "One Health" concept to sustainably improve the prevention of zoonotic diseases.

Bivariate Analysis

Table 2: Association between organizational variables and waste management procedure (Chi²)

Variable	Chi²	ddl	p-value
Structure	52.73	4	p < 0.001
Waste sorting	49.68	1	p < 0.001
Liquid treatment	34.06	1	p < 0.001
Regulation	28.66	1	p < 0.001

Table 2: Association between organizational variables and waste management procedure (Chi²)

Statistical analysis reveals significant associations between the variables studied and the observed phenomenon. The type of structure shows a highly significant association ($\chi^2 = 52.73$; df = 4; $p < 0.001$), indicating that the observed differences between the categories of structures are not due to chance.

Similarly, waste sorting is strongly associated with the variable of interest ($\chi^2 = 49.68$; df = 1; $p < 0.001$), suggesting that the absence or presence of sorting significantly influences the situation studied. Liquid waste treatment also shows a significant association ($\chi^2 = 34.06$; df = 1; $p < 0.001$), confirming its important role.

Finally, regulation is also significantly linked to the phenomenon ($\chi^2 = 28.66$; df = 1; $p < 0.001$), which underlines the impact of the regulatory framework on the observed practices.

Statistical analysis highlights significant associations between the variables studied and the observed phenomenon, reflecting the existence of structural links between the organization of structures and zoonotic disease prevention practices.

The type of structure shows a highly significant association ($\chi^2 = 52.73$; df = 4; $p < 0.001$), indicating that the observed differences between the categories are not due to chance. This result is consistent with work carried out in West Africa, which shows that public markets and informal slaughterhouses present higher levels of health risk than formal structures, due to inadequate hygiene conditions and weak regulatory oversight [1].

Similarly, waste sorting is strongly associated with the variable of interest ($\chi^2 = 49.68$; df = 1; $p < 0.001$), suggesting that its absence is a determining factor in the deterioration of sanitary conditions [14]. Studies conducted in African urban markets have shown that the absence of sorting promotes the accumulation of organic waste and the proliferation of pathogens, thus increasing the risk of zoonotic transmission [2].

Liquid waste treatment also showed a significant association ($\chi^2 = 34.06$; df = 1; $p < 0.001$), confirming its important role. This result is consistent with observations made in several African countries where untreated slaughterhouse effluents are directly discharged into the environment, contributing to water contamination and the spread of infectious diseases [3].

Finally, regulations are also significantly linked to the phenomenon ($\chi^2 = 28.66$; df = 1; $p < 0.001$), highlighting the impact of the institutional framework on sanitary practices. The lack of effective enforcement of standards has been identified as a key risk factor in meat value chains in Africa, limiting the adoption of good hygiene and waste management practices [4].

Overall, these results confirm that organizational and institutional factors play a crucial role in the prevention of zoonotic diseases. They justify the integration of these variables into the multivariate analysis in order to identify independent determinants of the phenomenon under study.

Multivariate Analysis

Table 3: Multivariate analysis of the determinants of waste management by binary logistic regression

Variable	GOLD	IC_inf	IC_sup	p-value
const	0.196	0.112	0.345	p < 0.001
Waste sorting	18.131	3.783	86.901	p < 0.001
Liquid waste treatment	7.231	1.301	40.202	P=0.0238
Regulation	3.962	1.804	8.702	p < 0.001

Multivariate analysis highlights factors strongly associated with the phenomenon studied. Waste sorting appears as the main determinant, with a very high odds ratio (OR = 18.131; 95% CI [3.783 – 86.901]; $p < 0.001$), indicating that the absence of sorting considerably multiplies the risk.

Liquid waste treatment is also a significant factor (OR = 7.231; 95% CI [1.301 – 40.202]; p = 0.0238), showing that a treatment failure is associated with a notable increase in risk.

Furthermore, regulation plays an important role (OR = 3.962; 95% CI [1.804 – 8.702]; $p < 0.001$), suggesting that the absence or non-compliance with standards significantly increases the probability of the phenomenon studied.

Finally, the constant of the model is significant (OR = 0.196; 95% CI [0.112 – 0.345]; $p < 0.001$), reflecting the baseline level of risk in the absence of explanatory factors.

Multivariate analysis highlights independent factors strongly associated with the phenomenon studied, confirming the central role of organizational determinants in the prevention of zoonotic diseases.

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Waste sorting appears to be the main determinant, with a very high odds ratio (OR = 18.131; 95% CI [3.783–86.901]; $p < 0.001$), indicating that the absence of sorting significantly increases the risk. This strong association suggests a major and independent effect of sorting on the sanitary organization of facilities. Similar results have been observed in several African studies, where the absence of waste sorting is associated with an accumulation of organic matter that promotes microbial proliferation and the transmission of zoonotic agents [1]. The magnitude of the OR observed in our study underscores the critical role of sorting as a priority intervention that is low-cost but has a high impact.

Liquid waste treatment is also a significant factor (OR = 7.231; 95% CI [1.301–40.202]; $p = 0.0238$), showing that inadequate treatment is associated with a significant increase in risk. Although the confidence interval is relatively wide, reflecting some variability, the association remains statistically significant. This result is consistent with work conducted in East Africa, which shows that untreated slaughterhouse effluents are a major source of environmental and water contamination, increasing population exposure to pathogens [2].

Furthermore, regulations play a significant role (OR = 3.962; 95% CI [1.804–8.702]; $p < 0.001$), suggesting that the absence or non-compliance with standards significantly increases the probability of the phenomenon studied. This result highlights the importance of the institutional framework in improving health practices. Studies conducted in Africa have shown that the effective application of regulations is a determining factor in the adoption of good hygiene and waste management practices [3].

Finally, the model constant is significant (OR = 0.196; 95% CI [0.112–0.345]; $p < 0.001$), reflecting the baseline level of risk in the absence of explanatory variables. This indicates that, even without the factors studied, a residual risk persists, probably linked to other unmeasured determinants such as general hygiene conditions, staff training, or available infrastructure [15].

These results confirm that inadequate waste sorting, insufficient treatment of liquid effluents, and the absence of regulations are major and independent determinants of zoonotic disease prevention [16-18]. The particularly strong effect of waste sorting suggests that it is a priority lever for intervention in public health strategies, consistent with the "One Health" approach aimed at reducing risks at the human-animal-environment interface [19,20].

Discussion

Among the studies examined, anthropomorphisms of nature was addressed [17] associated with proenvironmental attitudes and behaviors. These participants felt that leisure air travel should be restricted in order to mitigate the spread of the virus as well as promote climate change action during the COVID-19 pandemic. The authors believe that environmental guilt was key to such proenvironmentalism. Another study [18], testing for mortality reminders and how they might affect proenvironmental outcomes, did not find a meaningful effect. In particular, death anxiety affecting biospheric concern or mortality reminders on prosocial outcomes were not connected to proenvironmental outcomes. Therefore, these authors suggested exploring relations among mortality reminders and biospheric concern.

Several studies support the benefits for mental health and wellness of ecotherapy. For instance, participants had an increased awareness of how nature can help them shift their perspective, ground them in the present moment, and enable them to access a deeper sense of connection and belonging in something greater than themselves [16]. These benefits manifested in the regulation (stress reduction, presence) and reduction of stress and anxiety as a result of a brief ecotherapy program. Moreover, the program gave participants a sense of meaning (transcendence, awe). The research aligns ecotherapy with humanistic counselling principles and emphasizes including ecocentric values (e.g., interconnection, gratitude, reciprocal spiritual belonging) in therapy.

Among CITs, ecotherapy evoked deep thought and affected emerging identities as well as self-care [36]. For clients and counsellors alike, nature is a place of healing, and the class helped CITs recognize their own connection to nature and rekindled that connection through physical experiences. These led the authors to suggest moving class outside to give students a break from technology and allowing them to interaction with others in groups and to reflect about their outdoor activities and experiences. For CITs, being outdoors lowered their anxiety and improved their level of engagement as well as sense of classroom community and their sense of wellness [37]. These authors made an important observation, that students can still be exposed to the natural world using technology within a classroom environment. Stimulating the senses can be executed indoors, for example using scented candles for smell and natural objects (e.g., twigs, leaves, sand, water) for touch. Ultimately, these authors advocate that counselor educators integrate elements of nature into their practice, either real or technology-driven.

Ecotherapy provides options to address client themes, permitting them the freedom to choose client-suited exercises, stage of work, and setting [24]. The author suggest ecotherapy interventions when they were executable from the security of the room and clients did not have to move far beyond their comfort zone. Ecotherapy can be used as a way for participants to develop tolerance for traditional (indoor) settings. For instance, tolerance for working indoors was built up by several participants, who continued in individual art therapy [22]. Nature, natural materials, and the space shared

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reflecting created opportunities for exploration of loss, change, and resilience.

Ecotherapy seeks to enhance human health through sensory contact with the natural world [38]. Accordingly, being exposed to nature, as through homework exercises, has assisted clients who have experienced depression, anxiety, stress, and interpersonal difficulties. Therapists can bring nature indoors to their offices by enriching these spaces with nature, such as having natural views or by incorporating images of nature, to create a calming atmosphere. In this way, clients are reminded of nature and their connectedness to nature, which involves the recognition that they as individuals are not separate from the natural world [38]. These authors saw some of their study participants combine ecotherapy and art therapy by offering clients the opportunity to create art with the use of natural items or by integrating mindfulness and/ or meditation exercises. For example, homework exercises that involve clients taking notes of specific natural elements experienced through their senses when they visited a nature location. These participants experienced the value of relieving symptoms of stress and anxiety, since mental distress can (at least in part) be triggered by a disconnect between the individual and the (natural) environment.

Ecotherapy acknowledges the vital role of nature in the therapeutic process and sees the human-nature relationship as central to it [23]. Therefore, the "ecological self" begins with the individual and their emotional and psychological world. Adventure therapy (AT) among the homeless, for example, provides a safe emotional environment and fosters positive relationships with practitioners and peers that offer respite and facilitate the development of a sense of belonging [39]. Participants felt empowered by experiencing achievement and mastery, including overcoming physical and psychological challenges. Such positive experiences challenged negative beliefs about themselves and led them to a greater perceived self-efficacy and sense of personal agency [39]. Upon reflection, their views of others also became more positive. Therefore, they were able to improve their intrapersonal relating based on self-acceptance, self-value, and an increased desire to socially reintegrate.

Ecotherapy can be deployed when working with adolescents and their parents. Such participants experienced improvements in mood, self-esteem, confidence, and social skills in ecotherapy programs [40]. Accordingly, such improvements (in personal confidence and self-esteem) are critical for adolescents to overcome challenges associated with social ability. By exploring nature, it is possible to bring individuals with shared experiences together to engage in practical activities. Moreover, the undivided attention of support workers played crucial roles in enhancing the psychosocial well-being of adolescents in their program [40].

The studies by [41] convey that nature exposure can lead to recovery experiences (relaxation, detachment) and positive affective states (positive activation, serenity). However, being in a natural setting is not sufficient to foster recovery, since one must first be aware of the natural surroundings and subsequently evaluate these as aesthetic. Nevertheless, these authors saw the benefit of using the savoring approach to stimulate awareness and aesthetic appraisal of the natural environment and thereby reap the rewards of contact with nature for recovery.

Personality is an important aspect, however, as clients who open to experience and are cooperative and interpersonally outgoing may be more likely to seek out or be open to EcoWellness interventions [13]. Accordingly, individuals who are observant and able to describe their mental states may also be more likely to engage in nature-based interventions. Additionally, people who view nature on a continuum can benefit from a variety of types of nature experiences. EcoWellness-based work needs to be grounded on approaches that emphasize mindfulness and self/ other empathy (e.g., mindfulness-based cognitive therapy, dialectical behavioral therapy, acceptance and commitment therapy). EcoWellness is firmly embedded in holistic wellness. Humanistic counsellors can ask their clients about aspects of EcoWellness (present or desired) in their lives by recognizing client issues related to environmental justice and exploring the ways they might integrate the human-nature connection as part of their treatment plans [42].

In the therapeutic alliance, the natural environment can be seen as a third partner, which brings unpredictability and spontaneity to the relationship, fostering mutual vulnerability and share humanity [4]. As a creative space, the outdoors provides potential and depth for a growing and developing client-therapist relationship with nature. It offers a space for inquiry, reflection, and experimentation, while the environment also promotes relational equality.

Table 4: Performance and predictive capacity of the logistic regression model

Indicator	Value
AUC	0.844
Optimal threshold (Youden)	0.437
Sensitivity	0.833
Specificity	0.722
Accuracy	0.769
VPP	0.690
VPN	0.854

Model Performance:

The model exhibits good discriminatory power, with an area under the curve (AUC) of 0.844, indicating an excellent

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ability to distinguish between risky and non-risky situations. The optimal threshold determined by Youden's index is 0.437, providing a balance between sensitivity and specificity.

Sensitivity is high (0.833), meaning the model correctly identifies 83.3% of positive cases. Specificity is also satisfactory (0.722), indicating a good ability to exclude negative cases.

The overall accuracy of the model is 0.769, indicating that 76.9% of the classifications are correct. The positive predictive value (PPV) is 0.690, meaning that 69.0% of the predicted positive cases are actually positive. Conversely, the negative predictive value (NPV) is higher (0.854), showing that 85.4% of the predicted negative cases are indeed negative.

The logistic model developed in this study exhibits good discriminatory power, with an area under the curve (AUC) of 0.844. This value, above the threshold of 0.80, is generally considered to indicate excellent predictive performance in epidemiological models [1]. It reflects a strong ability of the model to correctly distinguish structures at risk from those not presenting a risk.

The optimal threshold determined by Youden's index (0.437) optimizes the trade-off between sensitivity and specificity. The use of this index is recommended in diagnostic studies to identify the classification point that maximizes the overall performance of the model [2].

The high sensitivity (0.833) indicates that the model is particularly effective at identifying at-risk structures, which is essential from a public health perspective where the main objective is to detect as many problematic situations as possible. This capability is consistent with recommendations in applied epidemiology, which favor high sensitivity for screening tools [3].

The specificity (0.722), although slightly lower than the sensitivity, remains satisfactory and reflects a good ability of the model to exclude non-risk structures. This trade-off between sensitivity and specificity is expected in models applied to real-world contexts, particularly in resource-limited countries where data may be heterogeneous [4].

The overall accuracy of the model (0.769) confirms its reliability, with nearly 77% of classifications correct. However, the analysis of predictive values provides important additional information. The positive predictive value (PPV = 0.690) indicates that a significant proportion of cases identified as at risk may not actually be so, which can be explained by the prevalence of the phenomenon studied. Conversely, the high negative predictive value (NPV = 0.854) shows that the model is particularly effective at identifying non-at-risk structures [21,22].

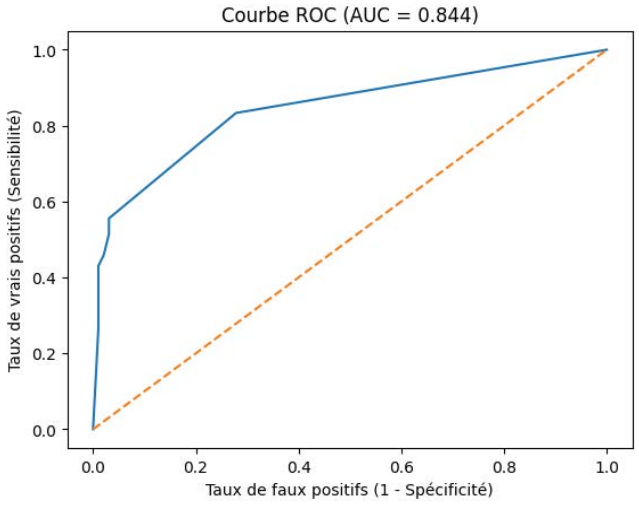
This asymmetry suggests that the model performs better as an exclusion tool than as a confirmation tool, which is common in public health models applied to contexts with high variability [5].

These results demonstrate that the model is robust and operational, with good discrimination capabilities and satisfactory overall performance. It can therefore serve as a relevant decision-making tool for identifying intervention priorities in the prevention of zoonotic diseases, particularly within an integrated "One Health" approach.

An AUC of 0.844 indicates good discriminatory ability.

According to **Steyerberg et al. (2019)**, an AUC greater than 0.80 is considered to reflect robust predictive performance in clinical and epidemiological research (DOI: 10.1007/s10654-019-00571-x).

Thus, our model exhibits satisfactory statistical validity.



The ROC curve shown demonstrates a satisfactory overall performance of the model, with an area under the curve (AUC) of **0.844**. This value, significantly greater than 0.5 (diagonal line representing randomness), indicates that the model has a **good ability to discriminate** between risky and risk-free situations.

Visually, the curve rises rapidly above the diagonal, indicating **good sensitivity for low false positive rates**. This means the model is able to effectively identify positive cases while minimizing errors.

The optimal point (Youden index ≈ 0.437) corresponds to a good compromise between sensitivity and specificity, with a **sensitivity of 0.833** and a **specificity of 0.722**, confirming the balance of the model.

The area under the curve (AUC) of 0.844 indicates good discriminatory power of the model. An AUC value greater than 0.80 is generally considered to reflect robust predictive performance in clinical and epidemiological research [1]. Thus, our model exhibits satisfactory statistical validity.

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The ROC curve presented shows satisfactory overall performance, with an AUC significantly greater than 0.5, a value corresponding to random classification. This indicates that the model has a good ability to discriminate between risky and risk-free situations [23].

Visually, the curve rises rapidly above the diagonal, indicating good sensitivity for low false positive rates. This means that the model is able to efficiently identify positive cases while limiting classification errors [24].

The optimal threshold determined by the Youden index (≈ 0.437) corresponds to a good compromise between sensitivity and specificity, with a sensitivity of 0.833 and a specificity of 0.722. This result confirms the balance of the model in the detection of at-risk cases and the exclusion of non-at-risk cases [25].

Limitations of the Study

This study has certain limitations that should be taken into account when interpreting the results.

First, the use of non-probability convenience sampling can introduce selection bias, thus limiting the representativeness of the structures studied and the generalizability of the results to the entire territory. Second, since the data collected are self-reported, information bias related to social desirability cannot be ruled out, as respondents may overestimate their good practices.

Furthermore, the cross-sectional nature of the study does not allow for establishing a causal relationship between the variables studied, but only statistical associations. Certain potentially important variables, such as the workers' level of education, available infrastructure, or effective health controls, were not taken into account, which could explain part of the observed residual risk.

Finally, although the logistic model performs well (AUC = 0.844), the width of some confidence intervals suggests variability that could be reduced by a larger sample size.

General Conclusion

The present study aimed to analyze the organizational determinants associated with the prevention of zoonotic diseases in structures handling animal products in the Democratic Republic of Congo.

The results highlight a significant deficiency in waste management practices, characterized by a low proportion of facilities with formalized procedures, a lack of waste sorting, and a frequent absence of liquid effluent treatment. Bivariate analysis showed significant associations between these variables and zoonotic disease prevention.

Multivariate analysis identified three major independent determinants: waste sorting, liquid waste treatment, and regulatory compliance. Waste sorting emerged as the most decisive factor, highlighting its central role in sanitation organization.

The model's strong performance (AUC = 0.844) confirms the robustness of the results and their relevance to decision-making. Overall, this study demonstrates that the prevention of zoonotic diseases relies primarily on the level of internal organization within structures and the effectiveness of the regulatory framework.

These results are consistent with the "One Health" approach, which highlights the interdependence between human, animal and environmental health, and underlines the need for coordinated action to reduce health risks.

Recommendations

To the health and veterinary authorities

- Strengthen the effective enforcement of regulations on animal waste management
- Establish regular sanitary inspection systems in markets and slaughterhouses
- Develop and disseminate technical guides adapted to the local context
- Integrate liquid waste treatment into mandatory standards
- Promoting the "One Health" approach in public policies

To managers of facilities (markets, slaughterhouses, butcher shops)

- Establish written waste management procedures
- Implement an accessible and functional waste sorting system
- Install simple liquid effluent treatment devices
- Organize continuing education courses in hygiene and biosecurity

To the workers

- Respect waste sorting and disposal practices
- Actively participate in health training
- Ensure regular medical follow-up and keep their vaccination status up to date.

Recommendations for future research

- Conduct longitudinal studies to establish causal relationships
- Incorporate microbiological analyses to assess the actual contamination
- Study the structural factors (infrastructure, training, governance)
- Developing community intervention models adapted to African urban contexts

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