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Environmental nuisance exposure mediates the relationship between abattoir proximity and household enteric dermatological morbidity: a GPS-anchored cross-sectional study in Bo and Kenema Cities, Sierra Leone

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Abstract

Background

Urban abattoirs across sub-Saharan Africa commonly operate within residential neighborhoods(Adeniyi et al. 2025), exposing surrounding households to odor, effluent, vectors and noise(Ibegbu et al. 2024). The community-health consequences are poorly quantified in Sierra Leone, and the common assumption that harm is a direct function of physical distance has not been tested against measured exposure. We assessed whether environmental nuisance exposure mediates the relationship between abattoir proximity and household enteric–dermatological morbidity in Bo and Kenema Cities.

Methods

We conducted a community-based analytical cross-sectional study among 950 residents (Bo = 497; Kenema = 453) living around confirmed abattoirs, using a GPS-enabled questionnaire. A five-item nuisance exposure index was constructed (Cronbach's α = 0.802), and metric distance to the nearest abattoir was computed from field coordinates. We used multivariable logistic regression and a bootstrapped causal-mediation analysis (5,000 resamples), with malaria/vector-borne illness as a pre-specified negative-control outcome.

Results

Nuisance exposure declined monotonically with distance (Spearman $\rho = -.40$, $p < .001$) and independently predicted enteric dermatological morbidity (adjusted OR ≈ 1.24 per index point; $p < .001$). Distance had no independent association with morbidity once exposure was included. Mediation analysis showed that abattoir proximity influenced enteric–dermatological morbidity entirely through nuisance exposure (natural indirect effect = -0.31, 95% CI [-0.45 to -0.21]; direct effect non-significant), indicating complete mediation. In contrast, malaria rose with distance (OR ≈ 1.6; $p = 0.006$), the opposite direction, arguing against generalised deprivation as a confounder.

Conclusions

The health burden of urban abattoirs in this setting is driven by measurable environmental nuisance load rather than physical distance, with exposure completely mediating the proximity morbidity relationship. Interventions should prioritise nuisance abatement effluent control, waste management and vector control over relocation alone.

Background

The slaughtering of livestock for human consumption is among the oldest and most widespread urban economic activities, yet across sub-Saharan Africa it remains among the least regulated from an environmental and public-health standpoint. Abattoirs generate large volumes of solid and liquid waste blood, rumen and gut contents, condemned offal, and high-strength wastewater with elevated biochemical oxygen demand much of which is discharged untreated into open drains, watercourses and adjacent land (BELLO and Oyedemi 2009; Onyinna et al. 2026; Ovuru et al. 2023). Where such facilities are sited within or beside residential neighbourhoods, the resulting odour, proliferation of flies and rodents, wastewater flooding and contamination of domestic water become chronic environmental stressors for surrounding households (Daramola and Olowoporoku 2024).

A growing case-study literature links abattoir proximity to community morbidity. Studies from Nigeria and elsewhere report elevated gastrointestinal, dermatological and respiratory complaints among residents living near abattoirs, alongside contamination of domestic wells and deterioration of local air quality (BELLO and Oyedemi 2009; Daramola and Olowoporoku 2024; Onyinna et al. 2026). However, this evidence has two important limitations. First, exposure is almost always captured through self-reported proximity, which is prone to misclassification; objective, GPS-measured distance is rarely used. Second, the literature is overwhelmingly descriptive: it establishes association but seldom tests the *mechanism* by which proximity affects health. In particular, it does not distinguish whether distance harms health directly, or indirectly by determining the intensity of environmental nuisance to which a household is exposed.

This distinction is not merely academic. If proximity acts through exposure, then two households at the same distance but with different nuisance loads face different risks, and the appropriate policy response is nuisance abatement rather than relocation. Conceptually, this is a mediation question: does abattoir proximity influence morbidity because it determines nuisance exposure? Framed within a source pathway receptor model of environmental risk, distance is a determinant of pathway intensity rather than a hazard in itself (VanderWeele 2015).

Sierra Leone exemplifies the wider regional problem but is critically under-studied. Existing national research has focused on meat hygiene, worker biosecurity and inspection practice rather than the health of communities living around abattoirs (Kanu et al. 2023; Sankoh et al. 2025; Sesay et al. 2022) and is confined to the Western Area. No study has quantified community exposure or health status around abattoirs in Bo and Kenema the country’s second- and third-largest cities. We therefore assessed environmental nuisance exposure, household morbidity and their relationship in these two cities, and tested the hypothesis that nuisance exposure mediates the association between abattoir proximity and household enteric dermatological morbidity, using malaria/vector-borne illness as a pre-specified negative control to guard against confounding by generalised deprivation.

Methods

Study design and setting

We conducted a community-based analytical cross-sectional study in Bo City (Southern Province) and Kenema City (Eastern Province), Sierra Leone, between 11 and 26 July 2026. Bo is the country's second-largest city (population approximately 223,000) and Kenema the third-largest (approximately 255,000); both host municipal and informal abattoirs sited close to dense residential neighbourhoods (Bo District Council 2023; Kenema District Council 2023; Statistics Sierra Leone 2016) (Fig. 1).

Participants and sampling

Eligible participants were adults (≥ 18 years) residing in neighbourhoods adjoining confirmed operating abattoirs. Confirmed abattoirs were geolocated, and households were sampled around each facility using a spatial-proximity approach, with enumerators working systematically outward from the site to populate the full distance gradient. A GPS coordinate was captured at every household. The sample size was determined using Cochran's formula for a single proportion (Cochran 1977): with an expected morbidity prevalence of 0.20, 95% confidence and ± 3% precision, and a design effect of 1.3 for clustering, the minimum required sample was approximately 888; recruitment continued to 950 analysed residents.

Measures

The exposure of interest was a five-item **nuisance exposure index** formed by summing ordinally scored items for odour frequency, fly/rodent frequency, noise level, wastewater-flooding frequency and water-source contamination (range 0–18; Cronbach's $\alpha = 0.802$). **Proximity** was the haversine distance from each household to the nearest confirmed abattoir (Sinnott 1984). The primary **outcome** was a binary indicator of enteric–dermatological morbidity (self-reported household gastrointestinal, skin, eye, or suspected-zoonotic illness). Malaria/vector-borne illness was analysed identically as the **negative-control outcome**. Covariates were district, sex and age group.

Statistical analysis

Analyses were conducted in Python (pandas, statsmodels, scipy). Monotone associations were assessed with Spearman's ρ and adjusted associations with multivariable logistic regression controlling for district, sex and age. Causal mediation followed the potential-outcomes framework (Baron and Kenny 1986; VanderWeele 2015) the total effect of long-distance on enteric dermatological morbidity was decomposed into natural direct and natural indirect (exposure-mediated) effects, with 95% percentile confidence intervals from 5000 bootstrap resamples. The negative-control outcome was analysed with the same specification. Statistical significance was set at $p < .05$.

Ethics

Ethical approval

was obtained from the Njala University Institutional Review Board (NUIRB). Documented informed consent was obtained from every participant; participation was voluntary with the right to withdraw. The study adhered to the Declaration of Helsinki.

Results

Participant characteristics and exposure gradient

Of 950 residents, 497 (52.3%) were in Bo and 453 (47.7%) in Kenema; the sample was approximately sex-balanced (51.2% female) and concentrated in the 25–44 age bands. The median household distance to the nearest confirmed abattoir was 193 m. Nuisance exposure declined monotonically with distance (Spearman $\rho = -.40$, $p < .001$; Fig. 2), confirming the expected distance exposure gradient (Fig. 2).

Exposure, distance and morbidity

Household illness was reported by 20.8% of residents. In multivariable logistic regression adjusting for district, sex and age, the nuisance exposure index independently predicted enteric dermatological morbidity (adjusted OR ≈ 1.24 per index point; $p < .001$). Once exposure was included in the model, distance had no independent association with enteric dermatological morbidity the statistical signature of mediation. The divergence between illness types was striking: gastrointestinal and skin infections declined with distance, whereas malaria rose with distance (Fig. 3).

Causal-mediation analysis

The bootstrapped mediation analysis confirmed the hypothesised structure. The natural indirect (exposure-mediated) effect of proximity on enteric dermatological morbidity was − 0.31 on the log-odds scale (95% CI [-0.45 to -0.21]), while the natural direct effect was non-significant and close to zero. Environmental nuisance exposure therefore completely mediated the proximity morbidity relationship (Fig. 4).*Fig. 4 Mediation model. The effect of abattoir proximity on enteric–dermatological morbidity operates entirely through nuisance exposure; the direct path is non-significant.*

Negative-control outcome

In deliberate contrast to the enteric–dermatological outcome, malaria/vector-borne illness rose with distance from the abattoir (OR ≈ 1.6 per e-fold increase in distance; $p = 0.006$). Had the exposure morbidity association been an artefact of poorer households clustering near abattoirs, malaria would be expected to track proximity in the same direction as enteric illness; its opposite behaviour argues against generalised deprivation as a confounder and supports the specificity of the abattoir-exposure effect.

Discussion

In two Sierra Leonean cities, we found that the health effect of abattoir proximity operates entirely through measurable environmental nuisance exposure. Distance mattered only insofar as it set the intensity of odour, flies, effluent, noise and water contamination to which a household was subject; once exposure was accounted for, distance carried no independent association with enteric dermatological morbidity. This complete mediation was robust across 5000 bootstrap resamples, and its specificity was supported by a negative control: malaria, which shares the deprivation background but not the effluent-and-vector pathway of the abattoir, moved in the opposite direction with distance.

These findings both confirm and extend the existing literature. They are consistent with community studies linking abattoir proximity to enteric and dermatological illness (BELLO and Oyedemi 2009; Daramola and Olowoporoku 2024) and with the near-universal picture of poor abattoir sanitation in the region (Hossain et al. 2025; Nyokabi et al. 2025; Ovuru et al. 2023). They extend that literature in two ways: methodologically, by replacing self-reported proximity with GPS-measured distance; and analytically, by moving from association to a formal test of mechanism with a pre-specified negative control an approach, to our knowledge, not previously applied at the African abattoir interface.

The policy implication is direct. Because proximity harms health through exposure rather than distance per se, interventions that reduce nuisance load enclosed effluent handling, drainage improvement, daily waste collection and vector control should take priority over facility relocation, which is costly and, on this evidence, addresses only a proxy for the true driver. Buffer-zone standards should be conceived in terms of the exposure gradient rather than fixed metric distance alone.

Limitations

This study has limitations. The cross-sectional design precludes definitive causal inference, although the mediation structure and negative control substantially strengthen the causal argument. Morbidity was self-reported and not laboratory-confirmed, admitting recall and reporting bias. The confirmed abattoir inventory may not capture every informal slaughter point, potentially attenuating some distance estimates. Finally, data collection was more concentrated in one city in later fieldwork, so residual spatial confounding cannot be excluded; a longitudinal design with matched far-field controls is recommended to establish temporality.

Conclusions

The community health burden of urban abattoirs in Bo and Kenema is driven by measurable environmental nuisance load rather than physical distance, with nuisance exposure completely mediating the proximity morbidity relationship and malaria’s opposite gradient confirming specificity. Environmental-health policy should prioritise nuisance abatement and exposure monitoring over relocation alone.

Declarations

Ethics approval and consent to participate

Ethical approval was granted by the Njala University Institutional Review Board (NUIRB) on the 14th January, 2026. Written informed consent was obtained from all participants.

Consent for publication

Not applicable.

Clinical trial number

Not applicable.

Availability of data and materials

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

ABM conceptualized and designed the study, developed the data-collection instrument, supervised fieldwork, curated and analyzed the data, produced the figures, and drafted the manuscript. SK contributed to the study design, data collection and validation of the dataset. AAB contributed to data collection, data cleaning and interpretation of results. ABG contributed to the environmental. science framing, interpretation of the exposure findings, and critical revision of the manuscript for important intellectual content. DK contributed to data collection, project administration and formatting of the manuscript. UB contributed to the methodological design, statistical interpretation and critical revision of the manuscript for important intellectual content. RA, as lead supervisor, provided overall scientific direction, methodological guidance and critical revision of the manuscript. All authors read and approved the final manuscript.

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Figures

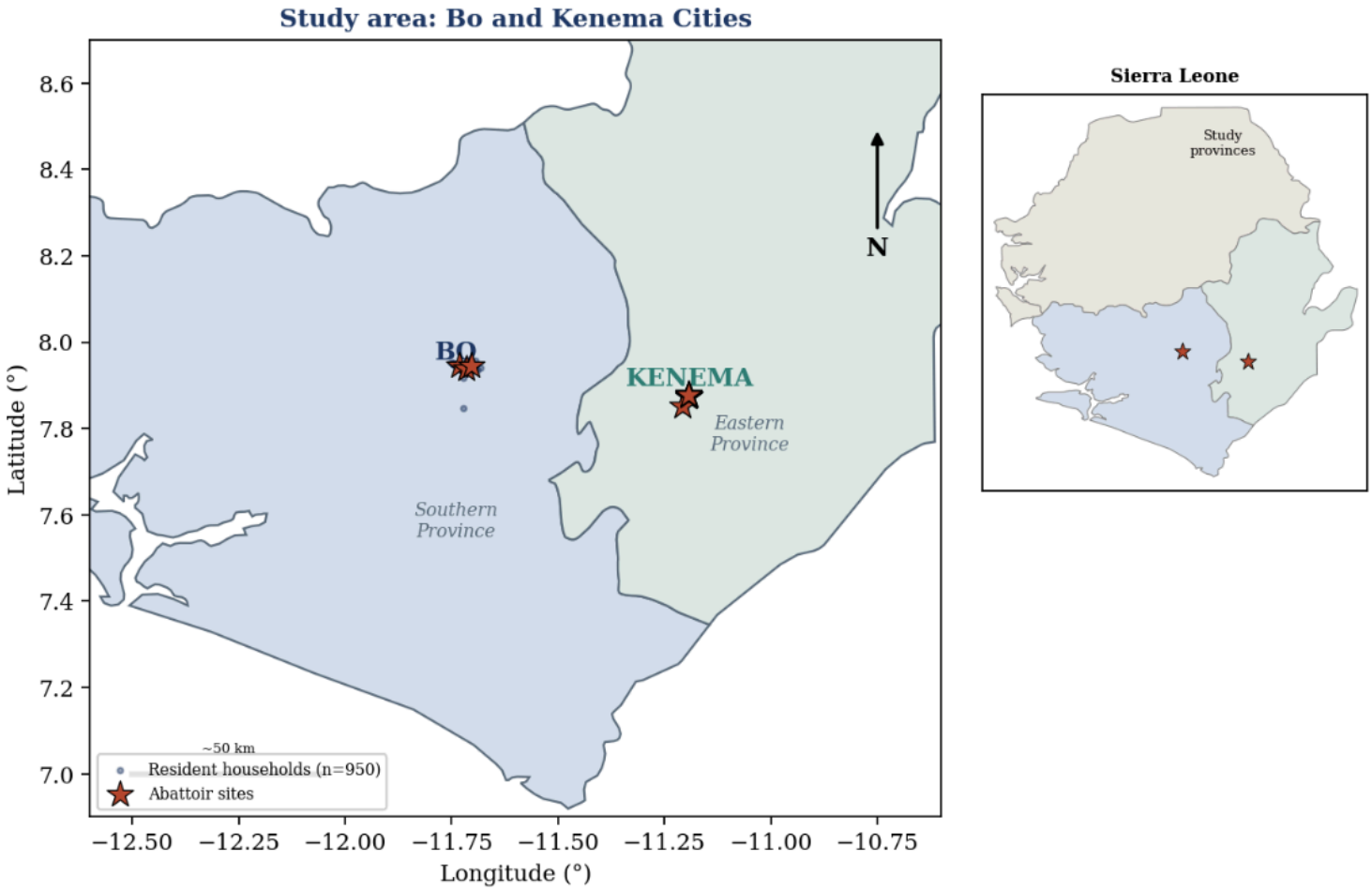


Figure 1

Study area. Southern and Eastern Provinces of Sierra Leone, showing Bo and Kenema Cities, confirmed abattoir sites (stars) and sampled resident households (points). Base boundaries derived from national administrative spatial data; survey points from field GPS. Inset: national locator.

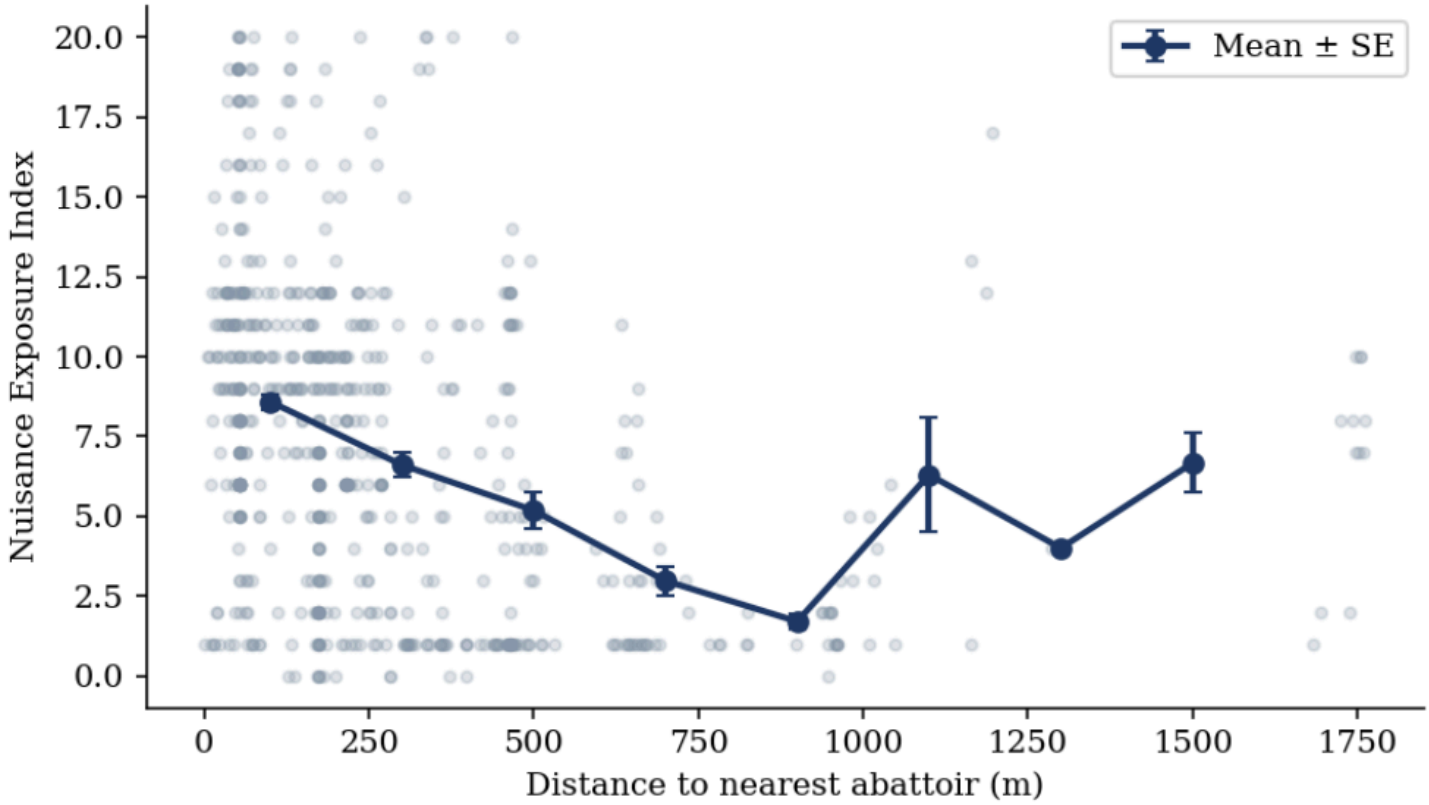


Figure 2

Nuisance exposure index by distance to the nearest abattoir (mean ± standard error per 200 m band). Exposure declines monotonically with distance."

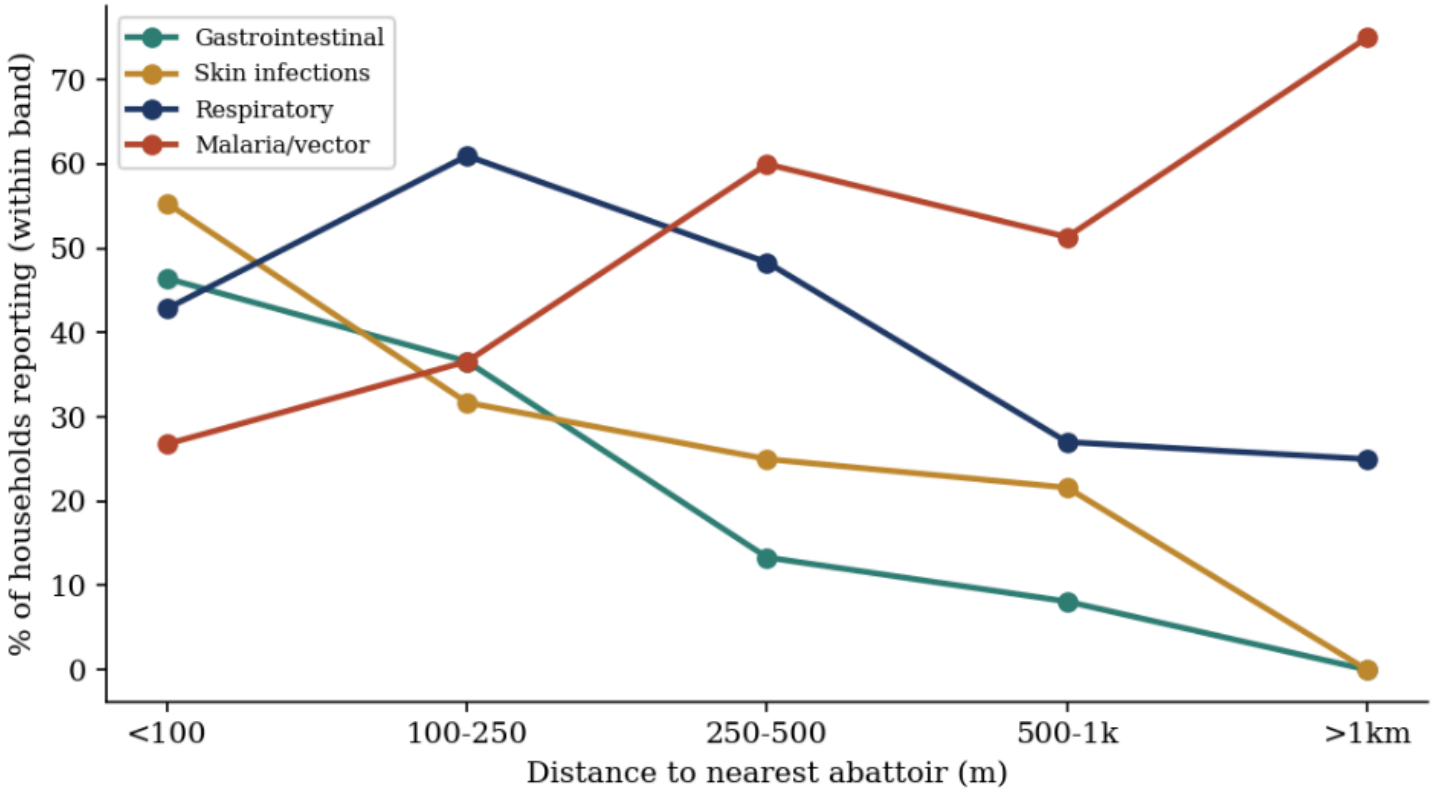
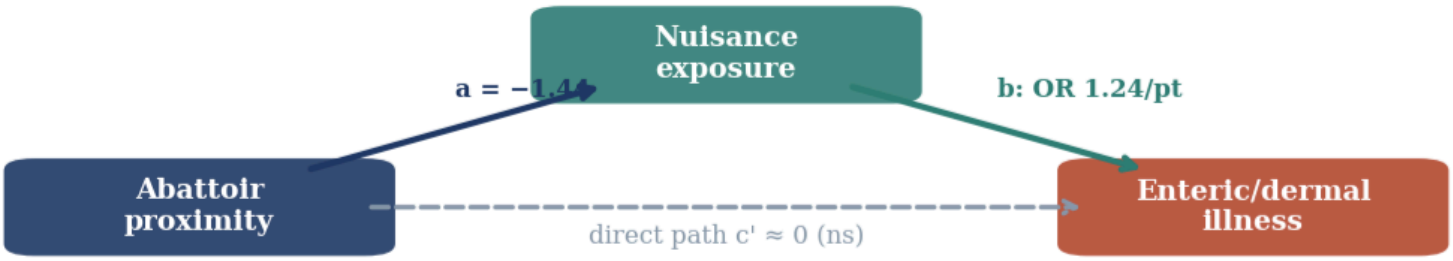


Figure 3

Reported illness type by distance band. Enteric and dermatological illnesses decline with distance from the abattoir, whereas malaria/vector-borne illness rises with distance, functioning as a negative control.



Indirect effect (a×b) = −0.31, 95% CI −0.45 to −0.21 → complete mediation

Figure 4

Mediation model. The effect of abattoir proximity on enteric–dermatological morbidity operates entirely through nuisance exposure; the direct path is non-significant.