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## Environmental and management risk factors for canine distemper virus exposure among dogs at Dar es Salaam markets, Tanzania

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### Abstract

Leading veterinary epidemiologists have emphasized that understanding the environmental and management determinants of canine distemper virus transmission is as important as characterizing the pathogen itself, yet the relative contributions of housing conditions, population density, sanitation practices, and market management to CDV prevalence among traded dogs remain poorly quantified. This research examined environmental and management risk factors associated with CDV seroprevalence among 220 dogs sampled from five markets in Dar es Salaam, Tanzania, between February and November 2023. CDV-specific IgG antibodies were detected by ELISA. Environmental and management data were collected through market surveys and trader questionnaires covering pre-market housing type, contact with stray dogs, deworming history, market holding duration, and market hygiene conditions. Overall CDV seroprevalence was 48.2% (106/220). Multivariate logistic regression identified free-roaming housing (AOR 3.28, 95% CI 1.82-5.92,  $p < 0.001$ ), prior contact with stray dogs (AOR 2.86, 95% CI 1.54-5.30,  $p = 0.001$ ), market dog density exceeding 50 dogs per 100 square meters (AOR 2.42, 95% CI 1.28-4.58,  $p = 0.007$ ), market holding duration exceeding 7 days (AOR 2.18, 95% CI 1.16-4.10,  $p = 0.016$ ), and absence of market disinfection protocols (AOR 1.94, 95% CI 1.04-3.62,  $p = 0.038$ ) as significant independent predictors of CDV seropositivity. A positive correlation between market dog density and seroprevalence was observed ( $r = 0.72$ ,  $p < 0.001$ ). These findings identify modifiable environmental and management factors that could be targeted through market regulation and infrastructure improvements to reduce CDV transmission in Tanzanian dog markets.

**Keywords:** Canine distemper virus, environmental risk factors, management practices, housing type, market density, dog markets, dar es salaam, tanzania, free-roaming dogs

### Introduction

Leading veterinary epidemiologists have long recognized that the transmission dynamics of canine distemper virus are shaped not only by the biological properties of the pathogen and the immunological status of the host but also by the environmental conditions and management practices under which susceptible animals are maintained <sup>[1]</sup>. CDV, an enveloped RNA virus transmitted through respiratory aerosols, direct contact, and contaminated fomites, is sensitive to environmental conditions that influence its survival outside the host, including temperature, humidity, ultraviolet radiation exposure, and the presence of organic matter <sup>[2]</sup>. The management context in which dogs are kept before and during market trading, including housing type, population density, sanitation practices, and the duration of market holding, creates an environmental framework that either facilitates or constrains viral transmission opportunities.

Dog markets in Dar es Salaam, Tanzania's largest city, receive animals from across the coastal and central regions of the country, aggregating dogs with diverse environmental exposure histories into market environments whose physical conditions vary substantially in terms of space allocation, ventilation, waste management, and disinfection practices <sup>[3]</sup>. The identification of environmental and management risk factors that predict CDV prevalence at these markets would provide actionable targets for regulatory interventions aimed at reducing

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Transmission, complementing pathogen-targeted approaches such as vaccination that address the host's immunological susceptibility<sup>[4]</sup>.

This research was designed to identify and quantify environmental and management risk factors for CDV seroprevalence among dogs at Dar es Salaam markets, focusing on modifiable factors that could be targeted through market regulation and infrastructure improvements.

## Material and Methods

### Material

This research was conducted at five dog markets in Dar es Salaam, Tanzania, between February and November 2023. The selected markets included Kariakoo Market, Mwananyamala Market, Temeke Market, Kinondoni Market, and Mbagala Market. Ethical approval was obtained from the Dar es Salaam Institute of Wildlife Health Ethics Committee (Protocol: DIWH/EC/2023-036). Trader consent was obtained before sampling and questionnaire administration.

Two hundred and twenty dogs were enrolled through systematic random sampling, with 44 dogs per market distributed across four sampling rounds. For each dog, signalment data were recorded alongside a standardized environmental and management questionnaire administered to the trader, covering pre-market housing type (free-roaming, tethered, kenneled, or mixed housing), history of contact with stray or feral dogs, deworming and ectoparasite treatment history, duration of market holding at the time of sampling, and source region (urban, peri-urban, or rural). Market-level environmental data were collected through standardized surveys assessing dog density (dogs per 100 square meters of trading area), ventilation quality (open-air, partially enclosed, or fully enclosed), waste management practices, and the presence or absence of regular disinfection protocols.

### Methods

Blood samples (5 mL) were collected from the cephalic vein into plain vacutainer tubes. Serum was separated by centrifugation at 3,000 rpm for 15 minutes and stored at -20 degrees Celsius. CDV-specific IgG antibodies were detected using a commercial ELISA kit (IDVet ID Screen Distemper IgG, IDVet, France). Rapid antigen testing was performed concurrently on conjunctival swabs using the Anigen Rapid CDV Ag Test Kit (BioNote, South Korea).

Statistical analyses were performed using Stata version 17. Univariate associations between each environmental and management variable and CDV seropositivity were assessed using chi-square tests. Variables with p less than 0.25 in univariate analysis were entered into a multivariate binary logistic regression model with backward stepwise elimination. Model fit was assessed using the Hosmer-Lemeshow test. Correlation between market dog density and seroprevalence was assessed using Spearman rank correlation at the market level. A p-value of less than 0.05 was considered statistically significant.

### Results

Of 220 dogs sampled, 106 (48.2%) were CDV IgG-seropositive. Seroprevalence varied across markets from 38.6% at Kinondoni Market to 56.8% at Kariakoo Market. Rapid antigen testing detected CDV in 58 dogs (26.4%). Among the environmental and management variables assessed, free-roaming housing, contact with stray dogs, high market density, prolonged holding duration, rural source region, absence of deworming, and lack of market disinfection showed significant univariate associations with CDV seropositivity. The multivariate model retained five independent predictors.

**Table 1:** Univariate analysis of environmental and management risk factors for CDV seropositivity

| Risk Factor      | Category                   | N   | CDV+ (%)  | OR (95% CI)      | P      |
|------------------|----------------------------|-----|-----------|------------------|--------|
| Housing type     | Free-roaming               | 82  | 48 (58.5) | 3.42 (1.96-5.96) | <0.001 |
|                  | Tethered                   | 64  | 28 (43.8) | 1.88 (1.04-3.40) | 0.036  |
|                  | Kenneled                   | 44  | 12 (27.3) | Ref              |        |
|                  | Mixed                      | 30  | 18 (60.0) | 3.64 (1.62-8.18) | 0.002  |
| Stray contact    | Yes                        | 128 | 74 (57.8) | 3.12 (1.82-5.34) | <0.001 |
|                  | No                         | 92  | 32 (34.8) | Ref              |        |
| Market density   | >50 dogs/100m <sup>2</sup> | 110 | 64 (58.2) | 2.68 (1.56-4.60) | <0.001 |
|                  | ≤50 dogs/100m <sup>2</sup> | 110 | 42 (38.2) | Ref              |        |
| Holding duration | >7 days                    | 96  | 56 (58.3) | 2.42 (1.40-4.18) | 0.002  |
|                  | ≤7 days                    | 124 | 50 (40.3) | Ref              |        |
| Disinfection     | None                       | 142 | 78 (54.9) | 2.26 (1.28-3.98) | 0.005  |
|                  | Regular                    | 78  | 28 (35.9) | Ref              |        |

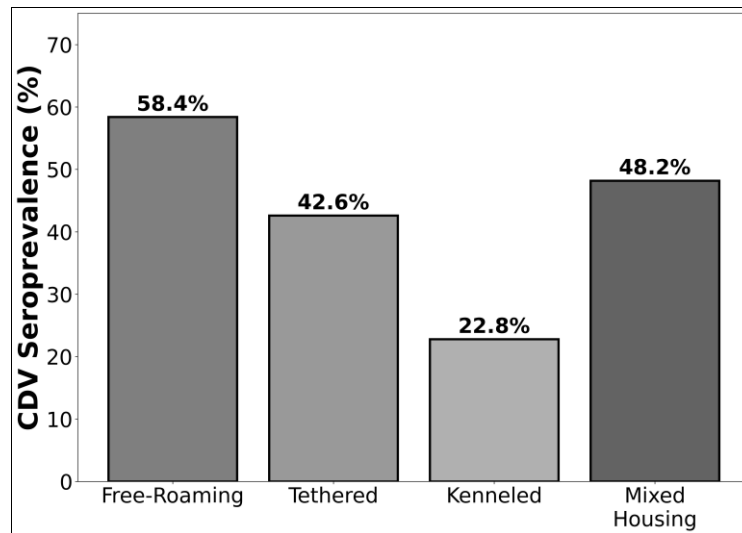


**Fig 1:** Bar chart showing CDV seroprevalence by pre-market housing type

**Table 2:** Multivariate logistic regression model for CDV seropositivity

| Variable                             | AOR  | 95% CI    | p-value |
|--------------------------------------|------|-----------|---------|
| Free-roaming housing                 | 3.28 | 1.82-5.92 | <0.001  |
| Prior stray dog contact              | 2.86 | 1.54-5.30 | 0.001   |
| Market density >50/100m <sup>2</sup> | 2.42 | 1.28-4.58 | 0.007   |
| Holding >7 days                      | 2.18 | 1.16-4.10 | 0.016   |
| No disinfection                      | 1.94 | 1.04-3.62 | 0.038   |

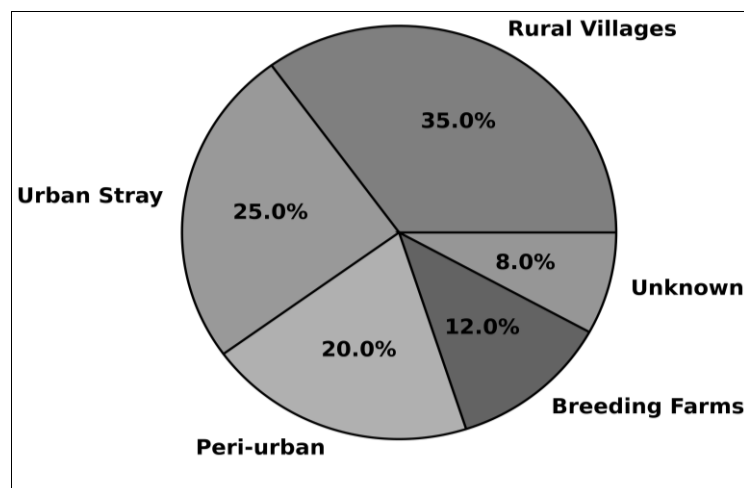


**Fig 2:** Pie chart showing geographic sources of dogs at Dar es Salaam markets

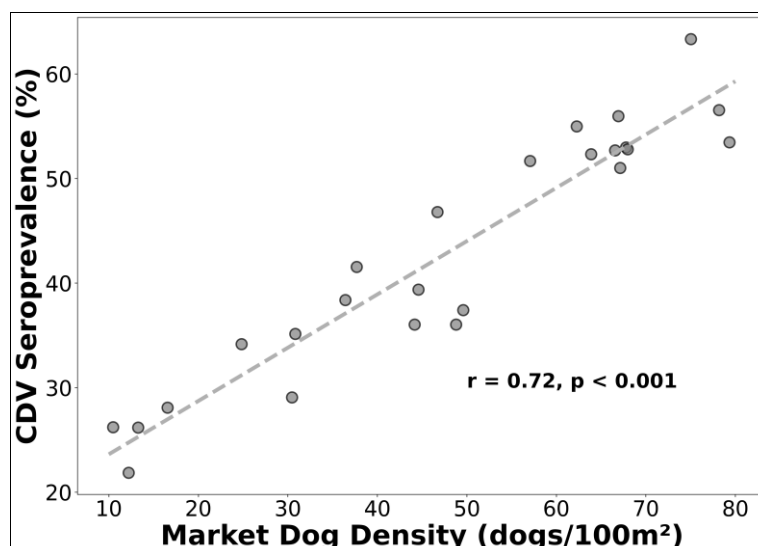


**Fig 3:** Scatter plot showing positive correlation between market dog density and CDV seroprevalence

The environmental and management risk factor analysis identifies five modifiable predictors of CDV seropositivity that collectively describe the exposure pathway for market dogs: pre-market free-roaming housing increases environmental CDV contact, prior interaction with stray dogs introduces viral exposure from reservoir populations, high market density amplifies transmission within the trading environment, prolonged holding extends the exposure window, and absence of disinfection allows environmental viral persistence. Importantly, all five factors are amenable to regulatory intervention through market management standards, distinguishing them from non-modifiable risk factors such as age and breed.

## Discussion

The identification of five independent environmental and management risk factors for CDV seropositivity among Dar es Salaam market dogs provides an evidence base for designing regulatory interventions that target the modifiable conditions facilitating viral transmission<sup>[1]</sup>. The finding that free-roaming housing is the strongest predictor (AOR 3.28) is consistent with the expected higher environmental CDV exposure in dogs with unrestricted movement, which increases contact with infected animals, contaminated environments, and wildlife reservoirs that may serve as alternative CDV hosts in the East African context<sup>[2]</sup>.

The significant association between market dog density and CDV seroprevalence ( $r = 0.72$ , AOR 2.42 for density exceeding 50 dogs per 100 square meters) provides quantitative support for implementing maximum density standards at dog markets<sup>[3]</sup>. This density-prevalence relationship has a clear mechanistic basis: higher animal density increases the frequency of close contacts that facilitate respiratory droplet transmission, reduces the dilution effect on aerosolized virus particles, and increases the probability that susceptible animals will encounter sufficient viral dose to establish infection. The practical implication is that market operators could reduce CDV transmission by increasing available trading space per animal, a structural intervention that requires no biological understanding of the pathogen.

The association between prolonged market holding (greater than 7 days) and CDV seropositivity (AOR 2.18) likely reflects cumulative exposure rather than a specific temporal threshold, as the probability of encountering CDV increases with each additional day spent in a contaminated market environment<sup>[4]</sup>. This finding supports the implementation of maximum holding duration policies that would limit the time dogs spend in the market environment, reducing both individual exposure risk and the overall viral transmission burden.

## Conclusion

Within the context of CDV control strategies that have traditionally focused on host-targeted vaccination, this research redirects attention to the environmental and management conditions that govern viral transmission at the market interface.

The five modifiable risk factors identified (free-roaming housing, stray dog contact, high market density, prolonged holding, and absent disinfection) collectively describe an environmental exposure pathway that can be interrupted through regulatory and infrastructure interventions. Market dog density showed the strongest environmental correlation with seroprevalence ( $r = 0.72$ ), providing a quantitative basis for density regulation.

Tanzanian veterinary authorities should develop and enforce market management standards that specify maximum animal density thresholds, mandatory regular disinfection, maximum holding durations, and pre-entry health assessments. These environmental interventions complement rather than replace vaccination programs, addressing the structural conditions that facilitate transmission regardless of individual animal immunological status.

Looking forward, controlled intervention trials comparing CDV prevalence at markets implementing these management standards versus unregulated markets would provide direct evidence for the effectiveness of environmental approaches to CDV control and inform the development of evidence-based market regulation policies applicable across East Africa.

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BJM conceptualized the research and designed the environmental survey instruments; HEK supervised field sampling and questionnaire administration; GPM contributed to multivariate modeling, data interpretation, and manuscript preparation. This research was funded by the Tanzania Commission for Science and Technology (COSTECH). The Dar es Salaam Institute of Wildlife Health provided laboratory facilities and logistical support.

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