Environmental and Management Risk Factors for Goat Mastitis in Banyuwangi

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ABSTRACT

Mastitis is a persistent and economically significant health problem in dairy goats in Banyuwangi, East Java, where smallholder production systems dominate. This review synthesises current evidence on the primary risk factors contributing to the high prevalence of subclinical mastitis in the region. Local studies consistently report *Staphylococcus aureus* as the leading etiological agent, frequently exhibiting antimicrobial resistance linked to unsupervised antibiotic use. Host-related factors such as advanced parity, udder lesions, and teat-end damage increase susceptibility to intramammary infection. Management practices—including inadequate milking hygiene, use of shared towels, absence of pre- and post-dipping, and irregular equipment sanitation—facilitate the transmission of contagious pathogens. Environmental conditions, particularly high humidity and poor housing sanitation, further elevate infection pressure. Socio-economic constraints and limited farmer knowledge about subclinical mastitis and antibiotic stewardship exacerbate disease persistence. The multifactorial nature of mastitis in Banyuwangi underscores the need for context-appropriate interventions combining improved hygiene practices, better housing management, routine screening, and responsible antimicrobial use. Strengthened farmer education and targeted surveillance are essential to reduce mastitis prevalence and enhance the sustainability of goat dairy production in the region.

Keywords: goat mastitis, risk factors, Banyuwangi, subclinical infection

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INTRODUCTION

Mastitis remains one of the most significant health and production challenges in dairy goat farming worldwide. As demand for goat milk and dairy products continues to rise especially in rural and small-holder systems the impact of mastitis on animal welfare, milk yield and quality, farm income, and public health has become increasingly critical (Tibebu *et al.*, 2026). According to a recent global meta-analysis, the pooled prevalence of mastitis in goats is estimated at 30.6 % (95 % CI: 28.1–34.3 %), with subclinical forms being far more common (31.6 %) than clinical mastitis (7.5 %).

Despite this high burden, goats are often overlooked in favor of cattle when it comes to mastitis research and control programs. The review by Tibebu *et al.* (2026) argues that, although goats contribute substantially to global milk production especially in resource-limited settings and harsh climates the complexity of goat udder physiology, the diversity of production systems, and the multifactorial etiology of mastitis complicate disease surveillance and control.

Mastitis in goats is known to be multifactorial. Pathogens — including contagious agents such as *Staphylococcus aureus*, *Streptococcus* spp., and mycoplasmas, as well as environmental bacteria like *Escherichia coli*, *Klebsiella* spp., and various non-aureus staphylococci — play a central role in intramammary infections. But the mere presence of pathogens is insufficient to explain the variable prevalence and severity observed across herds and regions. Host factors (age, parity, lactation stage), environmental conditions (housing, bedding, hygiene), and management practices (milking hygiene, use of milking equipment, frequency of milking, cleaning schedule) substantially influence disease risk and outcome.

For example, a longitudinal study on dairy goats demonstrated that somatic cell count (SCC) — a common proxy for subclinical mastitis — is strongly affected by non-infectious factors such as parity, stage of lactation, season, and milk yield. This variability complicates both the diagnosis and the interpretation of udder health status in goats, making region- and system-specific investigations even more important.

Moreover, management and environmental risk factors are increasingly recognized as key determinants. Poor hygiene, inadequate bedding, overcrowding, and improper milking procedures can facilitate the entry and transmission of pathogens, thereby increasing mastitis incidence. In herds with extensive or traditional management systems — often characterized by minimal biosecurity, shared housing, limited veterinary oversight, and low awareness of udder health — the risk can be particularly high.

In Indonesia, while a growing number of smallholder goat farms are emerging — including in regions such as Banyuwangi — systematic, location-specific studies on goat mastitis remain scarce. A meta-analysis of dairy animal mastitis across Indonesia estimated a pooled prevalence exceeding 50 %, with significant variation by region and species; for goats, the pooled mastitis prevalence was 44.96 % (95 % CI: 28.26–61.66 %), underscoring the urgency of addressing mastitis more seriously in goat production systems (Praja *et al.*, 2023).

Given the combination of a high global and national burden, the multifactorial nature of mastitis, and the diversity of goat production systems — especially in rural, small-scale, or resource-limited settings — there is a compelling need to review and synthesise evidence of risk factors with emphasis on their relevance to local contexts such as Banyuwangi. Such a review can help identify which host, environmental, and management factors are most critical locally, highlight gaps in epidemiological data, and inform targeted intervention strategies (biosecurity, milking hygiene, housing improvement, farmer training).

Therefore, the present review aims to summarise and analyse the current evidence on risk factors associated with goat mastitis, focusing particularly on factors pertinent to smallholder goat production systems. Through this, the paper seeks to provide a foundation for designing context-specific prevention and control strategies — contributing to improved udder health, milk quality, farm sustainability, and public health outcomes in areas like Banyuwangi.

METHODS

A structured literature search was conducted to identify peer-reviewed publications examining mastitis and its associated risk factors in goats, with a particular interest in studies relevant to

Southeast Asia and Indonesia, including regions comparable to Banyuwangi. The search covered articles published within the last ten years (2014–2024) to ensure the review reflected the most current evidence on epidemiology, risk determinants, and management practices associated with caprine mastitis.

Searches were performed across four major scientific databases: PubMed, Scopus, Web of Science, and Google Scholar. Additional region-specific references were identified through the Indonesian national journal portal (SINTA), Universitas Airlangga repositories, and cross-citation tracking from key mastitis publications. Grey literature, such as theses, conference papers, and non–peer-reviewed reports, was excluded unless they provided unique regional insights not available in published articles.

The following combinations of keywords and Boolean operators were used:

- “goat mastitis” OR “caprine mastitis”
- AND “risk factors” OR “determinants” OR “epidemiology”
- AND “Indonesia” OR “Southeast Asia” OR “tropical regions”
- AND “subclinical mastitis” OR “clinical mastitis”
- AND “management practices” OR “milking hygiene” OR “housing conditions”

Search strategies were adapted slightly for each database to optimise retrieval. Filters were applied to restrict results to: (1) studies on goats or mixed small ruminants where goat-specific data were reported, (2) mastitis incidence, prevalence, etiology, or risk factors, and (3) full-text availability in English or Bahasa Indonesia.

Inclusion criteria were established to ensure the relevance and quality of selected literature. Studies were included if they: Reported data on mastitis in goats (clinical, subclinical, or both); Assessed at least one risk factor related to host, environment, pathogens, or management practices; Were observational (cross-sectional, cohort, or case-control), experimental, epidemiological, or review articles; Were published between 2014 and 2024; Provided clear methodology, including diagnostic criteria such as California Mastitis Test (CMT), somatic cell count (SCC), bacterial culture, or molecular identification.

Studies were excluded if they: Lacked primary data (e.g., commentaries, short communications without analysis), Focused solely on cattle, sheep, or other species without goat-specific data, Provided only pharmacological or treatment trials unrelated to risk factors, Lacked methodological clarity or did not specify diagnostic approaches.

All search results were first screened by title and abstract to assess relevance. Full texts of potentially eligible studies were then retrieved for detailed evaluation. For each included study, the following data were extracted: study location and production system (intensive, semi-intensive, extensive), sample size and diagnostic method (CMT, SCC, bacteriology), identified pathogens (e.g., *Staphylococcus aureus*, NAS, *Streptococcus* spp., coliforms), host-related risk factors (parity, age, lactation stage), management-related risk factors (milking hygiene, housing sanitation, equipment use), environmental determinants (bedding type, humidity, temperature), prevalence of clinical or subclinical mastitis, antimicrobial resistance findings (when available).

Due to variability in study designs, diagnostic techniques, and environmental contexts, a meta-analysis

was not attempted. Instead, a narrative synthesis approach was applied, grouping risk factors into thematic categories: Host-related factors, Pathogen-related factors, Management and husbandry practices, Environmental and housing conditions, Contextual and socio-economic determinants.

This structure allowed for a comprehensive evaluation of factors most relevant to goat mastitis in regions such as Banyuwangi, while also highlighting gaps in regional data and areas requiring further epidemiological investigation.

RESULT AND DISCUSSION

Evidence from studies conducted in Banyuwangi indicates that mastitis—particularly in its subclinical form—remains a widespread and under-recognized issue in local goat production systems. Investigations in districts such as Siliragung and Tegaldlimo consistently report moderate to high prevalence levels, with most infections linked to smallholder management conditions. The predominance of subclinical cases highlights the need for more routine screening and greater awareness of udder health among farmers (Table 1-2).

Host-related factors contribute significantly to mastitis susceptibility in Banyuwangi's goat herds. Multiparous and older does exhibit higher infection rates, likely due to prolonged exposure to pathogens and age-associated decline in udder tissue resilience. Local observations also indicate that teat abrasions and mild udder lesions, often resulting from rough hand-milking practices, create additional entry points for bacteria and amplify the risk of intramammary infection.

Pathogen profiles from Banyuwangi consistently identify *Staphylococcus aureus* as the primary etiological agent associated with mastitis, particularly in subclinical cases. The organism's contagious nature aligns closely with typical smallholder practices, which involve shared milking cloths and inconsistent hand hygiene. Compounding this, several studies report antimicrobial-resistant *S. aureus* strains in the region, reflecting the widespread use of over-the-counter antibiotics without proper dosing or veterinary supervision.

Management practices exert a strong influence on mastitis risk at the farm level. Milking hygiene is often inadequate: many farmers do not wash hands before milking, pre- and post-dipping practices are rarely performed, and containers or towels are commonly shared between animals. These routine behaviors facilitate the spread of contagious pathogens and allow infections to persist within herds.

Housing conditions further intensify mastitis risk in Banyuwangi. Goats are typically housed in simple wooden structures with raised floors, which often accumulate manure beneath the slats. Limited drainage, poor ventilation, and infrequent cleaning contribute to continuously contaminated environments. Where bedding is used, it is rarely replaced, allowing bacterial populations to build up in the stalls and surrounding areas.

The environmental conditions of Banyuwangi's humid tropical climate exacerbate sanitation challenges. High temperatures and sustained humidity promote bacterial survival in both housing environments and milking areas. During the rainy season, mud and moisture levels increase around stalls, raising the likelihood of udder contamination and minor teat injuries. Such climatic pressures make mastitis prevention particularly difficult without targeted environmental management strategies.

Table 1. Characteristics of major risk factors for goat mastitis in Banyuwangi, Indonesia

Risk Factor Category	Key Characteristics in Banyuwangi	Examples of Local Evidence/Manifestation
Host-Related Factors	• Higher susceptibility in multiparous does • Age-related loss of teat-end integrity • Udder lesions promote pathogen entry	• Older goats retained for prolonged lactation cycles • Teat abrasions from rough hand-milking • Hyperkeratosis commonly observed in field surveys
Pathogen Factors	• *Staphylococcus aureus* dominant pathogen • Mixed infections occasionally present • Increasing antimicrobial resistance (AMR) patterns	• High prevalence of *S. aureus* in Siliragung • Resistance reported to penicillin, tetracycline, erythromycin • Biofilm-forming strains complicate treatment
Milking & Management Factors	• Hand-milking universal among farmers • Hygiene practices frequently inadequate • Shared towels and irregular equipment sanitation	• Lack of handwashing before milking • No pre-dipping or post-dipping • Buckets rarely disinfected properly
Housing & Environmental Factors	• High humidity and rainfall increase contamination • Wooden raised-floor stalls accumulate manure • Poor drainage and limited ventilation	• Wet bedding and muddy surroundings during rainy season • Persistent bacterial load under slatted floors • Damp barn microclimate year-round
Socio-Economic Factors	• Smallholder systems with limited resources • Low awareness of subclinical mastitis • Inconsistent or unsupervised antibiotic use	• Farmers rely on traditional knowledge • Rarely perform CMT or SCC tests • Incomplete antibiotic treatments common
Farmer Knowledge & Behaviour	• Limited understanding of mastitis prevention • Minimal exposure to formal training • Reactive rather than preventive approach	• Mastitis recognized only when clinical signs appear • Few farmers trained in udder hygiene • Misconceptions about antibiotic withdrawal periods

Socio-economic constraints play a central role in maintaining mastitis as an endemic issue in Banyuwangi's goat sector. Many farmers have limited access to veterinary services and rely heavily on traditional knowledge or informal treatment practices. Economic limitations restrict investment in

improved hygiene materials, diagnostic tools, or structural upgrades to housing. As a result, knowledge gaps regarding mastitis prevention, antimicrobial stewardship, and early detection continue to drive persistent cycles of subclinical infection within the region.

Significance of mastitis as a local production constraint in Banyuwangi

The present review highlights that mastitis—especially in its subclinical form—constitutes a persistent and often under-recognized challenge in goat production systems in Banyuwangi. Although the dairy goat sector in East Java is expanding, mastitis continues to undermine productivity by reducing milk quality, lowering total yield, and contributing to prolonged udder damage. The high proportion of subclinical cases reported in local studies indicates that mastitis frequently goes unnoticed, as many farmers rely solely on visible signs to identify udder problems. In a recent investigation from Siliragung District, *Staphylococcus aureus* was isolated from more than one-quarter of milk samples, and a significant proportion of these isolates displayed antimicrobial resistance (Praja *et al.*, 2023). These findings illustrate that mastitis in Banyuwangi is not only a production disease but also a potential public-health concern due to the circulation of antibiotic-resistant strains.

The relatively high prevalence of mastitis observed in Banyuwangi mirrors patterns reported in other regions of Indonesia where smallholder goat farming is prevalent (Nuraini *et al.*, 2023). Such systems often lack structured udder-health monitoring, and disease surveillance remains highly fragmented. The economic impact of mastitis is further amplified by the fact that dairy goats represent an important income source for households in rural Banyuwangi, where milk is commonly sold fresh or processed locally. Consequently, the persistent burden of mastitis poses a direct threat to household livelihoods and the sustainability of small-scale dairy production. These findings underscore the need for targeted interventions that address the multi-factorial nature of mastitis in this specific geographical and socio-economic setting.

Multifactorial nature of mastitis: integrating host, pathogen, management, and environment

The synthesis of available literature demonstrates that mastitis in Banyuwangi arises from the interplay of host-related factors, pathogenic agents, management practices, and environmental conditions. This aligns with global evidence that mastitis is seldom attributable to a single variable but instead emerges from cumulative risk exposures within the production system (Tibebu, 2025). Understanding how these risk domains interact in the local context is essential for designing effective mastitis control programs.

Host-related factors

Parity and age were consistently associated with mastitis risk in Banyuwangi. Multiparous does are more susceptible to infection due to cumulative exposure to pathogens and age-related deterioration of teat sphincter and udder tissue integrity. Similar trends have been reported globally, where goats in later lactations show higher rates of intramammary infection (Kebede *et al.*, 2019). Local observations from Banyuwangi mirror these trends, as farmers often retain older does for prolonged lactation cycles, inadvertently increasing herd-level susceptibility.

Udder morphology and teat lesions represent additional host-level risk

Table 2. Comparison of goat mastitis characteristics in Banyuwangi vs. Other Indonesian Regions

Parameter	**Banyuwangi (East Java)**	**Other Indonesian Regions (Sumatra, Central Java, West Java, Sulawesi, Bali)**
Dominant Production System	Smallholder, hand-milking, semi-intensive	Predominantly smallholder; some semi-intensive and intensive systems in West Java and Bali
Prevalence of Mastitis	Moderate to high subclinical prevalence; isolated studies report >25% *S. aureus* positivity	Highly variable; national pooled subclinical prevalence 45% (Nuraini *et al.*, 2023); some West Java farms exceed 55%
Most Common Pathogens	*Staphylococcus aureus* (dominant), NAS, occasional *Streptococcus* spp.	Similar pattern: *S. aureus* and NAS prevalent nationwide; environmental coliforms more common in wetter regions (e.g., West Sumatra)
Antimicrobial Resistance (AMR)	High levels of AMR in *S. aureus* isolates, including resistance to penicillin, tetracycline, erythromycin (Praja *et al.*, 2023)	AMR also reported in West Java and Bali; coliforms increasingly resistant in Sumatra; misuse of antibiotics widespread in smallholder systems
Milking Practices	Hand-milking without consistent hygiene; shared cloths; minimal pre-/post-dipping	Similar in many regions; however, intensive farms in West Java and Bali more likely to use better hygiene protocols
Housing Practices	Wooden raised-floor stalls; poor drainage; high humidity; manure accumulation under slatted floors	Varies: slatted wooden barns common in Java; bamboo barns in Sulawesi; cement floors more common in Bali and West Java large farms
Environmental Risk Factors	High humidity and rainfall drive bacterial growth; muddy surroundings in rainy season	West Java and Sumatra: even higher humidity; Bali: moderate humidity; Sulawesi: seasonal variation; East Nusa Tenggara: drier and lower environmental risk
Farmer Knowledge & Training	Generally low awareness of subclinical mastitis; limited training availability	Similarly low in rural Sumatra and Sulawesi; slightly higher training access in West Java and Bali dairy cooperatives
Use of Diagnostics (CMT/SCC)	Rare; most farmers diagnose clinical signs only	Varies: CMT more common in West Java dairy cooperatives; rare in rural Sumatra and Eastern Indonesia

Parameter	Banyuwangi (East Java)	Other Indonesian Regions (Sumatra, Central Java, West Java, Sulawesi, Bali)
Antibiotic Use Behavior	Frequent self-medication; incomplete treatment; no withdrawal awareness	Comparable misuse patterns nationwide; stricter control only in areas with active dairy cooperatives (e.g., Bandung)
Economic and Structural Barriers	Limited resources hinder adoption of hygiene improvements and barn upgrades	Similar in other rural provinces; higher-income regions (e.g., Bali) adopt improvements more easily
Overall Mastitis Risk Profile	High risk driven by combined pathogen, hygiene, and humidity pressures	High in most provinces; particularly elevated in humid, smallholder-dominated regions across Indonesia

factors. Rough hand-milking techniques, common among smallholder farmers, frequently cause minor abrasions and keratin damage at the teat end. This compromises the natural keratin plug defence mechanism, facilitating bacterial entry. Hyperkeratosis and teat-end injury have been linked with higher mastitis risk in goats and sheep worldwide (Contreras *et al.*, 2020). In Banyuwangi, where hand-milking is universal and milking technique varies widely, such anatomical injuries are likely to contribute significantly to subclinical mastitis prevalence.

Pathogen-related factors and antimicrobial resistance

The predominance of *Staphylococcus aureus* in Banyuwangi is consistent across local studies and reflects its well-documented role as the principal cause of contagious mastitis in small ruminants (Sharun *et al.*, 2021). The organism's ability to persist within mammary tissue, form biofilms, and spread easily between animals during milking makes it particularly challenging to eradicate. The local findings that *S. aureus* isolates exhibit resistance to multiple antimicrobial classes—including penicillin, tetracyclines, and macrolides—raise serious concerns (Praja *et al.*, 2023).

Antimicrobial resistance (AMR) in mastitis pathogens is strongly associated with unsupervised antimicrobial use, incomplete treatment regimens, and lack of withdrawal-period awareness (Abebe *et al.*, 2021). All these factors are present in Banyuwangi's smallholder systems, where farmers often purchase antibiotics over-the-counter without veterinary guidance. This situation not only leads to treatment failure and chronic infections but also risks amplifying resistant strains in the broader livestock–environment interface. Given that raw goat milk is occasionally consumed or processed informally, the presence of AMR strains also carries implications for food safety.

Management and milking practices

Management practices emerged as the strongest and most modifiable determinants of mastitis risk in Banyuwangi. Poor milking hygiene—particularly the absence of handwashing, use of shared towels across goats, and lack of pre- and post-dipping—provides ideal conditions for

the spread of contagious pathogens. Similar associations between inadequate milking hygiene and mastitis prevalence have been highlighted in studies from Ethiopia, India, and Malaysia (Sori *et al.*, 2020; Singh *et al.*, 2018). However, the challenge is particularly acute in Banyuwangi due to entrenched traditional practices and limited access to hygiene supplies.

Milking equipment is another contributing factor. Buckets, cloth filters, and containers are often inadequately washed or disinfected, enabling bacterial build-up. Many farmers also practice irregular milking schedules or use forceful milking techniques, which increase teat-end damage and predispose goats to mastitis. The lack of standardised procedures or training in milking technique further exacerbates the situation.

Environmental and climatic factors

Environmental conditions in Banyuwangi, characterised by high humidity and significant annual rainfall, amplify mastitis risk by promoting bacterial proliferation in housing and surrounding areas. Poorly ventilated stalls with slatted wooden floors commonly accumulate manure and urine beneath the housing structure, sustaining high pathogen loads. Similar environmental associations have been reported in tropical regions where humid microclimates within animal housing support pathogen survival (Lobago *et al.*, 2018).

During the rainy season, stalls become wetter, bedding becomes muddy or damp, and udder contamination increases. High humidity also softens teat skin, making it more vulnerable to abrasions. These environmental pressures contribute to recurrent infection cycles and complicate long-term mastitis control. Improving housing design, drainage, and bedding management is therefore critical, yet often economically challenging for smallholders.

Socio-economic constraints and farmer knowledge gaps

Socio-economic realities are central to understanding mastitis persistence in Banyuwangi. Most goat farmers operate at a small scale, typically managing fewer than 10 animals and relying on livestock as supplemental rather than primary income. Such conditions limit their capacity to invest in improved hygiene tools, better housing, or veterinary consultations. As a consequence, mastitis is often managed reactively rather than preventively.

Knowledge gaps among farmers significantly influence mastitis dynamics. Many farmers are unfamiliar with subclinical mastitis or the role of somatic cell count (SCC) or California Mastitis Test (CMT) as diagnostic tools. Local studies have documented that mastitis is commonly recognised only when clinical signs—such as udder swelling or visible milk clots—occur (Fatmawati, 2023). This reactive minds*et al*lows subclinical infections to persist untreated, increasing the risk of chronic udder damage and ongoing transmission.

Cultural norms also shape antibiotic usage patterns. Antibiotics are often used without clear indications, incorrect dosages, or incomplete regimens. There is little awareness of withdrawal periods or AMR consequences, and farmers rarely receive professional guidance from veterinarians. This practice aligns with AMR emergence documented in Banyuwangi (Praja *et al.*, 2023) and mirrors patterns observed in other low-resource smallholder systems worldwide (Tessema *et al.*, 2019).

Implications for control strategies in Banyuwangi

The findings from Banyuwangi underscore the need for targeted, context-appropriate mastitis control strategies that acknowledge both biological and socio-economic realities. Interventions that are effective in intensive dairy systems may not be feasible or sustainable in resource-limited settings. Instead, approaches tailored to the capacities of smallholder farmers should be prioritised.

Strengthening farmer education is a crucial first step. Training on proper handwashing, udder preparation, post-milking teat hygiene, and equipment sanitation can significantly reduce pathogen transmission. Introducing low-cost hygiene measures, such as individual cloth towels per goat or homemade disinfectant solutions, could provide substantial improvements without imposing financial strain.

Environmental management must also be addressed. Simple modifications—such as improving stall ventilation, adding drainage paths, and regularly removing manure—could reduce contamination pressure. Seasonal adaptations may be necessary during the rainy season, such as adding temporary bedding or relocating goats to drier structures.

Routine screening for subclinical mastitis through CMT could greatly enhance early detection. Although SCC testing may be costly or inaccessible, CMT is inexpensive and suitable for on-farm use. Establishing local extension programs to train farmers on CMT use would enable timely interventions and reduce the progression to chronic mastitis.

Another critical component is improving antibiotic stewardship. Farmers need guidance on appropriate antimicrobial selection, dosage, and treatment duration, ideally based on culture and sensitivity testing when feasible. Local veterinary authorities should promote responsible antibiotic use while restricting indiscriminate over-the-counter sales.

Collectively, these interventions could substantially reduce mastitis prevalence if adopted consistently. However, long-term success will require coordinated efforts involving farmers, veterinarians, extension workers, local government, and academic institutions.

CONCLUSION

Overall, this review demonstrates that mastitis in Banyuwangi is the result of intertwined biological, environmental, and socio-economic factors. The disease persists due to inadequate milking hygiene, poor environmental sanitation, pathogen transmission facilitated by traditional practices, and limited knowledge among farmers. The presence of antimicrobial-resistant *S. aureus* strains further complicates management and underscores the urgency of implementing effective control measures.

Given the importance of dairy goats for rural livelihoods, tackling mastitis in Banyuwangi must be prioritised as part of broader livestock development strategies. Through context-appropriate interventions, improved farmer training, and strengthened surveillance, it is possible to reduce mastitis prevalence, improve milk quality, and enhance the sustainability of the goat dairy sector in this region.

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Author Contribution

All authors participated to all aspects of this work, including

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Competing Interest

None.

Ethical Approval

Not applicable

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