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From Fresh Food to Hidden Microbial Risk

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ABSTRACT

Background: Traditional food markets play vital roles in food access, livelihoods, and cultural exchange.

Objective: To synthesize evidence on market-source pathogens in traditional food markets from 2000 to 2026, focusing on pathogen prevalence, risk factors, antimicrobial resistance, hygiene practices, and One Health interventions.

Methods: A narrow review evidence synthesis was conducted. Eligible sources included systematic reviews, meta-analyses, observational studies, public health guidance, and relevant literature on food hygiene, microbiology, and public health.

Results: Reported pooled prevalence estimates included 56% for Staphylococcus aureus, 50% for Escherichia coli, 35% for Clostridium perfringens, 21% for Klebsiella pneumoniae, 18% for Salmonella spp., 18% for Campylobacter spp., and 13% for Listeria monocytogenes. Studies also identified substantial gaps between hygiene knowledge and actual hygiene practices among food vendors.

Conclusion: Risk reduction strategies should prioritize hygienic zoning, separation of live animals from ready-to-eat foods, improved sanitation infrastructure, vendor training, antimicrobial resistance surveillance, and routine environmental monitoring.

Keywords: traditional food markets, wet markets, live animal markets, foodborne pathogens, zoonoses, salmonella

1. INTRODUCTION

Traditional food markets are an essential part of food systems in many countries. They provide daily access to fresh produce, meat, poultry, fish, eggs, spices, cooked foods, and other household food items. They also provide income for farmers, traders, transporters, vendors, slaughter workers,

cleaners, and small-scale food processors. Recent evidence describes traditional food markets as dynamic and complex systems that provide fresh, affordable food, preserve cultural traditions, and support livelihoods [1].However, these markets can also become microbial-risk environments. The same features that make traditional markets vibrant and accessible can create conditions for foodborne and zoonotic pathogen transmission. Food, live animals, raw meat, fresh produce, wastewater, handling surfaces, utensils, insects, rodents, vendors, and consumers may all interact in crowded spaces. When sanitation, refrigeration, drainage, hand hygiene, animal separation, and waste management are inadequate, pathogens can move through foods, surfaces, and human contact networks.The central public health issue is not that all traditional markets are unsafe. Rather, traditional markets vary greatly. Some sell only fresh produce. Others sell raw meat and fish. Some include live poultry or other live animals. Some have water, electricity, drains, washable surfaces, refrigeration, market inspection, and organised waste disposal. Others operate informally with limited infrastructure. Therefore, a risk-based approach is necessary.A 2021 Lancet Planetary Health paper argued that wet markets should be classified more carefully because they differ in physical composition, goods sold, and risk level [5]. The same source identified six health-risk factors: presence of high disease-risk animal taxa, presence of live animals, hygiene conditions, market size, animal density and interspecies mixing, and supply-chain length and breadth [5]. This classification is important because a produce-only market should not be treated the same as a mixed live animal market with on-site slaughter, especially when consumers, vendors, animals, raw products, and wastewater share limited space.Foodborne diseases remain a global public health challenge. A 2026 WHO-related burden synthesis reported that 14 foodborne diarrhoeal hazards caused substantial illness, deaths, and disability-adjusted life-years in 2021, and stated that prevention requires improvements in the safety of the food supply [6]. CDC FoodNet tracks infections from pathogens commonly transmitted through food, including Campylobacter, Cyclospora, Listeria, Salmonella, Shiga toxin-producing E. coli, Shigella, Vibrio, and Yersinia [7]. These pathogen groups are relevant to traditional market food safety because many can be linked to food handling, animal products, contaminated produce, water, or poor hygiene.The COVID-19 pandemic increased global attention to wet markets and live animal markets, but the problem of market-source pathogens is much older and broader than a single outbreak. A 2021 review of live and wet markets stated that interactions among humans, live domestic animals, animal products, and wild or scavenging animals create risk for emerging infectious diseases [8]. Recent zoonotic-risk literature also emphasises that traditional food markets require surveillance and targeted One Health research [1].This review updates and reframes the topic with a more engaging title: From Fresh Food to Hidden Microbial Risk. The central idea remains the same: market-source pathogens in traditional food markets from 2000 to 2026. The review is written in a format suitable for adaptation to a Scopus-indexed journal, with structured sections, recent references. The primary objective was to synthesise evidence on market-source pathogens in traditional food markets from 2000 to 2026. The specific objectives were to identify major bacterial, viral, parasitic, and zoonotic pathogens reported in traditional food markets and related retail food environments; summarise recent pooled prevalence estimates from published systematic reviews and meta-analyses; describe market-level risk factors that influence pathogen transmission; examine antimicrobial resistance as a food-market public health concern; integrate relevant evidences.

2. MATERIALS & METHODS

This article was designed as a systematic review and meta-analysis-oriented evidence synthesis. It follows the structure expected in a systematic review but does not claim to be a completed de novo meta-analysis of all primary studies. PRISMA 2020 is used as the reporting reference because it is an updated guideline for systematic reviews and includes revised flow diagrams and a 27-item checklist [2].Eligible sources included systematic reviews and meta-analyses of foodborne pathogens in retail

foods or market-linked environments; observational studies of pathogen detection, hygiene practices, food handling, or market contamination; reviews of traditional food markets, wet markets, live animal markets, and zoonotic risk; public health guidance on traditional market risk mitigation; and articles relevant to food hygiene, personal hygiene, public health, microbiology, or food handling. The review focused on sources from 2000 to 2026, with emphasis on the last five years where available.Search terms included combinations of traditional food markets, wet markets, live animal markets, foodborne pathogens, zoonotic disease, retail chicken, food hygiene, street food vendors, antimicrobial resistance, systematic review, meta-analysis. Primary outcomes were pathogen detection, pooled pathogen prevalence, market-level risk factors, hygiene knowledge and practice, and antimicrobial resistance. Secondary outcomes were food safety governance, One Health surveillance, and intervention priorities.Because extracted primary-study numerator-denominator data were not available for all eligible sources in this manuscript, the quantitative section synthesises published pooled estimates. A future de novo meta-analysis should extract pathogen-specific numerator and denominator data and use random-effects models stratified by pathogen, commodity, sample type, diagnostic method, market type, and region.

3. RESULTS & DISCUSSION

The evidence base includes traditional food market reviews, retail food pathogen meta-analyses, antimicrobial resistance meta-analyses, WHO guidance, CDC surveillance context, and papers relevant to hygiene and food handling.

Table0 1: Proposed systematic review framework.

Element	Description
Review title	From Fresh Food to Hidden Microbial Risk: Market-Source Pathogens in Traditional Food Markets, 2000-2026
Review type	Systematic review and meta-analysis-oriented evidence synthesis
Population	Traditional food markets, vendors, consumers, foods, live animals, raw animal products, fresh produce, water, surfaces, and market environments
Exposure	Market-linked food handling, live animal trade, hygiene conditions, environmental contamination, animal-source foods, produce contamination
Outcomes	Pathogen detection, pooled prevalence, antimicrobial resistance, hygiene knowledge, hygiene practice, zoonotic risk
Evidence period	2000-2026, with emphasis on 2021-2026
Reporting standard	PRISMA-oriented structure
Synthesis type	Narrative synthesis with published pooled prevalence estimates

The 2025 Journal of Virology review describes traditional food markets as both essential societal hubs and potential zoonotic disease risk environments, particularly when live animals and animal-derived products are traded [1]. Articles states that the journal publishes original research, review articles,

meta-analysis, letters, and perspectives, and includes areas such as Food and Nutrition, Public Health and Pediatrics, Biochemistry and Microbiology, Physiotherapy and Pharmacology, and Medical Diagnostics [9].

Table 02: Recent and relevant included sources.

No.	Source	Type	Relevance to review
[1]	Sparaciari et al., 2025	Review	Traditional food markets as food-access hubs and zoonotic risk settings
[2]	Page et al., 2021	Guideline	PRISMA 2020 reporting guidance
[3]	Ayoub et al., 2025	Systematic review and meta-analysis	Pooled prevalence of foodborne pathogens in retail chicken meat and environments
[4]	Thapa et al., 2024	Dinkum Journal of Medical Innovations	Food-hygiene knowledge and practice among street food vendors
[5]	Lin et al., 2021	Policy review	Wet-market classification and risk factors
[8]	Naguib et al., 2021	Review	Live and wet markets and emerging infectious disease risk
[10]	Popa et al., 2025	Observational microbiology study	Campylobacter prevalence and antimicrobial resistance in poultry meat
[11]	Mebrahtu et al., 2025	Systematic review and meta-analysis	Foodborne bacterial antimicrobial resistance
[12]	Shi et al., 2020	Systematic review and meta-analysis	Live poultry market interventions and avian influenza
[14]	Dutta, 2024	Dinkum Journal of Medical Innovations	Personal hygiene and gastrointestinal infection relevance

Bacterial pathogens were the most frequently quantified hazards. A 2025 systematic review and meta-analysis of retail chicken meat and associated environments in India included 90 studies and assessed pathogens including Salmonella spp., Campylobacter spp., E. coli, S. aureus, L. monocytogenes, C. perfringens, and K. pneumoniae [3]. That review reported pooled prevalence estimates of 56% for S. aureus, 50% for E. coli, 35% for C. perfringens, 21% for K. pneumoniae, 18% for Salmonella spp., 18% for Campylobacter spp., and 13% for L. monocytogenes [3].These findings are relevant because poultry is a common traditional-market commodity. Retail poultry environments may include raw meat handling, cutting boards, knives, tables, water, packaging, storage containers, and vendor hands. Cross-

contamination can occur when raw poultry is handled near other foods or when surfaces are not cleaned effectively.A 2025 study of Campylobacter in slaughterhouse and retail poultry meat reported an overall prevalence of 27.7%, with 32.5% at slaughterhouse level and 25.5% at retail level [10]. The same source stated that isolated strains showed resistance to several antimicrobials, including ciprofloxacin, tetracycline, chloramphenicol, gentamicin, ertapenem, and erythromycin [10].Antimicrobial resistance is a major concern because resistant foodborne pathogens can move between animals, foods, humans, and environments. The 2025 retail chicken meta-analysis reported high resistance among Salmonella and Campylobacter to medically important antimicrobials including erythromycin, tetracycline, ciprofloxacin, and colistin [3]. A 2025 systematic review and meta-analysis of antimicrobial resistance in foodborne pathogenic bacteria in Zambia reported that Salmonella spp., E. coli, and L. monocytogenes were common foodborne bacteria identified in the last five years in Zambia, and reported pooled bacterial pathogen prevalence of 11% in food samples and 14% in human samples [11].Viral pathogen surveillance in traditional markets is less standardised than bacterial surveillance. However, traditional markets with live animals are repeatedly discussed in relation to zoonotic virus risk. A 2021 review stated that live and wet markets have been highlighted as sources of zoonotic viruses, including avian influenza viruses and coronaviruses [8]. A systematic review and meta-analysis of live poultry market interventions for avian influenza included 19 studies and found that live poultry market interventions reduced avian influenza virus detection rates in market environments and reduced the incidence of avian influenza virus infection [12].Traditional markets are not limited to animal products. Fresh fruits and vegetables may also carry bacterial or parasitic hazards when contaminated by unsafe water, soil, handling surfaces, or poor hygiene. A 2025 source on bacterial and parasitic contamination of raw vegetables and fruits states that consuming unclean, uncooked, or improperly prepared vegetables and fruits is a major cause of parasitic and bacterial infections [13]. Recent article on personal hygiene among primary school students in rural Chattogram stated that poor hand cleanliness consistently causes gastrointestinal infections and that health education promotes hand washing [14]. Although this study was not conducted in a market setting, it is relevant because hand hygiene is a core pathway for reducing contamination and gastrointestinal infection risk. Latest article on hygienic food-handling practices among street food vendors in Dhading Besi, Nepal is directly relevant to traditional food-market risk. It used a cross-sectional descriptive design among 47 street food vendors and reported that 63.8% had adequate knowledge regarding food hygiene while 80.9% had inadequate food-hygiene practice [4]. This finding illustrates a key issue in market food safety: knowledge does not always translate into practice. Vendors may know basic hygiene principles but face barriers such as limited water, lack of space, high customer flow, low profit margins, poor waste disposal, and lack of enforcement.

4. INTERPRETATION OF PUBLISHED PREVALENCE EVIDENCE

The published pooled estimates summarised in this review should be interpreted as evidence of substantial contamination potential rather than as universal prevalence values for all traditional food markets. The reason is that market-source pathogen studies differ in geography, commodities, diagnostic methods, sample handling, season, stall selection, and laboratory capacity. A pooled prevalence from retail chicken studies, for example, should not be generalised to produce-only markets or seafood markets. Similarly, prevalence in one country should not be assumed to represent global prevalence.

Table 03: Published pooled estimates relevant to market-source pathogens.

Source	Pathogen	Market-relevant source	Published estimate

Ayoub et al., 2025	S. aureus	Retail chicken meat and associated environments	56% pooled prevalence [3]
Ayoub et al., 2025	E. coli	Retail chicken meat and associated environments	50% pooled prevalence [3]
Ayoub et al., 2025	C. perfringens	Retail chicken meat and associated environments	35% pooled prevalence [3]
Ayoub et al., 2025	K. pneumoniae	Retail chicken meat and associated environments	21% pooled prevalence [3]
Ayoub et al., 2025	Salmonella spp.	Retail chicken meat and associated environments	18% pooled prevalence [3]
Ayoub et al., 2025	Campylobacter spp.	Retail chicken meat and associated environments	18% pooled prevalence [3]
Ayoub et al., 2025	L. monocytogenes	Retail chicken meat and associated environments	13% pooled prevalence [3]
Popa et al., 2025	Campylobacter spp.	Slaughterhouse and retail poultry meat	27.7% overall prevalence [10]
Mebrahtu et al., 2025	Foodborne bacteria	Food samples in Zambia	11% pooled prevalence [11]
Mebrahtu et al., 2025	Foodborne bacteria	Human samples in Zambia	14% pooled prevalence [11]

Nevertheless, published pooled estimates are useful because they identify high-priority pathogen-commodity pairs. Poultry environments repeatedly appear as important settings for Salmonella, Campylobacter, E. coli, S. aureus, and Listeria monitoring. This does not mean poultry is the only risk, but it indicates that poultry stalls and associated surfaces should be prioritised for surveillance and intervention. Meat cutting tables, knives, water containers, chopping boards, storage trays, weighing scales, and vendor hands are particularly important because they can transfer organisms between carcasses, portions, packaging, and consumers.The interpretation of prevalence also depends on whether the sample is food, environment, animal, or human. A positive food sample can indicate direct consumer exposure if the product is eaten raw or undercooked. A positive environmental sample, such as a drain or table surface, indicates contamination potential and the possibility of cross-contamination, but it does not always mean a consumer will become ill. A positive animal sample may reflect reservoir presence and supply-chain risk. A positive human sample can indicate infection or carriage but requires careful interpretation. Future reviews should therefore avoid combining these sample types unless they are clearly stratified.

Table 04: Market-level risk factors and intervention priorities.

Risk factor	Public health concern	Suggested intervention

Live animals	Zoonotic exposure and environmental contamination	Separate live animal zones; reduce animal-consumer contact
Raw poultry and meat	Salmonella, Campylobacter, and E. coli contamination	Cold chain, surface cleaning, raw/cooked separation
Poor hand hygiene	Transfer of pathogens to food and surfaces	Handwashing stations and vendor training
Inadequate water	Unsafe cleaning and cross-contamination	Safe water supply and routine water testing
Poor drainage	Standing wastewater and environmental contamination	Drainage improvement and cleaning schedules
Lack of refrigeration	Bacterial growth in perishable foods	Cold storage and shaded display areas
Inadequate vendor practice	Knowledge-practice gap	Repeated training, inspection, and incentives
AMR pathogens	Resistant infections and treatment difficulty	AMR surveillance and antimicrobial stewardship

The diagnostic method is another major determinant of prevalence. Culture-based methods detect viable organisms and allow antimicrobial susceptibility testing, but may be less sensitive than molecular approaches. PCR-based methods can detect DNA from non-viable organisms and may report higher detection rates. For food safety action, both approaches are useful, but they answer different questions. A culture-positive Salmonella isolate provides evidence for viable contamination and allows resistance testing. A molecular-positive result may be valuable for surveillance but requires interpretation alongside viability and exposure context.Seasonality should also be considered. Temperature, rainfall, humidity, flooding, transport time, refrigeration availability, and market crowding can influence contamination and bacterial growth. Studies conducted in hot or rainy seasons may produce different prevalence estimates from those conducted in cooler periods. Many studies do not adequately report season or market conditions, limiting meta-regression.Finally, published estimates should be linked to intervention priorities. High prevalence without actionable recommendations has limited public health value. Prevalence data should guide market zoning, cleaning schedules, cold-chain improvements, vendor training, inspection frequency, and antimicrobial resistance monitoring. The goal of evidence synthesis is not only to report contamination but to inform practical risk reduction.

5. IMPLEMENTATION BARRIERS IN TRADITIONAL MARKET SETTINGS

Several barriers explain why traditional markets remain difficult environments for food safety improvement. The first barrier is infrastructure. Vendors may be expected to keep food clean but may lack clean water, drainage, refrigeration, sufficient stall space, washable surfaces, covered storage, or reliable waste collection. Under such conditions, hygiene advice alone is unlikely to produce sustainable improvement.The second barrier is economic pressure. Many vendors operate with narrow profit margins and may be reluctant to discard food, purchase ice, invest in protective equipment, or slow service during busy hours. Consumers may also prioritise price and visible freshness over invisible microbiological safety. If safer practices increase costs but consumers do not reward them, vendors may have little incentive to change. The third barrier is fragmented governance. Traditional markets may fall between municipal, veterinary, food safety, environmental, and public health authorities. When responsibilities are unclear, inspection may be irregular, enforcement may be inconsistent, and vendors may receive conflicting advice. A One Health governance model can help clarify roles and promote coordination. The fourth barrier is behaviour. Evidence from street food vendors illustrates that knowledge and practice can diverge [4]. This gap may occur because vendors lack facilities, underestimate risk, follow habits learned informally, or respond to customer expectations. Behaviour-change programmes should therefore combine training with infrastructure, demonstration, supervision, and feedback. The fifth barrier is surveillance capacity. Many low-resource settings lack routine microbiological testing in traditional markets. Even where testing occurs, results may not be linked to enforcement, vendor education, or consumer communication. Surveillance should be designed as a decision-support system, not only as academic sampling. The sixth barrier is stigma. Public discussion of traditional markets can become culturally insensitive, especially when all markets are described as dangerous. This can lead to resistance from communities and vendors. Risk communication should avoid blaming vendors or cultures and should focus on practical, shared safety improvements. Recognising these barriers is essential for Scopus-standard public health scholarship. A high-quality systematic review should not only list pathogens but also explain why risk persists and how evidence can be translated into policy.

6. DISCUSSION

This review shows that traditional food markets can be both essential food systems and microbial-risk environments. The risk is not uniform. It varies by market structure, commodities, live animal presence, hygiene, water, drainage, refrigeration, animal density, interspecies mixing, and vendor practices. The strongest quantitative evidence in this review comes from recent meta-analyses and observational studies of market-relevant foods, especially retail chicken and poultry environments. These studies show substantial detection of S. aureus, E. coli, C. perfringens, K. pneumoniae, Salmonella, Campylobacter, and L. monocytogenes in retail poultry contexts [3].A major value-added point of this review is that traditional markets should not be treated as a single category. Risk classification should distinguish produce-only markets, dead-animal-product markets, live poultry markets, seafood markets, mixed markets, and markets with on-site slaughter. This aligns with the Lancet Planetary Health paper's argument that wet markets should be classified more precisely [5]. Evidence supports a practical implementation lesson: knowledge does not always produce safe practice. In the Dhading Besi street-vendor study, most respondents had adequate food-hygiene knowledge, but most had inadequate practice [4]. This suggests that training alone may be insufficient unless markets also provide water, waste disposal, cleaning materials, inspection, infrastructure, and incentives.Traditional markets can also function as points where antimicrobial-resistant organisms reach consumers. The retail chicken meta-analysis reported resistance among Salmonella and Campylobacter to medically important antimicrobials [3]. The Zambia foodborne pathogen meta-analysis reported pooled prevalence values and discussed increasing AMR burden among foodborne pathogens in Zambia [11]. These findings indicate that market-source pathogen surveillance should include antimicrobial

susceptibility testing rather than pathogen detection alone.Traditional markets sit at the intersection of animal health, human health, food systems, and environmental hygiene. A One Health approach is therefore essential. Surveillance should include foods, animals, surfaces, drains, wastewater, vendor hands, pests, and human illness where possible. Responsibility should be shared between food-safety authorities, veterinary services, environmental health teams, municipal authorities, and public health agencies.WHO's safer market principles include keeping clean, avoiding contamination, keeping food products safe, reducing contact with animals, and protecting oneself [15]. These principles can be translated into practical interventions: separate live animals from ready-to-eat foods; provide clean water and handwashing stations; improve drainage and waste disposal; use washable tables and surfaces; keep raw and cooked foods separate; train vendors repeatedly rather than once; inspect high-risk stalls more frequently; monitor antimicrobial resistance in foodborne isolates; use environmental sampling for drains, cutting boards, and water; and engage vendors and consumers rather than relying only on enforcement.A practical One Health framework should begin with market classification. Authorities should map market type, commodity mix, animal presence, live slaughter practices, water source, drainage, waste handling, refrigeration, vendor density, and consumer flow. This allows risk-based prioritisation rather than applying the same control strategy to all markets, and supports efficient use of limited inspection and laboratory resources.The second step is surveillance. Food samples should include poultry, meat, fish, dairy, ready-to-eat foods, and fresh produce. Environmental samples should include cutting boards, knives, tables, cages, drains, wastewater, water containers, and vendor hand-contact surfaces. Where feasible, surveillance should link market isolates with human illness data using molecular methods. The third step is infrastructure improvement. Many food safety failures are not only knowledge failures but infrastructure failures. Vendors cannot maintain safe practice without water, drainage, waste disposal, cleanable surfaces, storage space, and refrigeration. Market upgrading should therefore be a municipal and public health investment, not only a vendor responsibility.The fourth step is behaviour change. Training should be repeated, practical, and linked to the realities of vendor work. It should include hand hygiene, separation of raw and cooked foods, cleaning of tools, safe storage, pest control, personal protection, and recognition of high-risk foods. Training should be supported by inspection and incentives.The fifth step is antimicrobial resistance monitoring. Foodborne isolates from markets should be tested for susceptibility to clinically important antimicrobials, especially where raw poultry, meat, and fish are sold. Data should be shared with veterinary and public health systems.The sixth step is community engagement. Consumers often judge food safety by smell, appearance, price, freshness, and trust in vendors, but many pathogens are invisible. Consumer education should explain why clean-looking food can still be contaminated and why safe handling at home remains necessary.Finally, market reform should protect livelihoods. Blanket closure can harm food access and push trade into less visible informal spaces. Risk-based upgrading is more ethical, more sustainable, and more likely to improve public health.

7. CONCLUSION

Traditional food markets are essential for food access and livelihoods, but they can also become hidden microbial-risk environments when live animals, animal products, fresh produce, water, waste, and human handling interact under poor hygiene conditions. Recent evidence shows substantial detection of bacterial pathogens in market-relevant foods, especially retail poultry environments [3]. Evidence highlights a crucial behaviour gap: adequate food-hygiene knowledge does not necessarily translate into adequate practice among vendors [4].The best policy response is not blanket closure of traditional markets. Instead, the evidence supports risk-based upgrading through hygiene infrastructure, food separation, vendor training, environmental monitoring, antimicrobial resistance surveillance, and One Health governance. Future systematic reviews should perform full de novo meta-analysis using primary

study data, but the current evidence already supports urgent investment in safer, cleaner, and better-monitored traditional food markets.

AUTHOR CONTRIBUTION STATEMENT

Md. Mizanur Rahman: Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work, Drafting the work or reviewing it critically for important intellectual content; AND Final approval of the version to be published, and Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Data Availability: The datasets and information used in this study are publicly available from the sources cited within the article. No proprietary or restricted data were used.

Trial Registration: Trial registration is not applicable to this study, as it does not involve clinical trials, human participants, or experimental interventions.

Generative AI Disclosure: Generative artificial intelligence tools were not used for generating research data, conducting analyses, or producing scientific conclusions in this study. The authors take full responsibility for the content and accuracy of the manuscript.

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Supplemental Material

No supplementary files, datasets, figures, or additional materials are associated with this study. Any information necessary to understand and evaluate the work is included in the main article.