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Research Article

Socio-Ecological Integrity of Community-Based Conservation of the Ganges River Dolphin (*Platanista gangetica gangetica*) in the Koshi River System, Nepal

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Background: The Ganges River dolphin (*Platanista gangetica gangetica*), an endangered freshwater cetacean, is recognized as a sentinel species for evaluating the ecological integrity of South Asian River systems. Its persistence reflects the condition of aquatic habitats, positioning it as a vital bioindicator for conservation planning. In Nepal, the Koshi River is one of six major river systems having particular importance as it supports the traditional Malaha community, whose livelihoods depend on fishing. The Malaha's cultural identity, oral traditions, and social practices remain closely linked to riverine resources, with dolphins symbolizing prosperity, ecological balance, and harmony between nature and society.

Methods: Between June 2022 and April 2024, dolphin abundance, socio-ecological linkages, and anthropogenic stressors were examined using systematic sighting surveys, stakeholder interviews, field observations, participatory threat mapping, and key informant interview.

Results: A localized population of 19–20 dolphins were recorded in 2024 near the Koshi Barrage, displaying cooperative foraging behavior that indirectly benefits local fishers. However, fish biomass has declined by nearly 75% over two decades due to overfishing, toxic catch practices, and cross-border barriers restricting migratory pathways. Additional pressures include agricultural runoff, domestic effluents, barrage operations, vehicular vibrations, and seasonal low flows that fragment habitats. Despite these threats, cultural reverence for dolphins and the Malaha community's traditional ecological knowledge provides crucial opportunities for inclusive stewardship.

Conclusion: Inclusive stewardship combining scientific monitoring, traditional knowledge, and regional cooperation is essential to safeguard Koshi River dolphins, restore fish biomass, and sustain Malaha livelihoods while preserving cultural and ecological integrity.

Keywords: *Ganges river dolphin, Koshi River, community-based conservation, ethno-ecological knowledge, freshwater biodiversity, threats assessment*

Introduction

The Ganges River Dolphin (*Platanista gangetica gangetica*), locally known as Sons or Susu, is now confined to the Ganga–Brahmaputra–Meghna River basins of India, Nepal, and Bangladesh (Labh, 2023). In Nepal, they are found in the Karnali River system, including the Mohana and Geruwa branches. They also live in the Bhada, Narayani, and Saptakoshi rivers.

The Saptakoshi system, especially within the Koshi Tappu Wildlife Reserve, supports a small but regularly monitored group (Paudel et al., 2015; Labh, 2023; DNPWC, 2021; Koshi Tappu Wildlife Reserve, 2024–2025). The Koshi River serves as one of the last ecological refuges for the species in Nepal and forms a vital transboundary link between the reserve and the lower Ganges region in India (Das et al., 2025; Shah et al., 2020; Khatun et al., 2024). Fewer than 52 individuals are estimated to remain in Nepal, with numbers steadily declining. The most recent and reliable population data come from the 2016 national dolphin census, as cited in Labh (2023). The main factors driving this decline include deteriorating water quality, habitat fragmentation, and overexploitation of aquatic resources (Braulik et al., 2018; Dudgen et al., 2006). As a sensitive indicator of freshwater ecosystem health, the Ganges River Dolphin plays a crucial role in monitoring riverine environments (Braulik et al., 2015). It is listed as Endangered on the IUCN Red List, classified as Critically Endangered at the national level, and protected under Appendix I of Nepal's National Parks and Wildlife Conservation Act (1973) and CITES (DNPWC, 2021). The ecological condition of the Koshi River has worsened due to increasing human activities. Inputs from household sewage, agricultural runoff, and livestock waste have degraded water quality and reduced dissolved oxygen levels (Dudgeon et al., 2006). Intensive fishing using monofilament and plastic gill nets reduces prey availability and increases the risk of dolphin entanglement (Kelkar et al., 2010). Maintenance of the Koshi Barrage, including repainting with synthetic coatings, releases volatile compounds that temporarily deter dolphins, while vehicle movement over the barrage generates vibrations that may disrupt dolphin echolocation and surfacing behaviour (Sinha et al., 2010). During the dry season, reduced river flow concentrates dolphins near barrage outlets, where food is abundant but human disturbance is high (Samad et al., 2021).

Downstream of the barrage, in the approximately 52-kilometer stretch leading to the confluence with the Ganges, transboundary pressures intensify. Fishing communities from both sides of the border often set nets across migration routes, fragmenting habitats and restricting dolphin movement (Smith & Reeves, 2012). The combined impacts of prey depletion, altered river flows, and rising pollution place increasing stress on dolphin populations in this region (Turvey et al., 2013; GoN/MoFE, 2021). Although Nepal's National Biodiversity Strategy and Action Plan (National Planning Commission, 2014) recognize the need to protect aquatic biodiversity, there is a lack of comprehensive research linking local livelihoods with dolphin conservation outcomes. Existing community-based initiatives and fisher awareness campaigns in the Koshi basin show promising engagement but lack systematic documentation (Paudel & Heinen, 2015; DNPWC, 2021). This study, therefore, aims to (i) assess the current abundance and distribution of Ganges River Dolphins in the Koshi River, (ii) identify the primary human-induced pressures affecting their behavior and habitats, and (iii) describe emerging community-driven conservation practices led by fishers and local institutions.

Materials and Methods

Study Area

The study was conducted along the Koshi River System in south-eastern Nepal, spanning from the Koshi Tappu Wildlife Reserve (26°39′ N, 86°59′ E) to the Koshi Barrage near the Nepal–India border. This 52-kilometer section comprises a diverse mix of braided river channels, sandbars, and floodplain wetlands, supporting a wide variety of aquatic life. Its ecological importance is underscored by its designation as a Ramsar Site (No. 1315), highlighting its global significance for wetland conservation. Communities living along the Koshi River in Sunsari, Saptari, and Udaypur districts depend heavily on the river's resources for fishing, irrigation, livestock, and household needs. These human uses intersect with the river's highly seasonal flow patterns, which include extensive monsoon flooding and significant reductions during the dry season. Such seasonal changes play a crucial role in shaping the river's ecological health, directly impacting habitat connectivity, prey availability, and the movement patterns of the Ganges River Dolphin and other aquatic species that share this ecosystem.

Data collection

Data were collected between April 2022 and June 2024 using a mixed-methods approach that integrated ecological monitoring with socioeconomic assessments.

(a) Dolphin sighting surveys

Systematic visual surveys were conducted from both motorized and non-motorized boats during early morning (06:00–09:00 h) and afternoon (15:00–17:00 h) periods. Observers recorded each dolphin surfacing, group size, and GPS location using handheld Garmin 64 devices. The river was divided into 5-kilometer transects, with each segment surveyed three times per season to ensure comprehensive coverage.

(b) Community and stakeholder interviews

Interviews were conducted with 85 fisher households from the Malaha, Musahar, and Khatbe ethnic groups to gather insights on aquatic biodiversity and conservation issues. Eight focus group discussions were organized with fisher groups, women, and youth from Buffer Zone User Groups (BZUGs), along with ten key informant interviews involving community leaders, officials from the Koshi Tappu Wildlife Reserve (KTWR), and representatives from the National Trust for Nature Conservation (NTNC). Six Eco guardianship training sessions were also organized to strengthen local conservation skills. These engagements explored perceptions of dolphin populations, fish catch trends, and community-based conservation activities.

(c) Formation of Biodiversity Conservation Groups (BCGs)

Four Biodiversity Conservation Groups were formed across major riverine settlements, involving 191 members from a population of 965. Each group selected a Dolphin Conservation Ambassador, all of whom were Malaha women, to lead local conservation initiatives and awareness efforts.

(d) Field observations and community engagement

The research team visited primary dolphin habitats and conducted participatory observations, engaging with local stakeholders and fisher cooperatives in interactive meetings to document challenges and opportunities in conservation from grassroots perspectives.

Data analysis

Quantitative data were processed using descriptive statistics (mean, a range). Scores from threat-ranking exercises were used to calculate weighted mean severity values. Qualitative responses were coded thematically under four categories: water pollution, fishing pressure, infrastructure disturbance, and hydrological alteration. Cross-verification between ecological observations and community narratives was applied to ensure consistency and reliability in interpretation.

Results

Population trend of Ganges River Dolphin

Over the last thirty years, the Ganges River dolphin population in Nepal's Koshi River has undergone notable changes, influenced by both natural factors and human-induced pressures. Historical data suggest that around 50 dolphins lived in the river in 1993 (unpublished DNPWC archives, cited in Paudel et al., 2015). The devastating flood of 2008 significantly changed the river's structure, eroding deep pools and harming prey habitats, leading to the local disappearance of dolphins (Paudel et al., 2015).

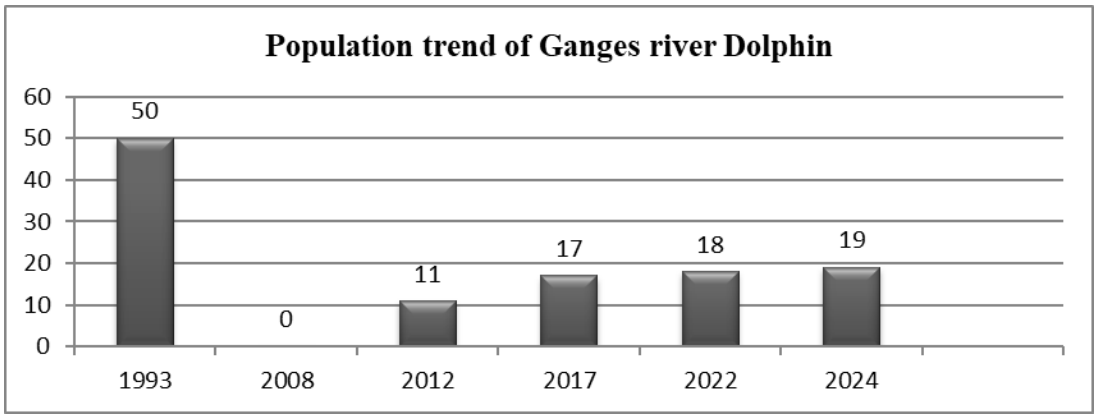

Figure 1. Trend of population of Ganges River Dolphin in Koshi River, Nepal (Source: Braulik et al., 2015, Dolphin Conservation Action Plan (2021–2025), Field survey in 2023, and NTNC 2024)

Subsequent monitoring indicated a gradual return, with 11 dolphins documented in 2012, the first count after the devastating flood, marking an important sign of population persistence (Kelkar et al., 2010). According to WWF Nepal (2022), continued collaborative monitoring by local communities and conservation officials recorded 17 dolphins in

2017, 18 in 2022, and 19 in 2024, reflecting a steady yet slow recovery trend (Figure 1).This limited resurgence suggests improvements in the river's ecological balance, likely linked to better water quality, reduced harmful fishing practices, and stronger community initiatives near Koshi Tappu Wildlife Reserve (Kelkar, 2012; Malla, 2009). However, ongoing issues such as sand mining, irregular water discharge, and extensive cross-border fishing nets still hinder dolphin movement and genetic exchange (Smith & Reeves, 2012). This upward trend demonstrates the dolphins' resilience when habitats are restored and human impacts are managed. As both a keystone and indicator species, the Ganges River dolphin reflects the health of the Koshi River ecosystem. Its revival underscores the importance of local involvement, habitat restoration, and coordinated conservation efforts across the Ganga–Brahmaputra–Meghna basin (GoN/MoFE, 2021; Braulik et al., 2015).

Ethno-Ecological knowledge and cultural values of the Ganges River Dolphin

The Malaha fishing community along the Koshi River has preserved generations of ethno-ecological knowledge about the Ganges River dolphin (*Platanista gangetica gangetica*), locally called Susu. Their understanding comes from daily life on the river, where continuous observation has shaped detailed insights into dolphin behaviour and seasonal patterns (Kelkar et al., 2012; Sinha & Kannan, 2014). Fishers consistently note that dolphins are most active during Ashadh–Shrawan (June- July), when monsoon waters rise and fish migrate upstream, and that mother–calf pairs are frequently seen between Asoj–Kartik (October- November) matching scientific descriptions of the species' breeding season (Malla, 2009). These observations show how closely the Malaha follow ecological signals in the river. The community also describes a cooperative relationship between dolphins and humans. During fishing, dolphins often drive fish toward shallow waters or traditional nets, feeding on the fish that escape while helping fishers increase their catch (Kelkar, 2012). This behaviour, observed repeatedly over the years, is understood as mutual support rather than competition. Because the Malaha spend long hours on the river, they can detect subtle changes in water flow, fish abundance, river channels, and dolphin presence which insights rapid scientific surveys may not capture (Chaudhary et al., 2020). Their local ecological knowledge (LEK) thus complements biological studies by adding long-term, place-based observation. For the Malaha, the Susu also holds deep cultural and spiritual meaning. It is considered a "water brother," a guardian of the river, and a symbol of purity and good fortune. Community elders often say, "When the Susu leaves, the river falls sick," reflecting their belief that the dolphin's presence signals clean, living water and overall ecosystem health (Braulik et al., 2015). These values reinforce strong social norms and taboos against harming dolphins or polluting the river. Sustainable fishing practices are central to their identity, supported by unwritten rules that discourage destructive methods and promote respect for the river as a living system (Kelkar, 2012). Life along the Koshi River is strongly shaped by fluctuations in water flow, which influence both dolphin behaviour and fishing activities. Monsoon currents create deep pools that support dolphin feeding, while low winter flows restrict movement and reduce fish availability. The Malaha adjusts their fishing schedule to these seasonal shifts, demonstrating how human livelihoods and dolphin ecology are tightly connected (Reid et al., 2019). However, new pressures are beginning to disturb this balance. Irregular water releases from the Koshi Barrage, expanding sand mining, and the use of toxic substances by fishers from other groups reduce fish populations and disrupt dolphin feeding grounds (Smith & Reeves, 2012). These activities damage the ecological integrity of the river and challenge traditional stewardship systems that have supported sustainable use for generations. Integrating the Malaha community's ecological knowledge into conservation planning provides a powerful opportunity to strengthen protection for the Ganges River dolphin. Their long-term observations offer valuable insight into seasonal changes, habitat conditions, and early warning signs of ecological stress. Grounding conservation strategies in their cultural values and practical experience creates more inclusive and effective management approaches (GoN/MoFE, 2021). By engaging the Malaha directly, conservation initiatives can support both the recovery of the Susu and the preservation of cultural heritage and ecological balance across the Koshi River system.

Socio-Cultural profile of the fishing community

The Malaha community, settled along Nepal's Koshi River, has traditionally relied on fishing as both a primary livelihood and a cornerstone of their cultural identity (Table 1). Generations of Malaha have synchronized their fishing practices with the river's natural rhythms, with activity peaking during the months of Asoj–Kartik (October to November) and Falgun–Chaitra (February to April), when fish are most plentiful. However, recent years have seen a sharp decline in the number of active fishers, driven by decreasing fish stocks, changes in river flow, and growing economic pressures that prompt many younger community members to seek wage labor or migrate elsewhere. The Malaha's fishing heritage is characterized by traditions such as night fishing, sharing communal nets, and making ritual offerings to the river, all of which underscore their profound respect for the local ecosystem. The Ganges River dolphin (Susu), regarded as sacred by the Malaha, serves as a symbol of both the river's health and the community's cultural legacy. Yet, the introduction of harmful modern fishing techniques, such as electric trapping, nylon gill nets, and fine-mesh nets has damaged the river's ecological balance and eroded age-old customs. Research by Braulik et al. (2015) and Dey et al. (2017) highlights that

the Malaha's changing connection with the Koshi River mirrors a broader pattern across South Asia, where indigenous knowledge and cultural practices are increasingly at risk from unsustainable resource use and the impacts of climate change.

Table 1. Socio-Cultural and livelihood profile of fisher community in Koshi River
(Source: field survey 2023)

Attribute	Description
Major community	Malaha (traditional fishing caste)
Average experience in fishing	25–40 years
Fishing seasonality	• Asoj–Kartik (October to November) • Falgun–Chaitra (February to April)
Fishing time	Night- time (6:00–11:00 PM)
Major fishing sites	Koshi Barrage and adjoining channels
Traditional gear	Cast nets (*Chhantijal*), hooks, wooden boats
Dependence on fishing	Approximately 300 households
Youth trend	Outmigration, declining interest in traditional fishing

The table reflects a clear linkage between socio-cultural practices and ecological cycles. Sustaining these traditions through community-led stewardship could reinforce riverine conservation at the grassroots level.

Economic trends and changing livelihood patterns

Economic and oral records (referenced in Table 2) show a notable contradiction: fish prices have increased significantly, yet both the number of fishers and overall fish harvests have decreased. Around twenty years ago, about 500–700 individuals fished during peak seasons, collectively catching 700–800 kg per day. Currently, only 50–100 fishers remain active, and their total daily catch has dropped to just 30–40 kg, sometimes even less. As a result, yearly fish production has fallen from roughly 410,000 kg to approximately 100,400 kg for the present group of fishers, even as market prices for fish have risen due to inflation.

Table 2. Economic trends in Koshi River fisheries over two decades
Source: Field Survey 2023, and personal communication with fish farmers 2023

Parameter	Past (2000s)	Present (2023)	Revised Scientific Analysis
Active fishermen	500–700	50–100	Decline of 80–90% - Indicates a collapse in fishing-based livelihoods, consistent with reduced resource availability and diminishing economic viability.
Average daily harvest	700–800 kg (community total)	5–6 kg per fisher; occasionally 30–40 kg	Decline of 85–90%- Strong evidence of stock depletion and fragmentation of traditional communal harvesting practices.
Annual total fish production	400,000–420,000 kg	100,400 kg	Reduction of 75%- Reflects long-term ecological degradation, reduced recruitment, and increased fishing pressure.
Fish price per kg (NRs)	50–100	300–500	Increase of 300–400%- Driven by scarcity, inflation, and market demand; indicates a resource becoming economically scarce.
Average annual income per fisher	2,000–10,000	351,500	Nominal increase of approx 3000% - Income rise is inflation-influenced and concentrated among fewer active fishers; does not indicate improved sectoral welfare.
Economic sustainability	Moderate	Declining	Marked decline- System trending toward economic and ecological unsustainability due to overexploitation, habitat change, and weakened traditional governance.

The increase in income does not signify prosperity; rather, it reflects market scarcity and resource depletion. The shrinking participation rate and catch per fisher underscore the urgent need for sustainable management and diversification of livelihoods.

Emerging threats to the Ganges River Dolphin in Koshi system

While the Ganges River dolphin holds a respected place in local culture, its survival is increasingly at risk due to human activities. Evidence from fieldwork and fisher accounts (see Table 3) points to pollution, overfishing, physical barriers, and habitat disruption as key reasons for the decline in dolphin numbers. The Koshi–Ganges River stretch, which spans about 120 kilometers, is a vital migration route for these dolphins. However, frequent blockages from fishing nets, especially in the downstream Indian sections, restrict their movement and reduce genetic diversity (Chaudhary, 2007; Frankham et al., 2014). The loss of dolphins from the Koshi River after the 2008 flood highlights how sensitive the species is to environmental changes. The flood altered the river's course, destroyed deep pools, and severely damaged important dolphin habitats (Khatri et al., 2010; Paudel et al., 2015). In the years that followed, increased fishing, sand mining, and river traffic made it even harder for the dolphins to recolonize these areas. Recent monitoring by community River Guards has documented fewer prey fish and more disturbances in the most important dolphin habitats (Bashir et al., 2010). These findings underline the urgent need for a comprehensive approach that restores river habitats, manages human impact, and supports the recovery of biodiversity. Such efforts are necessary to prevent the disappearance of freshwater dolphins and other endangered species in the Koshi basin (Chaudhary, 2007; Paudel et al., 2020).

Table 3. Major threats to the Ganges River Dolphin in Koshi River
Source: Field survey 2023; community consultation 2024.

Threat Category	Description	Ecological Impact
Water pollution	Discharge of household slurry in upstream	Reduces water quality and prey availability
Overfishing and nylon nets	Excessive use of fine-mesh nets	Hinders dolphin movement and traps juveniles
Synthetic paints on gates	Fresh paint emits strong odor	Dolphins avoid area until smell dissipates
Barrage operation	Gates concentrate fish; attract dolphins	Risk of interdependency and disturbance
Migration barrier	Continuous fishing nets in Indian stretch (120 km to Ganges)	Blocks migratory routes
Declining fish biomass	Reduced prey density	Limits dolphin food supply
Vehicular vibration	Constant movement over barrage	Affects echolocation and behavior
Seasonal water fluctuation	Extreme low flow in dry season	Restricts movement to disturbed zones
Sand deposition in the earlier habitat	Sand deposited completely in the north of Barrage	No more dolphins are found
Engine boats plying frequently	Dolphin niches in the past is turned into engine boat tourism place	Neither dolphin nor birds are there

The cumulative effect of these pressures manifests as habitat fragmentation and behavioural stress in dolphins. The interplay between reduced prey base and intensified human activity illustrates how ecological degradation and livelihood dependence are intricately connected.

Governance paradox and biodiversity implications for dolphin conservation

The conservation of the Ganges River dolphin in the Koshi Barrage area reflects a governance dilemma shaped by overlapping administrative mandates, cross-border water management issues, and unregulated exploitation of natural resources. The Koshi River, which demarcates the boundary between Saptari and Sunsari Districts, contains the barrage located inside Nepalese territory. However, under the provisions of the Nepal–India Koshi Agreement of 1954, later amended in 1966, its operation and control remain under the jurisdiction of the Government of India (Government of Nepal & Government of India, 1966). This arrangement limits Nepal's ability to manage water flow, aquatic biodiversity, and fisheries within the barrage zone. As a result, both district administrations and the Koshi Tappu Wildlife Reserve (KTWR), established under the National Parks and Wildlife Conservation Act 1973, face challenges in enforcing regulations related to river discharge, fishing pressure, and habitat quality. The lack of unified governance has led to the spread of harmful fishing methods such as fine-mesh nets, electrofishing, and trapping, which diminish fish stocks and affect the dolphin's food supply. Additionally, irregular water releases from the Indian-controlled side change sediment movement and breeding conditions, further stressing aquatic ecosystems (Braulik et al., 2021). To address these interconnected ecological and institutional issues, a collaborative and knowledge-driven management system is essential, one that goes beyond political boundaries. A joint Nepal–India river governance framework, involving KTWR

authorities, provincial offices, and fisher cooperatives, could enhance habitat monitoring, regulate water and resource use, and support sustainable livelihoods. Such cooperation would align conservation goals with the long-term ecological resilience of the transboundary Koshi River basin (DNPWC, 2021; Bashir et al., 2010).

Conclusion

This research demonstrates that protecting the Ganges River dolphin in the Koshi River is closely linked to the river's overall health and the well-being of the people who rely on it. In the last twenty years, the river has experienced a significant drop in fish stocks, daily catches, and the number of active fishers. Traditional practices like sharing nets, following seasonal fishing patterns, and honoring the river's spiritual significance have declined, largely due to the spread of harmful fishing methods and changing river conditions. These developments have negatively impacted both the dolphins and the Malaha community, whose way of life is deeply connected to the river.Despite these obstacles, the Malaha still hold the river dolphin in high regard. Their stories, rituals, and knowledge of the river's cycles reflect generations of close observation and adaptation. This cultural connection is a valuable asset for conservation, as local insights can help identify early warning signs of habitat loss and risks to aquatic species.To secure the future of the Koshi River, an integrated approach is needed to improve the river's ecological health, involves local communities, and provides economic opportunities. Restoration of riverbanks, measures to reduce pollution, and responsible fishing practices can help restore fish populations and dolphin habitats. Community groups, including fishers, youth, and women, can play an active role by monitoring river conditions, recording dolphin sightings, and reporting harmful activities. Combining their efforts with simple tools like basic mapping, water testing, and affordable monitoring devices can strengthen ongoing observation and data collection. Additionally, it's important to diversify sources of income so that fishing is no longer the sole livelihood. Initiatives such as eco-tourism, homestays, handicraft production, and small-scale nature-based businesses can provide alternative income, reducing the pressure on fish stocks. Access to training, markets, and financial support will be crucial for the success of these initiatives. Ultimately, conserving the Ganges River dolphin is about more than ecology. It's also about supporting local culture and improving social conditions. By recognizing traditional knowledge, restoring the river environment, and creating fair economic alternatives, the Koshi River can become a safer and more vibrant place for both people and wildlife. This inclusive approach offers a realistic and optimistic path toward long-term sustainability.

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Author contributions

The author independently conceptualized, designed, and implemented the study; conducted field investigations and data analysis; and prepared the manuscript.

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Conflict of interest

The author declares no conflict of interest related to this research.

Ethics approval

Not applicable.

AI tool usage declaration

The authors hereby declare that the consultation and citation of relevant literature were conducted in accordance with recognized academic and publication standards. Generative language, ChatGPT and Capilot tools were utilized solely

to enhance linguistic clarity and ensure grammatical consistency. The integrity and originality of the scholarly work have been maintained throughout, and all sources are appropriately acknowledged. This declaration is made in good faith and in compliance with international best practices for responsible authorship and publication ethics.

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