



RESEARCH ARTICLE

Information-seeking networks of paddy farmers during cyclone disasters: A social network analysis in coastal Odisha, India

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Abstract

This study examined agricultural information networks among 120 paddy farmers in cyclone-prone Balasore district, Odisha. Data were collected through structured interviews and social network analysis (SNA) was used to map information exchange. A two-mode affiliation network was constructed and centrality measures, including degree and eigenvector centrality, were computed using UCINET. Results revealed that WhatsApp recorded the highest degree centrality (0.71) and eigenvector centrality (0.45), indicating that it is the most connected and influential information source within the network. Fellow farmers (0.67; 0.43) and television (0.62; 0.39) also occupied prominent positions, highlighting the importance of interpersonal and mass media channels in information dissemination. Extension agents (0.55; 0.34) maintained a moderate role, while digital platforms such as Facebook (0.53; 0.33) and YouTube (0.52; 0.32) demonstrated emerging significance. In contrast, Agri apps (0.47; 0.29) showed relatively lower influence and traditional media such as radio (0.29; 0.17) and print media (0.29; 0.17) remained peripheral within the network. The findings highlight the dominance of digital and interpersonal communication channels in disseminating cyclone-related agricultural information. Integrating formal extension services with digital and community-based networks can enhance information delivery and improve farmers' preparedness and resilience in cyclone-affected regions.

Keywords: agricultural information; digital platforms; extension agents; information networks sources

Introduction

Odisha is one of the most cyclone-prone states in India, experiencing recurrent tropical cyclones originating in the Bay of Bengal. Its long coastline, low-lying deltaic plains and high dependence on rainfed agriculture render farming communities particularly vulnerable to extreme weather events. Paddy cultivation, the dominant cropping system in the state, is highly sensitive to cyclonic impacts such as heavy rainfall, flooding, lodging, saline water intrusion and damage to irrigation and storage infrastructure. Cyclones including Phailin, Hudhud, Fani, Amphan, Yaas and subsequent events have repeatedly disrupted paddy production and rural livelihoods across coastal and adjoining districts. In such a risk-intensive environment, access to timely, accurate and trusted information becomes a critical determinant of farmers' preparedness, response and recovery decisions. Information related to cyclone warnings, crop stage-specific advisories, emergency harvesting, drainage management, post-cyclone input use and institutional support is essential for minimising losses and facilitating recovery. Farmers perceive information not merely as knowledge but as a productive and protective resource, particularly during crisis situations (1, 2). However, the effectiveness of such information depends not only on its availability but also on how it

reaches farmers and through whom. During cyclone events, when uncertainty is high and decisions must be taken rapidly, farmers often rely more on familiar and trusted sources than on distant or impersonal channels. Access to cyclone-related information in Odisha operates within complex social systems comprising formal sources such as agricultural extension personnel, disaster management authorities and meteorological services; informal interpersonal sources including neighbours, relatives, progressive farmers and local leaders; and mass media channels such as television, radio and mobile alerts. Research in agricultural communication consistently shows that under conditions of risk, farmers place greater trust in interpersonal and socially embedded information sources, which allow contextual interpretation and validation of messages (3–5). Such reliance on social ties is particularly relevant in Odisha, where village-level interactions and community networks play a central role in coping with climatic shocks.

Social networks constitute an important form of social capital, facilitating information exchange, mutual support and collective action among farming households (6, 7). The structure of these networks—such as their size, density and the relative positions of actors—shapes how information flows and determines who gains timely access to critical knowledge (8, 9). In agricultural systems,

social network structures have been shown to influence technology adoption, learning processes and risk management behaviour (10, 11). Social network analysis (SNA) provides a robust framework to examine these relational dynamics by shifting the analytical focus from individual attributes to relationships among actors (12). Through measures such as degree centrality, betweenness centrality, closeness centrality and network density, SNA enables identification of key information providers, intermediaries and potential bottlenecks within information systems (13). Empirical applications of SNA in agriculture have demonstrated its effectiveness in mapping information networks related to specific technologies and advisory services. Studies of livestock farmers, groundnut growers and organic producers highlight the dominance of formal sources alongside the critical role of peer groups and small farmer collectives in providing information support (14–16). Disaster communication research further suggests that the effectiveness of early warning systems depends heavily on trust, social embeddedness and network cohesion rather than technological sophistication alone (17). Farmers embedded in denser networks are better positioned to access multiple sources, cross-verify information and adapt advisories to local conditions (18, 19). Despite Odisha's long experience with cyclones, empirical evidence on how paddy farmers seek, share and prioritise cyclone-related information through social networks remains limited. Against this backdrop, the present study examines the information-seeking networks of paddy farmers during cyclones in Odisha using SNA, with the objective of identifying dominant information actors, assessing the relative importance of formal, informal and mass media sources and understanding how network structure influences access to and use of cyclone-related information.

Materials and Methods

The investigation was carried out in Balasore district, one of the coastal districts of Odisha. The district was selected based on secondary data obtained from the State Relief Commissioner's reports, which identify the districts most frequently affected by cyclones in the state. Among the highly cyclone-prone districts, Balasore was selected purposively for the present study. The district has been subjected to recurrent cyclonic disturbances originating from the Bay of Bengal, which have significantly affected agricultural activities, particularly the production of paddy in the region. A multistage purposive sampling technique was employed to select the blocks, panchayats and villages within the district for the investigation.

Selection of block

Baliapal was selected for the study as it is located near the coastal area and is one of the most severely affected areas.

Selection of villages

Two villages namely Chaumukh and Dagara were randomly selected for the study.

Selection of respondents

The respondents were operationally defined as the farmers involved in paddy cultivation. A complete list of all the farmers residing in the sample area was considered while getting information from departments of agriculture situated at district levels as well as block level. The information obtained was cross-checked by resource personnel like teachers, sarpanches, religious leaders or any other

local leaders. A total of 120 households were randomly selected for the study. An interview schedule was prepared with expert guidance and literature reviews as tailored to the objectives of the investigation. The prepared schedule was pre-tested on 10 % of the sample size. The questionnaire was prepared in English language but, was read out to farmers in the local language of Odia to get responses from them. Feedback was taken from them. The interview schedule was rechecked for relevancy and validity before preparing a final draft of it. Data was collected by interviewing the farmers. Support from Kissan Saathi, local leaders, Sarpanch, Gram Panchayat members and Assistant Agricultural Officers of the respective region were taken. Data were collected through face-to-face interviews conducted at the respondents' homes and workplaces. Conducting interviews in a familiar and informal environment helped ensure that respondents provided accurate and honest responses without external influence. A structured questionnaire was used to collect information regarding the agricultural information sources utilised by the farmers. The questionnaire contained structured questions related to the use of various information sources. Responses were recorded in a binary format, where a score of 1 was assigned if the respondent used a particular information source and 0 was assigned if the respondent did not use the information source. These binary responses were used to construct the two-mode matrix for social network analysis.

Social network analysis methodology

Social network analysis was employed to map and quantify the structure of information networks operating within cyclone-affected farming communities. In SNA, individuals or entities are treated as nodes (actors), while the relationships or interactions between them are represented as ties (links). This approach enables the analysis of how information flows among actors and helps identify key information providers within the network (8, 9). A socio-centric (whole network) approach was adopted to examine the overall structure of information exchange within the selected villages. To capture the relationship between farmers and the information sources they use, a two-mode (bimodal) affiliation network was constructed. In this network, farmers represented one set of nodes and agricultural information sources represented another set of nodes. A link was established whenever a farmer reported using a particular information source for agricultural knowledge.

The collected network data were coded into binary matrices, where a value of 1 indicated the presence of a relationship between a farmer and an information source and 0 indicated the absence of a relationship. These matrices were used to represent the network structure. The network data were analysed using UCINET to compute network statistics and centrality measures. Network visualisation was performed using NetDraw to graphically depict the structural patterns of information exchange among actors. For centrality analysis, two-mode farmer-information source network was converted into a one-mode network of information sources using column-wise projection. In this approach, ties between information sources were established based on the number of farmers who reported using both sources (co-occurrence). The resulting one-mode network was normalised to account for differences in node connectivity and to ensure comparability of centrality measures across information sources. Normalised values of degree centrality were computed by dividing by the maximum possible number of connections, as implemented in UCINET. This transformation allowed the examination of relationships among the

information sources themselves and enabled the computation of centrality measures. Two important centrality measures were used to identify the influential information sources within the network.

Degree centrality

Degree centrality measures the number of direct connections a node has with other nodes in the network. It indicates how widely an actor is connected and reflects the popularity or accessibility of an information source within the network (20).

Degree centrality is calculated as shown in Eqn. 1:

$$C_D(i) = \frac{d_i}{N - 1} \quad \text{Eqn. 1}$$

Where,

$C_D(i)$: Degree centrality of node i

d_i : Number of direct connections (degree) of node i

N : Total number of nodes in the network

Higher degree centrality indicates that the information source is directly connected to a larger number of actors and therefore plays a more prominent role in the network.

Eigenvector centrality

Eigenvector centrality measures the relative influence of a node in the network by considering not only the number of connections it has but also the importance of the nodes to which it is connected. Nodes connected to highly influential nodes receive higher eigenvector scores (21).

Eigenvector centrality is calculated as shown in Eqn. 2:

$$C_E(i) = \frac{1}{\lambda} \sum_j a_{ij} C_E(j) \quad \text{Eqn. 2}$$

Where,

$C_E(i)$: Centrality of node i

a_{ij} : Connection between node i and node j (from adjacency matrix)

$C_E(j)$: Centrality of node j

λ : Largest eigenvalue

A higher eigenvector centrality value indicates that the node is connected to other influential nodes within the network and therefore holds a structurally important position in information dissemination. Together, these measures enabled the identification of the most influential agricultural information sources and the dominant communication pathways within the farmers' information network in cyclone-affected areas. The eigenvector centrality values were computed using UCINET software.

Results

As presented in Table 1, the socio-economic characteristics of the respondents indicate that the mean age of the farmers was 45.2 years with a standard deviation of 10.20, suggesting that the majority belong to the middle-aged group with moderate variability. The average education level was 10.50 years of schooling with a standard deviation of 2.10. The mean household size was 5.30 members with a standard deviation of 1.60, reflecting moderately sized families. The average farm size was 2.70 acres with a standard deviation of 1.10, indicating that the respondents

Table 1. Socio-economic characteristics of paddy farmers in the study area

Sl. No.	Variables	Mean	SD
1	Age of the respondent (years)	45.20	10.20
2	Education (years of schooling)	10.50	2.10
3	Household size (number)	5.30	1.60
4	Farm size (acres)	2.70	1.10
5	Farming experience (years)	18.60	8.10

are predominantly small and marginal farmers. Further, the mean farming experience was 18.60 years with a standard deviation of 8.10, suggesting that the respondents possess considerable experience in agricultural activities. These socio-economic characteristics provide a basis for understanding the structure of the information network.

As presented in Table 2, the centrality analysis of the farmers' information network reveals clear differences in the relative importance of various information sources. Among all the sources, WhatsApp recorded the highest degree centrality (0.71) and eigenvector centrality (0.45), indicating that it is the most widely connected and influential source within the network. This suggests that a large proportion of farmers rely on WhatsApp for accessing and sharing agricultural information and it is also connected to other important nodes in the network. Fellow farmers ranked second with a degree centrality of 0.67 and eigenvector centrality of 0.43, highlighting the continued importance of interpersonal communication and local knowledge exchange in rural communities. Television (0.62; 0.39) also showed a relatively high position, indicating its role as a traditional mass media channel for disseminating agricultural information. Institutional sources such as extension agents (0.55; 0.34) maintain a moderate position in the network, reflecting their role as formal knowledge providers but with comparatively fewer connections than digital or interpersonal sources. Similarly, Facebook (0.53; 0.33) and YouTube (0.52; 0.32) occupy intermediate positions, suggesting that social media platforms are emerging as important channels for agricultural information dissemination. In contrast, Agri apps (0.47; 0.29) show relatively lower centrality values, indicating limited adoption among farmers. Traditional media sources such as radio (0.29; 0.17) and print media (0.29; 0.17) recorded the lowest centrality values, suggesting that their

Table 2. Normalised degree and eigenvector centrality of agricultural information sources

Information source	Degree centrality (Normalised)	Eigenvector centrality
WhatsApp	0.71	0.45
Fellow farmers	0.67	0.43
TV	0.62	0.39
Extension agent	0.55	0.34
Facebook	0.53	0.33
YouTube	0.52	0.32
Agri apps	0.47	0.29
Radio	0.29	0.17
Print media	0.29	0.17

influence in the information network has declined compared to digital and interpersonal communication channels. The relative importance of the information sources based on degree and eigenvector centrality is illustrated in Fig. 1 and 2.

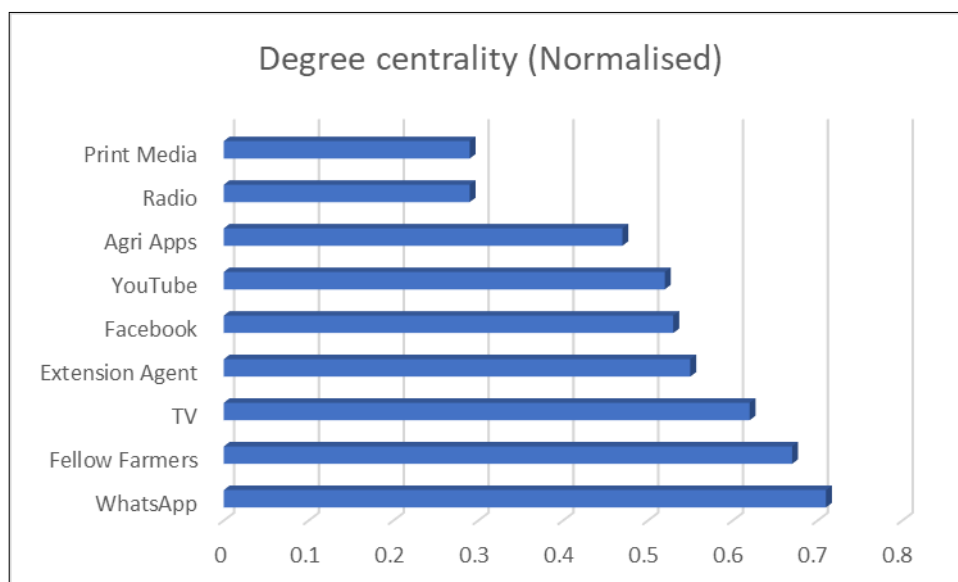


Fig. 1. Degree centrality (normalised) of agricultural information sources among farmers in the study area.

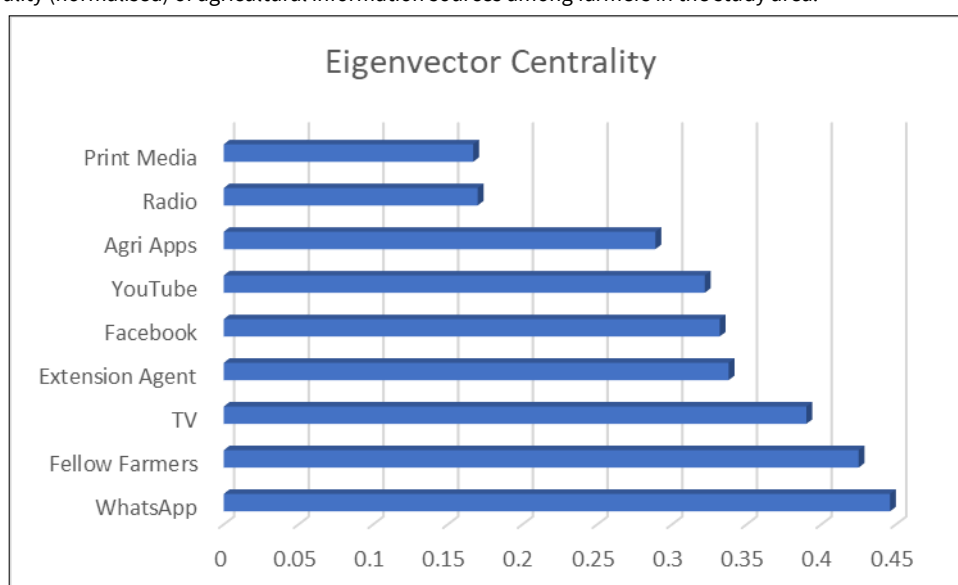


Fig. 2. Eigenvector centrality of agricultural information sources in the farmers' information network.

Discussion

Socio-economic characteristics of paddy farmers in the study area

The socio-economic profile of the respondents provides important insights into the observed structure of the agricultural information network. The relatively higher level of education among farmers facilitates their ability to access and use digital platforms, which helps explain the high centrality of sources such as WhatsApp and other social media channels in the network. At the same time, the substantial farming experience and middle-aged composition of the respondents strengthen reliance on interpersonal communication, thereby contributing to the prominent role of fellow farmers as key information sources. The moderate household size supports intra-household and community-level information exchange, further reinforcing local network interactions. Moreover, the predominance of small and marginal landholdings increases farmers' dependence on timely and reliable information for managing climatic risks, which encourages the use of multiple information sources within the network. Thus, the structure and centrality patterns observed in the social network analysis are closely influenced by the underlying socio-economic characteristics of the farming community.

Degree centrality and eigenvector centrality

The findings reflect the changing dynamics of agricultural information dissemination among farmers, particularly in the context of increasing digital connectivity in rural areas. The dominant position of WhatsApp and other social media platforms indicates a gradual shift from conventional extension channels toward more interactive and easily accessible digital communication tools. Information and communication technologies have become increasingly important sources of agricultural knowledge and advisory services for farmers in developing countries, improving access to timely and relevant information (22, 23). These platforms enable farmers to exchange real-time information related to crop management practices, weather forecasts, pest and disease management and market prices, thereby strengthening knowledge sharing within the farming community. In cyclone-prone regions, WhatsApp groups also play a crucial role in the rapid dissemination of cyclone warnings, precautionary measures and post-disaster recovery information among farmers. Studies on disaster communication have highlighted that digital platforms significantly improve the speed and reach of early warning information and help communities prepare for extreme weather events (24). Since members of these

groups often belong to the same locality and personally know one another, the information shared is perceived as reliable and trustworthy, which increases farmers' confidence in responding to cyclone alerts and precautionary advisories. The strong centrality of fellow farmers, particularly opinion leaders and progressive farmers, highlights the continued relevance of interpersonal communication and indigenous knowledge exchange in rural communities. According to previous researchers, interpersonal networks and opinion leaders play a critical role in influencing the diffusion of information and innovations among farmers (25). In cyclone-affected areas, farmers often rely on trusted community members to interpret cyclone warnings and decide on protective measures such as early harvesting, drainage management, crop protection and safeguarding agricultural inputs before landfall. Community-based knowledge sharing has been recognised as an important factor in enhancing disaster preparedness and resilience in coastal regions. Television (TV) also occupies a significant position in the information network as it continues to serve as an important medium for broadcasting weather forecasts, cyclone alerts and government advisories through news channels and agricultural programmes. Mass media has long been recognised as a key channel for disseminating agricultural and climate-related information to rural populations (26). Similarly, social media platforms such as Facebook and YouTube are increasingly becoming sources of agricultural knowledge where farmers can access instructional videos, demonstration tutorials and expert recommendations on climate-resilient agricultural practices and disaster preparedness strategies. Digital media platforms are playing a growing role in strengthening farmers' access to agricultural knowledge and climate information services (22). Extension agents remain important institutional actors in the information network by providing scientifically validated technical guidance, improved agricultural practices and disaster management advisories. However, their relatively lower centrality compared to digital and interpersonal sources suggests the need to integrate formal extension services with digital communication

platforms to enhance outreach and improve the timeliness of advisory services. Agri-apps, although designed to provide location-specific agricultural advisories, show moderate influence in the network, possibly due to constraints such as limited awareness, digital literacy and smartphone accessibility among farmers (23). In contrast, traditional information sources such as radio and print media occupy relatively peripheral positions in the network, indicating a gradual decline in their influence as farmers increasingly rely on faster and more interactive communication channels. Nevertheless, radio still retains importance for broadcasting emergency cyclone warnings in areas with limited internet connectivity. Overall, the social network structure demonstrates that a combination of digital platforms, interpersonal communication networks, institutional advisory services and mass media shapes farmers' access to agricultural and disaster-related information. Strengthening the integration of these communication channels, particularly digital and community-based networks, is therefore essential for improving the flow of timely information and enhancing farmers' preparedness, adaptive capacity and resilience in cyclone-affected regions.

Social network map

The social network map illustrating the relationship between farmers and various agricultural information sources is presented in Fig. 3. The network shows the interaction between farmers and different information sources used for obtaining agricultural and cyclone-related information. Visual inspection of the network indicates that some sources such as WhatsApp, fellow farmers and television occupy more central positions in the network, indicating their greater importance in the dissemination of information among farmers. These sources appear as highly connected nodes in the network, suggesting that a larger number of farmers rely on them for accessing agricultural information and advisories. In contrast, other sources such as radio and print media are located toward the periphery of the network, indicating relatively fewer connections

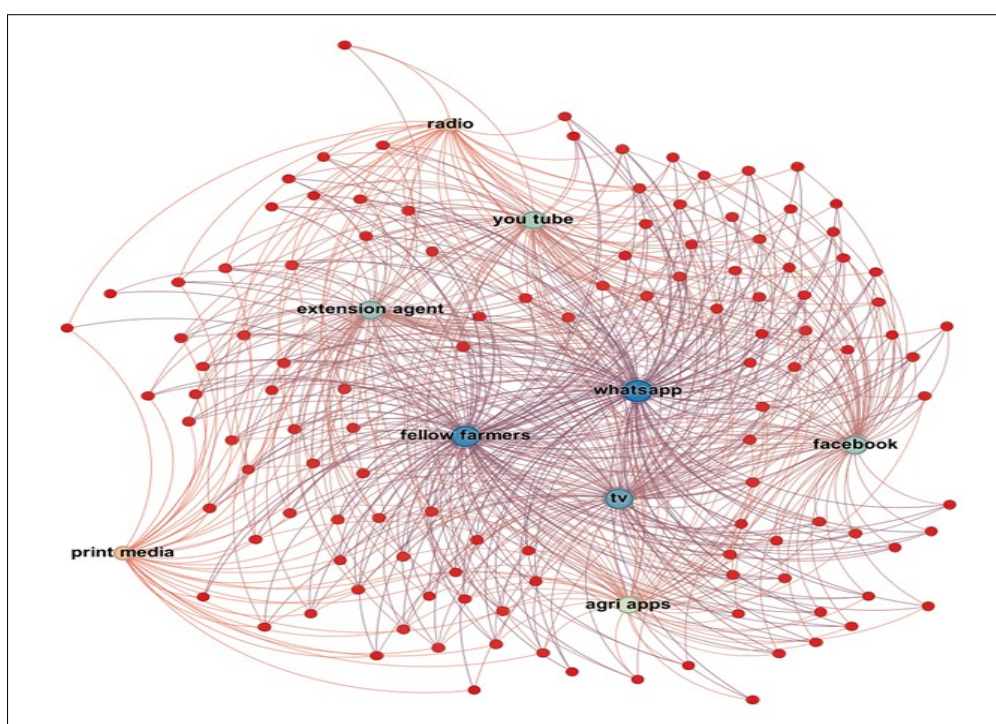


Fig. 3. Information network of farmers and agricultural information sources in the study area generated using social network analysis. Circular nodes represent farmers and information sources and connecting lines indicate the flow or use of information between farmers and the respective sources.

with farmers. The structure of the network also reveals that information exchange among farmers is not uniform, as certain sources act as key hubs facilitating the flow of information within the farming community. Overall, the network pattern highlights the relative prominence of digital platforms, interpersonal communication and mass media in shaping farmers' information access in the study area.

Conclusion

The study analysed agricultural information networks among paddy farmers in cyclone-prone coastal Odisha using social network analysis. The findings revealed that digital platforms, particularly WhatsApp, along with fellow farmers and television, are the most influential sources of cyclone-related agricultural information. Extension agents play a moderate role, while traditional media remain peripheral. The results emphasise the need to integrate digital communication with formal extension systems to ensure timely and effective information dissemination. Strengthening community-based communication networks can further enhance farmers' preparedness and resilience in cyclone-affected regions.

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Authors' contributions

JA led the writing of the manuscript. SD contributed to the design of the research methodology, data validation and refinement of the manuscript. MPN and BM conceptualised the research framework and provided overall study supervision. AD assisted in statistical analysis, interpretation of results, and development of data visualisations. KKS coordinated the drafting process and ensured clarity. All authors read and approved the final version of the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used Grammarly AI for language improvement and writing refinement. After using this tool, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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