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Research Article:

Livelihood Aspects of *Kappaphycus alvarezii* Seaweed Farmers in Valaippadu, Sri Lanka

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Abstract

This study examines the perceived socio-economic contributions of seaweed farming to the livelihoods of farmers in Valaippadu, Kilinochchi District, Sri Lanka, where seaweed cultivation has been practiced for nearly a decade with higher production rates compared to other Northern Province areas. The research involved all 88 seaweed farmers in Valaippadu, using questionnaires, interviews, and field observations from February to May 2022, supplemented by secondary data from the National Aquaculture Development Authority and relevant literature. The sole species cultivated was the red seaweed *Kappaphycus alvarezii*. Results showed that seaweed farming serves as the primary occupation for more than half of the respondents (54.5%), seaweed-only occupation (58.0%), and full-time work (56.8%) while others use it as supplementary income alongside traditional activities like fishing. The annual income for many farmers ranged between 100,000 and 300,000 LKR. Women constitute 62.5% of the seaweed farming population, highlighting its potential for female empowerment. Key challenges identified include unpredictable weather, water quality fluctuations, disease outbreaks, price volatility, poor-quality seedlings, and insufficient training. Despite these constraints, seaweed farming has notably improved the living standards of farmers by providing economic benefits and enhancing quality of life. To further improve livelihoods, addressing these challenges is essential. The study recommends implementing proper training and extension programs through public-private partnerships to develop seaweed farming into a sustainable commercial enterprise.

Keywords: Aquaculture; *Kappaphycus alvarezii*; Seaweed farming; Socio-economic status; Valaippadu

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1. Introduction

Commercial farming of red seaweed *Kappaphycus alvarezii*, was developed in the Philippines in the late 1960s and has been introduced to over 31 countries within 40 years (Jayasuriya, 1990; Shanmugam et al., 2017). Seaweed farming offers a potential source of income and an economically sustainable livelihood option for the coastal communities (Narayanakumar & Krishnan, 2013). Several studies have analyzed its positive impacts on the socio-economic conditions of coastal villages in countries such as the Philippines, Indonesia, Tanzania, India, Vietnam and Kiribati (Valderrama, 2012). For example, seaweed farming has provided several benefits to the populations of Indonesia. One of the improvements noted in the southwest region of Rote Island, Indonesia, is the higher education level of the children of seaweed farmers following the activity's introduction to the island, as seen by the parents' educational attainment relative to that of their children. The higher income of the families that the farmers indicated in the interviews was assumed to be related to it. Similar findings have been reported in Tanzania, the Philippines, other Indonesian regions, and India, where families that grow seaweed can afford to send their children to better schools than they themselves experienced (Marino et al., 2019).

Seaweed farming has emerged as a sustainable and economically beneficial livelihood option for coastal communities, particularly for fisherwomen. In Ramanathapuram, India, this practice has been estimated to provide employment opportunities equivalent to 7,65,000 man-days annually, contingent on specific conditions (Narayanakumar & Krishnan, 2013). The steady income generated from seaweed farming plays a pivotal role in bolstering the financial stability of fisher households, especially during lean seasons. Additionally, it has empowered individuals to make investments in livestock, procure high-quality clothing and durable goods, and facilitated easier access to funds for family celebrations and events. Moreover, this transformative practice has led to significant improvements in the socio-economic status of many fishermen who have embraced seaweed farming over the past decade. These findings underscore the substantial positive impact of seaweed farming on coastal communities, highlighting its potential as a sustainable and viable livelihood option (Msuya & Hurtado, 2017).

K. alvarezii seed material was brought from Malaysia in 2011 to introduce the seaweed farming industry in Sri Lanka, and pilot-scale trials and feasibility studies were initiated to assess site suitability in the selected coastal areas of the country (Shanmugam et al., 2017). In June 2012, enough seed materials were propagated from the experimental sites in Valaippadu and Nainativu areas in the Northern coast for the expansion of the industry (Shanmugam et al., 2017). Since then, seaweed cultivation has been practiced in the districts of Kilinochchi, Mannar, Jaffna, and Mullaitivu, in the northern part of Sri Lanka with the aim of enhancing socio-economic conditions. (Ginigaddara & Lankapura, 2018; Lankapura et al., 2017). The seaweed farming practice in the northern part of Sri Lanka was reported to be moderately profitable and socially acceptable, indicating the necessity of further investigation of its actual significance for the coastal community (Ginigaddara & Lankapura, 2018; Ginigaddara et al., 2018).

Seaweed beds are widespread in the coastal regions of Jaffna, Palk Strait, and Gulf of Mannar, as well as along Sri Lanka's southwest coast, which stretches from Ambalangoda to Galle. Roughly 50–60 species of seaweeds with potential commercial value are known to exist among the 320 species of seaweeds known to exist in Sri Lanka's deep water and intertidal zones. Green seaweed species, including *Halimeda* sp., *Ulva reticulata*, *U. lactuca*, *U. fasciata*, *Caulerpa racemosa*, *C. lentellifera*, *Codium* sp., *Enteromorpha* spp., and others; brown seaweeds, including *Padina* sp., *Sargassum* spp., and *Turbinaria* spp.; and red seaweeds, including *Gracilaria* spp., *Gelidium* spp., *Gelidiella* spp., and *Acanthophora* spp., among others, have significant economic potential for a wide range of industries that have not yet been commercially exploited. These resources offer Sri Lanka's seaweed-based

companies a lot of growth opportunities (Valderrama et al., 2015).

Although seaweed culture practices have been implemented in several areas in Northern Sri Lanka, many details are not available and are not discussed regarding the livelihood aspects of seaweed farmers. The Valaippadu village was chosen for the study because of its extensive seaweed-producing history and high seaweed productivity compared to other Northern Province areas. The present study focused on the investigation of livelihood aspects of seaweed farmers of Valaippadu village, such as educational status, profession, income, etc. and the substantial improvements in their livelihoods.

2. Materials and Methods

2.1. Study Site

Valaippadu village (9.3378°N, 80.0528°E), a seaweed farming village of Kilinochchi District, Northern Province, Sri Lanka, was selected as the study area for this research during the period February to May 2022 (Figure 1).

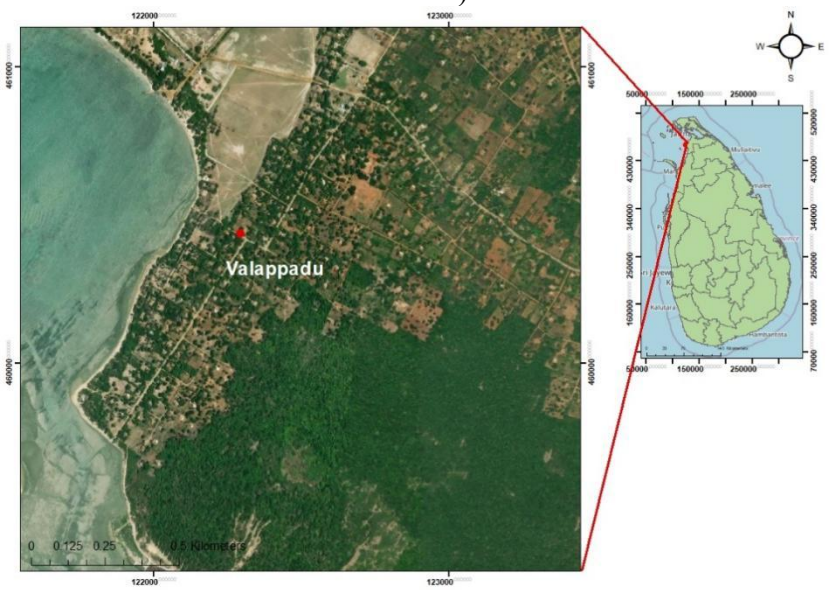

Figure 1. Location of the study area, Valaippadu village (9.3378° N, 80.0528° E), Kilinochchi District, Northern Province, Sri Lanka

2.2. Data Collection

The questionnaire survey, in-depth interviews, key personnel interviews, and nine focus group discussions with 7-10 farmers participating in each group were used as primary data-collection tools to gather information from all local Valaippadu seaweed farmers (n=88) based on the registration records maintained by the National Aquaculture Development Authority (NAQDA). The 88 seaweed farmers were identified using farmer registration records maintained by the National Aquaculture Development Authority (NAQDA). All identified farmers participated in the survey, resulting in a 100% response rate. Data were collected through face-to-face interviews conducted in Tamil using a pre-tested structured questionnaire. Formal ethical approval was not obtained for this study. However, the research was conducted with due consideration of ethical principles. Responses were documented through recording and note-taking. Before data collection, participants were informed about the purpose of the study and the voluntary nature of their participation., Informed consent was obtained from all respondents, and confidentiality was maintained by excluding respondents' names and other personally identifiable information from the reported findings. The district office of the National Aquaculture Development Authority, Poonagary, was consulted for secondary data and other basic details on seaweed farmers. Additional data and information were gathered from books, journal articles, and research reports.

Improvements in living standards are generally assessed by the ability of the seaweed farmers to meet their daily needs as well as

those of their family members. Another indicator is the possession of certain items before and after the introduction of seaweed farming and improvements in the houses which farmers are living in (Msuya, 2006). Following this, a series of questions were asked of the seaweed farmers about what they were able to achieve with the seaweed farming earnings to analyze their substantial improvements

2.3. Data Analysis

Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize the questionnaire responses. Graphical illustrations were used to present the findings. Responses obtained using the five-point Likert scale were coded numerically from 1 to 5 as strongly disagree (1), disagree (2), neither agree nor disagree (3), agree (4), and strongly agree (5). The frequency distribution and mean score for each statement were calculated to assess respondents' perceptions. Statistical Package for Social Sciences (SPSS 26.0 edition), Minitab 2019, and Microsoft Excel 2016 were used to analyze the data.

3. Results and Discussion

3.1. Demographic and Socioeconomic Characteristics

The demographic characteristics of seaweed farmers in Valaippadu reveal that the activity is both household-centred and labour-intensive (Table 1). Women make up most farmers (62.5%), reflecting seaweed farming's strong potential as a vehicle for female economic participation, while men also play an important role in farming operations and household income generation (Table 1). This finding is consistent with studies from Tanzania and other developing regions, where seaweed farming contributes significantly to female economic participation (Msuya, 2011; Msuya & Hurtado, 2017).

Most respondents were aged 21–60 years (Table 1). The survey did not directly assess whether physical labour requirements explain the age distribution. The relatively low participation of individuals above 60 years was also observed in other regions (Immanuel & Sathiadhas, 2004; Msuya, 2006)

Educational background among farmers is relatively high, with most having completed secondary or ordinary level education (Table 1). This may enhance their ability to adopt improved farming practices and respond to market opportunities. In contrast, lower education levels have been reported in some other seaweed farming communities (Marino et al., 2019).

Seaweed farming serves as the primary occupation for more than half of the respondents (54.5%), seaweed-only occupation (58.0%), and full-time work (56.8%), while others combine it with fisheries or alternative income-generating activities (Table 1). Before its introduction, many households lacked stable income sources, highlighting the role of seaweed farming in livelihood diversification. Similar patterns have been reported in Indonesia and India (Waters et al., 2019; Narayanakumar & Krishnan, 2013).

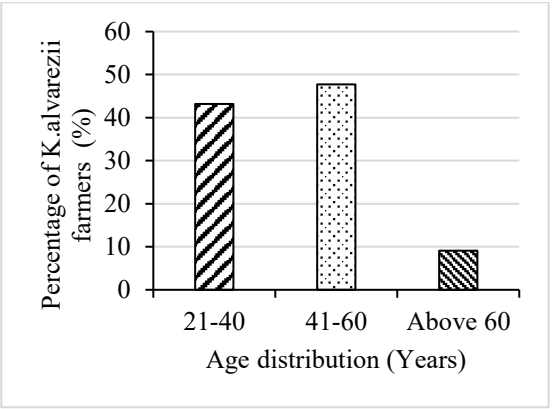

Figure 2. Age distribution of *Kappaphycus alvarezii* farmers in Valaippadu, Sri Lanka. (n=88)

Income distribution further emphasizes its economic importance. Most farmers earn between LKR 100,000 and 500,000 annually (Table 1). These findings demonstrate that seaweed farming is a viable and sustainable income-generating activity in rural coastal communities (Aslan et al., 2018; Ginigaddara et al., 2018; Seneviratne et al., 2026).

Table 1. Demographic characteristics of seaweed farmers in Valaippadu (N = 88)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	33	37.5
	Female	55	62.5
Age group (years)	21–40	38	43.2
	41–60	42	47.7
	>60	8	9.1
Marital status	Married	81	92.0
	Single	7	8.0
Household size (persons)	1–2	8	9.1
	3–5	53	60.2
	6–8	26	29.5
	>8	1	1.1
Education level	Primary	3	3.4
	Secondary	18	20.5
	Ordinary Level (O/L)	59	67.0
	Advanced Level (A/L)	8	9.1
Primary occupation	Seaweed farming	48	54.5
	Fisheries	33	37.5
	Agriculture	2	2.3
	Other	5	5.7
Employment status (before seaweed farming)	Unemployed	33	37.5
	Fisheries	2	2.3
	Agriculture	5	5.7
	Other	48	54.5
Annual household income (LKR)	<100,000	6	6.8
	100,000–300,000	46	52.2
	300,001–500,000	27	30.7
	500,001–600,000	6	6.8
	>600,000	3	3.4

According to Figure 2, most farmers belonged to the active age groups of 21–40 years (43.2%) and 41–60 years (47.7%), while only 9.1% were above 60 years. This indicates that economically active adults mainly practice seaweed farming due to the labour-intensive nature of the activity.

3.2. Farming System and Experience in Seaweed Farming in Valaippadu

3.2.1. Farming System in Valaippadu

Seaweed farming in Valaippadu has evolved into a well-established, community-based livelihood since its introduction in 2012 (Shanmugam et al., 2017). *Kappaphycus alvarezii,* a commercially significant red seaweed, is often grown in tropical coastal locations and is the only species farmed in the Valaippadu area (Rajapaksha et al., 2025).

Although culture durations of 45–60 days have been reported in other seaweed farming contexts [Shanmugam et al., 2017], 94.3% of the farmers surveyed in Valaippadu reported crop durations of six weeks or less. (Table 2). Cultivation is predominantly carried out using the monoline method (65.9%), while a smaller proportion of farmers employ ladder and mixed farming techniques (Table 2). These low-cost and relatively simple farming methods are consistent with practices reported in major seaweed-producing countries

such as Indonesia, the Philippines, and Tanzania (Valderrama et al., 2015; Msuya, 2006).

Farm management involves regular monitoring, usually 2–4 times per week, to remove epiphytes, debris, and damaged culture structures. Harvested seaweed is sun-dried for approximately one week before being sold to private companies through local coordinators. The absence of post-harvest processing beyond drying indicates that farmers are mainly engaged in primary production, limiting value addition at the community level (Table 3)

3.2.2. Farming Experience in Valaippadu

Seedling supply is primarily based on self-propagation from previous harvests from their own farm (46.6%) or exchange among farmers (Table 2), reflecting a cost-effective and locally sustained system. However, such practices may increase susceptibility to disease transmission if not properly managed. Furthermore, there have been reports of poor performance of commercial germplasm used in the same cultivation systems (Munisamy et al., 2023).

Most farmers (56.8%) are engaged in seaweed farming on a full-time basis, while the remainder practice it part-time (Table 2), indicating its importance as both a primary and supplementary livelihood strategy. Training exposure is moderate, with most farmers having received some form of training, mainly from private sector organizations (Table 2). Nevertheless, a considerable proportion of farmers lack formal training, which may constrain productivity and the adoption of improved techniques. Similar limitations in extension services have been documented in other seaweed farming regions (Marino et al., 2019).

3.3. Socioeconomic Impacts of Seaweed Farming

3.3.1. Social Benefits

In addition to economic gains, seaweed farming has positively influenced the social well-being of farmers. Respondents reported improved ability to support their children's education, participate in social and religious activities, and enhance overall living standards. A large proportion of respondents (88.6%) reported that income generated from seaweed farming improved educational opportunities for their children, consistent with findings from Tanzania, Indonesia, and the Philippines (Marino et al., 2019).

Furthermore, seaweed farming may provide an alternative livelihood opportunity within coastal communities, potentially reducing the economic pressures that encourage rural–urban migration. However, the present study did not directly assess migration patterns or establish a causal relationship between seaweed farming and migration reduction. This potential benefit is consistent with previous studies highlighting seaweed farming as a coastal livelihood option (Zamroni & Yamao, 2011; Rajapaksha et al., 2025), a pattern that aligns with fishers' generally positive perceptions of seaweed farming as a coastal livelihood option in other Indonesian studies (Zamroni & Yamao, 2011). This is particularly significant in remote areas such as Valaippadu, where alternative employment opportunities are limited (Ginigaddara et al., 2018).

3.3.2. Economic Benefits

Seaweed farming has contributed significantly to improving the economic status of households in Valaippadu. Farmers reported increased income levels and enhanced purchasing power, enabling investments in assets such as livestock, household appliances, vehicles, and housing improvements. Previous studies have identified seaweed farming as a low-cost, high-return livelihood option suitable for resource-limited communities (Ginigaddara et al., 2018; Waters et al., 2019).

3.4. SWOT Analysis of Seaweed Farming in Valaippadu

The internal and external factors influencing seaweed farming in Valaippadu are summarized in Tables 3 and 4

Table 2. Seaweed farming characteristics in Valaippadu (N = 88)

Variable	Category	Frequency (n)	Percentage (%)
Occupation pattern	Seaweed farming only	51	58.0
	Seaweed + fisheries	33	37.5
	Seaweed + other	4	4.5
Seaweed income (LKR/year)	≤100,000	15	17.0
	100,001–300,000	52	59.1
	300,001–500,000	18	20.4
	>500,000	3	3.4
Work involvement	Full-time	50	56.8
	Part-time	38	43.2
Training received	None	30	34.1
	Private sector training	54	61.4
	Other training	4	4.5
Farming method	Monoline	58	65.9
	Ladder	6	6.8
	Mixed	24	27.3
Seedling source	Own stock	41	46.6
	Own + others	29	33.0
	Other farmers	18	20.5
Production cycles/year	2–3	17	19.3
	4–5	49	55.7
	6–7	22	25.0
Crop duration (weeks)	≤6	83	94.3
	7–8	3	3.4
	≥9	2	2.3
Financial support	Own funds	59	67.0
	Microfinance	6	6.8
	Government banks	8	9.1
	Private sector	8	9.1
	Money lenders	7	8.0
Satisfaction level	Highly satisfied	13	14.8
	Satisfied	66	75.0
	Neutral	4	4.5
	Not satisfied	4	4.5
	No answer	1	1.1

3.4.1. Strengths and Weaknesses

Internal factor analysis (Table 3) reveals that extensive farmer experience, strong community cooperation, and family involvement are key strengths of the sector. In contrast, limited technical knowledge, inadequate market awareness, and poor post-harvest practices are identified as major weaknesses that constrain productivity and profitability (Ginigaddara et al., 2018)

Table 3. Internal factors (strengths and weaknesses) affecting seaweed farming

Factor	Code	Description	Weight	Rating	Score
Strengths	S1	Long-term farming experience (>10 years)	0.10	3	0.30
	S2	High farmer participation	0.07	3	0.21
	S3	Continuous production cycles	0.08	2	0.16
	S4	Strong labor availability	0.05	2	0.10
	S5	Large-scale farming area	0.05	2	0.10
	S6	Simple and low-cost farming method	0.07	2	0.14
	S7	High product quality	0.05	1	0.05
	S8	Family involvement	0.08	2	0.16
Weaknesses	W1	Limited technical knowledge	0.11	3	0.33
	W2	Poor market awareness	0.09	3	0.27
	W3	Weak post-harvest practices	0.08	2	0.16
	W4	Poor transport infrastructure	0.06	2	0.12
	W5	Inadequate farm maintenance	0.05	2	0.10
	W6	Non-compliance with regulations	0.02	1	0.02
	W7	Limited financial capital	0.04	2	0.08

*Weight. A number from 0.01 (not important) to 1.0 (very important) should be assigned to each strength and *Weakness. The sum of all weights should equal 1.0

Table 4. External factors (opportunities and threats)

Factor	Code	Description	Weight	Probability	Score
Opportunities	O1	Alternative livelihood during crises	0.08	1	0.08
	O2	Government support and subsidies	0.11	2	0.22
	O3	Market awareness potential	0.11	3	0.33
	O4	Value addition opportunities	0.12	3	0.36
	O5	Private sector support	0.09	2	0.18
	O6	High global demand	0.11	2	0.22
	O7	Favourable natural conditions	0.11	2	0.22
Threats	T1	Climate variability	0.10	3	0.30
	T2	Economic instability	0.06	1	0.06
	T3	Disease outbreaks (ice-ice)	0.11	3	0.33

3.4.2. Opportunities and Threats

External factor analysis (Table 4) highlights increasing global demand for seaweed products, government support, and opportunities for value addition as major growth drivers. However, climate variability, disease outbreaks such as "ice-ice," and economic instability pose significant threats to the sustainability of the sector (Rajapaksha et al., 2025).

3.3.4. Strategic Implications

The SWOT analysis (Table 3 and Table 4) suggests that strengthening farmer training, improving market access, and promoting value-added processing are critical strategies for enhancing the resilience and profitability of seaweed farming. Addressing infrastructural constraints and improving extension services will further support sustainable sector development.Figure 3 summarizes the major livelihood outcomes associated with seaweed farming in the Valaippadu community based on the findings of the present study. The figure demonstrates that increased farmer income generated through *K. alvarezii* cultivation acts as the central driver of livelihood improvement. Higher income levels enabled farmers to meet household expenses, improve purchasing power, support children's education, and enhance health and living conditions. The study revealed that most farmers considered seaweed farming as either a primary or supplementary source of income, highlighting its importance in strengthening household economic stability.

The figure further illustrates that improvements in education and health contribute to broader social development within the community. Increased educational opportunities for children, improved participation in social activities, and better living standards were commonly reported by respondents. In addition, seaweed farming has created employment opportunities for coastal households, particularly for women and previously unemployed individuals, thereby reducing dependence on traditional fisheries and seasonal income sources. These outcomes collectively contribute to improving livelihoods, enhancing social capacity, and promoting stronger farmer organizations.

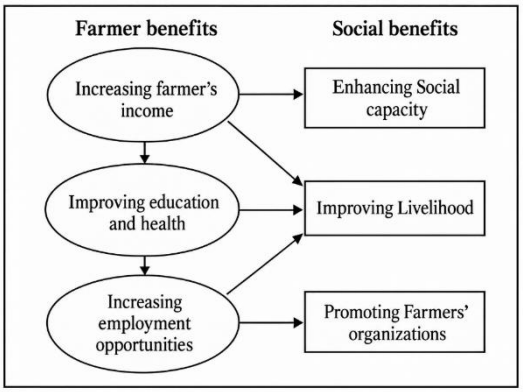

Figure 3. Conceptual framework illustrating the socio-economic benefits of seaweed farming for coastal farming communities (adapted from Msuya & Hurtado, 2017; Ginigaddara et al., 2018 and Mirera et al., 2020)

4. Conclusions

This study revealed that *Kappaphycus alvarezii* farming is an important livelihood activity for the 88 surveyed farmers in Valaippadu, Sri Lanka. Among respondents, 58% depended exclusively on seaweed farming, while 59.1% earned LKR 100,001–300,000 annually from this activity. Furthermore, a combined 89.8% of respondents reported being satisfied (75.0%) or highly satisfied (14.8%) with seaweed farming (Table 2), while 88.6% reported perceived improvements in educational opportunities for their children.

However, limited technical knowledge, inadequate market awareness, poor post-harvest practices, disease outbreaks, and climatic variability were identified as major constraints. Strengthening technical training, extension services, market access, and quality seedling supply could help address these challenges. Although farmers reported positive livelihood benefits, these findings are based on self-reported data from a single village and do not establish independently verified improvements in living standards or represent other coastal communities in Sri Lanka.

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Author contributions

A.J. Jensiya: methodology, data curation, formal analysis, writing – original draft, B.V.A.S.M. Bambaranda: conceptualization, methodology, supervision, writing – review & editing. J.A. Athula: conceptualization, methodology, supervision, writing – review & editing. B. Nirooparaj: conceptualization, methodology, supervision. R. Ruangchuay: conceptualization, methodology, supervision, writing – review & editing.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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Data availability

The data are available from the corresponding author upon reasonable request.

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