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RESEARCH ARTICLE

Primary trader preferences for participating in high-value markets in Black Pepper- A choice analysis

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Abstract

Facilitating the integration of primary traders into modern agricultural value chains, known as high-value markets (HVMs), presents a promising avenue for improving the sustainability of black pepper value chains in Kerala. Due to increased price volatility and risk exposure in trading conditions, primary traders are hesitant to prioritize quality aspects in their procurement decisions. A Best-Worst Scaling (BWS) experiment was employed with traders in the Agro-ecological units (AEUs) 12, 14, 15, 16, 17, 19, 20 and 21 of Kerala to comprehend their preferences regarding quality attributes that could promote sustained participation in HVMs. This study incorporates a unique aspect by examining the consistency of choices between the best and worst options, providing deeper insights into traders' decision-making processes and ensuring an accurate evaluation of preferences by minimizing biases. The choice experiment utilized fractional factorial and balanced incomplete block designs. The results indicate that traders predominantly favour a flexible, incentive-based pricing model and long-term formal relationships with buyers. Conversely, traders consistently rated premium payments and certification as the least favourable market attributes. Preference variations were influenced by traders' experience, income levels and location. The results reveal that primary traders possess the least understanding of factors that may facilitate their entry into HVMs. Our findings underscore the significance of educating traders on crucial market attributes that facilitate their participation in HVMs. Further research on their willingness to adapt to the requirements of HVMs to maximize the benefits to the system.

Keywords

black pepper; choice analysis; HVMs; primary traders' preferences; spice

Introduction

Trader preferences in agricultural markets are crucial for determining supply and demand dynamics, particularly for commodities like black pepper. Although traders play a crucial role in both local and global food systems, there is a significant lack of public information about their activities. While consumers initiate the food value chain, traders are essential for driving market expansion (1). The role of traders in market development should not be underestimated. They serve as a vital link between consumers and producers, continuously adapting to changing consumer preferences. For example, changes in consumer preferences, driven by shifts in income levels, lifestyle choices or food safety concerns (2) need to be communicated to producers by traders.

Several factors influence India's black pepper market, including quality, pricing and consumer trends (3). Quality is paramount; attributes such as size, appearance and moisture content significantly influence perceptions of value. Traders often seek uniformity in size and a rich aroma - which are indicators of quality that can command higher price. Kerala is recognized as a major producer of for its significant black pepper, production, contributing 32.60 % of India's total output (5). As of 2022-23, India had over 278, with an estimated production of 64000 tons (6). In 2022-23, India exported 17,958.26 MT of black pepper, valued at Rs. 72686.4 lakhs (7). However, the export value followed a different pattern, decreasing from 82078 lakhs in 2017-18 to 54446 lakhs in 2020-21, before increasing to 72686.4 lakhs in 2022-23 as shown in Fig .1.

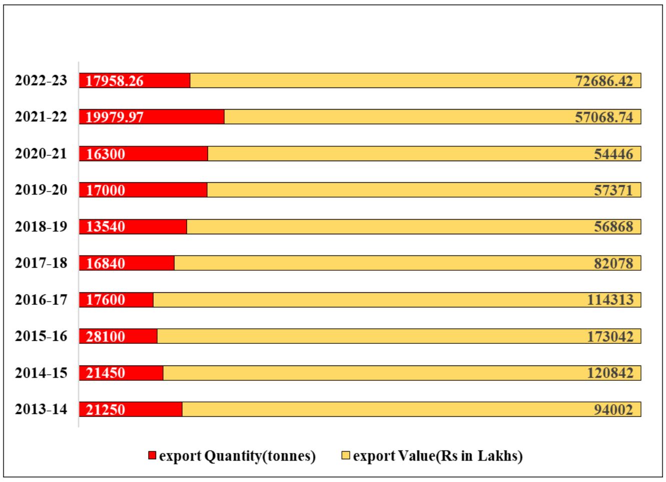

Fig. 1. Trend in export of pepper in India for the last 10 years.

Integrating primary traders into modern agricultural value chains, referred to as high-value markets (HVMs), offers a promising approach to enhancing the sustainability of black pepper value chains in Kerala. While black pepper, as a standard commodity, is typically not segmented into multiple products in general market transactions, high-value products (HVPs) significantly differ in demand and command higher prices. HVPs refer to agricultural goods that, are more valuable than standard commodities due to processing or other factors (8). These products offer greater value to customers and yield higher profits for farmers compared to basic commodity crops. Specialty crops and value-added products are considered high value if successfully differentiated, allowing farmers to command premium prices and achieve higher earnings (9). Products HVPs are defined as those with lower volume and targeted towards personal care and pharmaceuticals (10). Applying a similar framework to black pepper, high value products include white pepper and its derivatives, green pepper-based items, premium-quality pepper berries with detailed farm or place-of-origin information, fair-trade black pepper, organically certified black pepper, spice blends incorporating black pepper for various cuisines, ground black pepper and black pepper oleoresin and oil.

Black pepper oleoresin is in high demand within the nutraceutical and food industries due to its convenience in producing standardized blends and its resistance to microbial and fungal contamination (11). The domestic nutraceutical and food sectors are also increasingly shifting toward oleoresin over generic products. Spice technology companies source supplies from both domestic and international markets to meet their demands. Recent export trends in from India shows a rise in black pepper oleoresin exports, while black pepper oil exports are declining (12). Engaging in HVMs offers farmers the opportunity to significantly boost farm income by capitalizing the higher profits available in these markets (13). However, many smallholder farmers in developing countries continue to face difficulties in maintaing a consistent presence in HVMs. Recent empirical studies reveal that smallholders often exit HVMs shortly after entering because of significant post-entry transaction risks (14-16).

Traders play a pivotal role in shaping the food business ecosystem. Smallholder farmers in Kerala primarily sell their produce to primary traders (Malancharak Vyaparikal) before it moves through subsequent value chains. Research suggests that producers collaborating with traders are more likely to sustain and grow their businesses than those who do not (17, 18). High-value markets for black pepper from Kerala require strict quality standards throughout the value chain to meet customer expectations and sustain demand. Therefore, integrating traders into the value chains of high-value markets in developing countries is essential for ensuring farmers' continued participation in these markets.

Beyond monetary advantages, production systems for high value markets can have diverse ecological and social impacts. Ecologically, they may encourage sustainable farming practices, enhance biodiversity and mitigate environmental degradation. Socially, such systems can benefit local communities by offering fair wages, improving working conditions and promoting social equity, particularly when they align with certifications such as fair trade or organic standards. Despite this, there is a lack of information on traders' views regarding preferred transactional attributes that ensure their participation in HVMs. In this context, the current study examines the following research questions:

1. How are transactions between farmers and primary traders coordinated in Kerala's black pepper market?
2. What transactional attributes are crucial for sustained participation of primary traders in HVMs?
3. Are primary traders' preferences for black pepper consistent across Kerala?

Understanding traders' preferences can create the targeted interventions and strategies to enhance existing vertical coordination mechanisms, ensuring sustained involvement of both farmers and primary traders in HVMs. Insights into diversification and pricing opportunities within HVMs can help policymakers shape the farmer-primary trader transactional interface, thereby maximizing both monetary and social benefits derived from these markets.

Materials and Methods

2.1. Study area

The selection of study areas was guided by several key factors, with a primary focus on the significance of two districts in Kerala's black pepper production. Among Kerala's 14 administrative districts, Idukki and Wayanad were selected for their prominent roles in black pepper cultivation. Kerala is classified into 23 Agro-ecological units (AEUs) based on topography, soil types, climate patterns and vegetation cover. This classification acknowledges the varied nature of Kerala's terrain and the importance of integrating local environmental conditions into agricultural value chain studies. For this research, eight AEUs, specifically 12, 14, 15, 16, 17, 19, 20 and 21 were selected due to their extensive black pepper cultivation. The survey was conducted during the 2023-24 period.

A total of 120 primary traders were selected to participate in a Best-Worst Scaling (BWS) choice experiment aimed at evaluating their preferences for engaging in high-value markets for black pepper. The experiment was designed to assess the consistency of their preferences. Initially, a pilot survey was conducted in the study areas to collect information on market transactions attributes and vertical coordination mechanisms within the black pepper value chain. Based on the pilot survey, the research was refined to focus on attributes pertinent to primary traders in the study area, providing a comprehensive understanding of their decision-making processes related to sourcing and selling their produce.

2.2. Theoretical framework

Empirical research on preferences for transactional attributes in agricultural value chains primarily draws from Transaction Cost Economics (TCE), which emphasizes contracts as the primary coordination mechanism to mitigate the risks associated with participation in HVMs (20, 21). As a result, most studies focus on how value chain participants perceive various transactional attributes within the context of contracts as the coordination tool (22-24).

This review led to the identification of seven distinct attributes such as form of product sold, characteristics of farm owner, uncertainty on the transaction, asset specificity, uncertainty of product quality (drying method, threshing method, packaging method), cropping pattern and variety). These attributes were refined and validated through a pilot survey and expert interviews, which narrowed them down to four key attributes. These refined attributes aimed to capture the decision-making processes both before and after transactions. They represent critical factors that primary traders consider when deciding on sustained participation in HVMs. Additionally, a reference level was derived from the pilot survey, that defines the attribute position that an actor involved in decision-making is expected to attain.

The finalized set of attributes includes (A) familiarity with farm owners, (B) pricing options, (C) niche markets and (D) drying methods. Each attribute is further categorized into specific attribute levels. The attribute levels for attribute A are denoted as A_1, A_2 and A_3, while for attribute B, they are denoted as B_1, B_2, B_3 and so forth., which represent different conditions or characteristics within that attribute given (Table 1). These attribute levels were selected based on their relevance to real field conditions in the target regions.

2.2.1. Characteristics of buyers and markets

Familiarity with farm owners and an understanding of their social dynamics - such as trust, social networks, reputation and loyalty - highlight how these factors impact their engagement in HVMs (16). When these social elements are present in economic transactions, they result in favourable economic results not outcome (25). The market participants use these dynamics to address information asymmetry and market imperfections (26). Trustworthiness and a strong reputation are integral to ensuring good faith and overseeing the fulfilment overseeing the fulfilment of contracts between smallholders and buyer firms (27). Familiarity with buyers is categorized into three distinct preference levels: farm owners, absentee owners/commission agents and farmer producer organizations (FPOs). Farm owners typically engage in long-term, informal relationships with traders, characterized by ongoing transactions and a history of personal interactions that foster trust and familiarity.

Table 1. Selected attributes and attribute preferences for entering in

	Attribute	Preferences 1	Preferences 2	Preferences 3
A	Familiarity with farm owners	A_1. Farm owners	A_2. Absentee owners/ Commission agent	A_3. FPOs
B	Pricing option	B_1. Spot price	B_2.Seasonal highest price	B_3. Fixed premium price
C	Niche markets	C_1. Place of origin certificate	C_2. Fair trade certificate	C_3. Organic certificate
D	Drying method	D_1. Sun drying	D_2.Machine drying	D_3. Blanching and machine drying

In contrast, absentee owners delegate the sale of their produce to commission agents, with whom they lack personal relationships. Farmer Producer Organizations (FPOs), equity-based entities focused on aggregating and selling produce from primary producers, follow an agribusiness firm's dynamics. So, this preference level was included in the decision matrix to account for their role in the value chain. Pilot surveys revealed that trust is crucial in these relationships due to the absence of formal enforcement mechanisms, which can lead to opportunistic behaviour by both parties. Trust, in turn, influences various factors, including risk distribution, the trader's ability to switch farmers and decisions regarding investments in assets required to maintain high-quality production (28).

2.2.2 Uncertainty in the Transaction

The pricing options employed by value chain actors involve market uncertainty and transaction risks (29). We categorized three distinct pricing preferences: the spot price, the seasonal highest price and fixed premium price. The spot price reflects the current market rate at the time of sale; the seasonal highest price offers farmers the highest rate achievable during specific periods and the fixed premium price guarantees a predetermined minimum price agreed upon in advance by traders. While the fixed premium price provides smallholders with insurance against price volatility, it can disadvantage them if spot market prices exceed the agreed fixed rate (22).

In addition to pricing mechanisms, payment timing plays a crucial role in HVMs. Payments typically occur immediately after harvest - akin to traditional spot market conditions - or on a delayed basis, where farmers receive compensation at specified intervals after delivery (30). Another option involves partial payment before harvest, where a portion of the total payment is disbursed upfront and the remainder upon delivery of goods. Each payment structure has implications for cash flow management and risk mitigation for smallholders. Competition based on price and quantity differentiation can highlight the influence of factors such as product quality, branding and unique attributes on market dynamics and consumer preferences (31). This analytical approach provides insights into how differentiated products perform in competitive markets, aiding in strategic decision-making for both producers and buyers in HVMs (32).

2.2.3 Asset specificity

Asset-specific investments refer to the degree to which a firm's resource is tailored for a specific transaction and offers limited utility in alternative uses (20). In the context of niche markets, we focus on three distinct preferences: organic certification, fairtrade certification and place of origin certification. Organic certification verifies that that products are produced following stringent organic farming standards, ensuring minimal use of synthetic inputs and promoting environmental sustainability. Ensuring minimal use of synthetic inputs and promoting environmental sustainability. This certification grants farmers access to niche markets and aligns with consumer preferences for health-conscious, environmentally friendly products. Fairtrade certification provides farmers with mechanisms to manage price volatility and improve socio-economic conditions in their communities (33). By guaranteeing a minimum price and an additional premium, fairtrade-certified products empower farmers to reinvest in local development initiatives, thereby fostering sustainable livelihoods and community resilience (34). Place-of-origin certification emphasizes the traceability and authenticity of products, highlighting their geographical and cultural origins. This certification assures consumers of product provenance and quality, enhancing trust and perceived value in niche markets.

Certified farmers gain improved access to high-value markets through enhanced productivity, superior product quality and strengthened bargaining power, enabling secure, direct relationships with buyers (35). Certification labels serve as effective tools for brands to communicate the sustainability attributes of their products directly to consumers (36). The strategic adoption of certifications and sustainable practices enhances market access, builds consumer trust and improves socio-economic outcomes for farmers engaged in niche markets. By aligning with evolving consumer preferences and sustainability imperatives, firms can effectively differentiate their products and build resilient supply chains in competitive global markets.

2.2.4. Uncertainty about product quality

Product quality in HVMs encompasses specific standards regarding physical attributes like size, shape, tenderness and chemical properties such as the use of agricultural chemicals (37). One attribute that significantly influences product quality is the drying method employed. Drying methods are crucial in determining the uniformity of colour and moisture content expected in products sold within HVMs (38). The choice of drying method directly impacts the final product's sensory attributes and shelf-life stability.

We identified three distinct preferences for this attribute: sun drying, machine drying and blanching followed by machine drying. Sun drying utilizes natural sunlight to reduce moisture content, relying on ambient environmental conditions for the drying process. This traditional method is often preferred for its simplicity and low energy costs but, is sensitive to weather conditions, which can affect consistency in product quality. Machine drying employs mechanical equipment to control temperature and airflow, ensuring a more standardized drying process compared to sun drying. This method provides greater precision in moisture control and product uniformity, enhancing quality assurance and reducing variability in the final product. Blanching followed by machine drying involves a preliminary heating step (blanching) to deactivate enzymes and enhance colour retention, followed by machine drying to achieve desired moisture levels. This combined approach is favoured for products requiring specific colour attributes and extended shelf life, catering to stringent quality standards in HVMs.

Selection of appropriate drying methods is crucial for meeting consumer expectations and regulatory standards in niche markets (39). Factors such as sustainability, energy efficiency and the preservation of nutritional content are crucial when choosing drying methods, reflecting the broader trends toward eco-friendly and health-conscious consumer preferences. Optimizing drying processes is therefore essential for maintaining product competitiveness and market acceptance in HVMs, aligning with evolving industry standards and consumer demands for high-quality, sustainable agricultural products.

The wide range of market conditions analyzed in this study enables a comprehensive examination of various market attributes. According to the theory of bounded rationality (40-42), individuals often seek satisficing decisions rather than optimal ones. To address this decision-making scenario, we employed BWS, an alternative choice experiment method. This approach faciliatates a more detailed analysis of traders' preferences by capturing a wider range of relevant attributes related to HVMs, providing deeper insights into the factors influencing traders' decisions and their market participation dynamics.

2.3. Best-worst-scaling

Best-worst-scaling (BWS) is a survey-based technique employed to quantify individuals' preferences or attitudes concerning a defined set of attributes. It is characterized as a method for gathering preference data where respondents make successive choices across subsets of items (43). This approach offers insights into decision-making processes that are contextually relevant. In this study, BWS was chosen as the methodology due to its distinct advantages in assessing preferences and priorities. BWS facilitates systematic comparisons within sets of items, allowing respondents to identify both the most favourable and least favourable options (44). This capability yields more comprehensive data compared to conventional ranking methods (45). BWS enables the measurement of relative importance and preferences (46). Its capacity to quantify positive and negative evaluations provides deeper understanding of the underlying drivers of decision processes.

In addition to its methodological strengths, BWS was selected for its practical implementation and effectiveness in reducing respondent confusion when evaluating multiple profiles. BWS surveys are straightforward for participants, requiring them to select the best and worst options from a set of alternatives instead of assigning numerical rankings (47). This simplicity reduces the cognitive effort required of respondents, lowering the risk of survey fatigue or dropout and thereby improving response rates and data reliability. By prompting respondents to focus on identifying the best and worst options within each set, BWS reduces cognitive load and eliminates the potential confusion that can occur when ranking multiple profiles based on complex criteria.

2.4. Profile creation

A 3^4 orthogonal array (OA) was used to systematically generate profiles representing various combinations of factor levels for attributes related to familiarity with farm owners (A), pricing option (B), niche markets (C) and drying method (D). Each profile in the OA represents a unique combination of these attribute levels, facilitating structured experimentation and analysis. The use of orthogonal arrays offers several key advantages. Firstly, they enable the comprehensive exploration of diverse factor combinations efficiently, thereby minimizing the number of profiles required for the study (48). Additionally, OAs ensure a balanced distribution of factor combinations, ensuring adequate representation of each attribute and level. The OA was generated using the oa. design function from the DoE. base package (49) in R (50). The nine profile combinations are structured with attributes represented by columns and individual profiles by rows. In this structure, letters denote attributes (A, B, C, D) and numbers represents levels (1, 2, 3), as shown in Table 2. The nine profile generated by combining levels of attributes are further illustrated in Table 3 and Fig. 2 in a pictorial format.

2.5. Questionnaire

The questionnaire for this study was designed using the method (43), which involved developing a Balanced Incomplete Block Design (BIBD). A BIBD was created for 9 profiles (*v*) with 12 blocks (*b*) and each blocks having block size (*k*) of 6. Each profile was repeated (*r*) 8 times. Where each pair of the profiles was repeated (*l*) 5 times. It resulted in a BIBD with parameters ($v = 9$, $b = 12$, $r = 8$, $k = 6$, $l = 5$), expressed as a matrix with 12 rows shown in (Table 4) and three columns below. BIBD was created using the *find.BIB* function in *crossdes* package

Table 2. Orthogonal array showing 9 profiles generated through combining levels of attributes.

Profile	A	B	C	D
1	1	1	1	1
2	1	2	3	2
3	1	3	2	3
4	2	1	3	3
5	2	2	2	1
6	2	3	1	2
7	3	1	2	2
8	3	2	1	3
9	3	3	3	1

(Sailer, 2015; Sailer, 2022) in R (50).

To create the questionnaire, the treatment numbers in the BIBD (1, 2, ..., 9) were replaced with the corresponding profiles (Profile 1, Profile 2, ..., Profile 9) generated earlier. Each block now represented a choice set, consisting of 6 profiles. In total, 12 choice sets were generated, each comprising 6 profiles. Respondents were instructed to evaluate each choice set and select the best and worst options based on their preferences. This design allowed for efficient data collection while ensuring that each profile was evaluated multiple times across different choice sets. For example, the first-choice set consist of the profiles 1, 2, 6, 7, 8 and 9 and the 12th choice set consist of the profiles 1, 2, 3, 5, 8 and 9. A model choice set is given in (Fig. 3). The choice sets were presented to respondents as both pictorial and cards featuring options written in Malayalam, the vernacular language, facilitating comprehension and engagement with the decision-making process.

2.6. Statistical Analysis

2.6.1 Counting method

Consider that there are *P* profiles and *N* respondents. The counting approach calculates Best Worst Scale scores (BWS scores) based on the number of times (*i.e.*, the frequency or count) profile *i* is selected as the best (B_{ij}.) or worst (W_{ij}.) profile among all the questions for j^{th} respondent, where $i = 1, 2, \ldots, P$ and $j = 1, 2, \ldots, N$. An aggregated Best Worst score of i^{th} profile (BW_i) and mean standardized Best Worst score (meanstd.BW_i) is calculated for each profile using the equations (1) and (2) (51-53).The frequency with which profile *i* is selected as the best across all questions for *N* respondents is defined as B_i. Similarly, the frequency with which profile *i* is selected as the

Table 3. Nine profiles generated through combining levels of attributes.

Profile 1	Profile 2	Profile 3
I prefer to buy from the farm owner. I prefer to buy on spot price. I prefer to buy from a farmer who has place of origin certificate. I prefer to buy from a farmer who use sun drying method.	I prefer to buy from the farm owner. I prefer to buy at season highest price. I prefer to buy from a farmer who has organic certificate. I prefer to buy from a farmer who use machine drying method.	I prefer to buy from the farm owner. I prefer to buy on Fixed premium price. I prefer to buy from a farmer who has fair trade certificate. I prefer to buy from a farmer who use blanching and machine drying method.
Profile 4	**Profile 5**	**Profile 6**
I prefer to buy from the absentee owner. I prefer to buy on spot price. I prefer to buy from a farmer who produces organic certificate. I prefer to buy from a farmer who use blanching and machine drying method.	I prefer to buy from the absentee owner. I prefer to buy at season highest rate. I prefer to buy from a farmer who has fair trade certificate. I prefer to buy from a farmer who use sun drying method.	I prefer to buy from the absentee owner. I prefer to buy on Fixed premium price. I prefer to buy from a farmer who has place of origin certificate. I prefer to buy from a farmer who use machine drying method.
Profile 7	**Profile 8**	**Profile 9**
I prefer to buy from the FPOs. I prefer to buy on spot price. I prefer to buy from a farmer who has fair trade certificate. I prefer to buy from a farmer who use machine drying method.	I prefer to buy from the FPOs. I prefer to buy at season highest price. I prefer to buy from a farmer who has place of origin certificate. I prefer to buy from a farmer who use blanching and machine drying method.	I prefer to buy from the FPOs. I prefer to buy on Fixed premium price. I prefer to buy from a farmer who has organic certificate. I prefer to buy from a farmer who use sun drying method

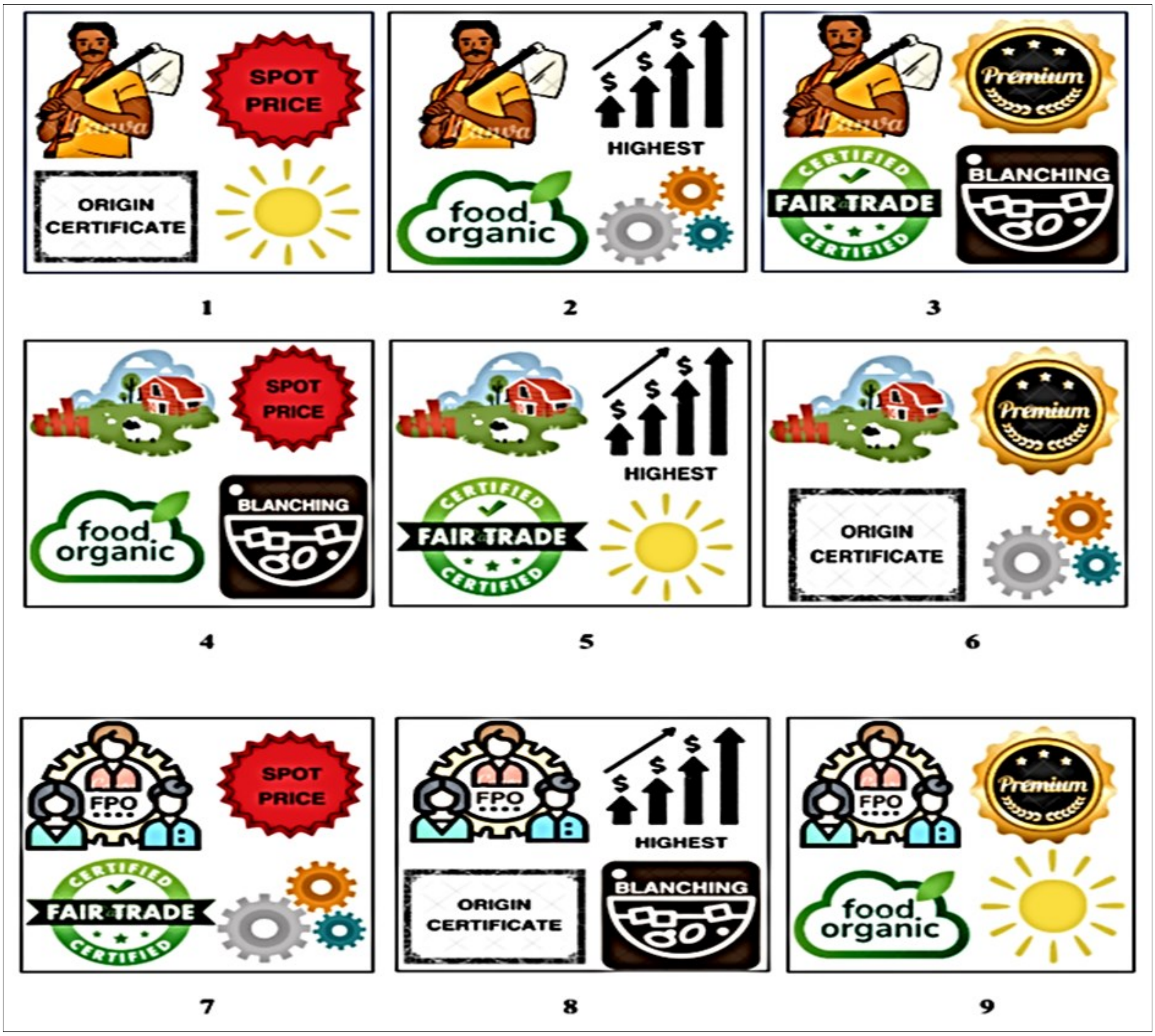

Fig. 2. Pictorial card of 9 profiles generated by combining levels of attributes.

Table 4. Balanced incomplete block design for questionnaire with 9 profiles arranged in sets of 6 across 12 choice sets.

Block	[1]	[2]	[3]	[4]	[5]	[6]
[1]	1	2	6	7	8	9
[2]	2	4	5	7	8	9
[3]	1	3	4	5	7	8
[4]	1	4	5	6	7	9
[5]	2	3	4	6	7	8
[6]	3	5	6	7	8	9
[7]	1	2	3	4	7	9
[8]	1	2	3	5	6	7
[9]	1	3	4	6	8	9
[10]	1	2	4	5	6	8
[11]	2	3	4	5	6	9
[12]	1	2	3	5	8	9

Fig. 3. A model choice set consisting of profiles 1, 2, 6, 7, 8 and 9.

worst item is defined as W_i. Where $B_i\Sigma^N_{j=1}B_{ij}, W_i=\Sigma^N_{J=1}W_{ij}$. *r* is the frequency with which profile *i* appears across all choice sets. A square root of the ratio of B_i and W_i for the i^{th} profile ($\sqrt{.}BW_i$) and standardized score is calculated using equation (3) and (4).

1) $BW_i = B_i - W_i$

2) $$\text{meanstd. } BW_i = \frac{B_i - W_i}{N_r}$$

3) $$\sqrt{.}BW_i = \sqrt{\frac{B_i}{W_i}}$$

4) $$std.sqrt.BW_i = \frac{sqrt.BW_i}{max.sqrt.BW_i}$$

Where max.$\sqrt{.}BW_i$ is the maximum value of $\sqrt{.}BW_i$. Profiles with higher BW_i scores and $\sqrt{.}BW_i$, accompanied by lower standard deviations std.BW_i and std.$\sqrt{.}BW_i$, exhibit more consistent and widely accepted preferences among respondents. Conversely, profiles with higher standard deviations may indicate greater variability in respondents' perceptions, suggesting diverse or polarized opinions regarding the desirability of those profiles. Hence, while high scores indicate favourable profiles, evaluating their standard deviations offers insights into the consensus or variability in respondents' preferences, aiding in the interpretation of the overall preference landscape. This suggests that profiles with high scores are perceived as more preferred attributes for engaging in high-value markets (HVMs).

2.6.2. Modelling Approach

In addition to analyzing responses at the profile level, it is imperative to gain clarity at the attribute level as well. This involves identifying the most preferred attribute levels to ensure a comprehensive understanding of respondents' preferences. By examining preferences at the attribute level, we can identify the specific attributes and attribute levels that are most favoured by respondents. Understanding the preferred attribute levels allows for the exploration of alternative combinations that align with respondents' preferences. The modelling approach employs discrete choice models to analyze the responses, with the dataset formatted according to the selected model specifications. Specifically, a maximum difference (maxdiff) model, is utilized for the analysis (54). This model assumes that respondents derive utility from each profile within a choice set and select the best and worst profiles based on their subjective utilities. In the maxdiff model, respondents are assumed to select profile *i* as the best and profile *j* (where $i \neq j$) as the worst because the difference in utility between these two profiles represents the greatest utility difference among all possible pairings. The number of utility differences in a pair is given by the total number of possible pairs in which profile *i* is chosen as the best and profile *j* is chosen as the worst out of *P* profiles, calculated as $P \times (P-1)$.

The probability of selecting profiles from a choice set S for each model can be represented using the conditional logit model. Under assumptions such as a choice set consists of nine profiles S = {1, 2, 3,…,9} respondent *k* selected Profile *i* as the first best (FB), Profile j as the first worst (FW). Where $i \neq j = 1, 2, \ldots, P$ and $k = 1, 2, \ldots, N$. then the probability can be expressed using the equation 5

5) $$\Pr(FB=, WB=) = \frac{\exp(v_i - v_j)}{\sum_{i,j \in S, i \neq j} \exp(v_i - v_j)}$$

Where $V_i = X'_i\beta$; x'_i is a vector of attribute-level variables for profile *i*; and β is a vector of the coefficients to be estimated.

Results and Discussion

The best worst scores were calculated using equations 1, 2, 3, and 4 and the results are presented in (Table 5) below. The profiles were ranked accordingly based on the mean BW_i, mean std.BW_i and sqrt.BW_i values.

The scatter plot in (Fig. 4), depicting the mean BWS score against the standard deviation of respondents' preferences, offers insights into the variability of preferences for different attribute represented by the profiles. Profile 1 (farm owner, spot price, place of origin certification and sun drying) stands out with a notably high mean BWS score of 3.375. This indicates that it possesses a highly desirable attribute that strongly appeals to respondents, consistently receiving positive evaluations. As a result, Profile 1 emerges as a standout choice,

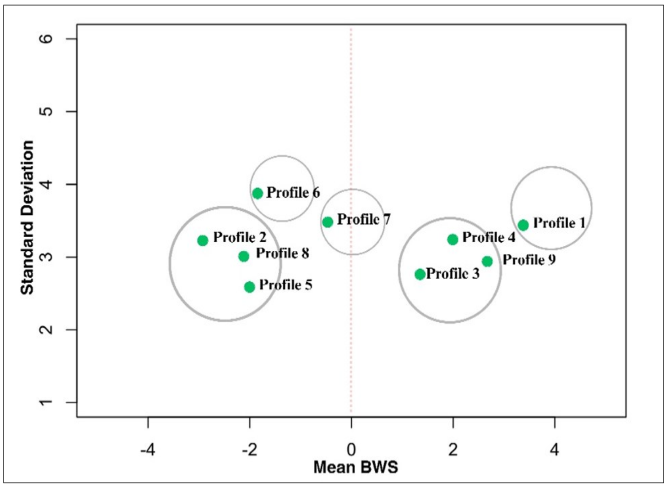

Fig. 4. Scatter plot based on mean BW_i and its standard deviation.

Table 5. Best worst score calculated based on the counting method for 9 profiles.

Profile	B	W	BW	Rank	meanBW	mean. stdBW	sqrtBW	std. sqrtBW
1	416	11	405	1	3.37	0.42	6.15	0.96
2	12	363	-351	9	-2.92	-0.37	0.18	0.03
3	183	24	159	4	1.32	0.17	2.76	0.43
4	275	34	241	3	2.01	0.25	2.84	0.44
5	13	256	-243	7	-2.02	-0.25	0.22	0.04
6	64	289	-225	6	-1.87	-0.23	0.47	0.07
7	119	173	-54	5	-0.45	-0.06	0.83	0.13
8	28	282	-254	8	-2.12	-0.26	0.31	0.05
9	330	8	322	2	2.68	0.34	6.42	1

reflecting a strong and widely accepted preference among respondents, in the context of HVM. In contrast, the majority of other profiles received negative or near-zero scores, indicating greater variability and ambiguity in respondents' perceptions regarding their effectiveness in participating in HVMs.

In addition to Profile 1, Profiles 9 (FPOs, fixed premium price, organic certification and sun drying), Profile 4 (absentee owner, spot price, organic certification and blanching and machine drying) and Profile 3 (farm owner, fixed premium price, fair trade and blanching followed by machine drying) also demonstrated positive BWS scores, indicating their effective participation in HVMs. These profiles are grouped closely together in the plot, following Profile 1, with BWS values of 2.683, 2.008 and 1.325 respectively. This clustering suggests that these profiles share similarities in their perceived efficacy and appeal among respondents. Profile 1 has high standard deviation indicating a varied response among the respondents. Profile 2 (farm owner, seasonal highest price, organic certificate and machine drying) is the least preferred with BWS score of -2.925. Fig. 5 displays the rank order arrangement of the profiles along with their meanstd.BW_i scores, effectively summarizing

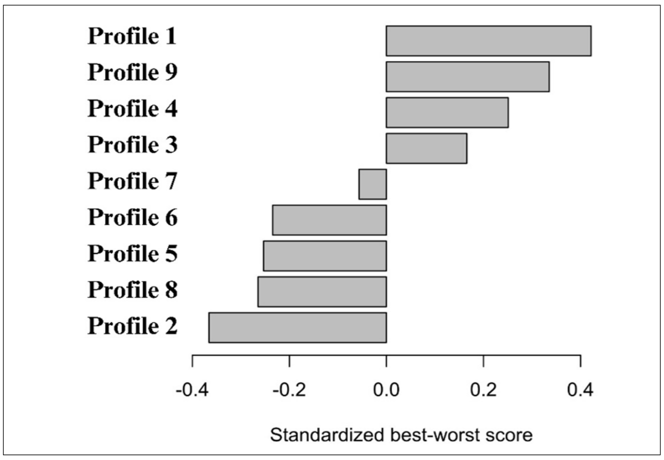

Fig. 5. Rank order arrangement of profiles along with meanstd.BW_i.

the findings. From Fig. 6, it is clear that profile 1 has fewer negative BW scores and it is noteworthy that Profile 9, 4, 3 has also achieved a maximum BW score frequency value of 7 for several respondents but also gained considerable high negative values indicative of mixed responses.

A utility function is developed to fit a conditional logistic model to the responses based on the maxdiff model to study the attribute level preference. While constructing the utility function using the attribute levels (Table 1), the following attribute levels were considered as references. (A_2) absentee owner, (B_2) seasonal highest price, (C_1) place of origin certificate, (D_2) machine drying is considered as a reference for dummy variables. These attribute levels were considered as reference levels considering the contextual factors in the study area.

By designating specific attribute levels (A_2, B_2, C_1, D_2) as reference points, the utility function contrasts preference for other attribute levels with these references. This comparison enables the identification of how respondents' preferences deviate from or align with the chosen reference levels.

Accordingly, the systematic component of a utility function for the nine profiles ($i = 1, 2, \ldots, 9$) is as follows

$$V_1 = \beta_1 A_2 + \beta_2 A_3 + \beta_3 B_1 + \beta_4 B_3 + \beta_5 C_2 + \beta_6 + C_3 + \beta_7 D_2 + \beta_8 D_3$$

Where A_3, A_1, B_1, B_3, C_3, C_2, D_3, D_1 are dummy variable taking the value of 1 if i^{th} profile has the attribute level A_3, A_1, B_1, B_3, C_3 ,C_2, D_3, D_1 respectively, 0 otherwise; β s are coefficients (parameters) for these variables. Conditional logistic model is fitted using *clogi* function of *survival* package in R (50). The results of the conditional logistic regression analysis presented in (Table 6) provide insightful implications regarding the influence of different attribute levels on respondents' preferences for entering in high value markets. The highly significant coefficient (β_1) of 1.1026 associated with attribute level D_1(Sun drying) indicates a substantial positive impact on preference. This suggests that respondents are 3.0121 times more likely to favour attribute level D_1 compared to the reference level, emphasizing

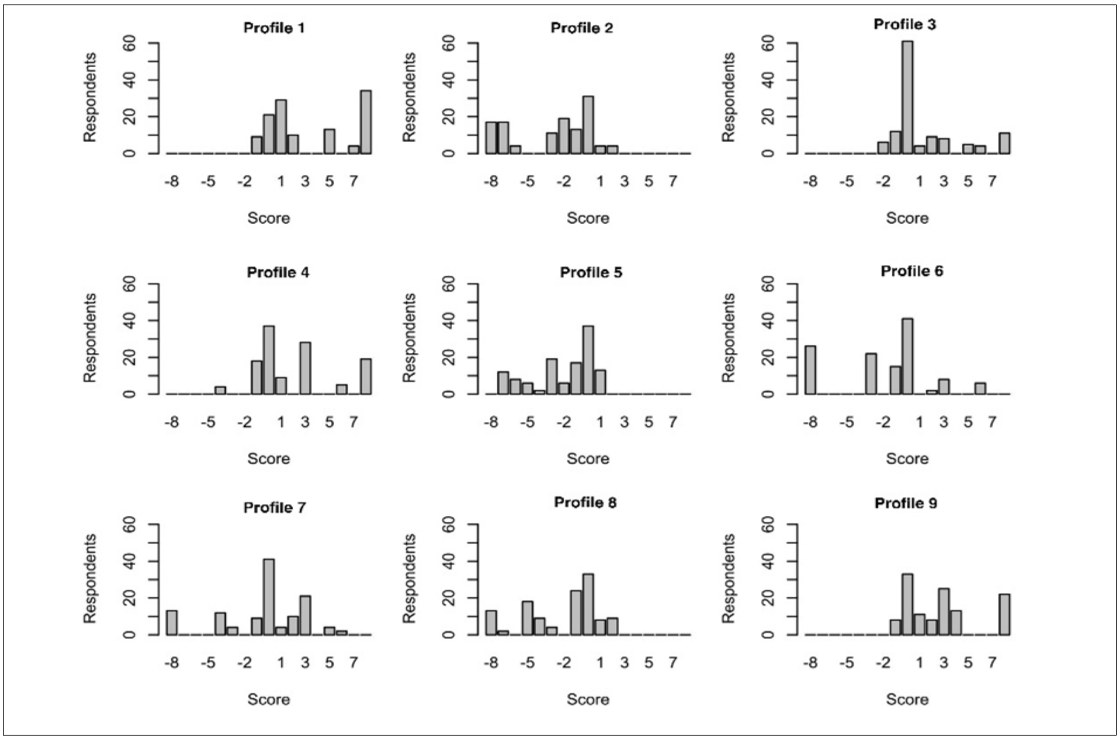

Fig. 6. Frequency of individual best worst (BW) scores of respondents.

Table 6. Conditional logistic regression results for attribute level prefer-

Attribute Level	β	se (β)	Odds ratio	Pr (>|z|)
A_3	-0.76	0.080	0.46	< 2e-16 ***
A_1	-0.15	0.071	0.86	0.0296 *
B_1	0.86	0.074	2.36	< 2e-16 ***
B_3	0.21	0.074	1.24	0.0044 **
C_3	-1.01	0.075	0.36	< 2e-16 ***
C_2	-0.22	0.074	0.80	0.0036 **
D_3	0.30	0.075	1.35	4.8e-05 ***
D_1	1.10	0.076	3.01	< 2e-16 ***

Note: ***denotes P<0.01, **denotes P< 0.05, *denotes P < 0.1

the perceived effectiveness of sun drying in entering in HVMs. In contrast, attribute levels A_1, A_3, C_2 and C_3demonstrate significant negative effects on preference with odds ratio less than 1 (one) when compared to reference level, indicating that respondents are less inclined to favour these levels compared to the reference level.

Attribute levels A_1 (farm owners) and A_3 (FPOs) were less preferred than the reference level A_2 (absentee owners/ commission agents). This is likely due to the fragmented land holdings in Kerala and the lower production of black pepper, which making the primary traders reliant on commission agents. The pilot survey revealed that the primary produce from the farms of absentee owners, procured by commission agents, clearly impacts quality as the agent neglect quality aspects of individual lots, leading to mixed quality at the source. apart from produce of farm owners (who maintain the trust factor by supplying properly dried black pepper) and FPOs (who supply according to quality specification contracts), the product sourced from absentee owners' farms through commission agents significantly differ in quality. Apart from this, quality of the produce from owner farmers is not acknowledged. Thus, farm owners typically market their premium berries directly to specialty shops, agro-ecotourism ventures, supermarkets, or through vertically coordinated supply chains. The Peermade Development Society (PDS) helps link progressive farmers with HVMs through vertical coordination. While FPOs are designed for aggregation, jurisdictional regulations limit their effectiveness in the study area, keeping them in an early developmental stage. In these organizations, quality control is often managed by less experienced farmer members, which may not meet HVM standards.

Attribute levels B_1(spot price) and B_3 (fixed premium price) display significant coefficients with odds ratios greater than 1, reflecting a stronger preference for these options compared to the reference level B_2 (seasonal highest price). By opting for B_1, traders can take advantage of current market conditions and adjust their purchasing decisions based on real-time prices, offering more flexibility and potentially lower costs compared to the B_3. The spot market allows for more frequent adjustments, enabling traders to optimize their purchase intervals and respond swiftly to market changes, thereby balancing their risk and potentially enhancing their profitability.

This implies that traders favour the flexibility and immediate benefits of spot and fixed premium prices. The scenario of achieving the seasonal highest prices assumes that traders capable of navigating market volatility through participation in HVMs will choose this pricing model. However, the limited interest in this approach indicates that many traders lack the necessary infrastructure and technical expertise to effectively manage the price risks associated with black pepper trading. If traders were better equipped to handle price risks for primary produce, they could offer more favourable pricing models to farmers. Thus, along with training on scientific procurement practices, primary traders should be exposed to various aspects of risk management. This would enable them to provide more stable and competitive prices for farmers, ultimately encouraging greater participation in high-value black pepper markets.

Pilot-scale interventions, similar to those introduced by enterprises like Samunnati for options contracts, could further support black pepper farmers and traders in hedging risks and adapting to HVM standards. Together, these strategies underscore the need for a coordinated approach to improve quality, enhance pricing and market resilience for black pepper producers in HVMs. Further studies are also needed to identify promising risk management strategies relevant to the crop.

Attribute level C_3(place of origin certification) is preferred over organic and fair-trade certifications for sourcing black pepper from Kerala. Primary traders in HVMs favour produce from specific regions or hills, valuing place of origin tags more highly than other certification systems. This preference highlights the need for local audits and the implementation of place of origin certification measures. The government could facilitate this by collaborating with existing private laboratories or NGOs, such as the PDS, to set up quality testing and control facilities, offering subsidized rate for both farmers and traders. In contrast, fair trade and organic certification are less favoured due to the limited number of certified supply chains, which makes it challenging to meet the sustainable volume demands of HVMs.

Additionally, attribute level D_1 (sun drying) exhibits a highly significant odds ratio of 3.0121, signifying a strong preference among respondents. Attribute level D_3 (blanching and machine drying) also shows significant coefficients with odds ratios greater than 1, indicating a higher preference relative to the reference level. Even traders with access to machine drying facilities tend to prefer sun drying. Previous studies have showed that sun drying can enhance the retention of piperine due to its slower drying rates, which better preserves the compound. The higher temperatures used in mechanical drying may lead to the degradation of piperine, reducing its concentration (55). Given the increasing unpredictability of rainfall patterns in the area, traders can no longer rely solely on sun drying. This underscores the need for further research to explore and evaluate alternative drying methods.

Conclusion

The uncertainty in the prices of the primary commodity (black pepper) and its specific production processes for high-value products suggest that vertically coordinated hierarchical structures are ideal for the sustained participation of primary traders entering HVMs. However, choice analysis reveals profile and attribute level preferences for mechanisms with less control over transactions. Therefore, for sustained participation, it is crucial to coordinate transactions at the interface between farmers and primary traders through government interventions. Field studies and a questionnaire survey pre- and post-choice analyses, have reaffirmed that primary traders lack formal orientation and training regarding the quality requirements of high-value markets. It is also observed that primary traders, currently less trained in quality requirements and high-value market coordination, mainly serve domestic supply chains. Without their integration into high-value markets, the value chain may remain unsustainable. Consequently, there is a need for enhanced efforts to improve the knowledge, skills and attitudes of primary traders to achieve better coordination and performance in these high-value markets.

Investigating the impact of education and training programs on traders' decision-making and examining the role of technology in improving market access and efficiency for both traders and farmers would provide valuable insights. Exploring the effects of market policies and regulations on trading dynamics in the black pepper sector could help inform more effective strategies for community development. Action research on digital transformation and agroecological innovations would be critical in identifying models that enhance income opportunities for farmers and traders. To further strengthen the black pepper value chain, it is essential to streamline efforts between the Spices Board, Department of Agriculture and research stations, to avoid duplication of efforts for both farmers and traders. Integrating traders' expertise into the FPO ecosystem and promoting small-scale farm machinery through initiatives like SMAM for better post-harvest management would be beneficial. Establishing dedicated supply chains for single-origin, sole-cropped black pepper and encouraging startups in the spice sector to attract youth, drive innovation, economic growth and sustainability in the industry.

These findings are relevant to policymakers and stakeholders interested in enhancing coordination in high-value markets for black pepper and other spices in Kerala. Future research could investigate how socio-economic characteristics influence the choice analysis scores of primary traders. Analyzing the preferences of traders across different AEUs could provide additional insights. A similar analysis could be conducted for farmers to understand their willingness to participate in HVMs and the barriers they encounter.

Authors' contributions

SPK helped for the conceptualization, data collection, review and editing; PPG done the conceptualization, formal analysis, review and editing; NRCD helped for the conceptualization, data collection, documentation and original draft, review and editing; YC done the data collection formal analysis, documentation and original draft, review and editing; AT done the review and editing.

Compliance with ethical standards

Conflict of interest: The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Ethical issues: None

Declaration: During the preparation of this work the author used ChatGPT/ Quill Bot for paraphrasing some sentences.

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