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EXPLORING KEY COMPETENCIES DRIVING FARMERS' INNOVATIVENESS: AN ANALYTICAL HIERARCHY PROCEDURE APPROACH

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ABSTRACT

Agriculture faces a range of complex and interconnected challenges that impact its sustainability, productivity, and resilience. Farmers, often working on the frontlines of these challenges, are uniquely positioned to develop and implement innovative solutions tailored to their specific environments and needs. These innovations range from advanced crop management techniques and sustainable pest control methods to cutting-edge technology for precision farming and resource conservation. Farmers' innovativeness refers to their ability to generate, adapt, and implement new ideas, methods, and technologies in agriculture. It is important to know the factors determining farmers innovativeness to nurture it and to provide a congenial atmosphere to innovate further. This paper focussed on studying farmers innovativeness by using expostfacto research design with a sample of 30 experts. Of the five dimensions, Conceptual competencies were ranked first (0.32), followed by Learning competencies (0.29) and Strategic competencies (0.26). Major indicators across the dimensions were proactiveness (0.115), inquisitiveness (0.106), persuasive ability (0.103), profit orientation (0.100) and social networking (0.064). To validate the judgments given by the experts, inconsistency ratio was also calculated for all the indicators, and it was below 10% indicating the consistent judgements. Hence, these indicators may be employed to nurtured farmers innovativeness.

Keywords: *farmers innovativeness, AHP, competencies*

INTRODUCTION

Agriculture, the backbone of India's economy, ensuring livelihood for millions, encounters wide spectrum of challenges that impede growth and sustainability. From climate change-induced disruptions to systemic issues like fragmented landholdings and inadequate infrastructure, the sector is grappled with multirole hurdles. Major challenges faced by Indian agriculture are climate change, land degradation, water scarcity, low productivity, market access and price volatility, decreased labour availability due to unprecented migration. Farmers due to the changing agricultural scenario, have gone beyond the role of adopting the innovations developed by other stakeholders to developing their own innovations or modify the innovations introduced by external stakeholders in the innovation ecosystem to suit their socio-economic conditions. Farmers innovations are key for agricultural growth and development. Rölling (1994), Farmers are not solely passive recipients of ideas of scientific outcome but also are active experimenters and researchers. Farmers are creative in developing and testing new ideas (Kibwana, 2000). In the face of increasing challenges, rural farmers are becoming more innovative (Sanginga et al., 2009; Lekha et al., 2024; Patel et al., 2024). Farmers often involve in innovation development activities such as experimentation or modification of existing innovations to fit their local setting and creation of new technologies. (Reij and Waters-Bayer, 2001; Leitgeb et al., 2014). The process involving innovation adoption and generation practices by farmers is called innovation generating capacities (farmers innovativeness). It encompasses their creativity, problem-solving skills, and willingness to experiment with novel approaches to improve farming practices and address various challenges. Farmers innovativeness with respect the present study was defined as the ability of a farmer to create or modify or adopt a new practice/existing technology respectively farmer to suit his needs and improve the efficiency in various agricultural operations. Though there has been gaining interest in promoting farmers innovations, only little interest has been paid on the capacity of the innovation generating capacity of the farmer i.e. farmers innovativeness. Hence, present study was carried out to measure farmers innovativeness using an index in all facets. Factors determining farmers innovativeness were weighed by using analytical hierarchy method. AHP method has been employed in various fields including agriculture for instance for determining indicators of organic farming (Sajadian et al., 2017), SWOT analysis of climate smart agricultural practices (Singh and Devi, 2022),

farmers preferences for fodder trees (Mukherjee et al., 2018).

OBJECTIVE

To identify the factors determining farmers innovativeness by using AHP approach

METHODOLOGY

The present study was conducted in Telangana State purposively as researcher has been pursuing doctoral degree from the same state. A total of 50 respondents including the Extension professionals in MANAGE, NAARM, academicians and Subject matter specialists were selected. Research tool was a pairwise comparison questionnaire consisting five dimensions with indicators under each dimension. The proforma containing the indicators was given in the pairwise comparison form to the respondents. Respondents were contacted through E-mail & through direct interview for identifying and prioritising the factors determining farmers innovativeness. A brief introduction was given to respondents about AHP and how to rank the factors in the questionnaire. Respondents were asked to prioritize the dimension and factors, based on their importance in farmers innovativeness. Though, frequent contact and iterations were made, only 30 respondents including the Subject Matter Specialists, Experts and faculties have responded and identified the indicators. To know the differences between the factors, either group decisions or individual decision can be applied. As, it is difficult to bring together all the individuals' decision in the group, combining individual judgements can be used (Saaty, 1989). In this study, Arithmetic mean technique was used in combining individual judgments.

Tools and techniques

The weights for the factors were calculated by utilizing Analytical Hierarchy Process (AHP) technique. AHP was introduced by Prof. Thomas Saty is a practical methodology for complex decision making. In this study, Analytical Hierarchy Procedure (AHP) was carried out in a three-step procedure.

Step 1: Defining and Structuring of the decision problem into a hierarchical model

In this step, goal is defined, factors contributing to innovativeness were identified and the hierarchy from the top through identified criteria at the intermediate level and options at lower level was worked out.

Step 2: Constructing the pair wise comparison matrix

In this step, pair wise comparisons of factors determining the innovativeness are made. The number of judgements required for a matrix size n are n (n-1). Comparisons were made both for different dimensions and also for different indicators. For each comparison, respondents were asked to prioritize the importance of each dimension or the indicator of the farmers innovativeness on a 1–9 continuum scale. Pairwise comparison scale used in the study (adopted from Saaty, 2008) i.e. 1 stand for equal importance, 3 for weak importance, 5 for strong, 7 for very strong and 9 for extreme or absolute importance. Whereas, 2,4 and 6 are intermediate values.

Pairwise comparison was presented in a reciprocal matrix where relative weights is entered into the matrix and its reciprocal is entered on the opposite side of the main diagonal (adopted from Stainback et al. 2012 and Afroz et al., 2021). In the matrix, a_{ji} = and thus, when i=j a_{ij} =1. Each element in the upper level in a matrix is used to compare with the respective elements in the level below (Mukherjee et al., 2018).

$$A = (a_{ij}) = \begin{bmatrix} 1 & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & 1 & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & 1 \end{bmatrix}$$

The value of w_i varies from 1 to 9. For every indicator in a dimension, pairwise comparisons were carried out independently, and the Eigen value approach was used to calculate the priority value for each indicator. Indicators with greater priority value under each dimension were brought forward for comparison with the highest priority value indicators from other dimensions.

Step 3: Aggregation of judgements

The individual judgements should be aggregated with either arithmetic mean or geometric mean and aggregate values should be used for further analysis.

Step 3: Calculating the consistency

In the matrix A, some inconsistencies exist and are accepted. If there is no inconsistency in the matrix, the judgements made by the expert have been consistent. To calculate the consistency in the judgements, Saaty (1977) has given consistency index (CI) which is related to the eigenvalue method. The sum of the products of each element of the "Eigen vector" multiplied by the total number of columns of the reciprocal matrix yields the 'Eigen value' (max λ).

$$CI = \frac{\lambda_{max} - n}{n-1}$$

Where, n= no.of dimensions in the matrix

λ_{max} = maximal eigenvalue

λ_{max} is calculated by the following steps

(1) Based on the judgements, comparison matrix with relative weightage is constructed for all the indicators under each dimension. In the next step, column wise sum for each indicator is carried out.

(2) In the second step, another table is prepared by dividing score of inter-compared indicators with sum of each column. After calculating this score, scaling factor is calculated by taking average row score of each indicator.

(3) Then calculate the weighted sum by multiplying the scaling factor value with the corresponding column wise each cell value and the row wise summation should be made. Then divide the weighted sum obtained with the corresponding scaling factors. Average of all the values should be taken to get the λ_{max} value.

Consistency ratio should be worked out by the following formula

$$CR = \frac{CI}{RI}$$

Where, CI= Consistency Index and RI= Random index

Random indices are given by Saaty, 1977.

CI evaluates the level of consistency with respect to a comparison matrix. As a rule of thumb, CR value should be less than or equal to 10% . If the CR value is more than 10% then some of the comparisons should be repeated to remove the inconsistencies present in the comparison matrix.

Step 5 : Determining local and global priorities

(1) Local priority weights are calculated by dividing respective eigen vector value/Total of Eigen vectors (Eigen vector is the geometric mean of all the entries in the respective row)

(2) Global or overall priority of the criteria can be achieved by multiplying priority of the dimension with priority of the indicator within dimension.

Thus, results of the comparisons made are quantitative values expressing the priorities of the indicators and dimensions of farmers innovativeness.

RESULTS AND DISCUSSION

Indicators used in the present study were divided into five categories or dimension and the weights and relative weights of each indicator was determined by personal interview and using google forms. Analysis of data was carried out using Excel and NAARM AHP analyser software developed by Soam et al., (2023) and the results were presented as follows.

(1) Weight of dimensions

Weights of the dimensions of farmers innovativeness were first determined.

Table 1: Weights of dimensions (n=50)

Sr. No.	Dimension/Category	Weight	Consistency ratio
1	Strategic competencies	0.265	0.07
2	Conceptual competencies	0.323	
3	Opportunity competencies	0.073	
4	Learning competencies	0.298	
5	Situational competencies	0.041	

Table 1 and Fig 1 shows the weights of dimensions. Among all the dimensions, conceptual competencies ranked first with weight of 32.3 %, followed by learning competencies (29.8%), strategic competencies (26.5%), opportunity competencies (7.3%) whereas situational competencies weighted least (4.1%). This shows that conceptual competency is the most important dimension for farmers innovativeness. Conceptual competencies consist of decision-making ability, resiliency, information management behaviour, social networking, persuasive ability and self-determination. Learning competencies consist of research orientation, progressivism, profit orientation and inquisitiveness. Situational competencies consist of deferred gratification and social norm weighted least among all the competencies. Kumar et al., (2015) and Rohan and Vinaya (2022) studied factors determining progressiveness of the farmers. Their results showed that scientific orientation (0.860), risk taking ability (0.841), profit orientation (0.755), information seeking behaviour (0.703) and resiliency (0.662) were the most weighted indicators. Patel et al., (2024) revealed that achievement motivation, risk taking ability, decision making ability, scientific orientation, management orientation etc., are the components of entrepreneurial behaviour.

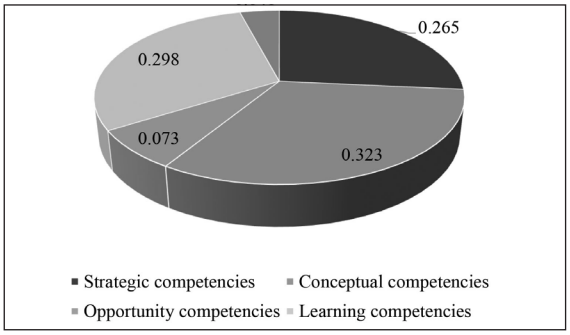

Fig 1: Weights of each dimension

(2) Weights of indicators

Table 2 and Fig 2 shows the values that correspond to each indicator's weight in relation to the other indicators in that category or dimension. Table 2 shows that proactiveness and change orientation had relatively high importance. Local priority/relative weight scores of proactiveness and change orientation are 0.435 and 0.172. Proactiveness is taking new initiative by anticipating and pursuing new opportunities. Individuals with proactive personalities possess greater extent of innovativeness as they identify opportunities, show initiative and they are oriented towards changes. Need or problem identification ability is also an important indicator as problems or needs are one of the major reasons behind innovations. Competition orientation is the least weighted indicator as farmer's often compete with self and adopt new technologies and innovate new technologies. Consistency ratio was 0.09 which is below the acceptable limit of 0.10. Hence, it can be inferred that the judgements were consistent.

Table 2: Relative weight of the strategic competency's indicators (n=50)

	Indicators	Local priority scores	Consistency Ratio
1	Resource use ability	0.106	0.090
2	Need/Problem identification ability	0.154	
3	Competition Orientation	0.036	
4	Change Orientation	0.172	
5	Proactiveness	0.435	
6	Persistence	0.097	

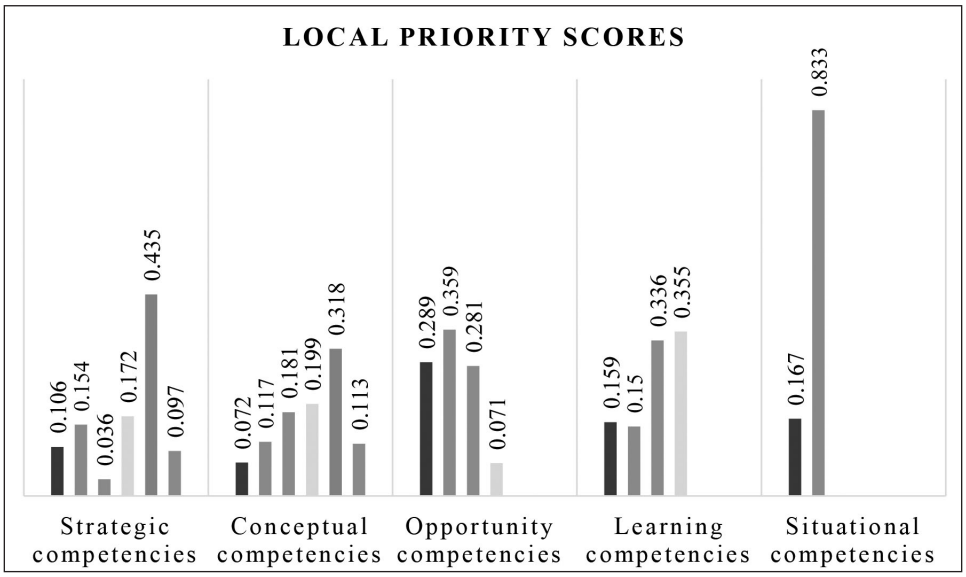

Fig 2: Relative weights/local priority scores of indicators under each dimension

Table 3 depicts the weightages of individual indicators under conceptual competencies. Among all the indicators, persuasive ability (0.318) weighted highest. Social networking (0.199) and information management behaviour (0.181) also have relatively high importance. Persuasive ability is the capacity of a farmer to influence an individual's the decision making pattern.. It will help or work for the farmers to accomplish their needs. Social networking is the extent to which one establishes and sustains social contacts. Farmers can always turn to those in their network for assistance and support. Though farmers have creative ideas, competence to develop innovations, but they also need complementary support to develop or to adopt innovations. Farmers often get support, knowledge and access to resources through their social networks. Hence, all the qualities are important to nurture farmer's innovativeness. Hence, it could be concluded that the relative importance or weightage of persuasive ability among other indicators in the category

was 31.80 per cent. The consistency ratio was 0.084 which is below the acceptable limit of 0.10 per cent.

Table 3: Relative weight of the conceptual competency's indicators (n=50)

	Indicators	Local priority scores	Consistency Ratio
1	Decision making ability	0.072	0.084
2	Resiliency	0.117	
3	Information management behaviour	0.181	
4	Social Networking	0.199	
5	Persuasive ability	0.318	
6	Self determination	0.113	

Table 4: Relative weight of the opportunity competency's indicators (n=50)

	Indicators	Local priority scores	Consistency Ratio
1	Technology orientation	0.289	0.079
2	Critical thinking	0.359	
3	Creativity	0.281	
4	Use of feedback	0.071	

Relative weights of each indicator under opportunity competencies were presented under Table 4. Critical thinking, technology orientation and creativity are the most important indicators with weightage of 0.359. 0.289 and 0.281, respectively. Critical thinking is the ability of an individual to use reasoning at the highest level of quality. Creativity is the tendency of an individual to generate or recognise ideas, alternatives or possibilities that may be useful in solving problems. Creativity is the spark that initiates innovation. Critical thinking influences innovativeness by enabling an individual to systematically evaluate and challenge existing methods or ideas. It is essential to assess the feasibility and potential of creative ideas to enhance their effectiveness and practicality. Being technology orientated leveraging technological tools and advancements to enhance or implement creative ideas. It enables individual to use modern tools to develop innovations. Feeback usage is also one of the important factors determining farmers innovativeness. Hence, it could be said that critical thinking is the most important indicator with weightage of 35.90 per cent. Khandave et al., (2022) reported that Decision making ability and self confidence were relevant with scale values of 6.99 and 4.66, respectively. The consistency ratio was 0.079 indicating consistent judgements.

Table 5: Relative weight of the indicators under learning competencies (n=50)

	Indicators	Local priority scores	Consistency Ratio
1	Research orientation	0.159	0.079
2	Progressivism	0.150	
3	Profit orientation	0.336	
4	Inquisitiveness	0.355	

As shown in Table 5, inquisitiveness is an important indicator under learning competencies. Inquisitiveness is the degree to which a farmer is curious for knowledge. Farmers with greater extent of innovativeness are more inclined to inquire so as to quench their curiosity, keen to investigate and learn new things. Profit orientation and research orientation are also relatively important indicators with weightage of 0.336 and 0.355, respectively. Profit orientation is the inclination towards maximizing financial returns from farming activities. It significantly influences the adoption of new technologies and creation of new technologies. Research orientation is the orientation towards an endeavor to discover new or collate old facts etc., by the scientific study of a subject or by a course of critical investigation. Farmers who are part of participatory research or on farm trials or farmers with research orientation generally are more inclined to engage in active experimentation and apply scientific knowledge to their farming practices. The inconsistency ratio calculated was less than 0.10 i.e., 0.079, indicates consistency among the judgements made.

Table 6: Relative weight of the situational competency indicators (n=50)

	Indicators	Local priority scores
1	Deferred gratification	0.167
2	Social norm	0.833

Table 6 shows the relative weightage of indicators under situational competencies. Social norm is the relatively most important indicator with weightage of 83.30 per cent. Social norm refers to the degree to which a farmer adheres to group-held beliefs and values and the degree to which his or her community or society approves of his or her behaviour. Innovativeness of farmer depends on how well the society approves of his/her innovative behaviour of the farmer. In environments where social norms favour creativity and innovation, individuals are encouraged to adopt, develop or modify innovations. Hence this indicator is considered quite crucial to analyse farmers innovativeness.

(3) Global priority scores of indicators

Table 7: Global priority scores between the indicators of different dimensions of farmers innovativeness

(n=50)

Sr. No.	Indicators	Global priority scores
X_1	**Resource use ability**	0.028
X_2	**Need/Problem identification ability**	0.041
X_3	**Competition Orientation**	0.009
X_4	**Change Orientation**	0.045
X_5	**Proactiveness**	**0.115**
X_6	**Persistence**	0.026
X_7	**Decision making ability**	0.023
X_8	**Resiliency**	0.038
X_9	**Information management behaviour**	0.058
X_{10}	**Social Networking**	0.064
X_{11}	**Persuasive ability**	0.103
X_{12}	**Self determination**	0.036
X_{13}	**Technology orientation**	0.021
X_{14}	**Critical thinking**	0.026
X_{15}	**Creativity**	0.020
X_{16}	**Use of feedback**	0.005
X_{17}	**Research orientation**	0.047
X_{18}	**Progressivism**	0.044
X_{19}	**Profit orientation**	0.100
X_{20}	**Inquisitiveness**	0.106
X_{21}	**Deferred gratification**	0.007
X_{22}	**Social norm**	0.034

Final weight of each indicator can be calculated after calculating the weights of the index dimensions as well as relative weights of the indicators under each dimension. This weight depicts each indicator's importance relative to the whole set of indicators across the dimensions. Table 7 and Fig 3 depicts the final weights of the indicators.

From Table 7 and Fig 3 it can be inferred that proactiveness, inquisitiveness, persuasive ability, profit orientation, social networking, information management behaviour, research orientation, change orientation and progressivism are the most important indicators with weights of 0.115, 0.106, 0.103, 0.100, 0.064, 0.058, 0.047, 0.045 and 0.044, respectively. Reshma and Sreedaya (2021) found that use of feedback (0.78), hope of success (0.74), knowledgeability (0.70), persistence (0.66), risk taking willingness (0.66), persuability (0.65) and self confidence (0.63) were the most important indicators in terms of entrepreneurship. Novanda et al., (2021) reported that creativity, internal locus of control, risk taking, feedback seeking and vision were the most important indicators of entrepreneurial characteristics with factor loadings of 0.605, 0.575, 0.568, 0.460 and 0.451, respectively. Singh et al., (2024) found that achievement motivation, decision making ability, economic motivation, risk taking ability, self-confidence, locus of control, planning ability and cosmopoliteness were the most relevant traits to measure entrepreneurial behaviour.

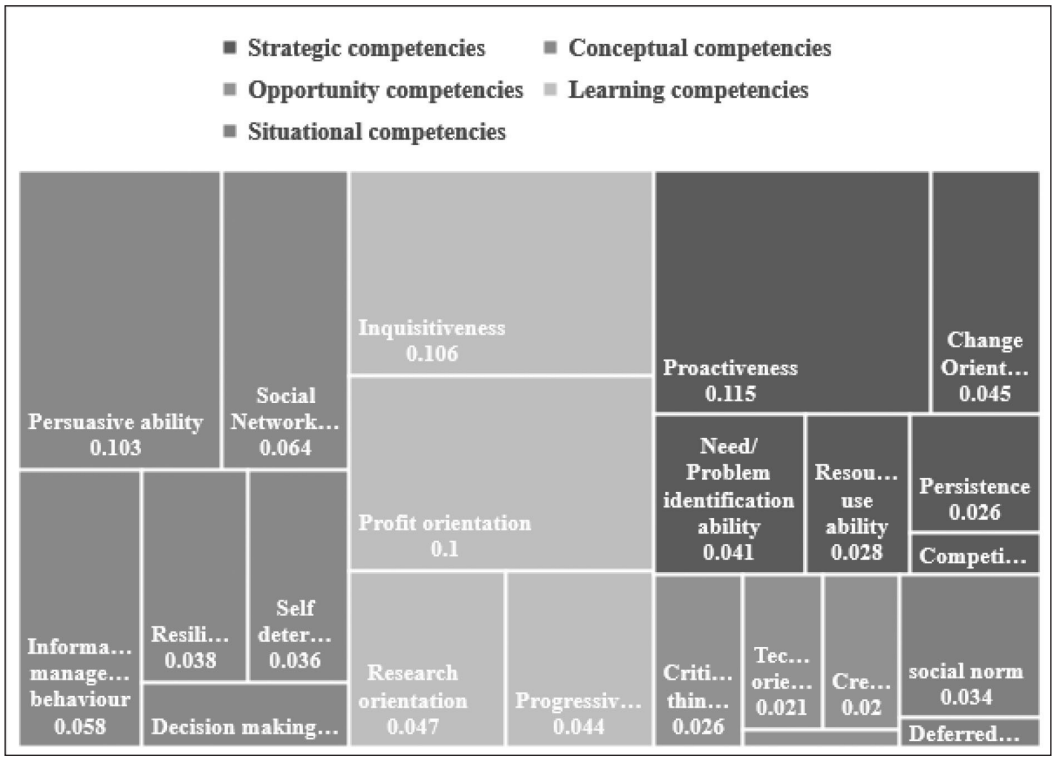

Fig 3: Global priority scores of individual indicators

CONCLUSION

Farmers innovativeness does not only specify the adoption of technologies introduced by research system, it also means the ability of the farmer to develop or modify the existing technology or innovations. Farmers innovativeness has been measured using an index with five dimensions and a set of indicators under each category. Total of 22 indicators were selected and weighted using AHP and the results indicate that all the indicators should be included. Indicators identified under each dimension have consistency ratio below 0.10 reflecting reliable judgement amongst the experts. Conceptual and learning competencies were relatively most important dimensions to measure farmers innovativeness. Of all the set of indicators across the dimensions, proactiveness, inquisitiveness, persuasive ability, profit orientation, social networking, information management behaviour, research orientation, change orientation and progressivism weighted highest. Hence, while measuring farmers innovativeness, these indicators should be considered and nurturing these indicators under each dimension may significantly influence the innovativeness of a farmer.

RECOMMENDATION

Farmers innovativeness can be measured with these indicators and any change in the indicators will bring a change in farmers innovativeness. Further, out of all the indicators, proactiveness, inquisitiveness, persuasive ability, profit orientation and social orientation had weighted highest. Weighing indicators in the way used in the study is highly region-specific, it should be noted that the perspectives of experts and farmers on farmers innovativeness differ across the world and employing the weights as in the study could affect the accuracy of inferences. However, the methodology is standard and can be used for similar studies.

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CONFLICT OF INTEREST

No conflict of interest

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