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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Challenges Of Precision Agriculture Application In Pistachio Orchards: Factor Analysis From Iranian Agricultural Experts' Perspective

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Abstract

Iran's agriculture is globally well-known for its pistachio product. However, traditional management approaches and poor application of proper new technologies have brought reduced productivity and environmental hazards. In the information age, in order to transition from traditional to modern horticultural model, the application of precision agriculture model is appropriate. Therefore the purpose of the present study is to determine the challenges of precision agriculture application in pistachio orchards in Semnan province. The research method was survey. The statistical population were 187 horticultural experts of Semnan and counties' agricultural research center. By of Cochran formulae, 124 people were selected as sample. It was used a stratified random sampling method. In field study step, it was used the questionnaire as the main research tool. It was confirmed the face and content validity and reliability of research tool. The results of prioritizing the challenges of application of PA in pistachio orchards showed that the respondents' point view, the lack of economic justification for PA from the point of view of gardeners in the area, fragmentation of lands and lack of integrated land management, lack of the technical infrastructure required for PA in orchards had the highest priority. Also, shortage of PA researches and the gap between research and extension, poor management of gardeners in the use of precision agricultural technologies, lack of providing consulting services to gardeners were identified as the least priority. Exploratory factor analysis results have demonstrated the exploitation of four factors, including investment and supportive, structural, human resource development and supply, finally organizational and program challenges.

Keywords: Precision Agriculture, Sustainable agriculture, Pistachio, Exploratory Factor Analysis, Iran

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1. Introduction

Pistachio production plays a vital role in Iran's non-petroleum exports. Up to 2010, Iran has produced about %55 of global pistachio production and supplied more than 70% of global pistachio exports. Iran was the greatest pistachio producer in the whole world. Since 2011, the United States of America is placed in the first rank of the pistachio production, while Iran occupies placed in the second rank. Compared to other products, the economic value and foreign exchanges of this product are higher, so that in 2018, the pistachio exports were about 51000 tones with a value of 460 billion dollars and a 61% loss compared to the previous year (TPOI, 2019). The pistachio production is considered as one of the main advantages of Iran's agriculture in the both national and international markets. In 2018, the pistachio orchards in Iran occupied a total area of 498693 ha with 172614 tons of products, and an average of 1440 kg/ha. Meanwhile, the mean dry pistachio production in California was 3500 kg/ha, and the cost of producing 1kg pistachio in Iran was 60% higher than in the USA (IPA, 2011). One of the main issues for the pistachio production in Iran is its management. Orchards with traditional methods and weak application of new proper technologies led to performance loss, increased production costs, uneconomical and unsustainable production so that a great number of Iran's pistachio orchards have been exited from the economic production cycle, resulting in a decrease in the compatibility of this product in global markets (Zare Mehrjerdi et al., 2016).

To solve these problems as well as to achieve green productivity in Iran's pistachio orchards, a proper current paradigm must be used. Therefore, in the information age in order to transit from traditional to modern agricultural and horticultural models, it is necessary to develop the application of a Precision Agriculture (PA) model. In the PA model, using the Smart Farming Technologies (SFT), precise consumption, and management of external inputs such as various kinds of chemical poisons and fertilizers, sowing seeds and seedlings, as well as irrigation has been based on correct data, local characteristics of gardens, and finally seedling or tree development stages and needs. On this basis, it is possible to achieve proper and sustainable performance, improved product quality, ecological balance, and environmental protection (Barnes et al., 2019b; Kountios et al., 2018).

In the 1980s, this technology was initially introduced in the USA. This technology was created to achieve product sustainability as well as to solve environmental problems. As a result, the farmer gain the capability to mechanize his farm or garden (Mishra et al., 2003). The PA is an information and communication technology-based management system that determines, analyzes, and manages changes in profitability, sustainability, and resource and garden protection. Accordingly, the PA model is an approach that requires a high level of orchard men's knowledge and skills. In the PA, divisions and actions are made for whole farm or orchard with regard to its every spot. In this method, every square meter (m^2) is considered as a farm, indicating that using precision technologies, inputs are applied precisely in the proper place. Therefore, the PA is a *precision* on agriculture which was first introduced in the United States in the 1980s. This technology was created in order to achieve sustainability of production and solve environmental problems so that the farmer has the ability to mechanize his farm or garden (Mishra et al., 2003). The PA is a management system based on information and communication technologies that determines, analyzes, and manages changes for profitability, sustainability, and protection of resources and gardens. Accordingly, precision farming is an approach or agriculture method that requires a high level gardeners' knowledge and skills. In precision farming, decisions and actions are made to fit any part of the garden or farm instead of the entire farm or garden. In this method, each square meter of the garden is considered as a farm. That is, inputs are used using technologies exactly as needed and in the right place and required. Therefore, precision farming is a reductionist rather than a holistic approach. The PA is a way to achieve sustainable agriculture, which has been accepted and extended in some countries due to its benefits (Barnes et al., 2019a; Izadi et al., 2015). At the first glance, it seems that the PA is not applicable in developing countries due to the presence of poor farmers, subsistence farming systems, small farmlands, lack of technical and software knowledge among farmers, and the high cost of application of its technologies. Whereas, this approach has great potential for developing countrie to improve agricultural production. Iran, as a developing country, has great potential for the use of the PA in its farms and gardens (Shirkhani and Pezeshki Rad, 2017). Also, the PA is considered as a science and art of applying advanced technologies in order to increase crop production, while minimizing potential environmental pollution (Karcik and Tasan, 2018). The PA, as a systemic approach to regenerate the overall agricultural system, was conceptualized to create sustainable low-input and high-performance agriculture (Mandal and Maity, 2013; Schaefer and Thinh, 2019). Due to the importance and benefits

of the PA, so far research have been done on the feasibility of the application of the PA in different countries and challenges incoming for the application of these technologies. For example, Mishra et al., (2003) argued that the limited adoption of the PA in India is due to the low risk-taking of farmers, poor economic and social conditions, and small sizes of farms. Griffin et al. (2004) in the study on the reasons for the delay in the adoption of the PA mentioned that it was due to the lack of harvesting machines, the high cost of soil network sampling, the lack of understanding of the benefits of sensors, and the small number of consulting companies. Fountas et al., (2005) stated that among the challenges of the PA development, we could refer to lack of technical skills, high time consumption, and hardware incompatibility. Mondal and Basu (2009) described the high level of technology used as one of the challenges of using the precision technology. Adrian et al., (2005) reported that being confident about the application of the PA technology, the perceived value, the farm size, and the farmer's education have affected various farmers' adoption of the PA. Pandit (2012) examined the adoption of the PA technology by cotton growers in the United States. The results of this study showed that farm size and formal education have influenced the adoption of the PA technology.

In Iran, although the PA technologies have not been used in a large-scale, respective studies have been don among which Zare Mehrjerdi et al. (2016) clarified that economic, educational, and technical factors play major roles in the possibility of using the PA technologies in pistachio production in Rafsanjan. Yazdanifar et al. (2016) stated that the lack of economic, technical, and cognitive requirements, weak socialization, poor support services, and incompatibility with environmental and social conditions are the most important barriers to the use of the PA by agricultural companies in Dezful. Bagheri and Bordbar (2013) argued that challenges in the application of precision farming in Iran include infrastructural, educational, contextual, managerial, human resources, extension, and planning issues. Izadi and Hayati (2013) found that the average knowledge about the PA effects among professionals of agriculture consulting services in Shiraz was moderate, and in the other aspects, it was below average. Shirkhani et al. (2017) also stated that the level of experts' awareness of the PA in Tehran province was low to moderate. The results of Eskandarzadeh and Rashidpour's (2016) study in West Azerbaijan province showed that seven skills of accounting, farming, recognizing variability, finding information, goals setting, and decision making, and technical and economic skills for the proper use of agricultural machinery are needed for the application of agricultural precision. The application of the PA plays the main role in the process of sustainable agricultural development. In Iran, the results of Tohidyan Far and Rezaei-Moghaddam's (2018) research showed that the protection of surface and groundwater resources, development of rural areas, increasing productivity, and increasing income had the most important effects on the PA technologies. Also, Experts' attitudes indicated that they had a positive vision about these effects. Allahyari et al., (2016) showed that technical, economic, and accessibility factors have influenced agricultural experts' attitude towards the PA. Izadi et al., (2015) in their research in Shiraz found that the capabilities required by the experts of consulting services companies for the PA extension and development were mainly practical, cognitive, and exploratory. Also, the results obtained by Tohidyan Far and Rezaei-Moghaddam (2017) showed that agricultural experts and consultants in Fars province intended to use the PA technologies. Attitude was the most important determinant of experts' intention to use the PA technology. Accordingly, if the PA technologies are to be used in the gardens located in Semnan province, the research problem is what challenges we face when applying precision technologies in pistachio orchards. Considering the fact that no research has been done in this area in the study area and this issue was not clear, the present study was conducted to fill this gap. Therefore, the main aim of this study was to determine the challenges of the PA use in pistachio orchards in Semnan province. The novelty of the present study can be considered from two aspects: first, the challenges of the PA application in pistachio orchards are analyzed, which had not been done so far; second, no study has been done so far on the use of the PA in the pistachio orchards in Semnan province.

2. Materials and Methods

2.1. Study area

The study area was Semnan province in Iran *(Figure 1).* Semnan province, especially Damghan county, has 700 years of background in pistachio production. Due to the climatic and geographic conditions of this county, its products have high quality. In 2018, the area of pistachio orchards in Semnan province was 20853 hectares, the amount of production was 15288 tons and the average yield was 1176 kg per hectare (Center of Information and Communication Technology, 2018) .

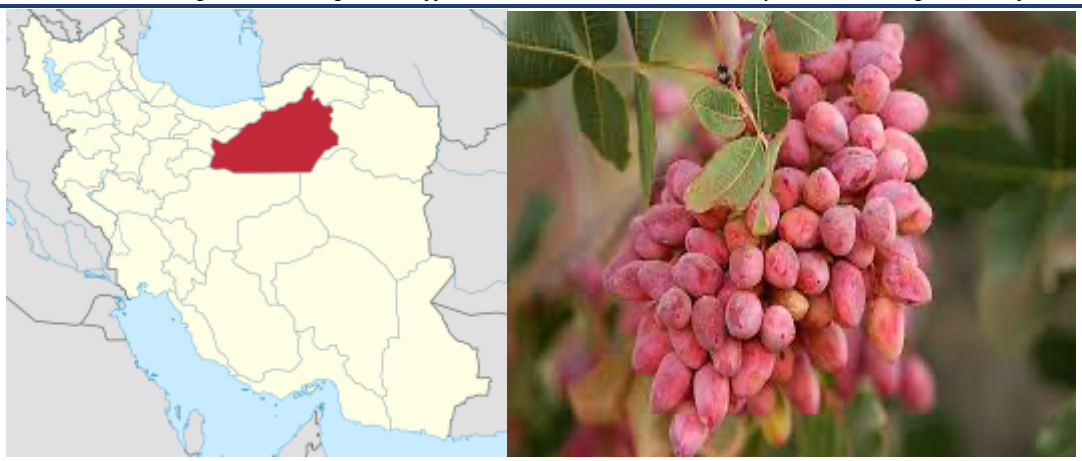

Figure1. Area of study (Semnan Province of Iran)

2.2. Data collection

The present research is applied in terms of purpose, non-experimental in terms of how to control variables, survey in terms of research method, a field study in terms of data collection, and cross-sectional in terms of data collection time. The population of the study consisted of 187 horticulture experts in the Agricultural Organization of the Semnan province and the subordinate counties and the Research Center of Pistachio in Damghan. The sample was determined using Cochran's formula for 356 people. The participants were selected through a stratified random sampling method. The data were gathered in two stages: the library study through search in the database and then conducting a field research. In the field stage, a questionnaire was used as the main research tool. The data collection was conducted through face-to-face interviews. The questionnaire consisted of two parts: the respondents' personal and occupational characteristics are asked in the first part; and in the second part, the challenges of application of the PA in pistachio orchards are examined in the Likert scale (very low = 1, low = 2, medium = 3, high = 4, very high = 5). To develop the questionnaire by reviewing the library aدی searching in the database as well as conducting interviews with a number of experts, the initial list of the pistachio challenges was extracted and developed. Then a questionnaire was distributed among the members of the board of researchers and experts. Accordingly, the content validity of the questionnaire was confirmed. In the next step, the pre-test study was conducted outside the study population by completing 30 questionnaires. The results of the Cronbach's alpha test related to the challenges of application of the PA technologies in precision orchards ($\alpha = 0.78$) confirmed the reliability. Finally, the data were analyzed by the use of the SPSS21 software. In the descriptive section, the central and dispersion statistics were used, and the inferential statistics were used in the exploratory factor analysis.

3. Results and Discussion

3.1. Gardeners' characteristic

The results showed that 74.2% of the respondents were male, and 25.8% were female. The mean age of the respondents was 42.71 years old, the highest score of responses was 43.5%, being in the 37-45 age group. The respondents' average work experience was 19.71 year, the highest score of work experience was 43.1%, being in the 12-21 age group. Among the participants, 62, 9.9, 25, and 12.1% had bachelor, graduate, postgraduate and doctoral degrees, respectively.

3.2. Prioritizing the Challenges of the PA Application in Pistachio orchards in Semnan Province

The results of the prioritization are presented in *Table 1*. According to the table, from the respondents' point of view, the lack of economic justification for the PA, and from the gardeners' point of view in the area, the fragmentation of lands and the lack of integrated land management, the lack of the technical infrastructure required for the PA in the orchards had the highest priorities. Also, the limited PA researches and the gap between research and extension, the gardeners' poor management in the use of the PA technologies, the lack of consulting services provided for gardeners were identified as having the least priorities. These results were consistent with the findings obtained by Barensa *et al.* (2019a), Mishra *et al.* (2003), and Kanter et al. (2019).

Table1. Prioritization of challenges of PA application in pistachio orchards

Items	Mean	Standard deviation	Coefficient of deviation	Priority
The lack of economic justification for the PA from the gardeners' point of view on the area	4.7177	0.5493	0.1164	1
The fragmentation of lands and the lack of integrated land management	4.2903	0.5950	0,1316	2
The lack of technical infrastructure required for the PA in the orchards	4.2823	0.6056	0.1414	3
The traditional gardening that was common in the study area	4.3871	0.6338	0.1414	4
The lack of economic support for gardeners in the implementation of the PA	4.3468	0.6631	0.1525	5
The low degree of mechanization of gardens	4.3472	0.6635	0.1526	6
Gardeners' lack of knowledge and technical skills in the use of the PA technologies	4.1935	0.7062	0.1684	7
The high cost of application of the PA technologies	4.3145	0.7365	0.1707	8
The responsible organizations' insufficient attention to the PA in the development programs of the country's gardens	3.8145	0.7475	0.1959	9
Insufficient government support to improve the PA	0.2032	0.8344	0.2281	10
Low adaptability of the PA technologies with regard to small gardeners' conditions	3.8710	0.8831	0.2281	11
Limited number of specialized manpower and the experts' low technical knowledge on the use of the PA technologies	3.5968	0.8640	0.2402	12
Poor communication, coordination, and cooperation among organizations responsible for the development of application of the PA in the pistachio orchards	4.0323	0.9705	0.2406	13
Time consuming application of the PA technology due to the need to provide technical, economic, and educational requirements.	3.9355	1.0339	0.2627	14
Gardeners' insufficient knowledge about the PA benefits and application	3.6613	0.9950	0.2717	15
Gardeners' low risk-taking for the application of the PA technologies	3.5161	1.0318	0.2934	16
Restrictions about the provision of satellite facilities and equipment	3.7097	1.1026	0.2972	17
The lack of research related to the PA and the gap between research and extension	3.6210	1.1159	0.3081	18
Gardeners' poor management in the utilization of the PA technologies	3.6210	1.2203	0.3370	19
The lack of delivering consulting services to gardeners	3.2016	1.0590	0.3377	20

3.3. Factor Analysis of the Challenges of the PA Application in Pistachio Orchards in Semnan Province

Given that 20 variables were presented as challenges of the PA application in pistachio orchards in the study area, the exploratory factor analysis (EFA) was used to reduce the number of variables. First, the KMO and Bartlett tests were used to ensure the appropriateness of the data. The results showed internal consistency and appropriateness of the data (KMO = 0.70 and Bartlett = 730.936; Sig = 0.000) for the factor analysis. The eigenvalue method was used to determine the number of extractable factors. Based on this, the factor with an eigenvalue greater than one was selected. Based on the results of the factor analysis, four factor that can explain the variance of all the variables were extracted and after factor rotation by use of the Varimax method, these four factors were found to lead to 60.013% of the variance changes in the challenges of the PA application in the pistachio orchards in Semnan province *(Table 2)*.

Table 2. Factors extracted from factor analysis

Factors	Eigenvalue	Percentage of variance explained	Cumulative variance percentage
The first factor	4.383	21.915	21.915
The second factor	3.703	18.517	40.432
The third factor	2.722	13.609	54.041
The fourth factor	1.194	5.972	60.013

The results presented in *Table 2* show that the first factor with an eigenvalue of 4.383 explains the variance of 21.915% as the most important factor. The variables representing the first factor include: Insufficient government support to improve the PA, the high cost of application of the PA technologies, the lack of economic justification for the PA from the gardeners' point of view on the area, the lack of economic support for gardeners in the implementation of the PA. The variables related to the first factor showed that these variables can be categorized as the investment and support challenges in the PA implementation. Li et al., (2020) and Barnes et al. (2019b) also confirmed this finding. The second factor with a variance of 18.517% and accordingly the constituent variables were categorized as structural challenges. This factor includes the following variables: Low adaptability of the PA technologies with regard to small gardeners' conditions, the fragmentation of lands and the lack of integrated land management, the traditional gardening that was common in the study area, the low degree of mechanization of gardens, the lack of technical infrastructure required for the PA in the orchards, restrictions about the provision of satellite facilities and equipment, and time consuming application of the PA technology due to the need to provide technical, economic, and educational requirements. These cases were consistent with the results of Griffin's et al. (2004), Mishra's et al. (2003), and Ozpinzr and Cay's (2018) studies. The third factor with a variance 13.609% and accordingly the variables in it are the challenges of providing and developing human resources needs in the PA implementation. The variables contained in the third factor include: Limited number of specialized manpower and the experts' low technical knowledge on the use of the PA technologies, gardeners' low risk-taking for the application of the PA technologies, gardeners' poor management in the utilization of the PA technologies, gardeners' insufficient knowledge about the PA benefits and application, and gardeners' lack of knowledge and technical skills in the use of the PA technologies. The results obtained by Tohidyan Far and Rezaei-Moghaddam (2017), Izadi and Hayati (2013), Yost et al. (2019), and Kountios et al. (2018) also confirmed these results. The fourth factor with a variance of 5.972% and accordingly its respective variables were categorized as the organizational and program challenges. The variables representing the first factor include: The lack of research related to the PA and the gap between research and extension, the lack of delivering consulting services to gardeners, the responsible organizations' insufficient attention to the PA in the development programs of the country's gardens, and poor communication, coordination, and cooperation among organizations responsible for the development of application of the PA in the pistachio orchards. These results are consistent with those obtained by Bagheri and Bordbar (2013) *(Table 3).*

Table 3. Results of rotation of factor by Varimax method

Factor	Variables	Factor loading
Investment and support challenge	Insufficient government support to improve the PA	0.817
	the high cost of application of the PA technologies	0.746
	the lack of economic justification for the PA from the gardeners' point of view on the area	0.724
	the lack of economic support for gardeners in the implementation of the PA	0.608
Structural challenge	Low adaptability of the PA technologies with regard to small gardeners' conditions	0.866
	the fragmentation of lands and the lack of integrated land management	0.834
	the traditional gardening that was common in the study area	0.791

	the low degree of mechanization of gardens	0.737
	the lack of technical infrastructure required for the PA in the orchards	0.615
	restrictions about the provision of satellite facilities and equipment	0.538
	time consuming application of the PA technology due to the need to provide technical, economic, and educational requirements	0.442
Providing and developing human resources challenge	Limited number of specialized manpower and the experts' low technical knowledge on the use of the PA technologies	0.682
	gardeners' low risk-taking for the application of the PA technologies	0.639
	gardeners' poor management in the utilization of the PA technologies	0.588
	gardeners' insufficient knowledge about the PA benefits and application	0.560
	gardeners' lack of knowledge and technical skills in the use of the PA technologies	0.446
Organizational and program challenge	The lack of research related to the PA and the gap between research and extension	0.660
	the lack of delivering consulting services to gardeners	0.601
	the responsible organizations' insufficient attention to the PA in the development programs of the country's gardens	0.486
	poor communication, coordination, and cooperation among organizations responsible for the development of application of the PA in the pistachio orchards	0.453

4. Conclusions

The results of prioritizing the challenges of the PA application in the pistachio orchards showed that from the respondents' point of view, investment and support challenge was the first priority for gardeners, indicating that the results of investing in the PA technologies in orchards and the efficiency and profitability of their use for gardeners are not clear. Therefore, among the necessary measures to expand the application of the PA technologies are to analyze the costs and benefits as well as to inform gardeners in order to make proper decisions. Also, the small size of the lands and the lack of integrated land management were determined as the second priority. Fragmentation, small size, and incoherence in integrated land management, while reducing product efficiency, will cause more waste of resources and increase production costs, and the continued use of new technologies will not be justified in pistachio orchards economically. Also, the lack of technical infrastructure required for the PA application in the pistachio orchards was stated as the third priority in the challenges of application of the PA technology in the pistachio orchards from the respondent's viewpoint. In order to encourage gardeners to invest and utilize the PA technologies, the infrastructure, and hardware, software, and network facilities required for the establishment and application of these technologies that are appropriate to the climatic and geographic conditions and type of product should be made feasible, studied, and made accessible.

The results of the factor analysis indicated that the challenges of the PA application in the pistachio orchards in Semnan province were categorized as the fourth group. The first factor was the investment and support challenge. In order to meet this challenge, while studying the cost-benefits and ensuring economic justification and investment return in these technologies, gardeners should be justified and encouraged to utilize these technologies. Also, directing researches towards the necessary equipment was made in-house to reduce the initial investment costs as much as possible. In addition, the government provided the gardeners with the necessary support using appropriate policies to spread the PA applications in the pistachio orchards in order to achieve sustainable agriculture and green productivity, by providing incentive packages. In this case, the gardeners' intention to accept the PA will be strengthened. The next factor was the structural challenge. Among the important structural and historical issues of Iranian agriculture are the fragmentation of lands and the lack of integrated land management. Agricultural land distribution issues are one of the reasons for decreasing productivity and instability of production in Iranian agriculture. In addition, the traditional system and the low degree of mechanization of orchards have reduced yields and increased production costs. Also, the traditional nature of the garden system does not allow application of the PA technologies. Therefore, in parallel with the efforts to integrate lands and their coherent management, the pistachio orchard system should be reconstructed, mechanized, and modernized by introducing the PA technologies to increase yield, improve quality, and reduce costs as well as to increase profitability. Also, necessary research should be conducted in order to appropriately utilize the PA technologies in the conditions for small gardeners and to provide the necessary infrastructure, facilities, and equipment with suitable prices and

payment conditions for the application of the PA technologies in pistachio orchards. The third factor was the challenge of providing and developing the required human resources. To overcome this challenge, capacity building should be done among agricultural experts and pistachio gardeners. Designing educational programs and opportunities such as workshops and training visits and apprenticeships for agricultural experts can increase their knowledge and skills, resulting in an improvement in their attitude towards precision agricultural technologies. If agricultural experts are empowered, they can transfer the PA information and knowledge to gardeners as well as train them. The application of the PA technologies requires a high level of knowledge, skills, and the desired attitude. Therefore, technical knowledge and skills have been one of the necessary requirements for the application of the PA technologies. The fourth factor was the organizational and programming challenge. Another weakness is related to the lack of attention to the organizational structure of the public sector in order to develop the PA technologies and the lack of a well-codified and approved program in this field. The lack of applied research and adoption caused the weak performance of the agricultural extension sector. Also, the executive and support departments were deprived of any strategic and operational plan for the PA with little attention in practice. In fact, the lack of a program, the lack of cooperation, and the inconsistency between the respective organizations and departments have caused the PA and its technologies in pistachio orchards do not be developed and expanded. If these challenges have not been overcome, Iranian pistachio orchards will face with more problems, such as decreased productivity and profitability, instability, and environmental and climatic hazards. It should be noted that one of the limitations of the present study included the use of questionnaire as a research tool in which there was the possibility that the respondents make mistakes when answering the questions, cross-sectional research, inability to fully control all unwanted variables, and non-generalizability of the results of the study to other areas.

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