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Investigation of the Temporal Management of Pistachio Pests Control in Iran

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ABSTRACT

In this study, we first identified the existing knowledge about temporal management of pesticide consumption. Then the growers view and performance in this regard was estimated. Comparing growers' knowledge with experts' idea, the pistachio producers score related to temporal management of pests control was calculated. Pistachio producers of Anar and Rafsanjan areas in Kerman province, Iran were considered as our study population. Using stratified random sampling method, a sample of 100 growers were selected. Pearson correlation, analysis of variance and regression were used to investigate the socioeconomic factors affecting growers' knowledge and the effect of this knowledge on growers' performance. The results showed that in the field of temporal management of pesticide use, growers' knowledge is low. Investigating the factors affecting growers' knowledge level showed that research, education and extension activities have had the significant effect on increasing knowledge of inputs temporal management. The results also showed that knowledge of temporal management pest control did not increase land use productivity (pistachio yield) but enhanced pesticide productivity. The amount of pesticide usage decreased by 0.477 l/ha/year, with increasing of each score to pest control knowledge. In other words, with increasing knowledge of pest control, not only the costs of spraying will be reduced, but it will also have environmental benefits. In short, current conditions are not suitable for precision agriculture application in Iranian pistachio orchards, but with increasing knowledge of growers, these conditions will be created.

Introduction

Currently, the agricultural sector faces many challenges, such as increasing production costs, and increasing public attention to the effects of production on the environment. To survive in the global market, producers must reduce costs and meet environmental concerns while increasing product quality (Nazoori *et al.*, 2022a). Today, it seems that using technology is one of the main means of achieving this goal. In this context, precision farming is a type of technology that makes access to the above three goals more practical (Watson *et al.*, 2003). In regular agricultural activities, inputs such as chemical fertilizers, pesticides, and

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water are used uniformly in fields and orchards, regardless of their actual need (Nazoori *et al.*, 2022b). Also, their management is usually based on the average response of these inputs to crop yield across the field. However, given the great emphasis on quality and efficiency of food production, it is necessary for inputs to be used based on real needs at the farm level. This type of farming is known as precision farming, a generic term that describes the method of managing consumption of inputs. Perhaps a better descriptor for this type of farming is site-specific management (Lascano and Li, 2003). Site-specific management (SSM) is the idea of doing the right thing, at the right place, at the right time. Temporal SSM requires management of inputs based on information about the life cycles of agricultural crops, livestock or pests. This temporal information is often referred to as developmental stage information. For instance, integrated pest management involves many cases of developmental stage management practices, such as the use of pest scouting to determine the need and timing of pest control (Bongiovanni and Lowenberg-Deboer, 2004).

According to Lowenberg-Deboer (2003), precision farming is a young technology. Therefore, many economic aspects of it should be considered in the future. It is also necessary to identify the socio-economic characteristics that affect the value of this information in the region before using it (Rejesus and Nelson, 2000). In this regard, Bullock *et al.* (2007) argue that in the case of SSM, the optimal management decision for a point does not depend solely on its location and its physical characteristics. Rather, the extent of the grower's knowledge of these traits and the ability of the grower to utilize the appropriate knowledge are effective in this success. In this regard, Kitchen *et al*. (2002) argue that precision agricultural education programs need to reflect constant changes in technology, but at the same time it must also be scientifically compatible with the range of people's abilities and skills. Producers, as the end users of precision agricultural technologies and methods, will ultimately detect the rate and extent to which precision agricultural is adopted. Research investigations and/or marketing strategies will fail in the end unless producers can realize value in such efforts, whether implicit or in absolute dollar terms. Therefore, a deep understanding of the specific understanding that producers have of precision farming technology should be measured when conducting research, development, training and trade.

Pistachio is an important crop in Iran (Behzadi Rad *et al.*, 2021). Insects attack all parts of the plant during the growing season (Nazoori *et al.*, 2022a). Pistachio pest control is a very complex task and has been a major issue for pistachio producers in Iran for the past 60 years (Mehrnejad, 2001). Regarding pistachio pest control, three issues are related to control costs, environmental issues and quality of production (Behzadi Rad *et al.*, 2021). So moving to precision farming is inevitable. Therefore, according to the recommendations of the mentioned researchers, the first step in this field is to know the growers' knowledge of the principles of pest control. One of the most important of these principles is the time of pest control. Therefore, it is important to measure growers' knowledge of pistachio pest control, especially the exact time of control. Therefore, in this study, the pistachio growers' knowledge about temporal management of pesticide using has been investigated and the role of this knowledge in promoting pistachio production efficiency has been considered.

Materials and Methods

The data used in this study were collected through a questionnaire from pistachio producers. For this purpose, the study sample was selected from Anar (30.8734°N, 55.2655°E) and Rafsanjan (30.4039° N, 55.9863° E) areas, Kerman province, Iran. The sampling method was multistage random sampling. From the total villages of the two areas, some samples were selected based on random sampling methods. Then, from the list of growers residing in the sample

villages, some growers were selected by random sampling. The number of growers in question was 100. Since different orchards and cultivars were studied from each grower, finally the number of samples was equal to 286 orchards. In the current study, we first interviewed researchers and experts of the Iranian Pistachio Research Center. In this interview, the scientific point of view and results of researches and experiences of these researchers and experts on the temporal management and amount of pesticide consumption for each pest were determined. Finally, these results were summarized and tabulated. Then, in an interview with growers through a questionnaire, their knowledge of temporal management and the amount of consumed pesticide for each pest was determined. Then, by comparing the growers' views with those of experts and researchers, the level of growers' knowledge was determined and the growers' scores were determined. Kitchen *et al.* (2002) and Robert *et al*. (2004) methods were used for this purpose.

In the next step, growers with high knowledge in temporal management of pesticide using were compared with growers with low knowledge. In this regard, the proximity of growers' views in temporal management with the experts' views was considered as its pest management knowledge. The yield per hectare and pesticide productivity was compared between the two groups and its relationship with the variables of their ability to manage was determined by Pearson correlation test (English *et al*., 1999; Watson *et al*., 2003). Following Cown (2000), socio-economic factors influencing the temporal management of pesticide consumption were identified. For this purpose, linear regression was used. In this regard, socioeconomic variables such as age, education, etc., as well as technical and field characteristics were considered as independent variables. The model is as follows:

$$TM = A + B_1X_1 + \ldots + B_nX_n \quad (1)$$

In this regard, TM is a dependent variable that represents the score of growers in managing pesticide use in pistachio orchards and X1 to Xn are independent variables including socio-economic and technical factors and A and B1 to Bn are estimated coefficients.

Results

Concerning the temporal management of pistachio pests' control, the results of the Pistachio Research Center experts' view are summarized in Table 1. As it is clear, two indicators are used to measure temporal management of pistachio pests. The first indicator is identifying the best stage of pest life, in which using pesticide has the most impact. This stage is different for different pests and is scientifically listed in the second column of Table 1. The second indicator is the time of pest in the orchard during the year and is the best month for spraying. This time period also varies for different pests and is listed in the third column of Table 1.

Table 1. Experts comment on the temporal management of pistachio pest control

Pest name	What stage of life is the proper time to pest control?	What month of the year is proper time to pest control?
***Agonoscena pistaciae* (Psylla)**	Nymph	Different times of year
Idiocerus stali	Adult + Nymph	Late of March+ late of April
Mirid bugs of pistachio	Nymph + Adult	Early of May
pistachio bugs	Nymph + Adult	Early of June until Early of July
Recurvaia pistaciicolla	First instar larvae at the same time with peak of adult emergence until one week later	middle until late of April
Kermania pistaciella	First instar larvae at the same time with peak of adult emergence until one week later	middle until late of April
pistachio scale	50% of the nymphs emergence	middle of April + late of April
Arimania komaroffi	First instar larvae at the same time with one week later peak of adult emergence	late of April+ late of June
Hylesinus vestitus	Overwintering stage + Adult	In winter pruning and burning pruning branches +chemical control in early of May
Polydrosus davatchii	Adult	Early until middle of April
Capnodis cariosa hauseri	Larvae of different ages	Spring or fall
Plodia interpunctella	Different stages of life	Time of product contamination

In order to measure growers' knowledge about temporal management of pistachio pests control, two questions were asked about the best stage of pest control (pest life cycle) and the best time of year. Then, by comparing the responses with the results in Table 1, growers were given a pest temporal management score. The scores are in Tables 2 and 3. As is known, most of the growers' knowledge of pistachio pest management is related to pistachio Psylla. The average score of growers in this regard was 18.17 (from 20) and varied from 0 to 20. Since there was a huge range of time of struggle against Psylla during the year from early April until late October, it was not possible to give a score to the growers in this regard. However, growers were rated as the best time of year to control other pests and the results are listed in Table 3. As this table shows knowledge of temporal management of other pest is very low among pistachio growers so that their average score is less than 10. However, there is a high dispersion between scores. In most cases, they range from at least 0 to a maximum of 20. Also, the high standard deviation of scores indicates the dispersion of scores. This indicates that the need to promote the knowledge of pistachio pest temporal management is strongly felt. The results of growers' behavior regarding pistachio pest temporal management are presented in Table 4.

Table 2. Pistachio producers score (from 20) on temporal management of pests control (Pest Life cycle).

Pests name	Min	Mean	Max	Standard Deviation
***Agonoscena pistaciae* (Psylla)**	0.00	18.17	20.00	5.35
Idiocerus stali	0.00	3.13	15.00	3.76
Mirid bugs of pistachio	0.00	5.92	15.00	7.29
pistachio bugs	0.00	8.79	20.00	3.93
Recurvaia pistaciicolla	0.00	0.26	15.00	1.69
Kermania pistaciella	0.00	3.48	20.00	4.56
pistachio scale	0.00	5.14	18.00	7.49
Arimania komaroffi	0.00	0.94	18.00	3.56
Hylesinus vestitus	0.00	1.97	20.00	5.45
Polydrosus davatchii	0.00	0.25	20.00	2.09
Capnodis cariosa hauseri	0.00	0.00	0.00	0.00

Table 3. Pistachio producers score (from 20) on temporal management of pests (time during the year).

Variable name	Min	Mean	Max	Standard Deviation
Idiocerus stali	0.00	7.11	20.00	8.50
Mirid bugs of pistachio	0.00	5.13	20.00	7.61
pistachio bugs	0.00	8.27	20.00	4.95
Recurvaia pistaciicolla	0.00	2.21	20.00	4.66
Kermania pistaciella	0.00	9.44	20.00	9.07
pistachio scale	0.00	6.33	20.00	6.83
Arimania komaroffi	0.00	9.11	20.00	5.06
Hylesinus vestitus	0.00	7.27	20.00	8.35
Polydrosus davatchii	0.00	2.74	20.00	6.83
Capnodis cariosa hauseri	0.00	0.74	20.00	3.71

Table 4. The performance of pistachio growers on pests control temporal management.

Variable name	Min	Mean	Max	Standard Deviation
The number of pesticides used to control *Agonoscena pistaciae* (Psylla)	1.00	2.26	6.00	1.15
Start time for spraying *Agonoscena pistaciae* (Psylla) (month of the year-April)	1.00	1.82	4.00	0.83
End time for spraying *Agonoscena pistaciae* (Psylla) (month of the year)	5.00	6.63	7.00	0.59
Number of spraying *Agonoscena pistaciae* (Psylla) during the year	1.00	6.54	15.00	2.84
Per turn amount of pesticide used for control of *Agonoscena pistaciae* (Psylla) (L / ha)	1.00	3.87	9.00	1.68
Total amount of pesticide used for control of *Agonoscena pistaciae* (Psylla) (L / ha/year)	3.00	25.56	67.50	14.21
Number of spraying *Idiocerus stali* during the year	0.00	0.17	3.00	0.51
Number of spraying Mirid bugs of pistachio during the year	0.00	0.12	2.00	0.34
Number of spraying pistachio bugs during the year	0.00	0.14	2.00	0.36
Number of spraying *Recurvaia pistaciicolla* during the year	0.00	0.04	1.00	0.20
Number of spraying *Kermania pistaciella* during the year	0.00	0.14	2.00	0.38
Number of spraying pistachio scale during the year	0.00	0.28	3.00	0.57
Number of spraying *Arimania komaroffi* during the year	0.00	0.13	1.00	0.33

As is clear, the fluctuation of variables in Table 4 is high. For example, the number of pesticides used to control Psylla varies from 1 to 6 or the time of first spraying to control Psylla is different from April to July. In other words, there were growers who did the first spraying against Psylla in March. However, there are other growers whose first spraying has been done in July. This is also the case for the last spraying for Psylla. So, for some growers the end of spraying has been done in August, while there have been some growers who have done spraying in April. As Table 4 shows, the number of spraying against Psylla is also very scattered. This number varies from at least one time to 15 times a year. In addition, the amount of pesticide used per turn per hectare and the total amount of pesticide used per hectare per year are also highly dispersed among growers. As the total amount of pesticide used to control Psylla varies from at least 3 liters to a maximum of 67.50 liters per hectare per year, this indicates a very wide variation in growers' control of Psylla because range (3-67.50) and standard deviation (14.21) are high . As for other pests, only the number of spraying is listed in Table 4. As the table shows, there is high variation in this regard as well.

To evaluate the economic and social factors affecting pistachio pest temporal management score, Psylla control score was used as representative of other pests. This was done for two reasons. First, growers' knowledge of Psylla was greater than other pests. The second reason was that there was a high correlation between the score of Psylla control time and other pest scores. This is illustrated in Table 5. As this table shows, the Pearson correlation coefficient has a direct and significant relationship with the score of Psylla control time and other pest scores. Therefore, the score of time of Psylla control can be considered as an indicator of growers' score on pistachio pests' temporal management.

Table 5. Pearson correlation test between the variables of temporal management of Psylla score with scores of other pests

Variable name	Pearson correlation coefficient	Significant level
***Idiocerus stali* life stage score**	0.131	0.035
Mirid bugs of pistachio life stage score	0.109	0.076
pistachio bugs life stage score	0.261	0.000
***Kermania pistaciella* life stage score**	0.144	0.020
pistachio scale life stage score	0.172	0.005
pistachio bugs month of the year score	0.114	0.063
***Recurvaia pistaciicolla* month of the year score**	0.093	0.127
***Kermania pistaciella* month of the year score**	0.122	0.046
***Hylesinus vestitus* month of the year score**	0.150	0.056
***Polydrosus davatchii* month of the year score**	0.144	0.019

The socioeconomic factors affecting growers' score on temporal management of pistachio pest control are shown in Tables 6 and 7. As these tables show, recording the history of agricultural activities has a positive effect on growers' scores on temporal management of pest control. In other words, growers who have registered their agricultural activities in accounting note books have more knowledge about temporal management of pest control. In this regard, it can be said that if the culture of the use of accounting note books and registration of agricultural activities spreads among pistachio growers, their willingness to acquire knowledge of pest management will be broadened.

One of the variables that influence the score on temporal management of pistachio pest control is the use of extension journals. The use of these journals has increased the growers' knowledge of pistachio pest control. Tables 6 and 7 also show that consulting with agricultural experts on temporal management of pest control has had a positive effect on increasing their knowledge. In other words, having experts available to growers to determine the best spraying time will be very effective. However, according to the results of Table 7, those who only consult other growers to determine when to deal with pests have a lower level of knowledge in this regard. In other words, pistachio growers should not only rely on consultations with their colleagues to determine the timing of pistachio pests control but also use the views of agricultural experts. According to the results of Table 6, those who do not believe in using agricultural experts and training in pest control have lower knowledge in this regard. In other words, those who have less information also feel less need to learn. This means, to increase growers' willingness to use pistachio pest control knowledge, must first inform them of their low knowledge of the issue. The bottom row of Table 7 confirms this. Table 7 also shows that people who imitate others to determine the spraying time have a lower score. In other words, imitation of others and the habit of doing so has made them less inclined to learn the necessary knowledge. So, instead of promoting the spirit of imitation of others, the spirit of inquiry should be developed among growers.

Table 6. Analysis of variance of different properties affecting growers' score on temporal management of Psylla control

Variable name	Psylla temporal management score when the variable value is zero	Psylla temporal management score when the variable value is one	F statistics value	Significance level of F statistic
Record the history of agricultural activities in the accounting note book (yes = 1, no = 0)	16.02	19.13	20.60	0.000
Using extension journals (yes = 1, no = 0)	17.66	19.18	6.08	0.014
There is a need for education on pest control (yes = 1, no = 0)	16.96	18.41	2.80	0.095
There is a need for experts on pest control (yes = 1, no = 0)	17.36	18.86	5.29	0.022
There is no need for training and expertise in pest control (yes = 1, no = 0).	18.52	15.33	9.65	0.002
Imitate others to determine the spraying time (yes = 1, no = 0)	18.68	16.21	9.73	0.002
Consult expert to determine spraying time (yes = 1, no = 0)	16.80	18.93	10.03	0.002
Do you have any questions about pest control (yes = 1, no = 0)	17.42	18.84	4.70	0.032

Table 7. Regression of socioeconomic variables on the growers' score on temporal management of Psylla control.

Variable name	Estimated coefficients	t statistics value	Significance level of t statistic
Constant	17.24	21.41	0.000
Consult with expert to determine spraying time (yes = 1, no = 0)	1.49	2.24	0.026
Consult with growers to determine spraying time (yes = 1, no = 0)	-2.16	-3.17	0.002
Record the history of agricultural activities in the office (yes = 1, no = 0)	1.93	2.91	0.004
Using extension journals (yes = 1, no = 0)	0.93	1.45	0.149
R^2 =0.12	adjR^2=0.11	F=9.18	SigF=0.000

Table 8 shows the effect of growers' score on temporal management of pistachio pest control on land and pesticide productivity. Land productivity is the amount of pistachio production per hectare of pistachio orchard. In other words, this table examines whether knowledge of temporal management of pest control increased pistachio yield. Also, pesticide productivity show the amount of pistachio is produced by using each one liter pesticide. As the results of table 8 shows, knowledge of the temporal management of pistachio pest control had no effect on land productivity. In other words, those who had low knowledge about the temporal management of Psylla have the same pistachio yield. That is to say, everybody has tried to fight off the Psylla at any price and prevent the damage of this pest. However, according to the results of table 8, increasing growers' knowledge about the temporal management of Psylla has increased the pesticide productivity. In other words, those who knew the exact time of spraying, eliminated the pest by consuming fewer pesticides. Although yield per hectare of pistachio orchards and consequently, pistachio growers' income did not change as a result of knowledge of pest control, the cost of spraying was lowered and thereafter the profit of one hectare of pistachio for growers with more knowledge in the exact time of pest control has increased. In other words, increasing the level of knowledge of growers about the time of pest control, by reducing the amount of pesticide consumption and increasing its productivity, increases the profit of growers. So, growers who recognize the proper time of the combating and spray at the critical stage of pest life, with less spraying, control the pest and reduce costs. In addition to economic benefits, this will also have environmental benefits.

Table 8. Investigation of the effect of the growers' score on temporal management of Psylla control on land and pesticide productivity.

Independent variable name	Dependent variable: pistachio yield (kg ha^{-1})			Dependent variable: pesticide productivity (kg l^{-1})		
	Estimated coefficients	t statistics value	Significance level of t statistic	Estimated coefficients	t statistics value	Significance level of t statistic
Constant	165.32	0.514	0.608	-6.70	-0.254	0.800
growers' score on temporal management of Psylla control (from 20)	-2.80	-0.265	0.791	1.68	1.87	0.063
Water consumption (cubic meter per hectare per year)	0.06	4.995	0.000	0.002	2.28	0.023
EC Water (micromhos / cm)	0.15	2.577	0.011	0.007	1.60	0.112
Second power of EC Water (micromhos / cm)	-0.000009	-2.864	0.005	-0.0000005	-1.94	0.054
Heavy soil (yes = 1, no = 0)	-360.18	-2.531	0.012	-20.63	-1.82	0.070
-	R^2 =0.18	adjR^2=0.16 SigF=0.000	F=9/72	R^2 =0.07	adjR^2=0.05 SigF=0.010	F=3/10

Table 9 shows the effect of the growers' score on temporal management of Psylla control on the amount of pesticide used for one hectare of pistachio orchards. As table 9 shows, by increasing each score to the growers' score on temporal management of Psylla control, the amount of pesticide consumptions decreased by 0.477 liters per hectare per year. In other words, increasing the level of knowledge of temporal management makes the pest control better with less pesticide consumption. This is in consistent with the results of Brevault and Clouvel (2019), who say: "Ecological regulation can be harnessed through better knowledge of the life system of pest populations". In other words, the productivity of pesticide use increases. This problem is also illustrated in Table 10 using Pearson's correlation coefficients.

Table 9.: Regression of the growers' score on temporal management of Psylla control on amount of pesticide used (liters per hectare per year)

Variable name	Estimated coefficients	t statistics value	Significance level of t statistic
Constant	33.770	9.82	0.000
score of temporal management of Psylla control	-0.477	-2.65	0.009
	R^2 =0.03 adjR^2=0.03	F=7/006	SigF=0.009

Table 10. Pearson correlation test between score of temporal management of Psylla control with pest control performance variables

Variable name	Pearson correlation coefficient	Significant level
First spraying time of the year for Psylla control	0.273	0.000
Last spraying time of the year for Psylla control	-0.111	0.097
The amount of pesticide consumed for Psylla control per turn per hectare	-0.137	0.038
Total pesticide consumed for Psylla control per hectare per year	-0.173	0.009
Number of spraying for Psylla control per year	-0.119	0.054
Number of spraying for *Idiocerus stali* control per year	-0.103	0.094
Number of spraying for pistachio bugs control per year	-0.116	0.060
Number of spraying for *Arimania komaroffi* control per year	-0.152	0.013

As Table 10 shows, those with a higher score of temporal management of Psylla control started spraying later at the beginning of the year and completed earlier in the end of the year. These individuals consumed less pesticide per turn and throughout the year. Growers, who have a higher score of temporal management of Psylla control, have fewer numbers of spraying against Psylla, *Idiocerus stali*, pistachio bugs and *Arimania komaroffi*. However, pistachio yield for these framers has not reduced. In other words, by precisely recognizing the time of spraying, it is possible to reduce the use of pesticide without reducing pistachio yield. Therefore, using precision farming tools in pistachio orchards can increase both economic and environmental benefits. Consistent with the results of this study, Larsen *et al*. (2019) concluded; "The enormity of intra-annual variation in pesticide use, as well as the consistency in those patterns through time, suggests opportunities for crop-specific pest management and region-specific mitigation approaches to limit environmental and human health hazards from agricultural pesticide use".

Discussion

In this study, at first, analyzing the viewpoints of experts of Iranian Pistachio Research Center, the existing knowledge about temporal management of pistachio pests control was identified. Then, growers' views and practices in this regard, were asked by completing a questionnaire. By comparing the growers' viewpoints with the scientific ones, the score of temporal management of pistachio pest control was calculated. Then, the effect of socioeconomic factors affecting the knowledge of temporal management of pest control was investigated. Also, the effect of growers' temporal management knowledge of pest control on their performance was determined.

The results showed that among the different pests, the highest growers' score was for Psylla control (18.17 from 20). However, this was not the case with other pests (10 from 20). The results, also, showed that the use of accounting note book increases growers' knowledge about temporal management of pests' control. Growers whose only source of information is other growers will not be able to get enough knowledge because there is not enough knowledge among growers anymore. Conversely, those associated with extension personnel,

researchers, and agricultural experts have been able to obtain sufficient knowledge of pistachio pest management and thus have a better temporal management score. The results also showed that among the extension channels, has been questioned, such as educational classes, extension journals, radio and television, only the extension journals had a positive effect on pistachio pest temporal management knowledge. This indicates that temporal management of pistachio pest control training should be done by providing appropriate photos of the different stages of pest to growers and completes focus; otherwise oral training will not have a lasting impact. Of course, in this study, the social net and expert group channels did not evaluated and should be considered in next researches.

At last, growers' knowledge regards to temporal management of pesticide has enhanced pest control efficiency. Although this knowledge has not increased land productivity, pesticide using productivity has enhanced. In other words, all growers try to decrease pests' damages, but growers with high knowledge do this work with using less pesticide. Thus, growers' knowledge regards to temporal management of pesticide has decreased costs of pest controls and has increased profit per hectare per year. Therefore, by increasing the knowledge of temporal management of pistachio pest control, two of the three goals of precision agriculture, reducing production costs and achieving environmental goals, can be achieved. Of course, the third goal, namely production of quality products, is also implicitly provided, because with less spraying the residual amount of pesticides on the product is reduced and the product quality is improved.

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Conflict of interests

The authors state that there is no conflict of interest in publishing this study.

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