agriculture

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Adoption Determinants of Modern Rice Cultivars among Smallholders of Northern Iran

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Received: 13 September 2019; Accepted: 21 October 2019; Published: 24 October 2019

Abstract: Several agronomic innovations and precision technologies have been developed and disseminated in rice cultivation, but adoption is often lagged, particularly in developing countries. The objective of this work was to collect information on the use of improved rice cultivars and factors affecting adoption through a farmers' survey in Guilan Province, northern Iran. About 4 out of 10 farmers (42.8%) used improved rice cultivars. Above half of the farmers (55.2%) recognized the high profitability of this technology and half (49.8%) realized that modern rice cultivars are of great importance. However, there were some farmers who perceived no profitability (14.8%) or no importance (12.5%) regarding this technology. Additionally, 9.8% were not aware of the profitability, and 16.2% were not aware of the importance of the technology. The majority of the farmers (60.5%) collaborated with fellow farmers about common production problems. Nevertheless, low cooperation with extension agents was noted for 58.5% of the farmers and low attendance of local agricultural offices activities was noted for 59.8% of the farmers. A logistic regression analysis showed that perceived profitability and perceived importance of modern varieties, background in rice farming, and size of livestock holdings were positively associated with the adoption of improved cultivars. It can be concluded that the low acceptance of modern rice cultivars in the study area is related to current farming socio-economic conditions. Dissemination of information on improved cultivars from experienced farmers to other farmers should be considered to promote adoption, along with financial incentives to low-income farmers.

Keywords: importance; profitability; seeds; technology adoption

1. Introduction

Rice (*Oryza sativa* L.) is a major crop in Iran along with wheat and barley. Based on statistics of the Ministry of Jihad-e-Agriculture of Iran, the country produced about 2.7 million metric tonnes of rice in 2011 [1]. Rice is mainly produced in the northern part of Iran near the Caspian Sea. More than 80% of the rice belt is spread in the provinces of Mazandaran and Guilan. Guilan Province is the most important province in this regard, followed by Mazandaran Province and much smaller areas in the rest of the country [2]. Despite the low productivity of local varieties (ranging between 2.5 to 3.5 t/ha), more than 80% of the total rice area in Iran is cultivated with these varieties owing to their high-quality traits (i.e., long slender grain, head rice recovery of 60% to 63%, intermediate amylose content, aroma, and elongation qualities). From an agronomic point of view, local rice varieties are characterized by tall stature, weak culms, and droopy leaves. Moreover, they are prone to lodging and susceptible to rice blast (*Magnaporthe oryzae*) and rice stem borer (*Chilo suppressalis*). Local rice varieties have been cultivated for a long time in various regions of Iran and have adapted to different environmental conditions over the years due to their relatively large diversity [3].

The adoption of new agricultural technologies can boost production and thus improve farmers' income [4–7]. However, new technologies often take time to disseminate among rural communities due to farmers' lack of awareness as well as lack of promotion [8,9]. Rice cultivation in the northern areas of Iran has a long history, with a significant part of the rice fields being cultivated with local varieties owing to their high quality characteristics [10]. However, low yields, lodging, and susceptibility to pests often limit production. Therefore, using new technologies could enhance return per unit area [11,12]. However, farmers tend to assess a technology with different criteria and objectives than those considered by scientists. Therefore, farmers may be reluctant to accept new technologies because of various obstacles, which will slow adoption [4]. Thus, understanding farmers' preferences is important for the successful adoption of improved rice varieties.

Different factors can influence technology adoption among farmers, especially the adoption of modern cultivars. Previous research in Pakistan [13,14], Nepal [15], southwestern Nigeria [16], and Ghana [17] showed that education, land size, land ownership, land area under cultivation, farming experience, connection with extension services, and characteristics of the varieties favored the acceptance of improved varieties of different crops. On the other hand, the high price of seeds, low product quality of the modern cultivars, low profitability compared with local cultivars, high demands of inputs (e.g., water and fertilizer), and sensitivity to common plant pathogens negatively impacted the adoption of modern cultivars [18]. Moreover, seed availability was reported as a significant barrier in the increase of rice production in western Niger [19]. Farmers' perceptions of yield and risk of improved maize cultivars affected adoption in central Cameroon [20]. Structural barriers that make improved cassava varieties less profitable for the poor need to be overcome to reduce poverty in Nigeria [21]. In Uganda, recent research on the adoption of drought-tolerant maize varieties identified gaps in potential adoption due to a lack of awareness as well as poor access to seeds and high seed prices [22]. Access to the market and contact with extension services promoted the adoption process of improved chickpea varieties in Ethiopia [23].

Increasing yield per unit area is a main target for increasing rice production, given the barriers to the expansion of cultivated lands in the study area (Guilan Province). In this sense, the acceptance of modern varieties can be promising. From an agronomic point of view, modern varieties typically have robust genotypes that are the outcome of breeding efforts for high yield and stable productivity under diverse growth conditions (e.g., stress imposed by diseases and insect pests, or abiotic stresses such as extreme water or temperature conditions). The development of modern cultivars is an essential aspect of sustainable cropping systems, as they can lead to land-saving, conservation of natural resources through their interaction with input use and through their impact on biodiversity, and benefits to poor farmers in marginal areas through the low prices of produce and increased opportunities for employment [24]. In addition, system stability in the face of external shocks is often used as a measure of sustainability. However, the acceptance of improved varieties is always affected by the process of transfer to farmers. Thus, solutions need to start by understanding farmers' needs and perspectives, so that specific barriers to technology uptake are well understood before policy solutions can be designed. This includes understanding, for instance, whether the primary binding constraint is a lack of information about agricultural technologies or poor-quality inputs and technologies.

In this study, we used the "farm structure model" based on the idea that larger and wealthier farms are more likely to have the economic flexibility to adopt innovations [25]. This model states that farmers must make economic choices in their day-to-day production decisions. Based on this model, farmers face three major types of constraints in their choices: economic, technological, and institutional. Therefore, they need to determine how to use land, inputs, and technologies in their economic profit calculations [26]. The farm structure model emphasizes profitability as well as economic incentives for innovation adoption, while farmers' ability to bear the risk involved in trying an innovation is also an important determinant of adoption. According to the rationale of this model, the existence of these incentives increases the profitability and consequently the acceptance of an innovation. An assumption of the model is that acceptance behavior is initially subordinate to the ability to act on innovation, and that the acceptance of innovation is limited by the lack of economic resources. Another assumption of the model is that individuals are unable to adopt technologies because they do not have the financial resources to operate them. The farm structure model states that the most important limiting factors for the adoption of innovations are access to capital and land [27], while the role of information and attitude factors has received less attention [28].

As already explained above, understanding the factors affecting the adoption of modern cultivars is essential for shaping appropriate policy measures to improve the livelihoods of smallholders following the assumptions of the farm structure model. By identifying what factors affect adoption, it is possible to identify how to induce adoption among non-adopters. Thus, the objective of this work was to highlight the drivers of the use of modern varieties among rice growers in Guilan Province, Iran.

2. Materials and Methods

2.1. Study Area and Sample Selection

Farmers of Rudsar County of northern Iran (Guilan Province) were selected for the study. All rice farmers living in the county were considered, irrespective of the adoption of improved varieties. The smallest sample size was determined to be 370 people according to Bartlett et al. [29], but an extra 10% was added to avoid non-response errors. The survey was conducted in 2015.

2.2. Data Collection

Data were collected on the basis of a questionnaire that was developed after a literature review [15,18,19]. The questionnaire assessed the adoption of improved varieties (non-adoption = 0, adoption = 1) as the dependent variable and various attributes as the independent variables. Among the independent variables, profitability referred to the capability of generating profits from the use of modern cultivars, while importance referred to adaptability, stability, and productivity of these cultivars under diverse growth conditions, reflecting farmers' level of necessity of this material. Independent variables were assessed with a 5-point scale: very low (= 1), low (= 2), moderate (= 3), high (= 4), and very high (= 5). The content validity of the research tool was tested by experts in agricultural extension and agronomy from the Jihad-e-Agriculture Organization. Before the study, a pilot study was conducted with 30 participants outside the study sample to assess the reliability of the questionnaire. Cronbach's alpha was 0.91, which indicated good internal consistency of the questionnaire. Face-to-face interviews were conducted for data collection, with participants being recruited using simple random sampling based on farmers' lists from the local authorities.

2.3. Data Analysis

Descriptive statistics were calculated for the independent and dependent variables. The independent *t*-test (for continuous variables) and Mann–Whitney test (for ordinal variables) were used to compare characteristics of adopters and non-adopters. In addition, logistic regression was implemented to determine the association of the independent variables with the adoption of the modern varieties. Logistic regression was used because of the dichotomous nature (no, yes) of the dependent variable. The independent variables in the model included perceived profitability and perceived importance (i.e., necessity) of the modern varieties, social participation of growers, demographic data, economic data, and technical data (related to farm structure). In statistical model building, it is common to minimize variables until the most parsimonious model fits the data, which also results in numerical stability and generalizability of the results; therefore, the backward stepwise selection approach was used. Data analysis was performed using Statistical Package for the Social Sciences (SPSS Inc, Chicago, USA).

3. Results

3.1. Farmer Profile

Participant ages ranged from 25 to 80 years, with a mean age of 51.26 (Table 1). Most farmers were in the age group of 40–50 years. Almost one-third of the farmers (31.5%) had a university degree and 26.2% had graduated high school. Nevertheless, the greatest part (40.0%) had primary or medium education, and a small fraction (2.3%) were illiterate. Farmers had variable experience in rice cultivation from 5 to 65 years with a mean of 29.73 years. Most farmers (34.2%) were in the category of 20–30 years of experience.

Table 1. Demographic features of rice growers in Rudsar County (n = 400).

Variable	Frequency	Percentage (%)	Mean	SD
Age (years)				
<40	58	14.5	51.26	10.872
40–50	182	45.5		
51–60	78	19.5		
≥60	82	20.5		
Education level				
Illiterate	9	2.3	-	-
Elementary and intermediate schools	160	40.0		
High school and diploma	105	26.2		
Academic education	126	31.5		
Experience in rice farming (years)				
<20	131	32.8	29.73	14.815
20–30	137	34.2		
31–40	44	11		
≥40	88	22		

Most farmers did not have livestock, but the average livestock of the farmers in the sample was 4.23 heads (Table 2). Moreover, most farmers were in the agricultural income group of <50 million Iranian rials (IRR) and non-agricultural income group of <50 million IRR. Rice production averaged 2153.25 kg/year. Farmers in the sample had an average of 48,632,500 IRR agricultural expenses and most were in the group of >30 million IRR. The average farm area was calculated to 1.60 ha, but most farmers (67.2%) had farm area <1 ha (Table 3). The highest proportion (53.0%) was associated to >3 field plots. The average distance of the household from farm was 2.10 km, but most households (52.5%) were within a distance of <1 km and few (17.4%) were within a distance of >3 km. The average distance of the household from the road was 0.92 km. For most farmers (56.2%) the distance of the household from the road ranged between 0.1 and 1 km.

Table 2. Economic aspects of rice growers in Rudsar County (n = 400).

Feature	Frequency	Percentage (%)	Mean	SD
Number of livestock (heads)			4.23	7.289
0	240	60.0		
1–10	98	24.5		
>10	62	15.5		
Number of poultries (hens)			24.46	53.478
0	144	36.0		
1–20	128	32.0		
21–40	76	19.0		
>40	52	13.0		
Agricultural income (million IRR)			117,557,500	105,674,165.56
<50	159	39.8		
50–100	108	27.0		
>100	133	33.2		
Non-agricultural income (million IRR)			91,350,000	103,998,397.42
0	72	18		
<50	122	30.5		
50–100	116	29		
>100	90	22.5		
Rice production rate (kg/year)			2153.25	1483.236
<1500	169	42.2		
1500–3000	177	44.2		
>3000	54	13.5		
Total agricultural expenses (million IRR)			48,632,500	52,430,284.96
<15	116	29		
15–30	93	23.2		
>30	191	47.8		

IRR: Iranian rials (at the time of the study 1 USD was equal to 28,000 Iranian rials).

Table 3. Technical aspects of rice growers in Rudsar County (n = 400).

Features	Frequency	Percentage (%)	Mean	SD
Land size (ha)				
<1	269	67.2	1.60	1.802
1–2	68	17.0		
>2	63	15.8		
Number of farm parcels				
1	106	26.5	4.96	4.186
2	56	14.0		
3	26	6.5		
>3	212	53.0		
House distance to farm (km)				
<1	210	52.5	2.10	2.333
1–3	120	30.0		
>3	70	17.5		
House distance to road (km)				
<0.1	93	23.2	0.92	0.731
0.1–1	225	56.2		
>1	82	20.5		

High levels of cooperation with colleague farmers, with *Dehyari* (local municipality), and with rural entities and cooperatives were noted among participants (Table 4). Nevertheless, there was low participation in Jihad-e-Agriculture programs and poor collaboration with extension services. It is noted that 59.8% of the farmers had very low or low participation in Jihad-e-Agriculture programs and a similar proportion had very low or low co-operation with extension agents.

Table 4. Social participation of rice growers in Rudsar County (*n* = 400).

Social Participation	VL	L	M	H	VH	Mean	SD
	Percentage (%)						
Cooperation with other farmers about production problems	2.0	8.5	29.0	28.5	32.0	3.80	1.045
Cooperation with *Dehyari* and Islamic Council of village	10.0	7.0	28.5	30.0	24.5	3.52	1.218
Membership and cooperation with rural entities and cooperatives	8.3	19.0	21.2	35.0	16.5	3.32	1.195
Attendance in educational-promotional courses	18.5	18.0	34.0	23.8	5.7	2.80	1.63
Cooperation in programs recommended by Jihad-e-Agriculture	36.2	23.6	12.2	19.5	8.5	2.40	1.368
Cooperation with extension agents	51.5	7.0	20.0	15.3	6.2	2.18	1.345

VL: very low, L: low, M: moderate, H: high, VH: very high.

3.2. Utilization of Improved Cultivars

Most farmers (57.2%) did not adopt the technology of improved cultivars—this technology was adopted by 42.8% of the respondents. Nevertheless, about half of the farmers (55.2%) perceived the improved cultivars as highly profitable and half of the farmers (49.8%) perceived them as highly important (Table 5). The most convenient information source among the rice farmers surveyed was information from other farmers (mean = 2.95), followed by TV and radio (mean = 2.51), while extension agents, education movies, and research centers showed low mean values (1.60, 1.59, and 1.28, respectively) (Table 6).

Table 5. Perceived profitability and perceived importance of improved cultivars among rice growers of Rudsar County (*n* = 400).

High-Yield Rice Cultivars	Percentage (%)					Mean	SD
	Do Not Know	None	Low	High	Very High		
Perceived profitability	9.8	14.8	20.2	41.2	14.0	1.60	0.937
Perceived importance	16.2	12.5	21.5	36.0	13.8	2.61	0.931

Table 6. Usefulness of information sources among rice growers of Rudsar County (*n* = 400).

Information Source	Mean	SD
Farmers	2.95	0.974
TV and radio	2.51	1.014
Extension agents	1.60	1.494
Educational movies	1.59	1.374
Research centers	1.28	1.360
Internet	1.14	1.405

3.3. Differences between Adopters and Non-Adopters of Improved Cultivars

Adopters of improved cultivars perceived higher importance and profitability of improved cultivars and had higher social participation than non-adopters (Table 7). Moreover, adopters were slightly older and had lower education than non-adopters. Adopters were more experienced farmers, had greater number of livestock and poultries, higher agricultural income, and greater number of land parcels than non-adopters (Table 7).

Table 7. Differences between adopters and non-adopters of improved cultivars among rice growers of Rudsar County (*t*-test and Mann–Whitney test).

Variables	Group	*n*	Mean	SD	*t* or Z	*p*-Value
Perceived profitability	Non-adoption	195	132.98		−10.072	0.000
	Adoption	166	237.41			
Perceived importance	Non-adoption	174	120.02		−9.959	0.000
	Adoption	161	219.85			
Social participation	Non-adoption	229	2.8617	0.81	−4.575	0.000
	Adoption	171	3.1969	0.66		
Age (years)	Non-adoption	229	50.03	9.74	−2.572	0.011
	Adoption	171	52.92	12.06		
Education level	Non-adoption	229	211.28		−2.293	0.022
	Adoption	171	186.06			
Experience in rice farming (years)	Non-adoption	229	27.07	13.67	−4.176	0.000
	Adoption	171	33.30	15.56		
Number of livestock	Non-adoption	229	3.38	6.70	−2.636	0.009
	Adoption	171	5.36	7.89		
Number of poultries	Non-adoption	229	16.66	25.5	−3.047	0.003
	Adoption	171	34.91	75.16		
Agricultural income (million IRR)	Non-adoption	229	10,287,336.24	9,263,646.47	−3.143	0.002
	Adoption	171	13,722,222.22	11,840,994.48		
Non-agricultural income (million IRR)	Non-adoption	229	10,052,401.75	10,984,672.57	2.095	0.037
	Adoption	171	7,906,432.75	9,453,447.22		
Number of farm parcels	Non-adoption	229	4.39	3.98	−3.145	0.002
	Adoption	171	5.73	4.34		

3.4. Logistic Regression Analysis

The logistic regression model showed high fit to the data with correct prediction 81.0% (Table 8), indicating the capability of the model to predict a high level of the amount of variance of the dependent variable. Perceived profitability and perceived importance of the improved varieties, background in rice cultivation, and size of livestock were positively associated with the adoption. Experience in rice cultivation, perceived importance, and perceived profitability of the improved varieties shared the maximum contribution in the prediction of adoption according to Wald values (Table 8). Perceived profitability showed the greatest contribution in forecasting adoption according to Exp (B) (i.e., the exponentiation of the B coefficient) odds ratio values.

Table 8. Technical factors affecting the adoption of improved cultivars among rice growers of Rudsar County.

Variables	B	SE	Wald	*p*-Value		Exp (B)
Perceived profitability	1.15	0.25	21.50	0.000	**	3.170
Perceived importance	1.08	0.22	24.06	0.000	**	2.940
Experience in rice farming	0.06	0.01	26.06	0.000	**	1.060
Number of livestock	0.05	0.02	5.86	0.015	*	1.050
Constant	−6.96	0.77	81.52	0.000	**	0.001

−2 log likelihood = 286.070; Cox & Snell R^2 = 0.406; Nagelkerke R^2 = 0.542; ** Significant at $p < 0.01$; * significant at $p < 0.05$; Correct prediction = 81.0%.

4. Discussion

This study determined drivers of the adoption of modern rice cultivars among smallholders of northern Iran, for which no relevant data exist in the literature. Significant relationships between the use of modern rice cultivars and several independent variables were identified with logistic regression analysis. Perceived profitability and perceived importance of improved seeds, background in rice farming, and livestock holdings were positively associated with the adoption of improved cultivars. Today, farmers, advisors, and policy makers face a wide range of technologies with uncertainties in the agri-food chain which they must deal with. Therefore, our findings assist in better understanding the adoption of this technology and thus may be important for seed delivery systems, pointing to policies for promoting acceptance of modern cultivars among non-adopters. The novelty of this research stems from the paucity of data in the literature on modern cultivar adoption concerning rice, as very few studies have assessed the adoption of modern rice cultivars, while no study has identified factors affecting the adoption of modern rice cultivars in Guilan Province, a major rice producing-province of Iran. Moreover this study provides a detailed regional representation of farmers included in the project, based on well-established data sources. Therefore, it adds useful information on the adoption of modern rice cultivars in the study area, and by identifying what factors affect adoption, one can determine how to induce the adoption of modern cultivars among non-adopters.

The perceived profitability of the technology was positively associated with the acceptance of modern rice cultivars ($p < 0.01$), in agreement with previous literature [30,31], which showed that stating the advantages and benefits of modern technologies to rice growers can encourage their use. A technology is useful to the extent that it improves production and profit, and it is applied to the extent that it generates and satisfies users' needs. Economic profitability is a crucial factor before farmers make adoption decisions [32]. Therefore, a lag in the spread of improved seeds use could be due to the perception of low profitability among farmers [33,34]. Other studies have shown that the adoption of different technologies was favored by positive perceptions of profitability of each technology among farmers [35,36]. Additionally, doubts about the benefits of variable fertilization rate among grain growers of Western Australia hindered adoption of the technology [37]. In our study, the perceived importance of improved seeds favored the adoption of modern cultivars ($p < 0.01$), showing that technologies that are tailored to farmers' needs are more likely to be accepted. The importance and usefulness of the technology have been reported to be significant determinants of the adoption of a technology in previous studies [38,39]. From this point of view, research centers should determine farmers' needs and provide technologies that are more interesting to them.

The adoption of improved varieties was positively favored by rice cultivation experience ($p < 0.01$), as also reported elsewhere [15,40,41]. Similarly, the adoption of current technology in rice management in India was constrained by lack of experience [42]. Farming experience reflects knowledge that farmers have gained, and can be used to tackle farm production problems [33]. Farming experience can play an important role early in the adoption because the advantages of the technology are still being assessed. From this point of view, to promote adoption there is a need for progressive growth of the technology and constant farmer training [43]. This finding is rational, as experienced farmers are generally more competent with better access to necessary information about modern technologies, implying that accumulated knowledge may help in better evaluating information and thus impacting adoption decision [40]. It is noteworthy that apart from solely being adopters, farmers are involved in the generation of innovations [44].

The adoption of modern cultivars was positively associated with number of livestock ($p < 0.05$); that is, farmers with large number of livestock were more willing to adopt the improved varieties. In agreement with the current finding, a previous study reported that owning oxen favored the probability of adopting modern varieties [45]. It seems that animal power is a significant factor in small cropped areas because it is available for plowing where tractor mechanization does not exist or perhaps is unprofitable. Moreover, livestock can be a source of off-farm income that can be exploited for supplying farming inputs. Livestock shows opportunity of working capital for farming tasks [46]. From this point of view, livestock can contribute to the diversification of income sources, and can thus allow the reallocation of other resources for improving farm productivity [47]. However, it is also possible that farmers with income from livestock may be reluctant to accept a new technology unless non-farm alternatives are more rewarding to them [35,48]. Additionally, the number of livestock held likely affects access to animal manure and hence soil fertility. From this point of view, the number of livestock may also be a proxy for wealth, and hence can increase farmers' capacity to bear the risk of trying a new cultivar. However, smaller and poorer farmers operating on less-favorable plots may correctly perceive that the new cultivars are not more profitable for them and thus that the new technology is "not important" for addressing their most pressing constraints, which could vary from labor availability at peak periods of the production cycle for the new varieties to access to finance for inputs.

The current study also showed that adopters had significantly higher agricultural income and greater number of parcels than non-adopters. Farm income promotes technology adoption by overcoming the credit constraints of rural households in developing countries [49]. Farm income offers liquid capital to farmers, thus enhancing capacity for purchase of inputs such as improved seed and fertilizers. It is likely that a great number of plots may allow for some kind of experimentation with the new technology by spreading out risk. In this context, the new technology, as developed by the researchers in the study area, may be suitable for only a subset of the farmers in the area (e.g., those who are wealthier and on more favorable plots). This problem seems to lie in the technology, not necessarily in those who do not adopt, as farmers who do not adopt may be acting very rationally given their circumstances. This point was made in much of the farming systems research of the 1970s and 1980s, when researchers at CIMMYT (International Maize and Wheat Improvement Center) developed the notion of "recommendation domains" for different types of technology (i.e., tailoring different products for different groups of farmers, even farmers living in the same area) [50].

5. Conclusions

This work highlighted drivers of the adoption of improved rice varieties among farmers of Guilan Province. Farmers in the study area are expected to use improved rice varieties in their fields if they perceive that the investment is important and will be profitable. On the other hand, low adoption seems likely to be connected with the inconsistency of the modern varieties with current farming socio-economic conditions. Where benefits from the adoption of sustainable technologies are expected to accrue only to people outside agriculture and where there are no markets for the benefits of those technologies, the levels of adoption could be sub-optimal. Based on the findings of this study, the most likely way to convince farmers to accept an innovation is the provision of basic information about the advantages of the technology through extension services, demonstration projects, participatory research, and close cooperation with other farmers. Using experienced farmers for information transfer to other farmers should be considered to promote adoption, along with financial incentives to low-income farmers. It is possible that tailoring different modern varieties to different groups of farmers would be required, as there may be a range of different recommendation domains. Appropriate policies facilitating the adoption of improved varieties, such as incentives, subsidies, or price supports as well as growth of the number of people involved in extension and their quality, could be put forth according to findings. Nevertheless, it should be kept in mind that while such incentives may be appropriate in the short term to mitigate the risk associated with adoption and to help farmers learn more about the technologies by trying them out, they may not be a financially sustainable strategy in the long run, as the budgetary costs of such measures can be high.

Author Contributions: D.A. conducted the survey, gathered data, and analyzed data; M.S.A. conceived the idea, planned the research, analyzed data, interpreted data, and wrote the article; A.B. contributed to data interpretation and edited the article; C.A.D. contributed to data interpretation and edited the article. All authors approved the final version of this article.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflicts of interest.

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