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**Agro-dealer's knowledge, perception, and willingness to stock a fungal based  
biopesticide (ICIPE 20) for management of Tuta absoluta in Kenya**

by Francis Ogutu

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## **Agro-dealer's knowledge, perception, and willingness to stock a fungal based biopesticide (*ICIPE 20*) for management of *Tuta absoluta* in Kenya**

### **1. Introduction**

Tomato is a popular vegetable that is extensively cultivated among the promising commodities in horticultural subsector in Kenya (Ochilo *et al.*, 2019). It plays an important role in meeting domestic and nutritional food requirements, through the creation of employment opportunities, generation of income and a great foreign exchange earner to the country. It is also a source of vitamin A, C, and lycopene which acts as an anti-oxidant and plays a critical role in the body in fighting cancer-health wise (Karuku *et al.*, 2017). Kenya is among the leaders in tomato production in Africa with an average annual production of approximately 410,033 metric tons (FAO, 2018), and the major tomato producing areas in Kenya are Kirinyaga Kajiado and Taita Taveta counties which accounts for 37% of total tomato output in the country. Over the past years, tomato production in Kenya has intensified. However, yields have remained low due to myriads of impediments, key among them being the leaf miner *Tuta absoluta*.

*Tuta absoluta* is the most threatening tomato infesting pest and causes significant damage to the crop by 80 to 100% if not managed. The pest is also known to attack other Solanaceous plants including pepper, potato, eggplant and the garden bean (Pfeiffer *et al.*, 2013). Since the invasion of *T. absoluta* in Kenya in 2013, tomato growers have chiefly depended on the use of synthetic chemical pesticides, which are stocked in large volumes by the Agro-dealers to manage this pest. Nderitu *et al.* (2018) also reported cultural practices such as uprooting infected tomato plants, crop rotation, and baiting and killing the adult moth from Kirinyaga County. Farmers use conventional synthetic pesticides since they are considered; Readily available, increases production as they protect the crop from pests, diseases, risks associated with unpredictable weather conditions, and save time and effort used in farming (Chandler *et al.*, 2011). The contribution of synthetic chemical pesticides to increase agricultural production cannot be underscored. However, these pesticides have caused unprecedented ecological damage. They have also induced serious health hazards among workers during their manufacture, formulation, handling at the sales point and field application in crop protection (Manikanta *et al.*, 2014). Continuous application has also led to pest resistance and

residues in food substances, which are harmful to human health and the environment (Chandler *et al.*, 2011). These chemicals are often associated with long-term health impairments such as cancer and therefore not sustainable for the production of food crops such as tomato (Rao *et al.*, 2009).

As a result of the negative effects of synthetic chemical pesticides to human health and the environment, there has been an increasing demand for organic food products (Moshi *et al.*, 2017). The growing demand has therefore stimulated the growth of organic farming which is now the fastest growing industry in agriculture in the world (Huebla, 2013). Organic farming combines both indigenous practices and science to produce crops that flourish in the absence of synthetic pesticides and herbicides. It also incorporates integrated pest management packages such as mass trapping of insect pests, orchard sanitation and biological control (Wafula *et al.*, 2018). Biological control (BC) takes into account the use of biopesticides and other living organisms such as parasitoids or a beneficial insect that destroys the harmful one (Barros *et al.*, 2018). BC replaces chemical pesticides, thus reducing chemical residues in food substances for consumers. The use of biopesticides therefore, is a sustainable alternative for the management of *T. absoluta* in the tomato fields (Huebla, 2013).

Biopesticides are specific to the pest organism with a correspondingly low risk to the non-target organism. They constitute a special group of active substances and some living organisms that occur naturally for plant protection (Wilson *et al.*, 2019). They are derived from naturally occurring materials such as animals, plants, and bacteria. These biopesticides are mainly constituted in fungi, protozoa, nematodes, baculoviruses, and bacteria. For example, the widely used *Bacillus thuringiensis* (Bt) in the United States of America to regulate the population of insect pests (Wilson *et al.*, 2019). Previous studies have demonstrated that biopesticides are effective and efficient in pest management. For instance in the management of potato tuber moth, rice ear head bug, and oriental armyworm for wheat sorghum and corn in India (Manikanta *et al.*, 2014). The corresponding yield increase in these crops supports the use of biopesticides which are sustainable and safe for both human health and the environment (Manikanta *et al.*, 2014). Therefore, there is a need to promote biopesticides among the Agro-dealers as an alternative to the harmful chemical pesticides for controlling the tomato leaf miner (*T. absoluta*).

In partnership with private and public sectors, the International Centre of Insect Physiology and Ecology (ICIPE) is introducing a fungal based biopesticide (ICIPE 20) for combating the tomato leaf miner (*T. absoluta*) in an integrated pest management approach. The IPM

technique which takes account of mass trapping of insect pests, orchard sanitation and biological control aims to combat the pest population for high-quality tomato and improved income. This study was conducted before the introduction of the biopesticide to determine the knowledge, perception and willingness to stock a fungal based biopesticide among Agro-dealers in Mwea, Kirinyaga County.

## **2. Theoretical framework**

This study takes into account the theory of profit maximization which states that; Traders are always compelled to search for new technologies to innovate efficient and effective products, in order to reduce costs of production and increase revenues. However, these products may not have readily available markets thus impractical to determine their profitability. Therefore, determining their feasibility is critical to the traders. A bidding game in the contingent valuation method (CVM) was used in this study. It involves a series of yes/no questions aimed at determining the maximum willingness to stock for new products by Agro-dealers. This approach is used in the valuation of non-market products for economic value (Migwi, 2016; Chege and Groote, 2008) The repeated nature of questions in the bidding game gives the respondent plenty of time to make a decision based on the maximum favourable price that he or she is willing to pay for the product. CVM employs three methods namely; single-bounded, double-bounded and the multi-bounded models. In the single-bounded model, the respondent is only offered one bid to either accept or reject. According to Hanemann *et al.* (1998), the method is not appropriate since it requires a large sample size and not statistically efficient. Studies have illustrated the effectiveness of double-bounded model since it incorporates more information about the respondents' willingness to pay, and therefore providing efficient estimates. The model has also been employed in valuing non market goods more appropriately. It offers a second bid, either higher or lower depending on the respondent's first response, unlike the single-bounded model (Carson *et al.*, 1998). The multiple bounded model allows for multiple bids and choices, which offers the possibility of including alternatives for uncertainty. However, the multiple-bounded models are design bias and influenced by bid range (Vossler *et al.*, 2004)

This study employed the double bounded model which has a good theoretical justification and provides unbiased estimates. In this model, the respondents are faced with a two sequence bid offer. They are asked if they will accept or reject the bid, then the next bid is asked depending on the respondent's initial response. Depending on the type of response

from the respondent of either yes/no, a higher bid is offered if the respondent said ‘yes’ and a lower bid offered if the respondent said ‘no’. The outcome presents four possible responses which include (i) Either both responses are ‘yes’, (ii) both of them are ‘no’, (iii) a ‘no’ followed by a ‘yes’ (iv) or a ‘yes’ followed by a ‘no’. An assumption prevails that when the maximum willingness to pay is less than or equal to the lowest bid ( $maxWTP \leq Bid_j^L$ ) then the first and second bid offers are rejected by the respondent. The maximum willingness to pay therefore lies between the lower and the first bid offer ( $Bid_j^L \leq maxWTP < Bid_j$ ), if the respondent rejects the first bid offer but accepts the second lower bid. If the respondent is willing to accept the first bid but rejects the second higher bid offer, then an assumption prevails that the respondent’s maximum willingness to pay lies between the second higher bid and the first bid offer ( $Bid_j^H > maxWTP > Bid_j$ ). Finally, if the respondent is willing to accept both the first and the second higher bids, then an assumption prevails that the respondent’s maximum willingness to pay is greater than or equal to the second higher bid ( $maxWTP \geq Bid_j^H$ ).

Agro-dealers were first asked the most demanded pesticide by farmers for control of the leaf miner, and at what price they usually pay for it per litre. Then they were asked if they would be willing to buy the fungal based biopesticide at the same price. Those who answered ‘yes’ were then asked if they were willing to pay for the fungal biopesticide at a higher price. Different premiums were assigned randomly to different Agro-dealers (5%, 10%, 20%, 30%, 50%) though each Agro-dealer was offered one second bid. The price of the most used pesticide plus the random premium level was then calculated by the enumerator and expressed in Kenya shillings per litre. The Agro-dealers who answered ‘no’ to the first bid were offered a lower price. The price of the most demanded pesticide reduced by a randomly assigned discount (5%, 10%, 20%, 30%, 50%) calculated in Kenya shillings per litre. The average price of the most used pesticide by farmers in control of *Tuta absoluta* was 621.96 Ksh per litre and the second bid ranged between 110 and 2200 Ksh per litre. The binary probit model was then employed to analyse the different factors influencing agro-dealers’ willingness to stock a fungal based biopesticide, and all the steps for mean willingness to pay in this research methodology are presented in the next section after materials and methods.

### **3. Materials and methods**

#### **3.1. Study area and data collection**

The data utilized in this study was obtained from Kirinyaga County in Kenya. Kirinyaga County was purposively selected since it is one of the leading tomato producing counties in Kenya (HCDA, 2018) Tomato production in Kirinyaga is approximated to about 17% of the total country's production, followed by Kajiado (11.8%) and Taita taveta (8.5%) (HCDA, 2018) The population of study constituted the agro-dealers trading in pesticides in urban dwellings of two purposefully selected Sub-counties of Kirinyaga County (namely Mwea East and Mwea West). Again the predominance in tomato production guided the selection of the two wards. A census of the agro-dealers was developed with the help of the agricultural officers from the two sub-counties. All the listed agro-dealers (141) were targeted for the survey. Data were collected by trained enumerators using a pre-tested semi-structured questionnaire programmed in CSPro version 7.0 software to reduce data collection errors.

The information collected included the agro-dealer's socioeconomic characteristics such as age, gender, education level and years in Agrovet operation, their knowledge, and perception towards the use of biopesticides, their capacity to stock new biopesticides, their willingness to stock the fungal based biopesticides for management of *T. absoluta*, and the costs and benefits associated with commercializing biopesticides. This study was approved by the International Centre of insect physiology and ecology (*icipe*) social science department, and the questionnaire also had an introductory statement that sought the agro-dealers consent to participate in the survey.

### **3.2. Empirical model**

According to Horowitz *et al.* (2001) A binary regression model is a type of regression in which the dependent variable  $y$  is a binary random variable that takes only the values of zero and one. The model gives the probability that  $y$  is equal to one, is chosen conditional on a set of independent variables. The most used approaches are the logit and probit models which assumes that the functional form of dependence on the independent variables is known. The multinomial versions of the probit and logit models are capable of producing misleading inferences when some of the alternatives are close substitutes, moreover, multinomial probit model with three or more choices is difficult to compute. Both the probit and logit models yields similar inferences though not identical since the logit regression has a standard logistic distribution of errors while the probit has normal distribution of errors (Van *et al.*, 2011) Therefore, the probit model is appropriate since it assumes normality that is; a mean of 0 and a standard deviation of 1. Therefore, the factors influencing Agro-dealers willingness to stock a fungal based biopesticide was estimated using the binary probit model of the form;

$$Y_i = B_0 + B_1X_1 + e_i \text{-----} (1)$$

Where  $Y_i$  is the outcome variable of interest for willingness to stock, and If  $Y_i^*$  which is an estimate of  $Y_i$  is greater than 0, then  $Y_i$  equals to 1. If  $Y_i^*$  is less than or equal to 0, then  $Y_i$  equals to 0. Thus,  $B_0$  represents the intercept  $B_1$  denotes the value of the regression coefficient,  $X_1$  is the value of the parameter to be estimated and  $e_i$  is the error term. The decision to use the independent variables in this study were guided by the review of previous literature on willingness to pay for new products (Van *et al.*, 2011; Lin, 2012; Beck, 2015), and knowledge, attitudes and practices towards pesticides use (Abudulai *et al.*, 2006; Trevor, 2014; Schreinemachers *et al.*, 2017)

## 4. Results

### 4.1 Selected socio-economic characteristics of the study population

A sample of 141 agro-dealers was interviewed, and the description and summary of selected socioeconomic characteristics of the sample are presented in Table 3 and Table 4 respectively. The overall mean or percentages and standard deviations for independent variables were derived from the survey data set. The survey results show that the average age of Agro-dealers was 35 years with 13 years of schooling. This illustrated that the highest level of education for most of the Agro-dealers was Secondary. Education is considered as a human capital that facilitates the use of available information to reduce the existing constraints. For example, agro-dealers who are better educated may have better business skills that enable them to operate their businesses more efficiently (Constantine *et al.*, 2020). The average years of business operation were 4 years, depicting the level of experience in the pesticides business.

Based on the findings by Chia *et al.*, (2020), it is expected that access to credit enhances willingness to stock new products, with a corresponding positive perception towards them. About 46% of the agro-dealers stated that they had access to credit facilities whenever they required them. In addition, only 7% of the Agro-dealers needed credit for the Agroveter operations. Previous studies have shown that, availability of manpower in businesses triggers expansion of the ventures and improved sales. This is because they are educated and trained on the new technologies in order to avoid obsolescence (Maunze, 2012). From the sampled Agro-dealers on employed labour also show that 33% had employees. Further, the



outcome of the survey indicated that 2% were part timers, 29% were full time employees and only 1% of them worked both full time and over time. The rest 67% of the Agro-dealers employed family labour. Access to market information by Agro-dealers on prices, new products, competition and market trends are seen to influence willingness to stock. This is justified by Lin *et al* (2012) on new product acceptance decisions. In this survey, the Agro-dealers who had access to social networks and market information on prices, new products, competition and market trends were 44% and 92% respectively, indicating that they have good knowledge and perception and thus willing to stock the new fungal biopesticide.

**Table 1. Socio-economic characteristics (n=141)**

<b>Agrodealer Characteristics</b>	<b>Statistics</b>
Age of the Agro-dealer (Mean)	35.7305 (10.6495)
Education level of Agro-dealers (Years of schooling) Mean	13.0071 (2,1331)
Years in Agroveter operation (Mean)	4.9716 (5.1906)
Agro-dealer access to credit (%Access)	46.1
Employed Labour in agroveter business (%Yes)	32.62
Access to Agrodealer networks (%Yes)	43.97
Agro-dealer access to information (%Yes)	92.20
Managerial support by manufacturers and suppliers (%Yes)	81.56
Agro-dealer Knowledge on none pesticide practices (%Yes)	70.92

Notes: Standard deviation in parenthesis

### **1.2. Agro-dealers knowledge on biopesticides**

Most of the Agro-dealers were aware of non-chemical practices for management of leaf miner. About 43% of the respondents were aware of the specific non-pesticide practices that could be used in control of the pest, and 79% of the respondents stated that crop rotation with non-host crop, is the main control measure put into practice by most tomato farmers in control of *Tuta absoluta*.

**Table 2. Agro-dealers knowledge on biopesticides**

<b>Characteristics</b>	<b>Percent</b>
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	n =141
Knowledge on non-chemical pesticides for control of Leaf miner (%yes)	70.92
Knowledge on non-pesticide practices for control of Leaf miner (%yes)	43.36
<b>Non pesticide practices</b>	
Do you know Planting resistant varieties (%yes)	29.51
Selecting healthy seeds or sanitizing seed treatment (%yes)	19.67
Soil tillage (%yes)	13.11
Crop rotation with non-host crop (%yes)	78.69
Adjust planting/harvesting dates to reduce pest damage (%yes)	31.15
Adjust irrigation timing/amount to reduce pest damage (%yes)	37.70
Grow tomato under insect net or net house (%yes)	50.82
Pick and destroy infected plant or plant parts (%yes)	54.10
Orchard sanitation (collecting fallen infested fruits and disposing away from the farm) (%yes)	54.10
Use Pheromones traps for scouting, monitoring and mass trapping (%yes)	40.98
Hang sticky traps (%yes)	16.39
Biological control using parasitosis/natural enemies (%yes)	32.79
Using a barrier crop (%yes)	18.03
Using water traps (%yes)	3.28

### 1.3. Agro-dealers' perception towards biopesticides

The principal component analysis (PCA) method was used to extract perception indicators from Agro-dealers, and the robustness of the analysis was tested using Kaiser-Meyer-Olkin (KMO) test, Bartlett's test and Cronbach's alpha tests as shown in table 5 in appendix 1. The KMO value of 0.8099 is higher than the accepted value of 0.5, which depict that the sample was adequate and principal component analysis could be used for the given data set. The p value of 0.0000 acquired for the Bartlett's test also indicate sufficient measure of sampling adequacy. Further, a Cronbach's alpha value of 0.7747 indicates a high level of internal consistency thus the indicators measured the same latent perception variables.

Agro-dealers were asked to rank their preference based on the use of biopesticides in crop protection. They were also asked if they consider pesticides characteristics such as price, the type of pesticide, the effect of pesticide on human health and the pesticides demand when making stocking decisions. Further, they were also asked to rank their level of agreement

concerning biopesticides which included; Biopesticides are effective in controlling *Tuta absoluta*, biopesticides are safe to both human and the environment, I am willing to trade in biopesticides, biopesticides contributes to high yield as compared to synthetic pesticides, and if they believe that biopesticides can replace synthetic pesticides. After running the principal component analysis, three principal components were extracted from the Agro-dealers, with the first one contributing the highest percentage (35%) to the variance. The second and third component contributed 15% and 13% respectively

The first principal component (PC 1) which captured the highest number of perception indicators, and the highest percentage of variation in the initial indicators (35%) had the following dominant factors; ‘Preference of biopesticide use in crop protection’, ‘Biopesticides are effective in controlling *Tuta absoluta*’, ‘Biopesticides contributes to high yield as compared to synthetic pesticides’ and ‘Biopesticides can replace synthetic pesticides’. These results show that the PC 1’s dominant factors were found to represent the effectiveness of Biopesticides in crop protection over synthetic chemical pesticides. The perception indicators captured in PC 2 were; ‘Biopesticides are safe to both humans and the environment’ and ‘I am willing to trade in biopesticides’ PC 2’s dominant factors were found to represent the general effect of Biopesticides on human health and the environment. PC 3 therefore captured the aspect of commercialization and factors considered in decision making when trading in pesticides which included; ‘Price when trading’, ‘the type of pesticide’ and ‘the demand’ (See appendix 1)

## **1.2. Willingness to stock for Biopesticides among the surveyed Agro-dealers**

The survey results show that the most used pesticide for management of *T. absoluta* is Collagen at an average price of Ksh 621.96 per litre. Eighty two (82%) of the Agro-dealers were willing to stock a fungal-based biopesticide, and to pay for it at the same price as Collagen. The analysis reveal that the mean willingness to pay was at a much higher price of approximately Ksh 1018.191per litre for the ICIPE 20, suggesting that the agro-dealers consider biopesticides efficient than the chemical pesticides.

## **1.3. Table 3: The Agro-dealers’ mean willingness to stock and mean premium price for biopesticide and commonly used synthetic pesticide**

Pesticide	Mean	Z stat	% change from market price
Fungal biopesticide (ICIPE 20)	1018.191	17.21***	38.92
Collagen	621.9568		

These results indicates that Agro-dealers have a positive perception towards ICIPE 20, and they consider it more effective than the already existing chemical pesticides such as Collage, therefore they were willing to pay more.

**Table 4: Factors influencing willingness to stock for a fungal based Biopesticide (ICIPE 20) in Kirinyaga County**

Variables	Coefficient	Standard error	Z
Age of Agro-dealers	-0.154**	0.0760	-2.03
Years of schooling of Agro-dealers	0.419*	0.2461	1.70
Agro-dealer access to social networks	5.063**	2.3158	2.19
Agro-dealer knowledge on none-pesticide practices	-1.985	1.2956	-1.53
Years of business operation	-0.073	0.0982	-0.75
Agro-dealer access to credit facilities	2.408*	1.2809	1.88
Managerial support from manufacturers and suppliers	1.477	0.9956	1.48
Availability of employees in the Agro-vets	-1.352	1.1243	-1.20
Agro-dealer access to information	2.199*	1.2325	1.78

Note: \*= significant at  $P < .1$ ; \*\*= significant at  $P < .05$ ; \*\*\*= significant at  $P < .01$   $Z = z$  statistics

Table 4 presents main factors influencing willingness to stock a fungal based Biopesticide (ICIPE 20), which included age, and years of schooling of the agro-dealer, Agro-dealer access to social networks, to credit facilities and to information. Age of the Agro-dealer is negatively related to their willingness to stock the fungal Biopesticide, suggesting that the older the trader the lower the willingness to pay for the Biopesticide. The findings corroborates that of Nyangau *et al.* (2020) and Bandara *et al.* (2013) who found that perception and willingness to pay for Bt 43 and ICIPE 78 in Uganda decreased with age of

the individuals. The coefficient for years of schooling was significant and had a positive effect on willingness to stock, implying that, well educated Agro-dealers have better knowledge on Biopesticides. These results are consistent with the previous studies such as Constantine *et al.* (2020) who found that educated individuals are more likely to pay for Biopesticides in Kenya.

Agro-dealer access to social networks indicated a significance at 5% thus depicting the positive relationship of Agro-dealers willingness to stock. This explains that the Agro-dealers who had access to social networks have information on the market trends based on new products, prices and consumer demand. The coefficient for access to credit facilities was also positive and significant, implying that Agro-dealers having access to the credit facilities are more likely to accept new products or increase their stocks in the stores due to availability of capital. The findings are consistent with the previous studies such as Chia *et al.*, (2020) who found that access to credit significantly and positively influenced willingness to pay for feeds among Agro-dealers in Kenya. In the pesticides industry, information is very critical to both Agro-dealers and the farmers. Access to information therefore significantly and positively influenced willingness to stock, implying that Agro-dealers who had access to reliable information on pesticides had knowledge about them and their demand (Table 4).

## **5. Conclusion and policy implication**

The survey results indicate that 26 percent of the Agro-dealers were aware of the use of Biopesticides in management of *Tuta absoluta*, with only 21 percent having stocked Biopesticides in their Agrovets. The Agro-dealers who have higher education, have access to social networks and information, and have been operating their Agrovets for many years, are more aware of biopesticide use in crop protection. The findings also depict that Agro-dealers attached a higher value to the fungal biopesticide (ICIPE 20) as an alternative pest management practice for the leaf miner. Thus, implying that there is much concern about the destructive nature and the huge losses of the pest. Moreover, over application of the synthetic chemicals due to pest resistance was pointed out as a factor that contributes to high cost of the pesticides. The main method used to control the leaf miner *Tuta absoluta* is the massive use of Collagen chemical in the fields by farmers, since this is what is stocked in large quantities by Agro-dealers.

The regression results indicates that factors such as age, years of schooling, access to social networks, access to credit facilities and access to information, influence the knowledge, perception and willingness to stock pesticides among Agro-dealers in Kirinyaga County. All these factors are positively related to willingness to stock except age. Agro-dealer knowledge on non-pesticide practices, years of business operation, managerial support from the manufacturers and suppliers, and availability of employees however, did not have significant effect on willingness to stock. Years of schooling positively influenced willingness to stock biopesticides among Agro-dealers, similar to the findings of Lusk *et al.* (2002) who found out that people with at least secondary education are more willing to pay for genetically modified food products in the United States. Previous studies have also shown that perception and willingness to stock decreases when age of an Agro-dealer increases (Bandara *et al.*, 2013). From a policy perspective, there is a need to increase the level of access to social networks, credit facilities and information among Agro-dealers, since they are critical factors that easily influences knowledge, perception and willingness to stock new products as illustrated by previous studies such as Constantine *et al.* (2020) and Nyangau *et al.* (2020)

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## **Conflict of interest**

There was no potential conflict of interest to be reported by the author(s)

## Appendix 1

**Table 5: Principal component analysis results with component loadings**

Variable	PC 1	PC 2	PC 3	Unexplained
	<b>Effectiveness in crop protection</b>	<b>Effect on health and environment</b>	<b>Commerciali zation aspect</b>	
Use of Biopesticides in crop protection	0.4676			0.2037
Effectiveness	0.4916			0.1683
Safe to human and environment		0.6635		0.3463
Willingness to trade		0.6139		0.4176
Contributes to high yield	0.4807			0.1646
Can replace synthetics	0.4671			0.225
Price when trading			0.6046	0.4575
Type of pesticides			0.6426	0.4002
Effect on health				0.6061
Demand			0.4319	0.6782
Test for robustness				
Kaiser-Meyer-Olkin	0.8099			
Bartlett's test	0.0000			
Cronbach's alpha	0.7747			

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