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Study on the influence factors of citizen's water behavior based on the polytomous logistic regression model

Wang yanrong[2], Xu ran[2], Sun yufei[3], Tian kang[2], Sun zhipeng[2]

Abstract. To clarify the influencing factors of citizen's water behavior, this paper puts forward the relevant research hypotheses on the basis of the existing research. Combined with the survey data, the hypotheses have been tested by polytomous logistic regression model and causal steps approach. The significant influences of water knowledge, water emotion and water responsibility on water behavior have been confirmed, while the mediating effects of water emotion and water responsibility have also been confirmed. The direct impact of water knowledge on citizens' water behavior is limited and relatively weak, however, with the help of water emotion and water responsibility, the indirect effect is more obvious.

Key words. Water behavior, influence factors, mediating effect.

1. Introduction

With the rapid economic development, water shortage becomes prominent increasingly. On the one hand, the problem of water is mainly caused by the behavior of the human; on the other hand, it also has a direct impact and threat on the daily lives of human. The protection of water resources requires both administrative, economic, legal and technical means, as well as public participation. Furthermore, the impact of active water behavior on the utilization of sustainable water resources is persistent.

It helps to explore the impacts of water behavior to pay attention to citizen's

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[2]Workshop 1 - School of Management and Economics, North China University of Water Resources and Electric Power, Zhengzhou, Henan450120, China

[3]Workshop 2 - Development Research Center of the Ministry of Water Resources of P. R. China, Beijing, 100038, China

water behavior and the relationships among water knowledge, attitude and water behavior. Thereupon then effective measures will be taken to guide citizens to understand the required water knowledge, form scientific water attitude and implement normative water behavior.

2. Literature review

2.1. Definition of water behavior

According to previous research of citizens' water behavior, the water-saving and consumption behaviors are the hot points. There are two main types of research on individual water-saving and consumption behaviors. One is to check water bills to reflect the water conservation, which is based on the economical principles and econometric models. The other is to use self-reporting or questionnaire to describe water-saving behavior multi-dimensionally. The use of water-efficient home appliances, water habits, ways and purposes of using water are often used to depict the water-saving behavior. Some scholars take public support for water conservation policies as a research object, for they consider it as a component of water-saving behavior [1-2]. These literatures limits citizens' water behavior to water-using or water-saving behavior, including the behavior that can reduce water consumption and regulate other's water-using behavior, but ignores behavior that can affect the water quality and water environment.

2.2. Study on influencing factors of water behaviors

Due to lack of systematic study on water behavior, scholars have had more research on the impacts of water-saving behavior. Impacts of water-saving behavior can be divided into two categories, namely, price factors and non-price factors. As water is the necessaries of life, the price factor had no obvious influence on water-saving behavior. According to previous research, the non-price factors covered an extensive range of specific elements, which can be divided into demographic variables, information variables and psychological variables.

The influence of demographic variables is different. Taking income as an example, the findings from the San Antonio study in Texas, USA, has showed a negative correlation between income and water saving behavior [3].However, the study of Barcelona in Spain is found out that there was no significant correlation between income and water-saving behavior [4].

There is little research on the influence of information variables. The finding of Clark and Finley (2007) has borne out that the understanding of water-saving methods had a significant impact on water-using behavior [5]. Some studies have showed that the impact of water-saving knowledge on water-saving behavior included two ways, directly affecting and indirectly affecting water-saving behavior through water-saving awareness.

The research into the effects of psychological variables on water-saving behavior is relatively rich. Most of the research results have proved that water-saving attitudes,

social norms and emotional factors have appreciable effects on the citizens' water-saving behavior.

3. Study design

3.1. Research method

The polytomous logistic regression model is applied to the situation that the dependent variable has a variety of possible and multiple values.

The dependent variable y is an ordered variable of the k level,$k = 1, 2, \cdots, k$. The independent variables $X^T = (X_1, X_2, \cdots X_P)$. Let the probability of level j be $P(y = j \,|x)$, then,

$$P(y \geq j \,|x) = P(y = j \,|x) + P(y = j + 1 \,|x) + \cdots + P(y = k \,|x) \tag{1}$$

Do logistic transformation on this (??)1), then,

$$\log it\, p_j = \text{logit}\left[p(y \geq j \,|x)\right] = \ln \frac{p(y \geq j \,|x)}{1 - p(y \geq j \,|x)} \, (j = 1, 2, \cdots k) \tag{2}$$

The polytomous logistic regression is defined as follows:

$$\log it p_j = \text{logit}\left[p(y \geq j \,|x)\right] = -\alpha_j + \sum_{i=1}^{M} \beta_i x_i \, (j = 1, 2, \cdots k - 1) \tag{3}$$

3.2. Research hypotheses

(??)1)Water knowledge and water behavior. Knowledge is regarded as an important factor in influencing behavior. Is there a relationship between water knowledge and water behavior? Few studies have been done. However, much research has been made on the relationship between environmental knowledge and behavior. Some studies have found that specific environmental knowledge, such as knowledge and behavioral consequences related to specific environmental behavior, has a greater impact on environmental behavior [6-7].

Behavior is guided and restricted by knowledge. Understanding of the distribution and properties of water, being familiar with knowledge and skills to protect water and aquatic environment, help citizens to self-restraint on water behavior and regulation of the water behavior of others.

So we make the following hypothesis:

H_1: Water knowledge has a significant effect on water behavior.

(??)2) Water attitude and water behavior. The positive impact of citizens' environmental attitudes on their environmental behavior has been confirmed in a large number of theoretical and case studies; furthermore, the effect of water attitude on water-saving behavior has been confirmed in many literatures.

From the existing research, when citizens have more hydrophilic emotion, water

crisis consciousness and water conservation responsibility, in addition, fell the pressure of social norms, such as ethics and moral principles from outside, they would like to take the initiative to learn more about water conservation, change habits, and persuade others to change water behavior in different ways, so as to reduce water consumption. Although the implementation of the behavior has eventually be affected by other factors, but the impact of attitude on behavior is significant and clear.

Based on previous literatures and experts' opinion, we argue that water attitude is composed of water emotion, water responsibility and water ethics. Specifically, water emotions include both hydrophilic and environmental concerns, water responsibility reflects saving water and protecting the water environment, and water ethics is the value orientation and moral principle that the citizens follow when they implement the water behavior.

So we make the following hypotheses:

H_2: Water emotion has a significant effect on water behavior.

H_3: Water responsibility has a significant effect on water behavior.

H_4: Water ethics has a significant effect on water behavior.

(??)3) Mediating effect of water attitude. Compared with the independent variable analysis, the mediator effect model can deeply analyze the process and mechanism of independent variable influencing the dependent variable. Some scholars have come to the conclusion that water-saving awareness is a mediator variable of water-saving knowledge and behavior, , and used model to prove the existence of "mediator effect", that is, the influence of water-saving knowledge on water-saving behavior includes two ways, direct and indirect through water-saving awareness.

So we make the following hypotheses:

H_5: Water emotion is the mediator of water knowledge and behavior.

H_6: Water responsibility is the mediator of water knowledge and behavior.

H_7: Water ethics is the mediator of water knowledge and behavior.

3.3. Design of questionnaire

(??)1) Design of questionnaire. The data used in this study is from a self-designed questionnaire. First of all, through the interviews and literature, the original information is collected and sorted out. Then, the first draft of the questionnaire is designed combining the hypotheses, after repeated panel discussions. Besides, a preliminary survey has been conducted for different groups of people. After that, the final draft of the questionnaire has been determined.

The questionnaire consists of water knowledge, water attitude and water behavior. There are 4 questions in water knowledge section, which are multiple-choice questions. The scoring standard is as follows. All correct = 4 points; some correct and no false=3 points; some correct and some false =2 points; no correct=1 point. Water attitude section has 7 terms, and water behavior section contains 14 ones. In the two sections, there are Likert-type scales consisting of 4 responses: strongly willing/always, willing/often, reluctant/occasionally, strongly reluctant/never. The responses are scored as: strongly willing/always=4 points, willing/often=3 points,

reluctant/occasionally=2 points, strongly reluctant/never=1 point.

Water knowledge is set as an independent variable, while water attitude is set as an independent variable and mediator variable. Water behavior is set as a dependent variable. Control variables include gender, age, education level, career, place of residence and household income.

(??)2) Reliability and validity analysis of questionnaire. SPSS22.0 software has been used to test the structural validity of this survey.

(??)3) Sample analysis. A survey has been carried out in Zhengzhou, Henan Province in China, in 2016.The data has been obtained from households or street random surveys. All samples are randomly selected using quota sampling. In order to ensure the representation of the questionnaire, the characteristics of the respondents, such as age, education, occupation and income, are controlled in the sample, thus ensuring that all kinds of people have been covered. A total of 350 questionnaires are issued and all recovered. The effective recovery rate is 98.86%.

4. Result analysis and discussion

4.1. Correlation analysis

The Pearson correlation coefficient is used to test the correlation between different variables.For all the control variables, only household income is negatively correlated with water behavior(r= -0.117, p<0.05), and the others do not show significant correlation. However, for independent variables, there is a significant positive correlation between water knowledge and behavior(r=0.111, p<0.05).The same correlation also exists between water emotion and behavior(r=0.454, p<0.05), both water responsibility and behavior(r=0.462, p<0.05). So H_1, H_2, H_3 are initially verified, yet H_4 do not pass the test.

4.2. Regression analysis

Based on the foregoing analysis, only household income, water knowledge, emotion and responsibility are significantly related to water behavior. Accordingly, in this part, the household income, water knowledge, emotion and responsibility are used as independent variables, while water behavior is dependent variable, and the polytomous logistic regression model is constructed. *Model 1* verifies whether household income has an impact on water behavior. On the basis of *model 1*, *model 2* introduced water knowledge to verify whether water knowledge affects water behavior. Further, water emotion, responsibility are introduced into *model 3*.

$LogitP = \alpha + \beta_1 Inc$ *model 1*

$LogitP = \alpha + \beta_1 Inc + \beta_2 Wknow$ *model 2*

$LogitP = \alpha + \beta_1 Inc + \beta_2 Wknow + \beta_3 Wemot + \beta_4 Wresp$ *model 3*

P shows the frequency of water behavior; *Inc* represents household income; Wknow represents water knowledge; *Wemot* represents water emotion, and Wresp represents water responsibility.

Regression analysis results are shown in Table 1.

Table 1 Regression analysis of water behavior

			model 1	model 2	model 3
Explanatory variables		Frequency	OR	OR	OR
Household income	30,000 yuan and below	124	5.86***	8.50***	12.58***
	30,000-80,000 yuan	125	7.01***	8.38***	10.76***
	80,000-120,000 yuan	65	3.32*	3.65**	5.21**
	120,000-200,000 yuan	24	4.80**	5.25**	5.53**
	200,000 yuan and above(reference group)	8	1.00	1.00	1.00
Water knowledge		346		1.55***	1.09*
Water attitude	Water emotion	346			4.50***
	Water responsibility	346			6.48***
Model fit degreeχ^2			14.487***	24.311***	164.65***
Cox & SnellR^2			0.041	0.068	0.377
NagelkerkeR^2			0.041	0.068	0.377

Tips: ***stands for p <0.01, **stands for p <0.05, *stands for p <0.1

Model 1 examined the impact of household income on water behavior. The result is that citizens with lower household incomes would implement more regulated water behavior. The model fitting degree of *model 2* is better than *model 1*, and the R^2-coefficient of *model 2* is also higher than that of *model 1*.This shows that the introduction of water knowledge leads to a significant increase in interpretation of water behavior in *model 2*(OR=1.55, P=0.020).The results shows that water knowledge has positive effect on water behavior. H_1 pass the test, that is, citizens with more necessary water knowledge will perform more standardized water behavior. Compared with *model 1* and *model 2*, the model fitting and R^2-coefficients of *model 3* were significantly improved. Thereinto, water emotion significantly affected water behavior positively (OR=4.50, P=0.000), as well as water responsibility (OR=6.48, P=0.000). Hypotheses H_2 and H_3 had pass the test, it means that citizens with more water emotion and responsibilities will implement more standardized water behavior.

4.3. Analysis of mediating effect

According to the causal steps approach proposed by Baron and Kenny[8], SPSS 22.0 is used to verify the mediating roles of water emotion, responsibility and ethics between water knowledge and water behavior.

The results of the analysis are shown as follows: (??)1) water emotion has a full mediation in the relationship between water knowledge and water behavior; (??)2) water responsibility has a partial mediation in the relationship between water knowledge and water behavior; (??)3) water ethics do not play a mediating effect in the relationship between water knowledge and water behavior. Consequently, the hypotheses H_5 and H_6 pass the test, but hypotheses H7 do not.

Figure 1 shows the results of the mediating effect.

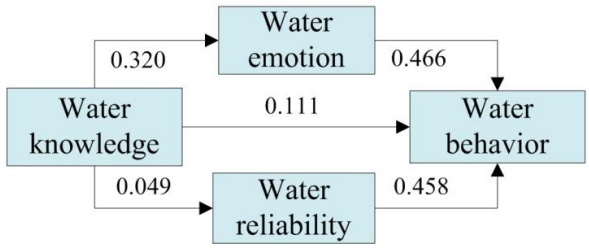

Fig. 1. Mediation of water emotion and water responsibility

5. Conclusion

Based on the analysis of existing research results, this paper divides water knowledge and water attitude into influencing factors of citizens' water behavior, and divides water attitude into three dimensions: water emotion, responsibility and ethics. The water knowledge, attitude and behavior of the urban and rural residents in Zhengzhou City of Henan Province are analyzed by means of questionnaires, and the first-hand information is quantitatively analyzed. Empirical studies on the relationship among water knowledge, water attitudes and water behavior have been carried out. The conclusions are as follows:(??)1) water knowledge, emotion and responsibility all have significant positive impacts on citizens' water behaviors; (??)2) water knowledge, on the one hand, influences water behavior directly; on the other hand, it affects water behavior indirectly through water emotion and responsibility; (??)3) there is no significant correlation between water ethics and water behavior, and the authors believe that it is because the citizen's water behavior belongs to the individual behavior, which occurs in the private domain, and is less influenced by social ethics, such as value orientation and moral principle.

Because that the direct influence of water knowledge on citizens' water behavior is limited and relatively weak, government and social organizations have mainly spread the knowledge of water to the public, but no significant results. Nevertheless, owing to the existence of mediating effects of water emotion and water responsibility,

the indirect effects of water knowledge on water behavior will be more significant through water emotion and water responsibility. Therefore, it should pay attention to the importance of citizens' water emotion and water responsibility, when launched campaigns of water conservation.

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