

Impact of perceived risk on the adoption of piped water among households in rural Northern Vietnam

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ABSTRACT

Using multiple water sources are ubiquitous in developing countries. This has led to the complexity in understanding the perception of households towards the use of piped water despite little constraint in connection. By employing semi-structured interviews and conducting survey in three Northern provinces in Vietnam, our research focuses on figuring out the impact of perceived risk among different sources of water (piped vs non-piped) on water using behaviour of rural households. Our research contributes to the existing perceived theory and risk dimensions when pointing out the role perceived health risk, perceived quality risk as well as perceived financial risk on the choice of water using behaviour among households. Also, the role of social influence also examined thoroughly in our research. Research findings help suggest policy recommendations for governments in understanding psychological behaviours in piped uptakes in rural towns of Vietnam.

1. Introduction

In the context of climate change, piped water is growing its importance in ensuring the water security. Piped water is an optimal solution for government in developing countries to cope with the situation due to its tremendous impact on health outcome compared with non-piped sources (Joe Brown et al., 2012) James C. Winter et al., 2021). By intervening and monitoring the process based on certain safety standards, government can control the water quality and quantity properly compared to unstable alternative sources. Households in developing countries, however, are often indifferent towards piped sources despite no supply constraints. As provided in the latest report by, only 43% of households potentially connected households were actually using the water for drinking in Vietnam. Only 51% of rural families, according to the MARD assessment, have access to clean water that satisfies the Ministry of Health's water quality criteria. 01:2009/BYT QCVN. One-fifth of Vietnamese children under the age of five are found to have stunted development, with the percentage among children of ethnic minorities being nearly twice (32%) due to a lack of access to clean water and adequate sanitation. This is considered as a dilemma for policy-maker in water governance sector, especially in the context Vietnam is setting new goals with 100% households using clean water by 2045.

To tackle the situation, it is crucial to contextualize the water using behaviour of households in developing countries compared to developed ones. In developed countries, households often have access to high-quality municipal piped water, occasionally supplemented with bottled water. Meanwhile, households in low and middle income countries often use more than one sources of water such as rainwater to meet their daily demand of water ((Tim Foster et al., 2021; Vedachalam et al., 2017). The availability of multiple sources leads to a complex decision-making process for source adoption and use allocation among sources. (Gross & Elshiewy., 2019; Smiley & Stoler., 2020). Typically, households often consider trade-offs among sources based on varied criteria such as cost, collection time, and proximity of water sources, taste preference to allocate the water sources for domestic purpose. Some households did not connect to piped-water at all, although there was a possible connection. Other households choose to connect, but indicated to use this water source for washing, cleaning and cooking only.

Due to complexity in the decision-making process of household towards their water sources strategies, many research have concentrated on examining the role of psychological factors in explaining households' choice. Among psychological factors, perceived risk is a crucial factor to understand the decision of a household towards water sources (Slovic et al., 1981). According to Hans-Joachim Mosler, 2012, risk-based approach via risk information

has been encompassed in the RANAS model for behaviour change in water and hygiene practices. Similarly, it is shown that household will be more likely to modify their hygiene-related behaviour and treat water if they are informed about the level of risk indicated through microbial contamination ([Robinson et al., 2018](#)). Meanwhile, Joseph Onjala et al (2014) indicated that households would treat unimproved water sources given their perceived risk increases. Despite long acknowledgement among field research and practitioners, insufficient explanation pertaining to perceived risk of multiple sources influence on households' choice source in terms of water treatment, source choice, use purpose, willingness to pay given the context of multiple water source use (MWSU).

Our research desires to address two specific gaps. First, encountering disruptive change in Vietnamese socio-demographic patterns, we would like to illuminate empirical evidence on perceived risk on rural household's source choice and their propensity.

Empirical and theoretical research claimed that perceived risk tends to be formed by subjective judgement based on social context ([Anadu and Harding 2000](#); [Carla Rodriguez-Sanchez & Francisco J. Sarabia-Sanchez., 2016](#)). Hence, the consolidation of contextual factors might lead to different interpretations of the role of perceived risk in the domestic choices's water sources. Notwithstanding, there is little updated research in Vietnam that integrated Vietnamese context-specific factors and the dual existence of piped and non-piped in rural areas as endogenous factors. The latest research about Vinamese household's perception towards piped water were conducted by [Gert-Jan Wilbers](#) and [S. Herbst](#) in 2004 and 2019 respectively. However, both research mainly concentrated on exploring household's perception and their behaviour towards water use rather than figuring out the causal effect of psychological factors such as perceived risk on the choice of multiple sources of water and use strategies among water sources. In fact, there has been rising living standards among households in income level that enabled households to afford piped connection more effortlessly. Besides, higher public awareness about clean water derived from the prevalence of mass media in rural areas might lead to a shift in psychological perception on source choice. Therefore, it necessarily requires updated research to assess whether these socio-demographic factors on household's source adoption. Additionally, the difference in water service quality in Vietnam compared to other developing countries can also contribute to different radical findings about the significance of perceived risk on source choices. **Second, we would like to provide theoretical justification for perceived risk theory in explaining household's preference of piped water or non-piped water.** Current research predominantly employs random utility theory, theory of planned behaviour which assumes human's choice are rational beings ([Joseph Onjala et al., 2014](#); [Carmen Anthonj et](#)

[al., 2022](#)). By assuming that households are likely to select the alternatives that they perceive less risky, we would like to identify the role of perceived risk theory in explaining their choice for primary water sources.

Our research aims to address these specific research questions including:

- How does perceived risk towards piped and non-piped water sources affect the households' choice of piped water?
- How does perceived risk towards piped and non-piped water affect willingness to pay for treatment measures and installation of piped water network?
- How does perceived risk towards piped and non-piped water affect the willingness to pay for the monthly piped-water service?
- How do demographic factors including education level, the availability of piped water, children's age status impact on source choice, willingness to pay for service use and piped network installation/treatment practices?
- How do perceived quality and social influence affect willingness to pay for service use and piped network installation/treatment practices?

2. Literature review

2.1. Rural water in developing countries

Water security is a multi-dimensional issue that drives the concern of policymakers and researchers, especially in rural and peri-urban areas of developing countries. Extensive literature has been conducted which ranged from the corporation of public and private sectors (Hoko, Z., & Hertle, J. (2006), Giné & Pérez-Foguet (2008), Rietveld, Haarhoff, & Jagals (2009), Chaudhuri, Roy, McDonald, & Emendack (2020).

Evaluative studies that uncover the inefficiency in water governance such as the assessment of public-private corporations or the operational management among sectors. For example, World Bank Group 2017 conducted a large-scale assessment to identify good practices and challenges toward building sectors capacity. Additionally, Kamruzzaman et al., 2013 evaluated the pros and cons of three rural water management models in developing context including community management models, private management models and hybrid model. Meanwhile, H. Tantoh et al. (2019) thorough his empirical study in rural northeastern Cameroon identified that insufficient coordination between central institutions and community level are crucial determinant constraining the effectiveness of water program. Another research conducted in Vietnam that studied the role of private sectors in the investment, management and operations of rural water supply facilities (Nguyen T.A. et al., (2022). Then, the research compared the satisfaction among households with different suppliers. These studies mainly focus on evaluate the relative effectiveness of water provision

among sectors through the lens of consumers, then suggesting policy maker insight about behavioral factors that can influence consumers' decisions to use water. Policies with a top-down approach have focused focuses on assessing the sustainability and finance of management, but has not yet approached the real desires of rural users in terms of convenience, purpose of using water resources and ways of consumers assessing water quality.

Exploratory and explanatory studies examine the behaviour of rural households in multiple water use context pertaining to attitudes towards water sources, factors affecting their water adoption and decision-making process of households. Generally, households in rural and peri-urban areas often adopt more than two sources of water based on their acceptable satisfaction level and show their preference towards a certain source (Daly, S. W., Lowe et al. (2021). Among the earliest research about sources of rural water supplies, Gyau-Boakye, 2001) highlights the reliance of rural communities in Ghana on natural sources such as surface and groundwater for daily use and uncover the impact of government management systems on households' preferences for water source. Besides, factors affecting households' water choice such as the role of time cost (L. A. T., & Sikod, F., 2012). Their preference, yet, does not necessarily reflect their trust in water. The complexity and heterogeneity in decision-making process among households highlight gaps in current research require further research into the motivations affecting people's decisions to use water sources. L. Rojas and A. Megerle (2013) and Francis et al. (2015) found that water-related knowledge and perception of the importance of water for health are two factors that affect water use behavior in rural areas. Additionally, resistance to changes in taste or odor of water and lack of support from male members of the household impede the sustainability of clean water campaigns. Research needs insights to measure sensory properties and effective ways to complement water quality perceptions.

It can be seen that in order for the above studies to suggest further directions for future research based on the factors that may influence the decisions of water users in rural areas in developing countries. These factors vary and are heavily determined by each country's economic, political and social context. Grady, C. A., et al. (2018) conducted the study in three communities in the Mekong Delta of Vietnam and found that for households without access to water or sanitation, three variables were statistically significant predictors of accessibility: distance to local government, floor material and the gender of the household water manager. On the other hand, study by (Carrard et al., 2019) provides insight into the local dynamics of the water - poverty relationship. Findings point to lower access to tap water for poor households across areas provided by government, private and community service providers.

The cost of installation and connection is the main reason leading to the disconnection between water consumers in these regions and safe water supply for daily life. With financial support or information, many households in rural areas are willing to consider switching to or using a combination of tap water - natural water. Thus, rural households do not want to use the best quality water, but they must face financial, information, institutional and cognitive barriers. Our study will delve into this research gap on the impact of people's perceptions on water use decisions.

2.2. Factors affecting on behavior of multiple water sources choice

a) Behavior of choosing water in situation that multiple water are available

In the context of multiple water sources, households' choice depends on many groups of factors: demographic (gender, family size, education level) (Khuda B., 2015; Luc A. T. F. & Fondo S., 2012; Jana.M & Jocelyn, O.A, 2021; Khuda B., 2015), organoleptic factors (smell, taste, color)(Sander et al, 2013), convenience (Neng Qian, 2018; Saylor et al, 2011; Viscusi et al, 2014), perceived benefit (Hindman, 2003). Taste is considered one of the organoleptic factors that residents may be concerned about. water show that beliefs about taste, health, lifestyle, and environment are related to bottled water consumption. (Saylor et al, 2011; Viscusi et al, 2014). Education level is a factor in people's awareness of types of water sources. (Jana.M & Jocelyn, O.A, 2021, Khuda B., 2015) showed that the higher the education level of an individual, the more preferable their intention to choose improved safe water sources is, The reason behind this is they can be aware of the health risk of unsafe water sources. A study (Abubakar, 2019, Eminike, 2017) in Nigeria investigated how the education level of household heads can affect household choice of water sources. In addition, household size, gender of household's head, trust in suppliers, perceived benefits are also determined as factors affecting household water sources choices (Neng Qian 2018, Luc A. T. F. & Fondo S., 2012, Hindman, 2003, Khuda B., 2015)

b) Effect of social influence on choosing tapped water

Social influence implies a social pressure perceived by individuals when they consider whether to carry out a particular action (Ding Lili et al., 2020). According to previous research, social influence has been indicated as a significant factor affecting people's intentions to accept different kinds of clean water (piped, desalinated, improved quality...). Social influence positively impacts people's intention to use clean water (Sohaib et al., 2022). Using TPB theory to define what factors affect residents' acceptance of using desalinated water, (Ding et al., 2020) also showed that social influence has a significant positive impact on residents's intentions of using desalinated water. People are influenced by society, when someone raises concern about the quality of water as well as its effect on daily life, the

community will discuss and research about that. (Wong et al., 2021) agreed with (Kumar 2019) that social influence plays an important role affecting the decision-making process of consumers, especially in the case of using clean water. Not only being influenced by society living nearby or friends, reference groups..., residents are also impacted by celebrity (Xu et al., 2017). The endorsement of a celebrity or prestigious individual plays a role as guidance of using quality things. Thus, the degree of people's acceptance of using clean water would be increased.

Informational influence is triggered by the desire to conform to an accurate view of reality (Turner, 1991). It is driven by uncertainty, which creates a dependence on others to provide valid information (Deutsch and Gerard, 1955), particularly when one's own ability to make a judgment is unclear (Cohen and Golden, 1972). Because objective evidence is challenging to obtain, individuals seek out valid information from trustworthy others, thus the source of the information is a key component in informational influence (Cohen and Golden, 1972). Source credibility has been widely studied in social psychology and communication literature (Pornpitakpan, 2004) and is an important component of social influence.

2.3. Perceived risk on the decision to choose water

Current research provides extensive literature about how households perceive multiple water sources. Among psychological risk dimensions, perceptions associated with health benefits and source quality are most likely to affect households' choices. In a research conducted by Lianne McLeod et al., 2015, while perceived health risks were directly linked to the fear of "someone might get ill from tap water", perceived quality risks were reported by the fear "water is not safe to drink" or "water being contaminated from septic tank leakage". Besides these perceived risks, additional risk types associated with multiple water sources are also indicated by households. Anidrya Nastiti et al., 2017 illustrated households' tensions between non-piped and piped water sources. Specifically, households with non-piped connections (spring wells), and commercial water vendors were mainly worried about the instability pertaining to continuity and water pressure. Meanwhile, piped water households were largely frustrated with financial concerns relating to water bill of the piped water source.

Risk perceptions were important determinants for the choice of basic drinking water and sanitation services and the prediction of averting behaviour (P. Levallois et al., 1999; Carmen Anthonj et al., 2022). Accordingly, Anthonj et al., 2018 highlighted the relevance of perceiving water as good or worrying about unsafe water causing diarrhoea in an increased likelihood of basic water services (defined as "drinking water from an improved source, provided collection time is not more than 30 minutes for a roundtrip including queuing"). Meanwhile, by running a randomized controlled experiment with a risk-based approach and

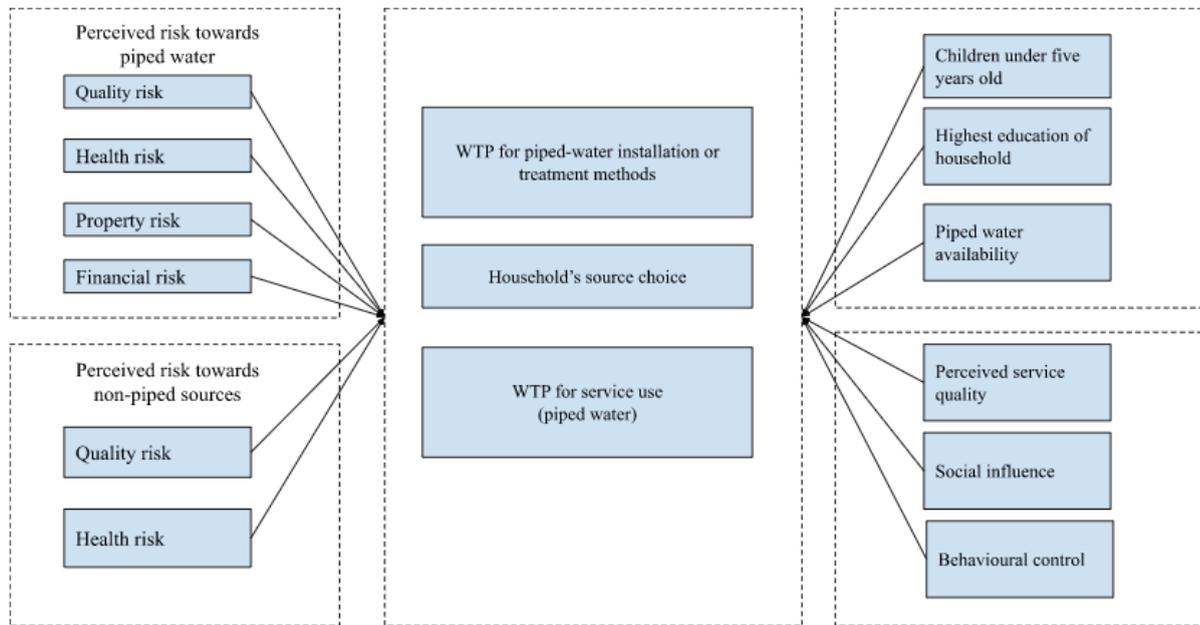
difference-in-difference analysis, Dorian Tosi Robinson et al., 2018 revealed the causal relationship between awareness of current level of water risk and a shift to a safer water source in a town. Regarding the uptake of treatment practices, Joseph Onjala and her research team (2014) employed a quantitative method and random utility theory of water treatment. The research showed that households would apply treatment methods for non-piped unimproved sources if they perceived an unacceptable level of quality. Another study by Anidrya Nastiti et al., 2017 even showcased the impact of specific risk facets on devising multiple treatment strategies for quality improvement. Health perceived risks such as fear of skin irritation and digestive diseases makes households filter and boil it carefully before drinking or washing. Whereas, fear of water instability, such as low supply pressure or continuity, requires households to store water so that they can ensure water sufficiency for domestic use. Joseph Onjala and her research team (2014) found that a household's treatment of non-piped water and its choice of piped water as a main source of drinking water may be seen as substitutes. Furthermore, the study even notified perceived risk differences among piped and non-piped sources on their allocation in water use as complementary in regard to both affordability and seasonal continuity. Households considered piped water, groundwater, and individual or shared access to spring water as primary water sources and bottled water for their drinking and eating purposes. This insightful finding has been validated by many other researchers in different water contexts.

Examining heterogeneity in perceived risk among households was also properly discovered in the literature. Miguel de França Doria et al (2009) used both quantitative and qualitative methods, the quantitative method was used to measure the relationship between tap water consumption and risk perception in two countries- the results indicated that perceived risk and context also influence perceived quality yet its impact depends on the country. Flavour and risk moderately explain tap water consumption, which in turn moderately explains the consumption of bottled water. The qualitative method was used to explore the moderating role of flavor, memorability, context, and negative information from friends. Little difference is discovered in terms of water quality, risk, flavour, odour, trust in water companies, hardness, lead, chlorine, and memorability among two countries.

However, Orgill et al., 2013 demonstrated that while perceptions of quality were highly related to taste preferences, actual water quality was relatively uncorrelated with water quality perceptions. The findings implied the rationale to explain the refusal of water sources use many households did not use. When investigating reasons for drinking water source choice in low-income populations in urban areas in the United States, Family et al. (2019) found that perceived health risks significantly predicted why survey participants did not drink

tap water, pointing to the perceived safety and taste of tap water being key barriers to drinking fluoridated water from the tap. Therefore, decision for water adoption were positively related to awareness of health risks.

3. Theoretical framework



3.1 Perceived risk theory

Perceived risk has long been used to explain the consumer's choice toward a product or service. Given the context of consumer behaviour, as defined by Bauer (1960), Loewenstein et al. (2001), and Slovic, 2016, perceived risk relates to the perception of the probability of failure and the associated negative consequences of buying/using a product. In the context of WASH practices, perceived risk is associated with negative feelings associated with health concerns such as worry, fear, dread, or threat arousal (Mitchell et al., 2018) or the perceived seriousness of a disease, such as "serious", "deadly," or "real" (Demolis et al., 2018). By definition, perceived risk is rather subjective and mainly elicited based on personal experience compared to objective risk.

Perceived risk is assessed based on a variety of criteria and facets. Mitchell (1998) argues that perceived risk is a "multidimensional phenomenon" that can be segmented into various different risk components. Perceived risk in the field of consumer behavior has been conceptualized as a multi-faceted construct. The facets identified include the potential financial, performance, physical, psychological, time, and social losses associated with a purchase decision (Jacoby and Kaplan, 1972; Peter and Tarpey, 1975; Shimp and Bearden, 1982; Schiffman and Kanuk, 2004; Laforet, 2007; Beneke et al., 2012).

Although risk dimensions are categorized into six characteristics as mentioned by above, Dholakia (1997) suggests that the significance of the contribution of these individual

facets to overall risk varies by product category. Therefore, after desk research, the most common risk facets were deliberately selected, corresponding to specific water sources and the research context of Vietnamese northern cities. Regarding piped water, health risk, quality risk, property risk, and financial risk are included. In terms of non-piped water, except for property risk and financial risk, all remaining risk and social risk were taken.

When perceived risk falls between the two thresholds, individuals will engage in their “normal” shopping behavior: The second section of a model would focus on the link between Overall Perceived Risk and the Risk Thresholds. Here the individual’s risk tolerance and wealth rescale overall perceived risk. If perceived risk then exceeds the individual’s maximum threshold, extra information search may be undertaken as a potential risk reduction strategy. The availability, perceived usefulness, and cost of this information will determine both the extent of use and the resultant reduction (or increase) in perceived risk. Perceived risk below the minimum threshold may stimulate curiosity or variety-seeking purchase behavior. When the level of perceived risk is between the two thresholds, “normal” shopping activity will be undertaken.

Perceived risk is a barrier preventing customers from making decisions to purchase when they can not be sure that goods can afford their expectation (Cox & Rich, 1964). In the context of online shopping, customers face some difficulties such as: can not test the quality of products or get trial experience; the return process of faulty products is complex and time-consuming; worry about business ethics of certain online platform (Spence et al., 1970; Gillett, 1970). These difficulties are supposed to lower the intention of online shopping buyers. As Dowling (1986) stated that, these uncertainties can affect choice decisions and motivate customers to seek more information and take risk-handling behaviour.

In comparison of several decisions with different levels of perceived risk, customers tend to choose the “normal” or “lowest” one to avoid as many losses as possible. Cox & Rich (1964) researched the phone-shopping and the result shows that the higher level of perceived risks of this shopping mode discourage customers using phone shopping. In the study about customer’s automobile repair decisions of Granzin and Schjelderup (1980), the highest risk situation (related to the distance from home) result in a different patronage decision than would be made under less risky situations. In addition, Dash et al. (1976) provided that audio equipment customers patronizing department stores perceived more risk than speciality stores.

Wu et al. (2013) show that perceived risk indirectly affects water usage intention, mediated by “attitude”. Po et al. (2005); Leviston et al. (2006); Hurlimann et al. (2008) also investigated that perceived health risk plays an important role in the background of using recycled water. Quality risk is defined as the degree an individual feels that the quality of

water cannot afford the standard requirement for domestic use, whereas financial risk relates to fears of payment for misuse or fault in the operation system of piped water. Property risk relates to the degree that households think water badly affects household electric devices like washing machines, water heaters... Social risk relates to the degree that social disputes of water use may happen due to a lack of awareness of residents, and lack of government's track and control. In the context of behavioural intention, perceived risk has been investigated as a crucial factor determining customer's intention (Mortimer et al., 2015). Amirtha et al. (2021) indicated social risk has significant effects on e-shopping of Indian women. Financial risk is considered as an important barrier to purchase online shopping (Shin et al., 2017; Yarimoglu, 2015). Moreover, (Pavlou, 2014; Featherman & Pavlou, 2003) also stated that quality and property risk are recognized in the context of e-commerce.

3.2 Perceived risk dimensions

3.2.1 Perceived health risk

Health risk perception implies the perception that individuals believe and feel about the risk of specific diseases or harmful health behaviors, which often gives rise to performing protective behaviors (Renner et al., 2015). The higher risk household perceive, the more they tend to treat water or choose the safer source. Onjala et al. (2014) stated that resident will treat water in case they perceive health risk of the wate source is unacceptable. The reason behind this decision is they know that treating water can lower the health-related risk of unimproved water source (Nauges & Van den Berg, 2006). Moreover, Dupont & Jahan (2012) indicated that household decide to spend money on treating tap water to reduce their perceived health risk when using tap water. This also represented for the believe they may gain when chososing these decisions.

According to previous research, perceived health risk has been indicated as a factor affecting a person's choice of water or decision to treat a water source. As Abrahams et al (2000) conducted research on Georgia residents' use of water behavior, the result shows that households perceiving health risks from piped water consumption tend to adopt averting behaviors like purchasing bottled water or filtering piped water at home. Similar to Abrahams, Dupont & Jahan (2012) also indicated that perceived health risks have negative impacts on the choice of using piped water in Canada. People consume bottled water or treat piped water at home if they think piped water may expose them to health risks. Using the multinomial logit model, Dupont et al (2010) showed that people may turn their perceptions about the safety of supplied piped water and health concerns about that into drinking water choices. It's also suggested that people find a way to reduce their perceived health risks from

using water. Moreover, in the field of willingness to pay for water, perceived health risk also play an important role (Wahid & Hooi, 2015; Cho et al., 2005; Malik et al., 2012)

->H1a: Households with higher perceived health risk towards non-piped water sources are more likely to adopt piped source

->H1b: Households with lower perceived health risk towards piped source are more likely to adopt piped source

-> H1c: Perceived health risk towards non-piped water sources positively impact willing to pay for water service use

-> H1d: Perceived health risk towards piped source negatively impact willing to pay for water service use

-> H1e: Perceived health risk towards non-piped water sources positively impact willing to pay for the installation of piped network or treatment methods

-> H1f: Perceived health risk towards piped water sources negative impact willing to pay for the installation of piped network or treatment methods

3.2.2 *Perceived financial risk*

Financial risk perception is reported as an beliefs, attitudes, judgments, and feelings about the risk properties of an investment or purchasing decision. Early researchers found decision-making theory variables such as the probability of loss, gain or loss outcome, and unstable income as the main factors influencing financial risk perception (Diacon & Ennew, 2001).

Perceived financial risk refers to the customer's concern that they might be spending money on not worthy product or service, which can be significant barrier to consumers' willingness to pay for a product or service. These severity of impact can be stronger for purchasing decision for basic necessities such as water, food, housing, and healthcare (Xu, Liu, Wang, Tang, & Liu, 2018). When consumers perceive a high level of financial risk associated with a product or service, they may be less willing to pay for it. This can be particularly challenging for people in rural areas who may have limited access to financial resources and face additional financial risks associated with living in rural areas. However, there is a research gap about rural people perception about financial risk they may deal with in daily consuming habits.

Perceived financial risk relates to fears of payment for misuse or fault in the operation system of piped water.

->H2a: Households with higher perceived financial risk towards non-piped water sources are more likely to adopt piped sources

->H2b: Households with lower perceived financial risk towards piped sources are more likely to adopt piped source

-> H2c: Perceived financial risk towards piped source negatively impact willing to pay for water use

-> H2d: Perceived financial risk towards piped source negatively impact willingness to pay for the installation of piped network or treatment methods.

3.3.3 *Perceived quality risk*

Perceived quality risk refers to the probability of functional defects that an individual can think about a product or service (Abbey et al., 2016). In the area of this research, the term “perceived quality risk” is defined as the probability of water quality defect (unsafe, contaminated, unusual taste, smell...) that a household thinks about a specific water source. As has been pointed out from several types of research, low-quality risk perception may lead to high consumption of this water source. Doria (2006) found that people are willing to pay more for the one they think is “purer” or “healthier” in comparison between bottled water and tap water. This finding had been supported in his later research, risk perception of poor quality has a negative impact on tap water consumption (Doria et al., 2009). Dupont et al (2010) also showed that if individuals rise a concern about the safety of tap water, they will significantly increase the consumption of alternative water sources like bottled water. In addition, households may tend to adapt some treatments when they feel lower water quality (Janmaat, 2007). As a result of Probit analysis, perceived quality risk plays an important role in determining averting behaviour of individuals. People are willing to pay more for an acceptable pollution level, this also is an implementation for policymakers to reduce habitants’ quality risk perception (Um et al., 2002)

-> H3a: Households with higher perceived quality risk towards non-piped water sources are more likely to adopt piped sources

->H3b: Households with lower perceived quality risk towards piped sources are more likely to adopt piped source

-> H3c: Perceived quality risk towards non-piped water sources positively impact willing to for water service use

-> H3d: Perceived quality risk towards piped source negatively impact willing to pay for water service use

-> H3e: Perceived quality risk towards non-piped water sources positively impact willing to pay the installation of piped network or treatment methods

-> H3f: Perceived quality risk towards piped source negatively impact willing to pay the installation of piped network or treatment methods.

3.3.4 *Perceived property risk*

People's perceptions of the risk to their property can vary based on several factors, including their individual experiences, cultural backgrounds, geographic location, and exposure to different hazards. (Sullivan-Wiley & Short Gianotti, 2017) First, personal experiences with past events, such as natural disasters or devastating incidents, can shape individuals' views on the vulnerability of their property if they choose one product but not others. (Perić & Cvetković, 2019) Secondly, the geographic location of a property can significantly influence people's perceptions about how and to what extent a risk may occur to their financial status and property. Conversely, individuals residing in regions with fewer historical occurrences of hazards might perceive a lower level of risk (McCoy & Zhao, 2018). On the other hand, the way individuals perceive and handle risks related to their property can be influenced by economic factors, including the property's value, insurance coverage, and available financial resources. In the specific case of rural water security, perceived asset risk is directly related to which water resources are owned (tap water, well water, shared) and the use of water for which purpose (irrigation, bathing, eating) (Singh, Osbahr, & Dorward, 2018). In addition, media coverage and information sources can influence how people perceive risk, especially when the risk can directly affect their personal lives or property. Extensive media coverage of specific hazards or disasters can amplify risk perceptions, while the absence of information or inadequate communication about risks may lead to underestimation or ignorance of potential threats. (Wahlberg & Sjoberg, 2000)

-> H4a: Households with higher perceived property risk towards non-piped water sources are more likely to adopt piped sources

->H4b: Households with lower perceived property risk towards piped sources are more likely to adopt piped source

-> H4c: Perceived property risk towards piped source negatively impact willing to pay for water service use

-> H4d: Perceived property risk towards piped source negatively impact willing to pay for the installation of piped network or treatment methods.

4. Methodology

4.1 *Study sites*

Our research aims to assess the significance of perceived risks towards both non-piped and piped sources on water behaviour of households. Therefore, we chose municipal areas where there is availability of piped and non-piped sources. Previous research showed that multiple water source use behaviour often occurs in rural settings and in distant locations

where public water sources are completely absent, together with municipal piped water services in heavily populated cities or in unplanned urban areas underserved by piped systems. As a result, three northern provinces of Quang Ninh, Ha Nam, Hai Phong were chosen as the official study sites of our research. Quang Ninh, Ha Nam, Hai Phong are three provinces that are pioneering in "new countryside" program of Vietnamese government. An important criteria for a commune to be considered "new commune" is the coverage of clean, piped water. Hence, by selecting these communes, the research ensures that there are no water supply constraints to piped sources. However, what pertains to this study is whether households in these communes can afford to connect pipelines to the water. The sample size of this study is 261 samples.

4.2 Study design

Regarding the research methodological choice: the research utilized a 6-step mixed method approach to uncover perceived risk of households in the context of multiple water sources. It has been verified as an effective strategy in previous literature.

Details of the methodological choice is as follows:

Step 1: in-depth interviews and discussion groups with 5 households were carried out to uncover existing problems and formulate research questions and questionnaires

Step 2: A questionnaire with likert 5-point scale was developed (See appendix)

Step 3: a pilot survey was the distributed. The objective of pilot survey in our research was to ensure that the survey is readable and comprehensible to local people. As respondents were in the countryside, some questions were adapted to this demography so that they can better understand them. Furthermore, the survey's length were then modified to minimize respondent's disengagements and avoid respondent's fatigue

Step 4: data was then collected. To increase the feasibility of data collection, the survey was distributed online for respondents in Ha Nam and via post office for those in Quang Ninh

Step 5: Survey data was then utilized in the model to test its correlational relationship with the behaviour of households pertaining to current and future water choice.

Step 6: a semi-structured interview with 5 households was conducted to reevaluate and reexamine the findings from the model

4.3 Empirical model

We use OLS regression and logistics regression to test the hypothesis as bellow

$$\log \log \text{pipedchoice} = \beta_0 + \beta_1 * \text{highedu} + \beta_3 * \text{Children} + \beta_4 * \text{pipe}_{connect} + \beta_5 * \text{qualityrisk}_{np}$$

$$\text{WTP}_{serviceuse} = \beta_0 + \beta_1 * \text{qualityrisk}_{np} + \beta_2 * \text{healthrisk}_{np} + \beta_3 * \text{qualitynp} + \beta_4 * \text{socialinflu}_{np}$$

$$WTP_{install} = \beta_0 + \beta_1 * qualityrisk_{np} + \beta_2 * healthrisk_{np} + \beta_3 * qualitynp + \beta_4 * socialinflu_{np} +$$

5. Result

5.1 Descriptive analysis

5.1.1 Demographic

Table 1 below describes the demographic of 261 respondents. More than 70% of households are led by male. About 58% of household head get no certification of education, and 21% get a college/ bachelor's degree whereas it's 44% and 42% respectively, for the highest education level in family. As shown in table x1, nearly 60% household earn an more than 10 million income per month and about 10% earn lower than 3 million per month. In addition, about two-thirds family don't have an under 5 kid and 20% of respondents recognize water diseases in one month recently.

Table 1: Demographic of respondents

Variables	Options	Freq	Percent (%)
Gender of household head	Female	74	28.35
	Male	187	71.65
Education level of household head	No schooling	151	57.85
	Short-term vocational courses	6	2.3
	Long-term vocational course	25	9.58
	Intermediate	23	8.81
	College/university	55	21.07
	Master	1	0.38
Highest education level in household	No schooling	115	44.06
	Short-term vocational courses	4	1.53

	Long-term vocational course	16	6.13
	Intermediate	15	5.75
	College/university	108	41.38
	Master	2	0.77
	PhD	1	0.38
Income	<1000000	8	3.07
	1000000 & < 3000000	16	6.13
	3000000 & < 5000000	22	8.43
	5000000 & < 10000000	63	24.14
	> 10000000	152	58.24
Having children under 5	No	173	66.28
	Yes	88	33.72
Having water diseases in one month recently	No	208	79.69
	Yes	53	20.31

5.1.2 Factors affecting household's water choice

Using a 5-point Likert scale, 1 = “Strongly disagree” and 5 = “Strongly agree”. Table 2 below shows the overview of the perceived quality of two types of water among residents. In general, the mean of these measures is around 3.1, which means that people show a normal attitude toward both types of water. However, we recognize some differences in comparison between piped and non-piped water. Households seem to perceive non-piped water as more qualified than piped water, non-piped water gets the mean of 3.28 while piped water gets 3.11

Table 2: Perceived quality of piped and non-piped water

	SD	Min	Mean	Max	Mode
Perceived quality (service)					
Piped water	1.23	1	3.11	5	4
Non-piped water	1.11	1	3.28	5	4
Perceived quality (organoleptic attributes)					
Piped water	1.11	1	3.15	5	4
Non-piped water	1.07	1	3.25	5	3

Table 3 below shows an overview of facility conditions and information on piped and non-piped water provided by the Government, Internet and news, cousins and neighbors. Overall, the average score of information provided by the government is around 3 whereas it's around 3.6 for both information provided by the Internet, news, and cousins or neighbors. Residents seek information from the Internet, news, cousins, and neighbors more often than from the government. There is a slight difference between piped and non-piped water, households ask for information about non-piped water from Internet, news, cousins, and neighbors more frequently than they ask for piped water. In contrast to that, people get more information about piped water from the government than information about non-piped water.

Table 3: Facility condition about information on piped and non-piped water

	SD	Min	Mean	Max	Median
Facility condition about information provided by Government					
Piped water	1.25	1	3.10	5	3
Non-piped water	1.25	1	3.07	5	3
Information about facility condition provided by Internet/news					
Piped water	1.11	1	3.66	5	4
Non-piped water	1.10	1	3.69	5	4

Facility condition about information provided by cousins, neighbors					
Piped water	1.05	1	3.61	5	4
Non-piped water	1.01	1	3.64	5	4

5.1.3 Households water use

Due to the “New Countryside program” of the government, almost every household reported that they can access piped water networks. Only 5.36% said that there is no availability to access piped water connection so they have to use non-piped water. Although 93.5% of households can access the network, 67.43% of respondents still use both sources. The data also shows that households tend to adopt water treatment if they use non-piped water, 239 out of 261 said they will (or currently) use some cleaning methods on non-piped water.

In terms of purpose of use, there is a significant difference between piped water use and non-piped water use. 59.5% of piped water users only use piped water for showering or irrigation instead of drinking and eating, and 19.03% use it for drinking and eating, although piped water is qualified enough for drinking and eating. In contrast, nearly half of non-piped water users use non-piped water only for drinking and eating, and just 15.34% only use it for showering or irrigation. In addition, we recognize the diversity of the degree of willingness to pay for the installation of piped networks. 500.000 - 1.000.000 VND/per installation, accounting for 29.12%, seems to be the most acceptable amount a household can pay. Taking 2nd place, 1.000.000 - 2.000.000 VND/per installation accounts for 26.82% of respondents. Moreover, almost two-thirds of households are willing to pay about 100.000 - 200.000 VND/month for using piped water. (See table 4 below)

Table 4: Households water use

Variables	Options	Freq	Percent (%)
Water sources choice	Piped Water	71	27.2
	Non-piped water	14	5.36
	Both	175	67.43
Accessibility to piped network	Yes	244	93.49

	No	14	5.36
	Don't know	3	1.15
Piped water use	Drinking and eating	47	19.03
	Other purposes (showering, irrigation...)	147	59.51
	Both	53	21.46
Non-piped water use	Drinking and eating	94	49.74
	Other purposes (showering, irrigation...)	29	15.34
	Both	66	34.92
Willingness to installation	<500.000 VND/per	55	21.07
	500.000 - 1.000.000 VND/per	76	29.12
	1.000.000 – 2.000.000 VND/per	70	26.82
	2.000.000-3.000.000 VND/per	52	19.92
	>3.000.000 VND/per	8	3.07
Willingness to service use	< 100.000 VND/month	66	25.29
	100.000 - 200.000 VND/month	163	62.45
	> 200.000 VND/month	32	12.26

5.1.4 Perceived risk across towns:

Table 5,6, and 7 display our assessment on people's perceptions of risks when using 2 water sources: tap water and other non-piped water sources. People evaluate on a scale from 1 (strongly disagree) to 5 (totally agree) with the following risks of using tap water: financial risk, water quality risk, physical risk (property damage), health risk. For the other water sources section, people were asked about their risk perception in three dimensions: quality, health and society.

As shown in Table 5, people who are using piped water are highly concerned about the water quality risk, especially about system disruption that leads to supply shortage/cutoff and a lack of belief in the amount of impurities, chemicals, residues,... in water. The mean score for the health risk is above neutral, around 3.8, which means they partly agree to consider it as a threat. The data also show that on average surveyed households do not pay attention to harmful chemicals in tap water (corrosion, rust, etc.) to water-using equipment, domestic water pipes, with 3.04 on scale. Among households using water at the time of the survey, concerns about maintenance costs or incorrect measurement of water use by the system (financial risk) were the most varying risk perceptions, with the standard deviation up to 1.3. Health and property risk perceptions, with all the modes of 5, received the highest agreement from households.

Table 5: Perceived risk among the people using piped water

Variables	Options	SD	Mean	Mode
Financial risk	Maintenance costs of the water system and the possibility of false measurements due to the system.	1.3	3.53	4
	Costs of system depreciation	1.22	3.68	4
Quality risks	Quality (impurities, chemicals, residues, ...) is not up to the commitment of the suppliers	1.24	3.82	5
	System disruption leads to supply shortage/cutoff	1.12	3.83	5
	Chemical disinfectants (such as chlorine) affect the sensory perception of water (smell, taste, color, etc.)	1.1	3.72	4
Property risk	Chemical substances in piped water harm (corrosion, rust, ...) to water-using equipment, indoor water pipes.	1.16	3.04	5
	Rearrange existing properties to use water sources (installing additional works, new pipelines, ...)	1.11	3.66	5

Health risk	Dermatological or digestive diseases caused by water disinfectants (chlorine)	1.15	3.79	5
	Disinfectants in water lose essential minerals in water, indirectly causing weakness in eyes, bones and joints	1.2	3.78	5

For households using non-piped water sources, we looked at their risk perception in both water sources: the water they were using and the piped water sources. The average perception of these households on social risks such as disputes over water use is low as 2.5 score of the mean. From the value for the mode of this risk is 1, it can be inferred that they all partly disagree that this is not a risk when considering using a non-piped water source. On the other hand, the mean score for concerns about the appearance of water (color, smell, taste), residues after home-treatment, and stability of water due to external causes was high (around 3.8) and hardly fluctuated (standard deviation was around 1). In addition to the perceived quality risk, households are relatively certain that their water supply will be affected by pollution from the surrounding environment sooner or later, reaching the mean of opinion scale in 4.

Table 6: Perceived risk among the people using non- piped water on Non-piped water

Variables	Options	SD	Mean	Mode
Quality risks	Sensory properties (color, smell, taste) do not meet safety standards	0.94	3.86	4
	Self-treated water but still has residues	1.01	3.81	4
	The quality and stability of water flows can be affected by natural factors (e.g. seasonality) or man-made factors (pollution, depletion, alum contamination, etc.)	1.08	3.86	4
Health risk	Chemical impurities in water sources (lead, alum, ...) and bacteria can cause digestive	1.37	3.27	5

	diseases, dysentery, diarrhea, typhoid, cholera, or water-borne diseases.			
	Water does harms to the health of children in the household (e.g: skin or gastrointestinal allergies)	1.25	3.6	5
	Worried about the probability of continuing to suffer from diseases directly or indirectly related to non-piped water sources	1.17	3.68	5
Social risk	Disputes over water use in the neighborhood	1.62	2.5	1

As for risk perception on piped water, households currently using other sources of water are acutely aware of the financial and financial risks they may take if installing and using this system with the mean around 3.9 displayed in table 7 below. Average perceived risk that residues after treatment and disinfectants such as chlorine can reduce the external quality of water (color, odor, taste) to a level of near disagreement (the mean of 2.15 and 2.31) and with little variation (standard deviation 0.72). People's average perception to health risks is neutral (about 3.3) and relatively low fluctuating with a standard deviation of 1.05

Table 7: Perceived risk among the people using non- piped water on Piped water

Variables	Options	SD	Mea n	Mod e
Financial risk	Maintenance costs of the water system and the possibility of false measurements due to the system.	1.37	3.9	5
	Costs of system depreciation	1.05	3.9	5
Quality risks	Quality (impurities, chemicals, residues, ...) is not up to the commitment of the suppliers	1.13	2.31	3
	System disruption leads to supply shortage/cutoff	0.81	3.81	4

	Chemical disinfectants (such as chlorine) affect the sensory perception of water (smell, taste, color, etc.)	0.72	2.15	2
Property risk	Chemical substances in piped water harm (corrosion, rust, ...) to water-using equipment, indoor water pipes.	1.01	3.72	4
	Rearrange existing properties to use water sources (installing additional works, new pipelines, ...)	1.05	4.1	5
Health risk	Dermatological or digestive diseases caused by water disinfectants (chlorine)	1.11	3.63	4
	Disinfectants in water lose essential minerals in water, indirectly causing weakness in eyes, bones and joints	1.05	3.02	4

5.2 Regression analysis

5.2.1 Impact of perceived risk towards the piped-choice

Table 8: Logistics regression results on impact perceived risk on piped-choice

pipedschoice	Coef.	St.Err.	t-value	p-value	[95% Conf	Intervall]	Sig
highedu	1.1	.241	0.44	.662	.716	1.691	
Children	2.296	2.166	0.88	.378	.361	14.59	
pipeds_connect	.176	.146	-2.10	.036	.035	.892	**
qualityrisk_np	1.093	.58	0.17	.867	.386	3.094	
healthrisk_np	3.187	1.783	2.07	.038	1.064	9.542	**
quality_np	.866	.571	-0.22	.827	.238	3.152	
socialinflu_np	2.892	2.536	1.21	.226	.518	16.126	
quality_p	1.943	.9	1.43	.151	.784	4.816	
socialinflu_p	.074	.064	-3.02	.003	.014	.4	***
finanrisk_p	.562	.257	-1.26	.208	.23	1.378	
qualityrisk_p	.937	.518	-0.12	.907	.317	2.769	
healthrisk_p	.893	.344	-0.29	.769	.42	1.899	
behavctrol_p	1.354	.597	0.69	.492	.57	3.215	
behavctrol_np	1.921	1.16	1.08	.28	.588	6.277	
Constant	27.48	61.333	1.48	.138	.346	2181.741	

Mean dependent var	0.938	SD dependent var	0.241
Pseudo r-squared	0.333	Number of obs	211
Chi-square	32.507	Prob > chi2	0.003
Akaike crit. (AIC)	95.134	Bayesian crit. (BIC)	145.412

*** $p < .01$, ** $p < .05$, * $p < .1$

Source: Authors

Fig 2 shows the result of logistics regression using STATA. The $\text{Prob} > \text{Chi}^2 = 0.0034 < 0.05$ providing that the model is statistically significant. The result shows that the availability of piped connect, perceived health risk toward non-piped water, social influence toward piped water statistically significant and play a positive role affecting the decision to adopt piped source of household. In particular, the odds ratio of perceived health risk toward non-piped water is $3.18 > 1$ meaning that the odds of adoption piped water will increase 3.18 times when the perceived health risk toward non-piped water increases 1 unit. Moreover, social influence toward piped water claim the odds ratio of $0.07 < 1$, providing that the more household seek for information about piped water, the less they tend to adopt piped network, this result maybe related to the concept of information they get from society. Therefore, the hypothesis H1a is supported whereas H1b, H2a, H2b, H3a, H3b, H4a, H4b are rejected.

5.2.2 Impact of perceived risk on WTP service use:

Table 9: OLS Regression results on WTP service use of piped water

WTP_serviceuse	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
qualityrisk_np	.151	.083	1.82	.071	-.013	.315	*
healthrisk_np	-.007	.072	-0.10	.921	-.148	.134	
qualitynp	-.064	.086	-0.74	.458	-.234	.106	
socialinflu_np	-.017	.099	-0.17	.862	-.213	.178	
quality_p	-.078	.068	-1.14	.255	-.212	.057	
socialinflu_p	-.019	.095	-0.20	.842	-.206	.168	
qualityrisk_p	.11	.08	1.38	.17	-.048	.268	
healthrisk_p	-.101	.057	-1.77	.078	-.214	.012	*
propertyrisk_p	.083	.068	1.23	.22	-.05	.217	
finanrisk_p	.002	.059	0.03	.975	-.115	.118	
behavctrol_p	.044	.068	0.65	.519	-.091	.179	
behavctrol_np	.08	.053	1.49	.137	-.025	.185	
Children	.388	.094	4.14	0	.203	.573	***
highedu	.051	.024	2.10	.037	.003	.099	**
piped_connect	.11	.184	0.60	.55	-.253	.474	
Constant	3.676	.52	7.07	0	2.651	4.702	***

Mean dependent var	4.711	SD dependent var	0.654
R-squared	0.204	Number of obs	200
F-test	3.152	Prob > F	0.000
Akaike crit. (AIC)	383.174	Bayesian crit. (BIC)	435.947

*** $p < .01$, ** $p < .05$, * $p < .1$

Source: Authors

Fig 3 shows the result of OLS regression using STATA. The Prob > F = 0.0001 < 0.05 meaning that the predictor of our model reliably predict the willingness to pay for water service use of households. As shown in Fig x, the status of having children under 5 and the highest edu of household have a significant effect on willingness to pay for water service use at 95% confidential interval and perceived quality risk toward non-piped water, perceived health risk toward piped water have a significant effect on willingness to pay for water service use at 90% confidential interval. In particular, the parameter of perceived quality risk toward non-piped water and perceived health risk toward piped water respectively are 0.15 and - 0.1, which provides that perceived quality risk toward non-piped water positively effect on willingness to pay for water use whereas perceived health risk toward piped water plays a negative role. Therefore, the hypothesis H3c and H1d are supported while H1c, H2c, H3d and H4c are rejected. In addition, the parameter of highest edu of household and the status of having children under 5 are respectively 0.05 and 0.38 >0, providing that the higher education level an individual in family get, the higher their willingness to pay for water use is and household are more willing to pay for water use if they have kids under 5.

5.2.3 Impact of Perceived risk on WTP for installation piped water or treatment methods

Table 10: OLS Regression on WTP for installation piped water or treatment methods

WTP_install	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
qualityrisk_np	-.194	.139	-1.40	.164	-.469	.08	
healthrisk_np	.245	.122	2.00	.047	.003	.487	**
qualitynp	.363	.159	2.28	.024	.049	.676	**
socialinflu_np	-.286	.171	-1.68	.095	-.623	.051	*
quality_p	-.051	.12	-0.42	.673	-.287	.186	
socialinflu_p	.315	.159	1.98	.049	.001	.63	**
qualityrisk_p	-.443	.131	-3.39	.001	-.701	-.185	***
healthrisk_p	-.182	.097	-1.88	.062	-.374	.009	*
propertyrisk_p	-.021	.116	-0.18	.855	-.249	.207	
finanrisk_p	-.363	.099	-3.67	0	-.558	-.168	***
behavctrol_p	-.075	.113	-0.67	.505	-.297	.147	
behavctrol_np	.003	.091	0.03	.977	-.177	.182	

Children	.311	.163	1.92	.057	-.009	.632	*
highedu	-.028	.042	-0.67	.505	-.112	.055	
piped_connect	.34	.278	1.22	.224	-.209	.888	
Constant	4.168	.861	4.84	0	2.471	5.866	***
Mean dependent var		2.640	SD dependent var		1.123		
R-squared		0.174	Number of obs		203		
F-test		2.628	Prob > F		0.001		
Akaike crit. (AIC)		615.360	Bayesian crit. (BIC)		668.371		

*** $p < .01$, ** $p < .05$, * $p < .1$

Source Authors

Fig 4 shows the result of OLS regression using STATA. The $\text{Prob} > F = 0.0008 < 0.05$ meaning that the predictor of our model reliably predict the willingness to pay for installation of piped water network. The result indicates that perceived health risk toward non-piped water, perceived quality toward non-piped water, social influence toward piped water, perceived quality risk toward piped water and perceived financial risk toward piped water have a significant effect on willingness to pay for installation of piped water network or treatments methods at 95% confidential interval. The social influence toward non-piped water, the status of having children under 5 and perceived health risk toward piped water have significant effect at 90% confidential interval. In particular, the parameters of perceived quality risk, health risk and financial risk toward piped water are -0.44, -0.18 and -0.36 respectively, providing that these 3 perceived risk negatively impact willingness to pay for installation of piped water network. In contrast, the parameter of perceived health risk toward non-piped water is 0.25, meaning that perceived health risk toward non-piped water plays a positive role. Therefore, the hypothesis H1e, H1f, H2d and H3f are supported while H3e and H4d are rejected. In addition, the parameter of status of having children under 5 is $0.31 > 0$, providing that households are more willing to pay for installation or treatments methods if they have kid under 5.

6. Discussion

6.1 The role of perceived risk dimensions on the probability of piped water adoption among piped households

Our research analysis demonstrates a causal relationship between perceived risk and current piped water behaviour of households, then contributes to the literature pertaining to critical factors on the piped choice among households. In the context of MUWS, the

availability of piped water and non-piped requires households to compare the different attributes among source choices with their current water to choose the ones that get them the least exposure to risks. Generally, the perceived health risk and quality risk towards non-piped is the most important determinant that explains the adoption of piped water among households (including non-piped, piped and both), supported by the perceived quality towards the piped network. Our findings are completely aligned with the literature which emphasizes the imperative role of perceived risk in the adoption of water sources. Research by Dupont & Jahan (2012) shows that people in a Canadian community are willing to spend more money to simultaneously use other water sources (treated water, bottled water) if their perception of the quality and health risk of the current-using water is high. This study shows that people's consumption decisions water change in the face of health risks.

Given the impact of perceived health risk towards non-piped on source choice, our results reinforce the significance of perceived risk theory in interpreting households' behaviour towards piped adoption. Households that currently choose piped networks will inherently choose piped water to keep them from suffering from risk exposure caused by residuals in non-piped systems. Also, their perceived quality of piped network motivates them to use the current source choice. This is an iterative process in which perceived risk explains why households do not choose non-piped sources for primary purposes. Simultaneously, perceived quality provides them with evidence to trigger their continuance with their current piped sources. These findings have contributed to resonating rationale behind the decision to adopt piped sources. From there, policymakers can apply the policy implications of this study to the design and implementation of educational programs that help increase the perceived risk of households towards non-piped, instead of focusing only on the benefits of piped networks, especially in the context of multiple water use sources.

6.2 The role of perceived risk dimensions on the willingness to pay of households towards service use; installation and service use

As shown, quality risk and health risk towards piped are two main motives that affect the willingness to pay of households towards water service (including installation and service use fees). This implies that the larger the improvement in water service quality, the higher the predicted WTP values. This finding is in line with the meta-analysis of Van Houtven et al. (2017). One interesting finding to note is that financial risk towards piped water is a determinant that prevent households from willingness to pay for piped water.

According to perceived risk theory, households want to minimize their risk exposure. Consequently, the positive relationship between the health risk and quality risk of non-piped and willingness to pay for piped network indicate their high expectation towards safer water

sources in the piped network. They expect that their price premium will help them stay away from residuals in water quality as well as sufferings to their health. In terms of health risks and quality towards piped water, positive relationship indicate that they will expect lower risk as possible as a result of their premium.

6.3 Factors influence piped adoption; WTP towards service use as well as installation

Although the perceived risk might considerably trigger the uptakes of households towards piped use and households' WTP for piped use, it should be noted that the adoption of preventive behaviours not solely depends on perceived risk, but is also greatly influenced by other demographic factors and social, cultural and economic factors, and not limited to infrastructure development and education (Carmen Anthonj et al., 2019; Britta Renner et al., 2008; Elijah Bisung et al., 2014)

In our findings, social influence assimilated through informational sources from official channels such as the Internet, news, and television and informal media such as friends, relatives, and neighbours is shown to significantly affect not only the piped choice but also the willingness to pay for households. In line with our research findings, research by Mosler et al. (2010) also confirmed the strong influence of family members and friends on decision-making on water use and purposes (drinking or other purposes). Through discussion and chatting with relatives of those who currently use arsenic-contaminated sources, cautionary actions towards water use were taken by households. Likewise, public information about piped water still positively impacts the use allocation of households despite limited socio-economic backgrounds. Additionally, Sohaib et al., 2022 have also shown that information to support the decision towards source choice is mainly spread by the government, the media and universal education programs.

Besides the information source, our research also notified the difference in the strategy households collect the information for their water choice. Through the in-depth interview, households reported that if public information helps them be aware of knowledge about piped sources, shared information disseminated by the mutual network seems to be more trustworthy due to real experience. This implies that households consider mass media channels as a typical platform to gain public knowledge about source choice. Whereas, informal channels used to ask for practical advice for actual decisions. A similar conclusion was reached by McAlpine (2018) shows that the source of informal information (face-to-face communication) has wider coverage, and flexibility, and is faster than the official information. However, the impact of this way of spreading information on the decision to use water filtration and cooling equipment is not strong and fluctuates according to the moderating variable, which is the credibility of the information source and the level of the respondents.

To explain the rationale behind the impact of social influence on source choice, a quantitative study by Mudasir Ahmad Sofi, Irshad Ahmad Reshi, & Dr. T. Sudha. (2023) stated that social influence is a reference that helps them minimize the probability of risk exposure. Besides, individuals are often influenced by the behavior of others, and social norms can strongly influence economic behavior. However, the way in which people receive information passively or actively, formally or informally, has not yet been considered. This is a gap that needs more information to explain cognitive needs, behaviours, and, thus, decisions to use water in rural areas where people's decision to use water is under pressure from many factors.

By definition, perceived risk is mainly formulated by subjective judgment through personal and community experience (Loewenstein et al. (2001); Slovic, 2016). Meanwhile, in the Vietnamese context, especially in rural and peri-urban areas, households are often close-knit with their relatives and neighbors, subsequently leading to a strong social network. Consequently, information sharing has a direct influence on individual decisions. Therefore, it is highly recommended that the government educate households about the benefits of piped water not only via public education but also through information sharing with local people and local governments to disseminate the risk-related experience with non-piped sources. (Mosler et al. (2010))

Besides, there are other demographic factors which are also important in explaining households' choices toward a piped decision. First, having access to piped water is also an essential determinant that positively influences households. Although the provinces chosen in the study are provided with piped networks, there are still some areas where the piped network might be quite far from these households. To connect, households must pay additional costs for pump connection systems. Thus, it is easily understood that households will be less likely to connect to the piped network compared to households with access to the piped network. Therefore, the government should prioritize the facilitation of piped infrastructure to enable households to connect to piped networks. Besides, the level of education also positively determines the willingness to pay for installation and service use. Education level helps households be aware of the benefits as well as the drawbacks of being unqualified for their health and personal well-being

7. Conclusion & policy Implications

7.1 Policy recommendation

It is important to make risk perception a priority in decision making to identify high or low-risk communities, and challenges that communities are really facing beyond what is on political agendas (Abu and Codjoe., 2018). A deeper understanding of place- or

community-based knowledge may positively influence policy development and management-level decision making (Castleden et al., 2015). Policy should be tailored to target the identified behaviour determinants (George et al., 2017) to customize risk communication plan for each regions

7.2 Awareness raising

Risk awareness is lacking in several studies (e.g., Blum et al., 2014; Chaturvedi et al., 2017; Crampton and Ragusa, 2016). Risk awareness campaigns increase knowledge and facilitate participation in prevention practices (Aziz et al., 2006; Castro et al., 2009; Haenchen et al., 2016; Islam et al., 2011). However, they are not always successful. Information should always be communicated with a variety of audience profiles in mind (Hynds et al., 2018). Therefore, an in-depth understanding of risk perception help campaigns include a clear description of the risk (Hyllestad et al., 2019), be timely, relevant and easily understandable (Crampton and Ragusa, 2016) and be based on personal and social norms (Musacchio et al., 2021).

7.3 Behaviour change

There is growing consensus that local perceptions and indigenous knowledge should be important elements in evaluating programmes aimed at improving health (Andrade et al., 2019). Thus, future mitigation programmes should be looking beyond merely increasing knowledge, but should devise an approach based on reliable information on risk perceptions and tailored to target the locally identified behavioural determinants (Jones et al., 2007; Seimetz et al., 2016; George et al., 2017; Gamma et al., 2019). Implementing behaviour change interventions will be efficacious only if they are tailored to current behaviours, knowledge, and perceptions of the target population (Watson et al., 2015), as well as their cultural context (Sundaram et al., 2014) especially in the context of decentralization where local communities take more responsibility in handling and managing the water infrastructure. Therefore, it becomes crucial to define existing behavioural situation regarding the link between perceived risk among multiple water sources, and how these beliefs relate to environmental management practices (Randell et al., 2010).

8. Limitations

Our research still has pitfalls and limitations which require further justifications from future research. Limitations are mainly concerned with a small sampling, especially the number of non-piped households. Future research should increase the sample size in more Northeastern provinces to justify the impact of perceived risk on the disconnections of households towards non-piped sources.

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