Model for determining the adequacy of drinking water intake in the Nambo coastal area of Indonesia

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Abstract

The availability of drinking water in the Nambo coastal area is still challenging, leading to inadequate water intake. This research investigates a model for evaluating the adequacy of drinking water consumption in the Nambo coastal area. The study employs a quantitative cross-sectional design involving 100 participants aged 15 years and older. Data analysis was conducted using the partial least squares structural equation modeling (PLS-SEM). The findings indicate that a person's belief has a positive and moderate effect on their water intake (p=0.000; R^2=0.352; CI 97.5%: 0.179-1.531). This belief mediates the person's knowledge and attitudes about the importance of staying hydrated (p=0.046; R^2=0.226; CI 97.5%: -0.005-0.440). Additionally, knowledge positively and moderately affects individual attitudes (p=0.000; R^2=0.369; CI 97.5%: 0.226-0.635). Belief also has a positive and moderate influence on health maintenance (p=0.000; R^2=0.428; CI 97.5%: 0.189-0.604). In conclusion, personal beliefs about the benefits of drinking water are critical to increasing water intake. Confidence in these beliefs stems from knowledge and positive attitudes toward the health benefits of water.

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Introduction

Lack of water intake can cause disorders of the body's organs, including chronic kidney disease (CKD).[1-4] Chronic kidney disease is often referred to as a "silent killer" because patients are usually unaware of it until it advances to a more severe stage.[5-8] This disease has led to numerous deaths around the world, including in the coastal regions of Kendari City, Southeast Sulawesi, Indonesia. The prevalence of CKD is often hard to identify because many individuals do not seek early examination at health centers. As a result, the reported prevalence of CKD seems significantly lower compared to other chronic diseases, such as hypertension and diabetes mellitus. For example, in 2018, the prevalence of CKD in Southeast Sulawesi Province was 0.35%, showing an increase compared to 2013 (0.2%).[9,10]

The undetectability of chronic kidney sufferers makes it difficult for policymakers and health service units to develop chronic kidney disease control programs. However, previous studies have shown that water consumption of less than 2000 mL a day is one of the main causes of chronic kidney function disorders in Kendari City.[3,11-15]

The insufficient water intake among residents in the coastal areas of Kendari City, Southeast Sulawesi, is closely linked to their access to drinking water sources. Specifically, certain coastal regions, such as the Nambo area, still struggle with limited access to these sources. However, this limited access may not be the only cause of insufficient water consumption, as people in these areas can still buy bottled water. Other factors affect adequate water intake in coastal communities, including knowledge and attitudes regarding the health benefits of drinking water for the body's organs.[16-20] In addition, confidence and motivation to make efforts to maintain health have been stated as determinants of water intake adequacy in individuals.[21-25] Despite this, the specific ways in which these factors lead to inadequate water intake in the Nambo Coastal area of Kendari City, Southeast Sulawesi, Indonesia, have not been clearly described. Therefore, this study aims to develop a model for determining the appropriate level of daily water intake for residents in the Nambo coastal area of Southeast Sulawesi, Indonesia. It is hoped that the findings will serve as a reference for policymakers and health programs, ultimately increasing access to drinking water sources. Consequently, this should lead to an increase in water consumption among the local population.

Materials and Methods

Study design

The research employs a quantitative approach utilizing causal explanatory methods. This design aligns with the research objectives, as it effectively explains how one variable can influence or cause changes in other variables.[26]

Study setting

This research was conducted in the Nambo Coastal area, Kendari City, Southeast Sulawesi, Indonesia, from May 2024 to July 2024. The research objectives and the limited access to adequate drinking water sources guided the selection of the location. Trends indicate that the percentage of households with access to sufficient drinking water has declined in Southeast Sulawesi, particularly in coastal and rural areas. In 2022, the percentage was around 94.11%, which decreased to 93.88% in 2023.[27] The Nambo Sub-district includes five villages: Petoaha, Nambo, Sambuli, Tondonggeu, and Bungkutoko.

Sampling

The study's population consisted of 1788 households distributed across five villages in the Nambo Sub-district. The households were allocated as follows: 420 in Petoaha Village, 310 in Nambo Village, 379 in Sambuli Village, 274 in Tondonggeu Village, and 405 in Bungkutoko Village. To select samples from this population, the study employed a cluster random sampling technique. The sample selection process began with determining the overall sample size, followed by calculating the proportional sample sizes for each of the five villages.

Sample size

The study included a sample size of 100 participants, which was calculated using the Slovin formula. This formula considered a population of 1788 and an error margin of 10%. The calculation resulted in 95 participants; however, to account for potential dropouts, the researchers increased the sample size by 5% to 100 samples. Based on the sampling technique used, the participants were distributed as follows: 23 from Petoaha village, 17 from Nambo subdistrict, 21 from Sambuli village, 15 from Tondonggeu village, and 23 from Bungkutoko village.

Data collection

The data collection tool utilized a structured questionnaire that includes questions regarding knowledge, attitudes, beliefs, maintenance, and the amount of water intake. Valid knowledge questions include understanding the benefits of adequate water intake for regulating the body's calorie consumption (P.11.B), protecting sensitive tissues such as the eyes (P.15.S), and preventing issues like dizziness or headaches (P.17.S). On the other hand, questions about attitudes focus on the effects of insufficient water consumption, such as muscle weakness (S.7.N), joint pain (S.8.N), and a dull or unattractive appearance of the skin (S.13.N). Questions regarding beliefs focus on the effects of insufficient water intake on the occurrence of kidney disease (K.19.N), body weakness (K.20.N), and joint pain (K.21.N). Maintenance-related questions include the maintenance of body fluids (PM.1P), the process of food digestion in the body (PM.2.N), and the circulation of body fluids (PM.4.P). A valid question about water intake is the amount of drinking water consumed in the morning and afternoon, measured in glasses (each glass was converted to 250 mL). The instrument has been tested for validity and reliability before data collection. Based on the results of the construct reliability and validity tests conducted with PLS-SEM using Smart PLS software version 3.0, it was determined that the instrument was reliable and the questions for each variable were valid. As shown in Table 1, the Cronbach's alpha value is >0.6, the average variance extracted (AVE) value is >0.6, and composite reliability is >0.7.

Participant characteristics

The participants in this study were predominantly women, accounting for 78% of the total, while men comprised 22% (Table 2). The average age of participants was 33.8 years, with a standard deviation of 10.1 years. The highest level of education was high school (47%), and the least was higher education or above diploma (18%). Most participants were housewives (64%). Additionally, 21% were entrepreneurs, while only 9% worked in government roles.

Outcome measures

The variable measurement of the water intake level includes three categories: good, medium, and low. It is categorized as "good" if the value is >2000 mL per day, "medium" if the value is between 1000 and 1999 mL per day, and "poor" if the value is <999 mL per day. Knowledge and maintenance variables are measured in three categories: good, average, and poor. The knowledge or maintenance category is "good" if the score is 3, "medium" if the score is 2, and "poor" if the score is 1. Measurements of attitudes and beliefs are also divided into three categories: good, average, and poor. It is categorized as "good" if the score is between 9 and 12, "medium" if the score is between 5 and 8, and "poor" if the score is 4 or less.

Data quality management

Prior to conducting the interview, the research team received training on interview techniques and questionnaire comprehension. Preparatory meetings were also held to divide tasks in data collection. After collecting the data, each team coordinated the number of respondents interviewed and created a form for entering the data into a master table in Excel. They also divided tasks for inputting the data into SPSS version 25. Before the master table was imported into SPSS version 25 and Smart PLS version 3.0, the accuracy of the data was thoroughly reviewed.

Table 1. Construct reliability and validity.

Variables	Cronbach's alpha*	Validity	Average variance extracted (AVE)*	Reliability
Attitude	0.739	Valid	0.656	Reliable
Belief	0.823	Valid	0.736	Reliable
Knowledge	0.682	Valid	0.605	Reliable
Maintenance	0.767	Valid	0.682	Reliable
Water intake adequacy	0.626	Valid	0.726	Reliable

*PLS-SEM test.

Statistical analysis

Data analysis uses partial least squares structural equation modeling (PLS-SEM) with Smart-PLS software version 3.0.[28] PLS-SEM is used to predict endogenous latent variables or identify main variables and develop a model for determining the adequacy of water intake in coastal areas. The process involves several steps. The first step is testing the outer model, which aims to establish the relationships between the latent variables and their corresponding observed indicators. The outer model test results assess the data's validity and reliability using three key metrics: Cronbach's alpha, Average Variance Extracted (AVE), and composite reliability. The data is considered valid and reliable when the following conditions are met: Cronbach's alpha is >0.6, the AVE is >0.6, and the composite reliability is >0.7.[29,30]

The second step consists of evaluating the inner model to understand the relationship between independent and dependent latent variables. Interpretation of the direction and strength of the relationship is based on the R-Square (R^2) value; R^2>0.67 is a strong relationship, R^2=0.33-0.66 is a moderate relationship, and R^2=0.19-0.32 is stated to be weak.[31] Additional analyses were conducted using the Goodness of Fit approach to determine the model's suitability. A model is considered fit if the NFI value is close to 1 and the SRMR value is <0.10.[32,33]

Results

The results of the SEM-PLS analysis show that the level of water intake in the Nambo coastal area is directly influenced by the level of individual belief (Figure 1). The direction of the relationship between belief and adequate water consumption is positive and moderate (R^2=0.352). Knowledge and attitudes are indirectly related to adequate water consumption, primarily through the influence of individual beliefs. Specifically, knowledge is connected to beliefs both directly and indirectly. The indirect connection between knowledge and beliefs is mediated by attitudes. The relationship between knowledge and attitudes is positive and moderate (R^2=0.369). Similarly, the relationship between attitudes and beliefs is also positive but weaker (R^2=0.198). Additionally, the direct relationship between knowledge and beliefs is positive but weak (R^2=0.226). The belief variable is also related to the health maintenance variable. The direction and strength are positive and moderate (R^2=0.428). In this case, the belief variable is also a mediating variable between knowledge and attitudes towards maintenance. The model used to determine adequate water intake has been deemed suitable because the NFI value is 0.529, which is close to 1, and the SRMR value is approximately 0.1 (Table 3). The

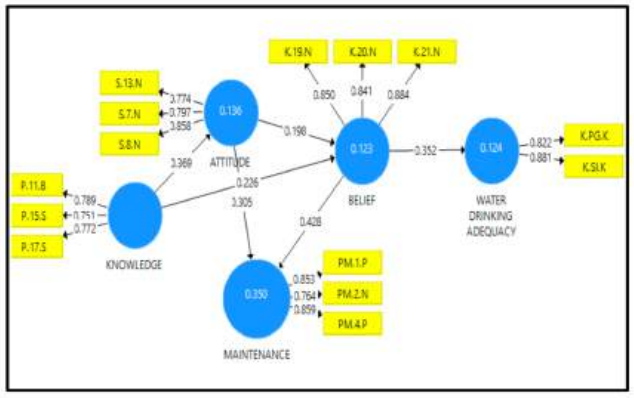

Figure 1. Model for determining the adequacy of water intake in the Nambo coast in 2024.

Table 2. Participant characteristics.

Participant characteristics	Frequency	Percent
Gender		
Male	22	22.0
Female	78	78.0
Age Group (Years)		
15-24	18	18.0
25-34	35	35.0
35-49	39	39.0
50-59	7	7.0
60-65	1	1.0
Mean ± SD	33.8±10.1	
Occupation		
Government employees	9	9.0
Entrepreneur/Private	21	21.0
Fisherman	3	3.0
Farmer	1	1.0
Honorary	2	2.0
Education levels		
Low (Under junior high school)	35	35.0
Medium (Senior high school)	47	47.0
High (Above diploma)	18	18.0
No working/ housewife	64	64.0
Total	100	100.0

SD, standard deviation.

Table 3. Path coefficients in the model of determining drinking water intake in the Nambo coastal area in 2024.

Variabel relationships	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	p	Confidence intervals (CI) 2.5%	97.5%	Fit summary
Knowledge and attitude	0.369	0.390	0.079	4.677	0.000	0.226	0.535	SRMR=0.10
Attitude and maintenance	0.305	0.315	0.975	4.052	0.000	0.172	0.460	NFI=0.529
Belief and maintenance	0.428	0.425	0.108	3.959	0.000	0.189	0.604	Chi-Sqare=268.300
Belief and water intake	0.352	0.360	0.090	3.916	0.000	0.179	0.531	
Attitude and belief	0.198	0.192	0.090	2.217	0.027	0.009	0.359	
Knowledge and belief	0.226	0.235	0.113	1.997	0.046	-0.005	0.440	

*PLS-SEM test.

calculated chi-square (χ^2) value is 268.300, which is higher than the table value (χ^2 table with df=99, alpha=0.05), which is 113.145. This indicates that the model is significant. Among the variables assessed, the R^2 coefficient for the maintenance variable is the highest at R^2=0.350, compared to the R^2 values for attitude (R^2=0.136), adequacy of drinking water (R^2=0.124), and belief (R^2=0.123). There are two key indicators of adequate water intake: morning and afternoon water consumption. The R^2 coefficient value for afternoon water consumption is 0.881, which is higher than the morning water consumption value of 0.822.

A significant indicator of belief is the perception of how inadequate water intake influences the risk of kidney disease (K.19.N), physical weakness (K.20.N), and joint pain (K.21.N). The R^2 value for belief about the effect of insufficient water intake on joint pain is the highest (R^2=0.884), followed by belief regarding its impact on kidney disease (R^2=0.850). In comparison, belief related to its effect on physical weakness is lower (R^2=0.841).

The indicators related to the knowledge variable include three main aspects: understanding the benefits of sufficient water intake for regulating the body's calorie intake (P.11.B); the protection of sensitive tissues, such as the eyes (P.15.S); and the prevention of dizziness or headaches (P.17.S). Among these, the R^2 for knowledge about regulating the body's calorie intake is the highest (R^2=0.789). This is followed by knowledge of the benefits of drinking enough water to avoid dizziness (R^2=0.772), and knowledge regarding the protection of sensitive tissues like the eyes (R^2=0.751).

The indicators for the attitude variable consist of three aspects: attitudes regarding the effects of insufficient drinking water on muscle weakness (S.7.N), joint disorders (S.8.N), and skin dullness or poor appearance (S.13.N). Among these, the attitude towards the impact of insufficient water intake on joint disorders has the highest R^2 coefficient value (R^2=0.858), followed by attitudes about the effect of insufficient water on skin performance (R^2=0.774), and the impact on muscle weakness (R^2=0.797). The indicators for the maintenance variable include the following: maintenance of body fluids (PM.1P), digestion process (PM.2.N), and circulation of body fluids (PM.4.P), which is linked to adequate daily water intake. The coefficient for body fluid circulation maintenance is slightly higher (R^2=0.859) than that for body fluid balance maintenance (R^2=0.853). However, it surpasses the coefficient for food digestion maintenance (R^2=0.764). The relationship between variables results as follows: relationship between knowledge and attitude (p=0.000; CI 97.5%: 0.226-0.535); between attitude and maintenance (p=0.000; CI 97.5%: 0.172-0.460); between belief and maintenance (p<0.0001; CI 97.5%: 0.189-0.604); between belief and the adequacy of water intake (p<0.0001; CI 97.5%: 0.179-0.531); between attitude and belief (p=0.027; CI 97.5%: 0.009-0.359); between knowledge and belief (p =0.046; CI 97.5%: -0.005-0.440). The distribution of the R^2 coefficient for the relationship between belief and daily drinking water adequacy ranges from 0.10 (low) to 0.60 (medium) (Figure 2). The highest proportion, approximately 60%, falls within the moderate range (R^2=0.33-0.60), while about 40% are in the low range (R^2=0.10-

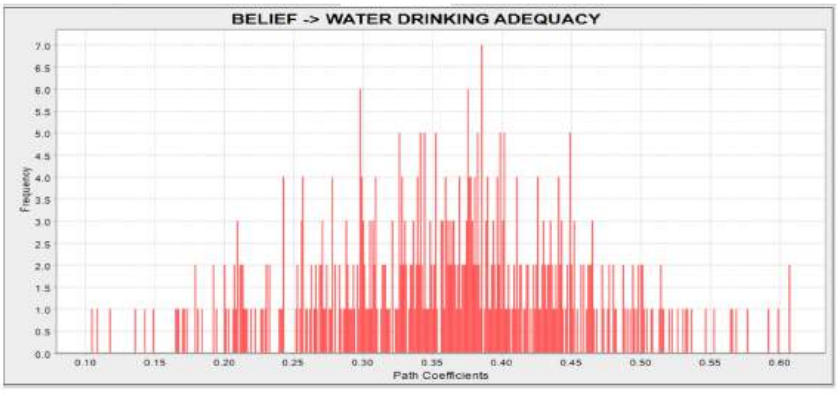

Figure 2. Path coefficients of the relationship between belief and drinking water intake in Nambo coastal area.

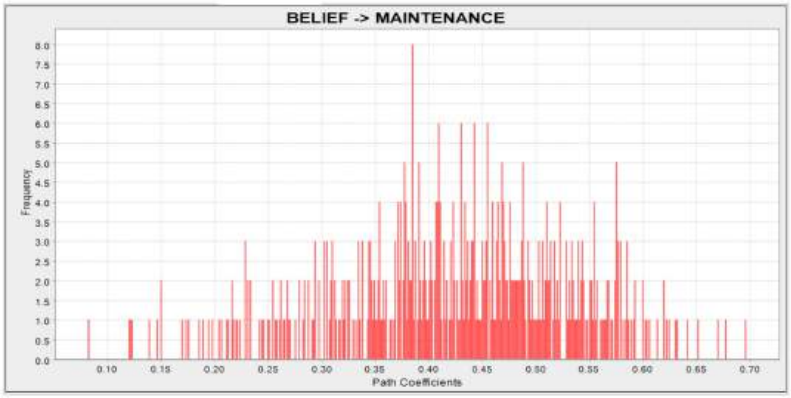

Figure 3. Path coefficients of the relationship between belief and maintenance in Nambo coastal area.

0.32).

The distribution of the R^2 coefficient for the relationship between belief and maintenance ranges from 0.07 (low) to 0.69 (strong) (Figure 3). The highest proportion, approximately 75%, falls within the moderate range (R^2=0.33-0.66), while around 22% show a low relationship (R^2=0.19-0.32), and only 3% exhibit a strong relationship (R^2>0.67).

The distribution of the R^2 coefficient for the relationship between attitudes and beliefs ranges from -0.09 (low) to 0.48 (medium) (Figure 4). The proportions of low (R^2<0.19-0.32) and medium (R^2=0.33-0.48) relationships are almost identical, each representing about 50%.

The distribution of the R^2 coefficient for the relationship between knowledge and trust ranges from -0.20 (low) to 0.56 (medium) (Figure 5). The largest proportion, about 75%, falls within the low R^2 range (R^2<0.19-0.32), while approximately 25% show a medium relationship (R^2=0.33-0.56).

The distribution of the R^2 coefficient for the relationship between knowledge and attitude ranges from 0.16 (low) to 0.61 (medium) (Figure 6). The highest proportion, around 75%, falls within the medium range (R^2=0.33-0.61), while the remaining 25% have a low relationship (R^2<0.19-0.32).

The distribution of the R^2 coefficient for the relationship between attitude and maintenance ranges from 0.09 (low) to 0.57 (medium) (Figure 7). The proportions of low (R^2=0.19-0.32) and medium (R^2=0.33-0.57) relationships are almost equal, with each representing around 50%.

Discussion

A person's belief in the Nambo coastal areas directly influences the adequacy of water intake. Individuals who have good belief about the benefits of drinking water, especially for joint health, body strength, and preventing kidney disease, will tend to drink water according to the standard, namely a minimum of 2000 mL per day. Conversely, people who do not believe in the benefits of drinking water tend to consume less water each day than needed. There are various perspectives on how individual belief influences the adequacy of water intake in the Nambo coast area, ranging from low to moderate levels of belief. The community's overall belief in the benefits of water is still at a moderate level, without being strongly ingrained. Several factors contribute to this, and the first is related to limitations in drinking water supply in coastal areas. People often rely on purchasing bottled water, which tends to be more expensive than in urban centers. However, many individuals are already convinced of the health benefits of adequate water intake. Research suggests that behavioral changes, such as increased water consumption and adherence to healthy habits, are more likely to occur as individual belief strengthens.[34,35]

Water consumption in the Nambo coastal area is significantly higher in the mornings than in the afternoons. This aligns with the coastal environment, where the heat from the sea surface creates a strong need for hydration during the day. In contrast, the need for

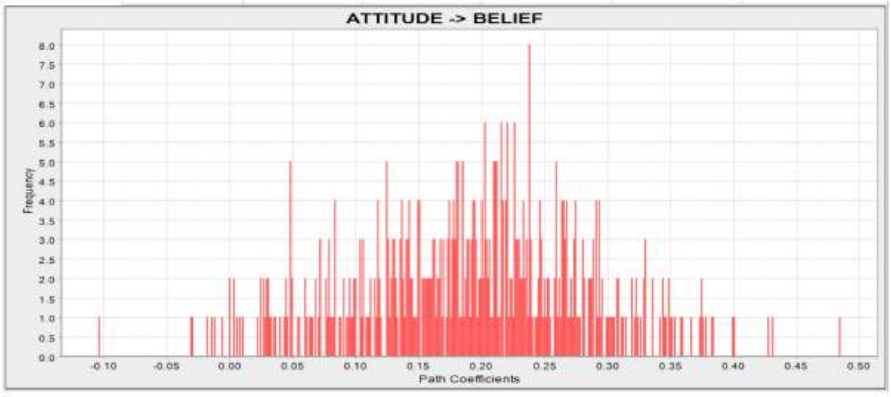

Figure 4. Path coefficients of the relationship between attitude and belief in Nambo coastal area.

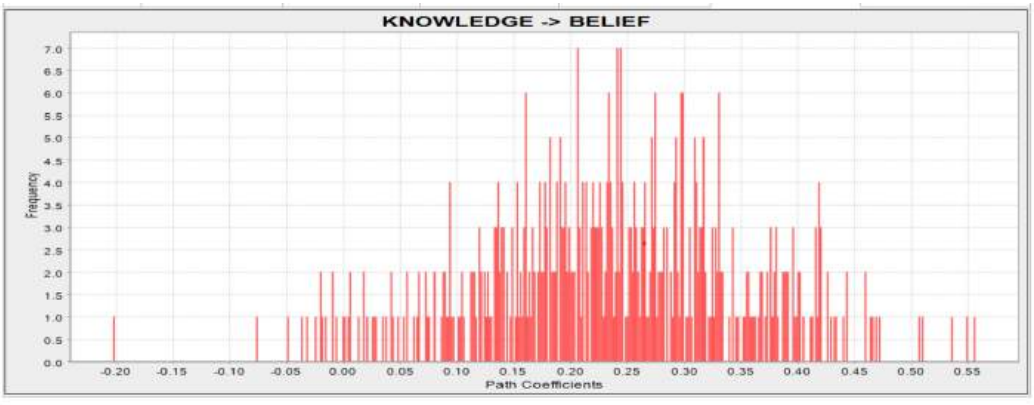

Figure 5. Path coefficients of the relationship between knowledge and belief in Nambo coastal area.

water in the Nambo coastal community decreases in the afternoon and evening as the weather cools, a change also influenced by sea air circulation.

Additionally, the level of knowledge and attitudes among individuals in the coastal area indirectly influences their drinking habits. People who are well-informed about the benefits of drinking water—such as its role in regulating calorie intake, protecting sensitive tissues, and preventing dizziness—tend to meet the recommended daily intake of water, which is at least 2000 mL. People with good knowledge will immediately encourage their positive attitude toward the importance of drinking water for healthy muscles, joints, and skin. The individuals' attitude in the coastal area is not only influenced by the health information that they have received but is also related to the weather of this area. This can be seen from their attitude towards skin health. The sun on the coast will directly impact the skin, which is why the response to the need to drink water is related to the appearance of the skin for coastal communities. Previous studies also stated that increasing water intake in the human body enhances skin extensibility and elasticity[36] and increases the water content in the dermal layer.[37] As a result, those who drink sufficient water have better skin performance than those who drink less.

Good individual knowledge can also directly encourage the emergence of good beliefs about the benefits of water for joint health, body strength, and preventing kidney disease. Coastal communities' beliefs about the importance of drinking enough water have also contributed to kidney disease prevention. Health messages aimed at coastal areas have already been implemented and have had a positive impact on the management of chronic kidney disease. However, a study found that attitudes have a stronger influence in pushing individuals towards adequate water intake compared to knowledge.[38] In this case, knowledge has less influence due to the inaccurate information received by society. In contrast, attitudes play a stronger role in influencing behavior because they directly shape individual beliefs.

The development of personal attitudes and beliefs about water intake also affects health maintenance actions. Individuals with a positive attitude and belief in the benefits of drinking water are more likely to engage in health maintenance activities. Coastal communities rely on drinking water to maintain fluid balance and support digestion. These factors play a key role in encouraging individuals to drink sufficient water, particularly in the morning and afternoon. The importance of hydration is especially pronounced in maintaining the circulation of body fluids. This need is heightened during the day, when coastal communities lose a significant amount of fluids through sweating. The warm coastal air encourages the body to sweat, increasing fluid loss. As a result, the body naturally requires more water to restore fluid balance. This phenomenon is observed in coastal regions worldwide, where drinking water is essential to replace fluids lost through perspiration.[39] Consequently, this study highlights that the need for hydration is the most influential factor in encouraging water consump-

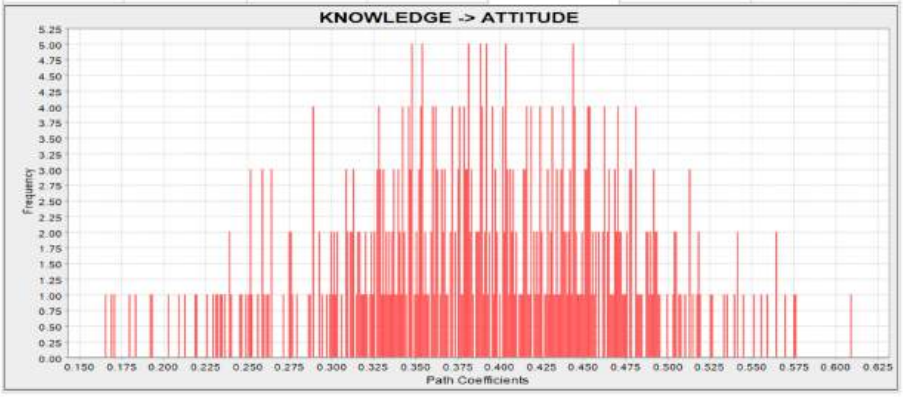

Figure 6. Path coefficients of the relationship between knowledge and attitude in Nambo coastal area.

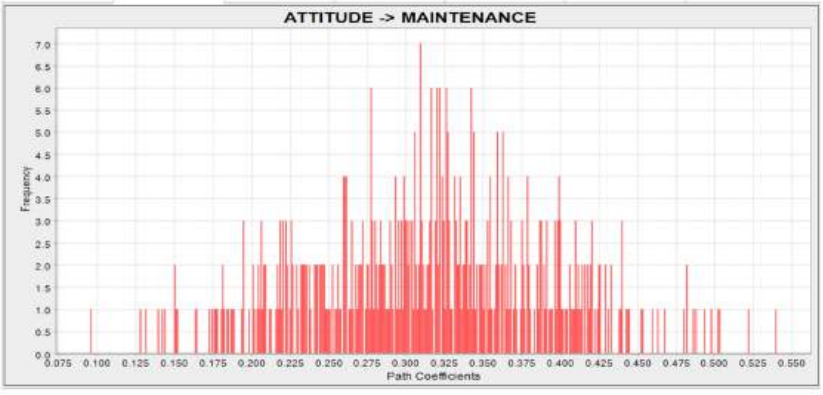

Figure 7. Path coefficients of the relationship between attitude and maintenance in Nambo coastal area.

tion, surpassing attitudes and beliefs in driving the motivation to drink enough water.

There are several variable relationships that influence water intake in the Nambo coastal region. Firstly, the relationship between knowledge and individual attitudes leads to maintenance actions to prevent the lack of fluids in the body and smooth the process of food digestion. Moreover, people's beliefs, shaped by acquired knowledge, promote the necessity of drinking water to support public health. The study indicates that approximately 75% of the influence of community beliefs has contributed to efforts to improve the physical health of the Nambo coastal population. Belief has a slightly stronger impact on promoting health maintenance behaviors than individual attitudes. Therefore, it can be concluded that fostering and sustaining the belief in the importance of drinking adequate water is key to improving the health of coastal communities.

However, for drinking to be beneficial to public health, the dangers of physical, chemical, and biological contamination must be considered. Numerous contaminants are likely to occur in the drinking water supply in coastal areas, including contamination from wastewater from residential toilets, the discharge of toxic chemicals, including fluoride, and other anthropogenic activities, posing a risk of disease transmission.[40,41] In light of these, it is essential to provide health education to the communities in the Nambo coastal area to improve their dietary habits, including proper water intake. Such education effectively enhances knowledge and attitudes toward healthy living.[42]

Limitations

This study did not examine the type of water consumed. It focused solely on water intake among the Nambo coastal communities. Additionally, the research did not assess public health status. As a result, this paper is unable to provide information about the relationship between beliefs, adequate water consumption, and health maintenance efforts. Future studies could address this gap, providing clearer and more in-depth evidence regarding the influence of beliefs and sufficient water intake on health outcomes.

Conclusions

The beliefs held by coastal communities play a crucial role in ensuring that individuals drink sufficient water. When these beliefs are strong, they motivate people to take proactive steps to safeguard their health. This research indicates that the community's beliefs are influenced by health messages highlighting the benefits of drinking water for overall wellness. Consequently, this fosters a strong sense of trust within the coastal communities.

Implications for health programs

A strategic approach to increasing drinking water intake in coastal areas is building public awareness about water's health benefits for body organs and tissues. One method is to provide training or health education, which serves as a form of health promotion. This knowledge enhancement is crucial, as it encourages individuals to adopt more positive attitudes. Additionally, fostering a belief in the health benefits of drinking water will motivate coastal communities to undertake actions that improve their overall health.

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