JPH RECODE March 2024; 7 (2): 100-108
http://e-journal.unair.ac.id/JPHRECODE
http://dx.doi.org/10.20473/jphrecode.v7i2.43589

RELATIONSHIP BETWEEN OPERATOR KNOWLEDGE AND HYGIENE WITH BACTERIOLOGICAL QUALITY OF REFILL DRINKING WATER IN BANYUWANGI, INDONESIA: A CROSS-SECTIONAL STUDY

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ARTICLE INFO

Article History:
Received: 20th, February 2023

Revised:
From 22nd, February 2023

Accepted: 04th, May 2023

ABSTRACT

Background: Refill Drinking Water (AMIU) is one of the alternatives used by the Indonesian people in meeting their drinking water needs. However, there are still AMIUs that do not meet the total coliform standard. **Purpose:** This study aimed to analyze the relationship between DAMIU operators' knowledge and hygiene measures on the bacteriological quality of AMIU in Banyuwangi Sub-district, Banyuwangi, East Java Province, Indonesia. **Methods:** This was an observational study with a cross-sectional approach. Water samples from 33 DAMIUs in Banyuwangi sub-district were tested for total coliforms. DAMIU operators were interviewed using a structured questionnaire regarding knowledge and hygiene. Data were analyzed using Chi-square test. **Results:** Twelve out of 33 (36.4%) AMIUs did not meet the total coliform standard. Thirty-one (93.9%) DAMIU operators had excellent knowledge, and 23 (69.7%) had good personal hygiene. There was a significant association between operator hygiene and total coliform quality of AMIU (p=0.016; OR=8.4). **Conclusion:** Operator hygiene is an important factor in meeting the bacteriological quality standards of AMIU. It is recommended to make efforts to raise awareness of DAMIU operators to always apply hygiene while working.

Keywords: refill drinking water, coliform, hygiene, knowledge.

Cite this as: Ramadhan, S., Adriyani, R., Larasati, A. A., Husaini, A., & M. S, Shaharuddin. 2024. Relationship Between Operator Knowledge and Hygiene with Bacteriological Quality of Refill Drinking Water in Banyuwangi, Indonesia: A Cross-Sectional Study. *Journal of Public Health Research and Community Health Development*. 7(2), 100-108. http://dx.doi.org/10.20473/jphrecode.v7i2.43589

INTRODUCTION

Drinking water is one of the media that can transmit disease. Drinking water should not contain pathogenic bacteria or other substances that can harm human health. (Aziz *et al.*, 2019). Consumption of unhygienic drinking water can cause diseases, including gastrointestinal disorders. A disease that is often found in Indonesia related to hygiene is diarrhea. Diarrhea is a potential disease of extraordinary events (KLB), endemic in some areas, and often accompanied by the death of sufferers. Based on data from the Health Profile of Banyuwangi Regency in 2017, the number of diarrhea cases in Banyuwangi Regency reached 32,329 cases and Banyuwangi District was the second highest case (Dinas Kesehatan Banyuwangi, 2017). The data on diarrhea cases found in the 2017-2021 timeframe are as follows: in 2017 32,329 cases were found, in 2018 43,461, in 2019 43,578, in 2020 43,681, and in 2021 43,808 cases. Where the trend in the discovery of diarrhea cases has relatively not changed much in the last five years.

One of the causes of diarrhea disease can be transmitted through the medium of drinking water. As part of the government's effort to protect public health, Regulation of the Minister of Health of the Republic of Indonesia no.2 of 2023 on the Implementation Regulation of PP no.66 of 2014 on Environmental Health was issued, which regulates the mandatory Environmental Health Quality Standards (SBMKL) for drinking water quality, namely the maximum allowable level for the microbiological parameters E. coli and total coliform is 0 CFU/100ml. The presence of coliform bacteria in drinking water samples indicates contamination of drinking water by microbes that may be pathogenic and can endanger health. With the contamination of coliform bacteria in drinking water, the risk of the presence of other pathogenic bacteria is greater. (Pakpahan *et al.*, 2015)

The fulfillment of drinking water needs in the community can be obtained through various sources and processing methods. There is water that can be drunk directly without processing and water that goes through processing first so that it can be drunk. As it develops, water that used to have to be processed at the household level in order to be drunk is now ready-to-drink water that is sold in the market. The sale of drinking water is a form of innovation offered to the community in fulfilling practical and easy drinking water needs, namely in the form of Refillable Drinking Water (AMIU) and Bottled Drinking Water (AMDK) products. There are currently more than 350 bottled drinking water industries with a production output of more than five billion liters per year. In addition to the AMDK industry, the AMIU industry is also growing rapidly because it is an alternative drinking water supply in big cities and has even begun to penetrate rural areas. As time goes by, the price of bottled water is getting more expensive, so AMIU produced by Refillable Drinking Water Depots (DAMIU) is an alternative solution to anticipate this, because it is practical and affordable for the community. The public's tendency to consume drinking water produced by DAMIU is increasing. (Khoeriyah and Anies, 2015).

Banyuwangi Regency is in the top 5 after Surabaya City, Sidoarjo Regency, Tuban Regency, and Bojonegoro Regency in terms of AMIU consumption. Based on data from the Central Statistics Agency published in the People's Welfare Statistics of East Java Province, the percentage of households using AMIU as a source of drinking water in Banyuwangi Regency in the 2017-2021 period is as follows: in 2017 it was 14.33%, in 2018 it increased to 16.56%, in 2019 it experienced a slight decrease of 12.76%, in 2020 it increased sharply to 19.77% and in 2021 it was 21.67%. The trend of the percentage of households in Banyuwangi Regency consuming AMIU is getting bigger. Based on data from the Banyuwangi Health Office, the number of DAMIUs in Banyuwangi Regency has an increasing trend: 333 DAMIUs in 2017, 395 DAMIUs in 2018, and 409 DAMIUs in 2019, with the highest number of DAMIUs in Banyuwangi sub-district, with 36 DAMIUs. Between 2017 and 2019, only 7 out of 409 DAMIUs in Banyuwangi district had a sanitary hygiene certificate (Dinas Kesehatan Banyuwangi, 2019). Based on data from the Sobo Health Center, Banyuwangi Regency in February 2020, routine inspection results showed that 4/12 samples (33.3%) of DAMIU production water did not meet the microbiological parameter requirements because they contained coliform bacteria in 100 ml of AMIU samples.

Based on Minister of Health Regulation No. 2 of 2021, food handlers, which for DAMIUs are often called DAM operators, have several requirements that must be met. Among them are the hygiene measures of DAM operators. A person's actions or behavior are influenced by knowledge, attitude, and practice. The higher one's knowledge, the more correct and appropriate one's attitude and actions are expected to be (Notoatmodjo, 2015). DAMIU operators' knowledge of hygiene also affects the quality of drinking water produced (Trisnaini *et al., 2018*). This study examined the knowledge and hygiene practices of AMIU operators, especially at AMIUs operating in Banyuwangi Subdistrict, which has not been studied before. The purpose of this study was to analyze the relationship between operator knowledge and hygiene with the bacteriological quality of AMIUs in Banyuwangi Sub-district, Banyuwangi Regency.

METHOD

This study was an observational study, namely making observations in the field with a cross-sectional approach where observations of the independent and dependent variables are made at the same time span.

Independent and dependent variables are carried out at the same time span. The independent variables in this study were operator knowledge and hygiene actions of DAM operators. While the dependent variable was the bacteriological quality of AMIU, especially total coliform in drinking water samples.

The population in the study was all DAMIUs located in Banyuwangi Sub-district, whether or not they had a sanitary hygiene certificate. At the time of the study, there were 36 DAMIUs in Banyuwangi Sub-district, which were divided into 3 working areas of Sobo Community Health Center, Kertosari Community Health Center and Singotrunan Community Health Center (Dinas Kesehatan Banyuwangi, 2019). The sampling technique used a total sampling technique where the sample in the study represented the entire population, namely all 33 DAMIUs in Banyuwangi Subdistrict, because 3 others were not willing to participate in the study.

Before data collection was carried out, a research protocol was prepared. This research protocol has been declared ethically feasible by the Health Research Ethics Commission of the Faculty of Dentistry, Universitas Airlangga, based on certificate no. 139/HRECC.FODM/III/2020. Informed consent was given to the DAMIU operators/owners to be interviewed and the consent was in written form.

Data collected on DAMIU characteristics, characteristics, knowledge, and hygiene practices of operators were collected using questionnaires and observation sheets. Respondents were DAM owners/operators who serve consumers. DAMIU production water sampling was then conducted. Interviews and water sampling were conducted voluntarily with the owner and/or operator of the DAM signing a written informed consent form. DAMIU production water was tested in the laboratory to analyze the bacteriological quality of total coliforms using the Most Probable Number (MPN) method.

An assessment of the operator's knowledge was conducted by the administration of twelve questions covering topics such as personal hygiene, DAMIU cleanliness, raw water transportation regulations, operator hygiene standards, equipment cleanliness, and consequences associated with improper DAMIU sanitation. The accurate responses of each responder will then be given a value of 1, while the incorrect responses will receive a value of 0. Individuals with an overall score below 60% are deemed to possess inadequate knowledge; those with a score between 60 and 75% are deemed to possess acceptable information; and those with a score between 76% and 100% are deemed to possess good knowledge (Notoatmodjo, 2015). Operators were also given 15 questions about personal hygiene, cleanliness, and hygiene practices, wearing specific, well-groomed work attire, and attending the DAMIU sanitation hygiene training to gauge their hygiene practices. According to the Ministry of Health, operator hygiene metrics are only accepted if they account for more than 70% of the total score (Kemenkes, 2014). They receive no credit if their worth is less than 70% of the final score. The category for quantifying total coliforms in water samples is ineligible if more than 0 coliform bacteria are found in 100 milliliters of the sample; otherwise, it was approved. The data analysis process was carried out using

statistical software tools using the Chi-Square Test ($\alpha<0.05$).

RESULT

Characters of Operator, Drinking Water Depots and Refills, and Total Coliform of Drinking Water Depots

Based on the results of observations and interviews conducted, the characteristics of DAMIU operators in Banyuwangi District were mostly male (78.8%) which 60.6% had an educational level of at least high school. DAMIU characteristics include operating for more than six years (63.7%); selling prices per gallon ranging from IDR 4000 to IDR 7000 In Banyuwangi District; nevertheless, the majority (63.7%) charge IDR 5,000 for AMIU per gallon. Thirty-one depots (93.9%) of the processing system use microfiltration and disinfection, with reserve osmosis (RO) technology being used for the remaining portion. According to RI Minister of Health Regulation no. 2 of 2021, the total coliform content of the production water was 21 DAM (63.6%), satisfying the SBMKL for drinking water, and 36.4% AMIU did not meet the requirements, according to the results of laboratory testing related to the water. Then, bacteriological quality requirements were met which was 12 DAM (36.4%). The complete data was presented in Table 1.

Relationship between Knowledge and Operator Hygiene Actions on SBMKL Total Coliform in Drinking Water Depots

Based on statistical tests, there was no significant relationship between DAM operator knowledge and SBMKL total coliforms of DAMIU production water in Banyuwangi District ($p = 0.523$), while operator hygiene measures have a significant relationship with SBMKL total AMIU coliforms ($p = 0.016$, OR= 8.4). DAMIUs whose operator hygiene measures did not meet the requirements were 8.4 times more at risk of being contaminated with coliform bacteria compared to DAMIUs whose operator hygiene measures meet the requirements. The data and analysis results were presented in Table 2.

Table 1. Frequency Distribution of Operator Characteristics and Refill Drinking Water Depots in Banyuwangi District, Banyuwangi, East Java, 2020.

Operator Sex	Frequency	Percentage (%)
Male	26	78,8
Female	7	21,2
Latest Education of Operator		
Primary School	4	12,1
Junior High School	6	18,2
Senior High School	20	60,6
Bachelor	3	9,1
DAMIU's Operation		
< 1 year	3	9,1
1-5 years	9	27,3
6-10 years	14	42,4
11-15 years	5	15,2
16-20 years	2	6,1
DAMIU's Treatment System		
RO Technology	2	6,1
Microfiltration and disinfection	31	93,9
Selling Price of Drinking Water Per Gallon		
Rp. 4000	4	12,1
Rp. 5000	21	63,6
Rp. 6000	7	21,2
Rp. 7000	1	3,0
Total Coliform of AMIU		
Fulfil Health Requirement	21	63,6
Not Fulfil Health Requirement	12	36,4
	33	**100,0**

Table 2. Cross-tabulation of Operator Knowledge and Hygiene Actions on the Bacteriological Quality of Drinking Water Depots in Banyuwangi District, Banyuwangi, East Java, 2020

	Coliform Total AMIU				Total		*p-value*	*Odd Ratio*
	Fulfil Requirement		Not Fulfil Requirement					
	n	%	n	%	N	%		
Sex								
Male	19	57,6	7	21,2	26	78,8	0,071	-
Female	2	6,1	5	15,2	7	21,2		
Education								
Primary School	2	6,1	2	6,1	4	12,1	0,372	-
Junior High School	5	15,2	1	3,0	6	18,2		
Senior High School	11	33,3	9	27,3	20	60,6		
Bachelor	3	9,1	0	0,0	3	9,1		
Operator Knowledge of DAMIU								
Good	19	90,5	12	100,0	31	93,9	0,523	-
Sufficient	2	9,5	0	0,0	2	6,1		
DAMIU Operator Hygiene Measures								
Fulfil Requirement	18	85,7	5	41,7	23	69,7	**0,016**	**8,4**
Not Fulfil Requirement	3	14,3	7	58,3	10	30,3		

DISCUSSION

Most study participants (27.3%) were between the ages of 33 and 40, and most of them was male (78.8%). According to Badun's research from 2021, which included 10 respondents (76.9%), most respondents in the gender category were male. This condition was consistent with that research. High school level accounted for most responses (6,22%). Since DAMIU started operating in the Banyuwangi District more than six years ago. DAMIU's water treatment system used Reserve Osmosis (RO) technology in the remaining depots, while microfiltration and disinfection were used in 31 of the 33 depots (93.9%). The results of this research were in line with field data conducted in Sukajaya Village, Palembang City which showed the majority of DAMIUs used filtration systems and UV light in drinking water treatment (Tominik, dkk 2018). The disinfection process is frequently applied in drinking water treatment technology, both on local and big scales. The use of Ultraviolet (UV) light to irradiate and sterilize drinking water is one form of disinfection that can be applied to this process. Water treatment using the Reverse Osmosis (RO) technique works by filtering water which is driven by a booster pump through a membrane that has pores measuring 104 microns. Hence, the resulting water can be close to pure water because dissolved substances in the water medium cannot pass through the membrane (Nurkhikmah dan Budiono, 2018). The drinking water treatment system used can influence the bacteriological quality results. This can be seen from the presence of coliform bacteria in production.

The microbiological parameter measured in this study was total coliform. These parameters are indicators of the presence of microbes such as pathogenic bacteria, parasites, and viruses (Slamet, 1994). The research results stated that of the 33 DAMIU production water samples in Banyuwangi District, 12 (36.4%) did not meet the SBMKL for total coliforms. According to research conducted in Demak Regency, of the 38 DAMIUs that made up the research sample, 8 DAMIUs (21.1%) did not fulfill the requirements for total coliforms, with an estimated total of coliforms ranging from 2 to 10 MPN/100 ml drinking water sample. In line with this situation (Mirza, 2014). In addition, studies carried out in the working areas of the Cipendeuy and Padalarang Health Centers in the Bandung Regency revealed that, upon analysis of the production water from 5 out of 8 DAMIUs, coliforms with a concentration of 3 MPN/100 and 1 DAMIU with a concentration of 4 MPN/100 mL were found in the production water (Khoeriyah and Anies, 2015). The majority of AMIUs in this study that did not match the standards for bacteriological quality were found in the Kertosari Community Health Center's operational area, which was also known to contain the greatest number of DAMIUs. Water contaminated with coliform bacteria can lead to health issues, particularly water-related illnesses like cholera, typhoid, diarrhea, and dysentery (Wais *et al.*, 2022).

Knowledge is the output of curiosity through sensory processes regarding certain objects. Knowledge is also the most important domain in shaping behavior (Donsu, 2017). The majority, 31 of 33 (93.9%) respondents had good knowledge because they already know how to maintain personal hygiene, DAMIU cleanliness, requirements for transporting raw water, operator hygiene requirements, equipment cleanliness, and the impacts that arise from not maintaining DAMIU sanitation. The results of statistical analysis tests stated that there was no significant relationship between the knowledge of DAMIU operators and the bacteriological quality of production water (p = 0.523). In line with the results of research regarding the knowledge of angkringan drink handlers in Barru Regency, South Sulawesi, there was no significant relationship between the knowledge of drink handlers and the presence of MPN coliform in the drinks they sold (p= 1,000) (Rostina & Mutiara, 2018).

In other research, the same results were also obtained where there was no significant correlation between knowledge and depots' sanitation hygiene (p=1,000) (Ismiati., 2020). Knowledge can be influenced by a person's age. Factors that can influence a person's knowledge are the level of education. The education level of most respondents was high school (60.6%). Based on the results of data analysis, it was found that all operators with a high school education level had good level of knowledge. However, good knowledge does not reflect good hygiene practices implementation. However, the understanding of personal hygiene knowledge was needed since it influenced personal hygiene actions (Kusuma *et al.*, 2017). More in-depth research is needed to obtain an explanation about someone with good knowledge but reluctant to take good actions or practices.

The measurement of personal hygiene was a determining factor that influences the bacteriological quality of refilled drinking water in this study. The personal hygiene actions observed included behavior regarding maintaining personal health, hygienic and sanitary behavior, the usage of special, neat and clean work clothes, as well as participation in the sanitation hygiene course. The results of the research showed that 18 (85.7%) operators' hygiene measures met the requirements for having production water that met the Environmental Health Quality Standards for drinking water. Based on the Fisher Exact test, the p-value is 0.016 (p<0.05). It can be concluded that there was a significant correlation between the hygiene actions of depots' operators and the total coliform quality of depots' production water. The results of this research were in line with several studies conducted in various locations in Indonesia, including research conducted in Makassar City (Kasim *et al*., 2014) dan penelitian yang dilakukan di Kabupaten Demak (Mirza, 2014). and research conducted in Demak Regency (Mirza, 2014). A similar study regarding the bacteriological quality of coliforms in drinks served at stalls in Barru Regency, South Sulawesi also showed results that there was a significant correlation between the hygiene actions of handlers and the bacteriological quality of the drinks served (Rostina & Mutiara, 2018). The measurement of depots' operators' hygiene was one factor that really needs to be paid attention to, since it was closely related to the bacteriological quality of drinking water or beverages.

Based on the results of interviews and observations regarding the hygienic actions of Refill Drinking Water operators, all operators (100.0%) did not wear special work clothes as an effort to prevent contamination of drinking water. In addition, there was direct contact between Refill Drinking Water operators and water produced during the drinking water processing process and when filling gallons. Most Refill Drinking Water operators, besides filling the gallons, are also tasked with delivering gallons to consumers' homes and undertook other work. Some examples are that most Refilled Drinking Water Depots are merged with other businesses such as grocery stores. Some Refill Drinking Water operators also skip the washing hands procedure every time they serve customers and smoke when serving customers. Smoking and dirty hands are not permitted since this behavior can pollute drinking water. Dirty hands after delivering drinking water to consumers' homes and carrying out buying and selling transactions and then not washing their hands can cause bacterial contamination in produced water. Poor hand hygiene of operators can contaminate refilled drinking water. Qualitative research on Refilled Drinking Water Depots in Bandung found that the conditions did not meet the requirements

due to the owner's knowledge regarding the importance of implementing handler hygiene was still low. The attitude of managers and operators towards community health center sanitarians who inspect Refilled Drinking Water Depots sanitation was responded to and accepted well, however they did not implement actions that support efforts to fulfill operators' hygiene requirements: not implementing regular inspections of drinking water samples, lack of sanitation facilities (unavailability of closed trash cans), refill water depots managers/handlers/officers/operators do not practice hand washing, smoking and eating behavior when serving customers, and wearing sloppy clothes (Raksanagara *et al.*, 2018). The cleanliness factor of refill drinking water containers brought by customers can also influence the quality of refill drinking water. This can affect the quality of the water even if the bacteriological quality of water itself is good, due to the contamination from outside the production process (Agustina, 2021).

Referring to RI Minister of Health Regulation No. 2 of 2021, a Drinking Water Depot operator must be in good health and free from various infectious diseases and not be a carrier of germs. In conclusion, the health condition of Drinking Water Depot operators had an important role in food and beverage sanitation hygiene. Operator hygiene measured that do not meet the requirements are 8.4 times more likely to result in Refilled Drinking Water Depot production water quality being contaminated with coliform bacteria compared to operator hygiene measures that meet the requirements. There needed to be socialization and training about the importance of operator health and hygiene measures to ensure the quality of Refilled Drinking Water. Efforts that can be made by Drinking Water Depot operators to prevent contamination were by wearing neat and clean work clothes, wearing a hair cover, and wearing special clothes that are only used while on duty. In addition, it must be supported by the implementation of Clean and Healthy Living Behavior, including not smoking while working, not spitting or sneezing carelessly, and the habit of washing hands with soap in running water when serving customers. (Faujia, 2020).

Preventing coliform contamination of Refill Drinking Water is one of the efforts to prevent diarrhea. According to research by Jayadisastra (2013) here is a significant relationship between bacteriology in drinking water and the incidence of diarrhea in Refill Drinking Water consumers (p=0.009). Therefore, in the contaminated Refill Drinking Water with coliforms, the most likely way to kill bacteria in it is by disinfection by administering UV light or ozone (Sofia, 2019).

Limitations

There were only total coliforms that were analyzed by environmental health quality standards for drinking water produced by Refilled Drinking Water Depot, using the Most Probable Number (MPN) testing technique. The total coliform examination method was based on applicable laws and regulations using the Total Plate Count (TPC) testing technique, but at the Banyuwangi Regency Regional Health Laboratory, examination using this method is not yet available.

CONCLUSION

Based on the research results, it can be concluded that the DAM operator's actions have a significant relationship to the total coliform drinking water SBMKL of DAMIU produced water. DAMIU operator hygiene measures have an important role in maintaining the bacteriological quality of AMIU.

SUGGESTION

Drinking Water Depots operators should serve clean to customers and wash their hands frequently when they come into contact with production equipment, gallons and Refilled Drinking Water Depot production water. Its owners provide hand washing facilities and always remind operators to wash their hands frequently. The Banyuwangi District Health Service through community health centers can improve and expand the reach of sanitation hygiene training for Refilled Drinking Water Depot operators/owners/managers in their work areas in accordance with the Regulation of the Minister of Health of the Republic of Indonesia No.2 of 2021. Further research can analyze sanitation hygiene factors in a more complete aspects according to Minister of Health Regulation no. 2 2021. In addition, bacteriological quality testing of drinking water needs to be undertaken using the Total Plate Count testing technique.

ACKNOWLEDGEMENT

Authors would like express gratitude to all operators and managers of Drinking Water Depots in Banyuwangi District, who are willing to be respondents in this research.

CONFLICT OF INTEREST

This research was undertaken without any commercial relation that potentially triggered conflict of interest. All authors have no conflict of interest.

FUNDING SOURCE

This article was funded by the author's personal funds.

AUTHOR CONTRIBUTION

Author Syahrul Ramadhan served on Author Syahrul Ramadhan oversees data analysis and writing the manuscript. Author Retno Adriyani oversees the research concept, designing research methods, editing the manuscript, and corresponding author. Moreover, author Adella Atika Larasati oversees the research concept, collecting data, compiling, and administering ethical tests. Author Ahmad Husaini oversees reviewing the manuscript and editing. Finally, author Shaharuddin bin Mohd Sham oversees supervision and reviewing the manuscript.

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