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# The Role of Hygiene and Sanitation to the *Escherichia coli* Contamination in Drinking Water in Depok City, Indonesia

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**Abstract**

**BACKGROUND:** Drinking water is a vital aspect in human life. The quality of drinking water should be monitored to ensure public from any health effects caused by contaminated water. *Escherichia coli* (*E. coli*) is one of the indicators of fecal contamination should not be present in drinking water (0 cfu/100 ml). However, poor hygiene and sanitation contributes to *E. coli* contamination in drinking water, particularly in developing countries.

**AIM:** We investigated the household hygiene and sanitation factors and the relationship with *E. coli* detection in the household drinking water.

**METHODS:** A cross-sectional study design was conducted to collect the data from three districts in the Depok city, that is, Sawangan, Bojongsari, and Cipayung. A total of 300 houses and the corresponding drinking water samples were collected during August–September 2019. *E. coli* was determined as microbiological indicator using total plate count method.

**RESULTS:** The results showed that *E. coli* was detected in 174 (58%) of household water samples. The water container condition (OR = 2,60; CI 95%: 1.18–5.71) and the hand washing practice with soap (OR = 1,65; CI 95%: 1.04–2.62) were significantly correlated with the presence of *E. coli* in the water samples.

**CONCLUSIONS:** The condition of the water container was the most dominant factors which contributed to *E. coli* content in the household drinking water.

## Introduction

The water quality, especially drinking water, can directly affect human health. The importance of maintaining the water quality has been globally recognized as one of the goals of the United Nations' (UN) Sustainable Development Goals (SDGs) (number 6) which related to the clean water and sanitation aspect. The goal is to achieve 100% proper, safe, and affordable drinking water available for all people [1].

The quality of drinking water is determined by its physical, biological, and chemical indicators. The biological indicators, especially the presence of *Escherichia coli* (*E. coli*) bacteria, are considered as the essential criteria of drinking water quality. *E. coli* is commonly found in the lower intestine of humans and animals. The presence of *E. coli* in drinking water can be affected by several factors, one of them is the poor sanitation hygiene condition, for example, fecal disposal facility, clean water facility, and the hand washing practice with soap [2].

To date, the UN and the World Health Organization (WHO) estimated that there are more than 844 million people in the world who has limited access to safe drinking water. Globally, 2.3 billion people are living without any access to proper sanitation. Besides that, there are around 892 million people around the world without a proper way to dispose a fecal matter [3]. The lack of clean water and sanitation hygiene contributed to 600,000 children's death caused by diarrhea [3]. Furthermore, 70% of children are sick with diarrhea which caused by the contamination of water container during the rainy season [4].

The Depok city has been stated as an open defecation non-free. This condition may have been contributed to the risk of *E. coli* contamination in the water sources. Meanwhile, diarrhea is the third major cause of children death in Depok city [5].

Up to our knowledge, this is the first study in Depok city investigating the relationship between personal sanitation and hygiene with the household drinking water quality. We expect that the results of this study can contribute to new insight and valuable

data to support policy-making on drinking water quality in Depok city. Besides that, the information gathered in this study will help to determine the proper effort to achieve the goals of the SDG in the year 2030.

## Materials and Methods

This study was conducted using a cross-sectional design in three districts of Depok city, that is, Sawangan, Bojongsari, and Cipayung (Figure 1). Questionnaire data and water samples were collected from August 2019 to September 2019 with a total of 300 households samples from 15 subdistricts. Household samples were selected randomly. The personal hygiene and sanitation data were collected through interviews and observations with the questionnaires. The water samples were collected using clean cup at around 200 ml and stored in sterilized PP bottle container in each household (a total of 300 samples). Water samples were then kept in refrigerator under 4°C before analysis. The sampling procedure in this study was done with clean practice to prevent any cross-contamination from the tools and the officer. *E. coli* in drinking water was determined using the total plate count method [2]. This study has been approved by the ethics committee in fulfilling research protocols. Ethical clearance was obtained from the Universitas Indonesia [1].

**Table 1: The presence of *E. coli* in the household drinking water from the three districts of Depok city**

| The presence of E. coli in the drinking water | District name | | | | | |
|---|---|---|---|---|---|---|
| | Sawangan | | Bojongsari | | Cipayung | |
| | n | % | n | % | n | % |
| Positive | 50 | 62.5 | 71 | 64.5 | 53 | 48.2 |
| Negative | 30 | 37.5 | 39 | 35.5 | 57 | 51.8 |

*E. coli*: *Escherichia coli*.

## Results and Discussion

### *E. coli content in the household drinking water*

*E. coli* detection in drinking water was found higher in Sawangan (62.5%) and Bojongsari (64.5%) and lower in the district of Cipayung (48.2%) (Table 1).

Based on the rules and regulations established by the WHO, proper drinking water should not contain any *E. coli*. However, in this study, we found that there were 174 (58%) of water samples that did not meet this criterion and contained *E. coli* with a mean value of 35 cfu/100 mL. Several studies reported a similar result, for instance, *E. coli* was also found in the drinking water refills (i.e. drinking water treated by local vendors) in the city of Kupang and Sleman, Indonesia [6], [7]. There were also *E. coli* found in 37% of bottled water (i.e. drinking water treated by a legitimate company) samples in Sierra Leone [8].

The presence of *E. coli* in drinking water can be caused by many factors including environmental contamination of the water source such as river and flood, and cross-contamination from human with improper hygiene and sanitation during water handling [9].

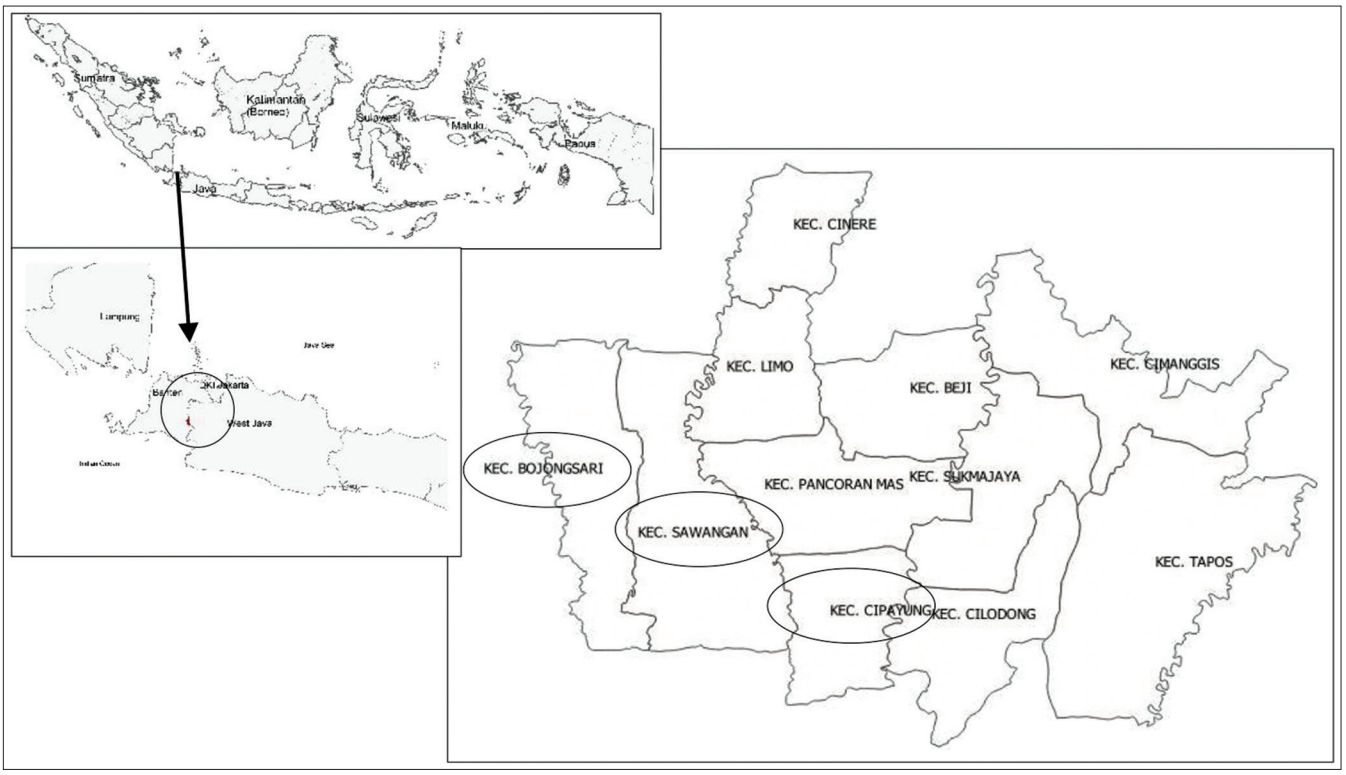


*Figure 1: The map of the study location. The three studied districts were marked with circles*

### *The description of the household sanitation hygiene*

The percentage of the household sanitation hygiene factors, that is, fecal disposal facility, clean water source, condition of the clean water source, drinking water container, and hand washing practice with soap is presented in Table 2.

**Table 2: The household sanitation hygiene factors of the three districts in Depok city**

| Variable(s) | Frequency (n) | Percentage |
|---|---|---|
| Fecal disposal facility | | |
| Unimproved | 11 | 3.7 |
| Improved | 289 | 96.3 |
| Clean water source | | |
| Unimproved | 229 | 76.3 |
| Improved | 71 | 23.7 |
| Clean water source condition | | |
| Unprotected | 15 | 5.0 |
| Protected | 285 | 95.0 |
| Drinking water container | | |
| Without lid/not clean | 38 | 12.7 |
| With lid and clean | 262 | 87.3 |
| Hand washing practice with soap | | |
| No | 143 | 47.7 |
| Yes | 157 | 52.3 |

The results showed that hygiene and sanitation facility have achieved proper condition for fecal disposal facility (96.3%), condition of the clean water source (95%), drinking water container (87.3%), and hand washing practice with soap (52.3%). However, clean water source was still very low at 23.7% of the total samples. Our investigation found that almost all of household has a properly structured and protected dug or drilled well for their clean water source needs. However, most of these wells were not able to provide the households with clean water due to its close proximity (<10 ml) to the septic tank in other study, *E. coli* was detected in 30 different water sources ranging from < 30 to 4.35 × 107 cfu/100 ml. The contamination was caused by fecal contamination from drinking water source with inadequate protection and latrine proximity to sources of water [4]. This condition may directly contribute to the contamination of *E. coli* to the water source. Most of household also has a proper drinking water container, that is, equipped with a lid and clean. The hygiene habit of washing hands with soap has also been done by most of the household.

### *The relation between hygiene and sanitation with E. coli content in the household drinking water*

The result on the relation between *E. coli* content in the household drinking water with several sanitation hygiene factors is presented in Table 3.

Our statistical analysis found that the clean water source condition was not significantly correlated with *E. coli* content, but had a high-risk factor (OR >1). Another study in Uganda showed similar results that all water samples from unprotected sources were contaminated with *E.* coli [10]. It was found that 43% of water samples from unprotected well in Uganda contained *E. coli* more than 100 MPN/100 ml [11].

**Table 3: The relation of sanitation hygiene factors with *E. coli* content in the household drinking water**

| Variable(s) | *E. coli* content in the drinking water | | | | Total | | OR (CI 95%) | p-value |
|---|---|---|---|---|---|---|---|---|
| | TMS | | MS | | | | | |
| | n | % | n | % | n | % | | |
| Fecal disposal facility | | | | | | | | |
| Unimproved | 4 | 36.4 | 7 | 63.6 | 11 | 100 | 0.40 (0.12–1.39) | 0.212 |
| Improved | 170 | 58.8 | 119 | 41.2 | 289 | 100 | | |
| Clean water source | | | | | | | | |
| Unimproved | 132 | 57.6 | 97 | 42.4 | 229 | 100 | 0.94 (0.55–1.61) | 0.930 |
| Improved | 42 | 59.2 | 29 | 40.8 | 71 | 100 | | |
| Clean water source condition | | | | | | | | |
| Unprotected | 11 | 73.3 | 4 | 26.7 | 15 | 100 | 2.06 (0.64–6.62) | 0.334 |
| Protected | 163 | 57.2 | 122 | 42.8 | 285 | 100 | | |
| Drinking water container | | | | | | | | |
| Without lid/not clean | 29 | 76.3 | 9 | 23.7 | 38 | 100 | 2.60 (1.18–5.71) | 0.023* |
| With lid and clean | 145 | 55.3 | 117 | 44.7 | 262 | 100 | | |
| Hand washing practice with soap | | | | | | | | |
| No | 92 | 64.3 | 51 | 35.7 | 143 | 100 | 1.65 (1.04–2.62) | 0.045* |
| Yes | 82 | 52.2 | 75 | 47.8 | 157 | 100 | | |

(*): Significant in bivariate and multivariate analysis, *E. coli*: *Escherichia coli*.

In this study, we found that there were two variables that significantly correlated with *E. coli* content in the drinking water, that is, the drinking water container and the hand washing practice with a soap. Other studies also showed the importance of having a proper drinking water container, that is, clean and covered with a lid. A study in Laos and Thailand showed that a lidless drinking water container increased the risk of *E. coli* contamination [12]. A properly covered container with small openings has successfully decreased *E. coli* contamination in drinking water [13].

The hand washing practice with soap also showed a significant correlation with *E. coli* content in drinking water in several studies. A study in Uganda showed that lack of hand washing practice after toilet use was correlated with the coliform bacterial contamination in drinking water [14]. It was also suggested that washing hands before and after doing activities can reduce the incidence of diarrhea, meanwhile, pet ownership also increases *E. coli* contamination in the soil and correlated with contamination of hands before washing [9]. Human hands act as a media where *E. coli* can be transferred and contaminated the drinking water. A study in India showing that there was a correlation between *E. coli* in hands of household mothers and the presence of *E. coli* in the drinking water [10]. Indeed, washing hands with soap proved to reduce the amount of *E. coli* in the hands effectively and the effect increased as the increase of washing duration [15], [16].

Our multivariate analysis showed that the most dominant factor influencing *E. coli* content in drinking water was the water container condition. This was probably caused by the existing contamination in the water container before refilling the drinking water. Other study showed similar results that the water container was a significant factor influencing the water quality [17]. Even though the drinking water was obtained from an improved water source, the quality will be determined by the storage since contamination mostly happened when using an unsafe and improper container. The

previous studies have shown that storage with metal containers/pots/vessels was the safest choice to keep the drinking water. Metal container could control *E. coli* contamination and reduction of tested organism within 0–5 h of holding time [18], [19], [20].

## Conclusions

Almost all of household drinking water samples were contaminated with *E. coli*. the condition of the drinking water container and the hand washing practice with a soap showed significant correlation with the presence of *E. coli* in the drinking water samples. The most dominant sanitation hygiene factors contributed to *E. coli* content in the household drinking water was the condition of the water container.

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