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Correlation between Sanitation Facilities and Health Outcomes in Indonesia

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Abstract

Poor sanitation is a significant contributor to health problems in developing countries. The improper handling of household waste contaminates soil, surface water, and groundwater, posing health risks to communities through water consumption and exposure. This study utilizes data from the National Socioeconomic Survey (Susenas) conducted by the Indonesian Central Bureau of Statistics (BPS) from 2016 to 2018 to examine the relationship between sanitation facilities and household health quality in Indonesia, analyzing a sample of 883,845 households. Using ordinary least squares (OLS) regression, the findings indicate that households with adequate sanitation facilities generally experience better health outcomes. This study underscores the importance of policy prioritization in establishing communal waste treatment facilities, such as wastewater treatment plants (WWTPs), particularly in densely populated areas. This approach aims to mitigate the adverse health impacts of domestic waste pollution on public health.

Keywords: Household Health; Wastewater Treatment Plants, Susenas, Indonesia, Urban, Rural

Introduction

Poor sanitation conditions are among the leading causes of health issues in developing countries (Bartram, et al., 2005; Bancalari & Martinez, 2017). A report by UNICEF in 2023 indicates that diarrheal diseases cause approximately 480,000 deaths among children each year, while almost 60 per cent of them are attributable to unsafe drinking water and poor hygiene and sanitation.

Inadequate household waste management leads to contamination of soil, surface water, and groundwater, thereby impacting the health of surrounding communities through groundwater consumption and exposure (Palamuleni, 2002; Murray & Drechsel, 2011). The consumption of water contaminated with household waste can result in gastrointestinal diseases, while exposure to such pollution can cause skin infections and trachoma (White, et al., 2002). Compared with their peers, children exposed to household waste pollution in their environment experience more frequent diarrhea and lower growth rates (Checkley, et al., 2004; Andres, et al., 2017).

The health impacts of sanitation issues can be mitigated through equitable access to adequate sanitation facilities. Adequate sanitation facilities constitute a system that separates human excreta and domestic waste from human contact (U.N. Water, 2018). In Indonesia, a sanitary toilet is considered to effectively disrupt the chain of disease transmission (Ministry of Health Republic of Indonesia, 2014).

A sanitary toilet consists of two parts that function as barriers between waste and human contact, namely, the upper structure and the substructure. The upper structure primarily refers to the type of toilet used, with the pour-flush toilet (PFT) being the most effective in breaking the disease transmission chain. PFTs have standing water in the toilet bowl, which serves as a barrier against odors and disease transmission within the toilet room (Central Statistics Agency, 2015).

Apart from the upper structure, the substructure of the toilet also serves to separate domestic waste from human contact. This separation occurs through the sedimentation of the solid waste and treatment of the wastewater before it can be discharged into water bodies. The operation of domestic waste treatment systems in Indonesia is regulated by the Ministry of Public Works and Housing Regulation No. 04 of 2017, where on-site wastewater treatment facilities at the household scale include individual septic tanks and/or communal wastewater treatment plants (WWTPs). Thus, adequate household sanitation facilities not only are limited to the use of pour-flush toilets but also need to be connected to waste treatment systems before discharge into water bodies.

Unfortunately, it is common to find toilets used without accompanying waste treatment facilities in Indonesia. According to data from the National

Socioeconomic Survey (Susenas) by the Central Bureau of Statistics (BPS), approximately 12.38% of households using PFTs were not connected to waste treatment units in 2018. This figure is slightly higher than in 2016 when only 11.26% of PFT users lacked septic tanks. Meanwhile, the proportion of households with PFTs connected to WWTPs remained steady at around 65% from 2016 to 2018. This stagnation may be attributed to the misconception that a safe toilet is a clean toilet, regardless of its potential to pollute the environment (CNN Indonesia, 2020). This indicates a societal tendency to prioritize the cleanliness of the visible parts of the toilet, neglecting the importance and function of its substructure.

Empirical evidence on the differential impact of household sanitary facilities on health outcomes can help raise public awareness, ultimately contributing to the increased availability of adequate sanitation facilities. Therefore, this study investigates the relationship between sanitation facility conditions and household health outcomes in Indonesia, emphasizing the presence and availability of waste treatment facilities. It compares health outcomes across households with varying sanitation setups: those without toilets, households with PFTs unconnected to WWTPs, and households with PFTs integrated into WWTPs. The findings offer valuable insights into the role of waste treatment facilities and provide recommendations for enhancing sanitation policies in Indonesia.

Methods

This research uses data from the National Socio-Economic Survey (Susenas) conducted by the Central Statistics Agency (BPS) for 2016, 2017 and 2018. The unit of analysis consists of 883,845 households (RTs) obtained from combining data for these three years. As the household identification variable is not available, we cannot perform a panel data analysis. As an alternative, we use pooled cross-sectional data to capture variations over time while controlling for time-specific effects. This method enhances the robustness of the findings and provides a dynamic view of the impacts of sanitation facilities on household health.

The analysis was carried out using pooled ordinary least squares (POLS) to estimate the health production function. The following are the empirical specifications used to investigate the relationship between sanitation facilities and neighborhood health quality.

$$Morbidity\ Rate_{it} = f(PFT_{it}, PFT\ with\ WWTP_{it}, Control\ Variables_{it}$$

The dependent variable, “Morbidity Rate”, reflects the ratio of household members experiencing health problems affecting daily activities in the past month. The value ranges from 0 to 1, with values closer to 1 indicating poorer health quality. Two categorical variables describe sanitation facilities: "PFT" for households with PFTs unequipped with waste processing facilities and "PFTs with WWTPs" for households with such facilities, such as septic tanks or wastewater treatment plants (*Instalasi Pengolahan Air Limbah*/IPAL). The control variables include "Clean Water" (1 if using suitable clean water), "Vulnerable Age Rate" (the ratio of vulnerable members under 5 and over 60 years old), and the education level of the head of household (categorized into four levels, with those with a maximum of primary education as the reference), "city" (urban/rural status), and "expend" (monthly household expenditure).

Results

Table 1. Descriptive Statistics of the Continuous Variables

Variable	Statistics	Total	2016	2017	2018
(1)	(2)	(3)	(4)	(5)	(6)
Morbidity Rate	*N*	**883.845**	291.414	297.276	295.155
	Mean	**0,157707**	0,163988	0,154545	0,154692
	std. dev	**0,2655901**	0,267637	0,263486	0,265563
	Max	**1,00**	1,00	1,00	1,00
	Min	**0,00**	0,00	0,00	0,00
Household Expenditures in million Rupiah	*N*	**883.845**	291.414	297.276	295.155
	Mean	**3,761226**	3,469497	3,765105	4,045352
	std. dev	**3,474927**	3,238756	3,459402	3,685693
	Max	**186,1922**	89,83256	117,5338	186,1922
	Min	**0,1276238**	0,140635	0,1276238	0,1342917
Vulnerable Age Rate	*N*	**883.845**	291.414	297.276	295.155
	Mean	**0,1879817**	0,1850275	0,1862565	0,1926359
	std. dev	**0,2609898**	0,2616961	0,2608934	0,2603248
	Max	**1**	1	1	1
	Min	**0**	0	0	0

Table 2. Descriptive Statistics of Categorical Variables

Variable		Total		2016		2017		2018	
		N	%	N	%	N	%	N	%
PFT	*Yes*	**107.863**	**12,2%**	32.819	11,26%	38.494	12,95%	36.550	12,38%
	No	**775.982**	**87,8%**	258.595	88,74%	258.782	87,05%	258.605	87,62%
PFT with WWTP	*Yes*	**573.209**	**64,85%**	191.826	65,83%	188.843	63,52%	192.540	65,23%
	No	**310.636**	**35,15%**	99.588	34,17%	108.433	36,48%	102.615	34,77%
Main Water Source	Safe	**648.559**	**73,38%**	231.074	79,29%	206.176	69,36%	211.309	71,59%
	Risky	**234.286**	**26,62%**	60.340	20,71%	91.100	39,64%	83.846	28,41%
Location	Rural	**505.076**	**57,15%**	166.901	57,27%	169.586	57,05%	168.589	57,12%
	Urban	**378.769**	**42,85%**	124.513	42,73%	127.690	42,95%	126.566	42,88%
Household Head Last Education	Max. elementary school	**494.855**	**55,99%**	181.473	62,27%	158.519	53,32%	154.863	52,47%
	Middle school/equivalent	**108.732**	**12,30%**	18.458	6,33%	45.470	15,3%	44.804	15,18%
	High school/equivalent	**206.517**	**23,37%**	67.266	23,08%	69.419	23,35%	69.832	23,66%
	University	**73.741**	**8,34%**	24.217	8,31%	23.868	8,03%	25.656	8,69%

Table 3. Household by Sanitation Type and Location

Year	Statistics	Total			Urban			Rural		
		Sanitation Type			Sanitation Type			Sanitation Type		
		No Toilet	PFT	PFT with WWTP	No Toilet	PFT	PFT with WWTP	No Toilet	PFT	PFT with WWTP
2016	Observation	66,769	32,819	191,826	10,622	11,769	102,122	56,147	21,050	89,704
	%	22.91	11.26	65.83	8.53	9.45	82.02	33.64	12.61	53.75
2017	Observation	69,939	38,494	188,843	11,774	13,267	102,649	58,165	25,227	86,194
	%	23.53	12.95	63.52	9.22	10.39	80.39	34.3	14.88	50.83
2018	Observation	66,065	36,550	192,540	10,945	12,629	102,992	55,120	23,921	89,548
	%	22.38	12.38	65.23	8.65	9.98	81.37	32.69	14.19	53.12
Total	Observation	202,773	107,863	573,209	33,341	37,665	307,763	169,432	70,198	265,446
	%	22.94	12.2	64.85	8.8	9.94	81.25	33.55	13.9	52.56

Table 4. Household Morbidity Ratio Based on Sanitation Facilities and Location

Year	Location	Sanitation Type			Total
		No Toilet	PFT	PFT with WWTP	
2016	Rural	17.12%	17.23%	16.90%	17.01%
	Urban	18.53%	16.64%	15.14%	15.58%
	Total	**17.35%**	**17.02%**	**15.96%**	**16.40%**
2017	Rural	16.26%	15.48%	15.88%	15.95%
	Urban	17.86%	16.10%	14.27%	14.79%
	Total	**16.53%**	**15.70%**	**15.01%**	**15.45%**
2018	Rural	17.22%	16.83%	16.28%	16.66%
	Urban	17.64%	14.80%	13.37%	13.88%
	Total	**17.29%**	**16.13%**	**14.72%**	**15.47%**

Table 5. Regression Results

Variable	Specification 1	Specification 2	Specification 3
Push-Flush Toilet	-0.00503***	-0.00144	-0.000322
	(0.000996)	(0.000998)	(0.000999)
Push-Flush Toilet with Wastewater Treatment Plants	-0.0123***	-0.00586***	-0.00375***
	(0.000714)	(0.000727)	(0.000731)
Access to clean water	-0.00552***	-0.00393***	-0.00324***
	(0.000636)	(0.000636)	(0.000637)
Vulnerable Age Rate	0.146***	0.139***	0.136***
	(0.00107)	(0.00108)	(0.00109)
Urban	-0.0116***	-0.00553***	-0.00376***
	(0.000596)	(0.000609)	(0.000613)
Completed Junior High School		-0.0150***	-0.0143***
		(0.000896)	(0.000896)
Completed Senior High School		-0.0265***	-0.0240***
		(0.000723)	(0.000730)
Completed College/University		-0.0398***	-0.0309***
		(0.00108)	(0.00113)
Expenditure			-0.00222***
			(8.95e-05)
2017 Year Dummy	-0.0103***	-0.00880***	-0.00809***
	(0.000688)	(0.000692)	(0.000692)
2018 Year Dummy	-0.0108***	-0.00904***	-0.00779***
	(0.000688)	(0.000692)	(0.000693)
Constant	0.155***	0.158***	0.162***
	(0.000885)	(0.000890)	(0.000904)
Observations	883,845	883,845	883,845
R-squared	0.022	0.025	0.025

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Discussion

Descriptive Statistics

The descriptive statistics are presented in Table 1 (for continuous variables) and Table 2 (for categorical variables). Table 1 shows a slight decrease in the overall morbidity rate from 16.4% in 2016 to 15.5% in 2018. This improvement occurred even though the percentage of vulnerable individuals slightly increased from 18.5% in 2016 to 19.2% in 2018.

In terms of adequate sanitation facilities (PFTs with WWTPs), there was no significant improvement during the observation period. The share of households connected with wastewater treatment facilities remained at approximately 65% in 2016 and 2018 (Table 2). When we disaggregate observations by type of sanitation facility and location, there is a significant difference between rural and urban households. As depicted in Table 3, the share of households with adequate sanitation facilities in urban area was at least 80%, while households without toilets contributed almost 10% of the total number of households during our observation period. On the other hand, the share of rural households connected with wastewater treatment facilities ranges between 50% and 53%. The fact that approximately 33% of rural households do not have toilets is concerning. The absence of adequate sanitation facilities implies that household waste is directly disposed to the environment. A house with PFTs that are not connected to WWTPs essentially practices open defecation, similar to a house without a toilet, as untreated waste is discharged directly to the environment.

The extent of open defecation poses a substantial risk to human health. This is because open defecation introduces bacteria and toxins into the ecosystem and is harmful to human health. Indeed, empirical studies provide strong evidence of this impact (see, for instance, Blum, 1974; Andres et al., 2017; Bancalari and Martinez, 2017; Bartram et al., 2005, Daniels et al., 1990; Duflo et al., 2015; Wibowo and Tisdell, 1993; Vlahov et al., 2007; Esrey et al., 1991)

To identify whether households with poor sanitation facilities tend to have a higher morbidity rate, we compared the morbidity rate with that of households with proper sanitation facilities. The results are presented in Table 4. As depicted in Table 4, households without toilets tend to have a greater morbidity rate than households with toilets. Households connected with wastewater treatment facilities tend to have a lower morbidity rate. This result holds for both rural and urban areas.

The morbidity rate for urban households without toilets is consistently greater than that for those in rural areas. One possible explanation is that urban areas tend to have a higher population density. Consequently, harmful bacteria and toxins can spread more easily in densely populated areas.

Empirical Results

We estimate the morbidity rate sequentially to identify whether the result is sensitive to different specifications. Initially, we regressed the morbidity rate as a function of sanitation facilities, access to clean water, vulnerable age, location, and time effects. The argument for excluding education level and monthly expenditure is because of a possible correlation between these two variables and the type of sanitation facility. For instance, a household head with higher education may have better knowledge regarding the importance of adequate sanitation facilities for household members' health. Similarly, household income (proxied by monthly expenditure) is potentially correlated with the ability to have adequate sanitation facilities. Specifically, households with higher incomes are more likely to have adequate sanitation facilities. Including these two variables will result in inaccurate conclusions regarding the impact of sanitation facilities on morbidity.

However, education and income may also directly affect morbidity. For instance, education level may affect household preventive actions and directly affect household member health conditions. Similarly, income may also affect households' ability to afford preventive measures and thus affect morbidity. To account for this possible direct effect, we include these variables sequentially.

The empirical results are presented in Table 5. Except for PFT, the significance and sign of each parameter remain consistent across different specifications. Since specification 3 involves more variables that are found to be significant (and thus reduce the risk of omitted variable bias), we use the result from specification 3 as the basis for our analysis.

As shown in Table 5, the order of parameter magnitudes remains consistent across specifications. For example, households with PFTs connected to wastewater treatment plants have lower morbidity rates than those without toilets. The morbidity rates for households with PFTs not connected to wastewater treatment plants are not significantly different from those without toilets. As previously mentioned, the lack of adequate sanitation facilities means household waste is directly disposed of in the environment, posing health risks.

Households with access to clean water tend to have a lower morbidity rate. Although the parameter magnitude of clean water access in specifications 1 and 2 is less than the parameter for adequate sanitation (i.e., PFT with WWTP), the parameter of both variables is close in specification 3.

The share of vulnerable household members is positively correlated with the morbidity rate. A higher morbidity rate can also result from the impact of one person's illness on the health of others in the same household, regardless of whether the disease is communicable. If a nonvulnerable household member falls ill, there will be fewer people available to care for vulnerable members, thereby increasing their health risk. Conversely, if a vulnerable member is the first to suffer from an illness, they will require care from an adult (nonvulnerable member). The time allocated for caregiving may reduce the rest of the caregiver's time, increasing their own risk of illness.

The results in Table 5 suggest that urban households tend to have better health conditions than those living in rural areas, as indicated by the negative parameter for urban areas. One possible explanation is that urban areas generally have more healthcare facilities, providing better access to healthcare for their residents

(Blum, 1974).

The parameters for education indicate that households whose heads have not attained a junior high school education (the reference group) tend to have higher morbidity rates. Conversely, the higher the education level of the household head is, the lower the morbidity rate. This is likely because higher education levels provide better knowledge, leading to more effective preventive and curative measures, thereby improving health conditions (Wibowo & Tisdell, 1993).

The parameter for expenditure is negative and significant, indicating that wealthier households tend to have better health conditions. As discussed earlier, income (proxied by expenditure) is positively correlated with a household's ability to afford preventive and curative measures. Although income may also affect health outcomes through the availability of adequate sanitation, we do not investigate this channel. The primary reason is that a two-stage estimation is needed: the first stage involves nonlinear estimation (such as probit or logit), and the second stage involves linear estimation. Even if such an estimation were performed, it would not guarantee an accurate result for the indirect effect of income through adequate sanitation. This is because income may vary over time, while the type of sanitation facility tends to remain constant once installed. As an illustration, if a household with adequate sanitation experiences a decrease in income, the sanitation facilities will not be downgraded. Therefore, despite not accounting for the indirect effect of income, we are confident that our results remain robust.

The parameters for the year dummies are both negative, indicating a general improvement in the health conditions of Indonesian households. However, the parameters are very small, suggesting that the progress was slow from 2016 to 2018.

Conclusion

This research underscores the critical importance of adequate sanitation facilities, particularly Pour-Flush Toilets (PFTs) with waste treatment, for communities in Indonesia. Despite ongoing efforts, access to such facilities stagnated between 2016 and 2018, with urban areas generally faring better than rural areas. Our empirical findings highlight the significant impact of various sanitation facilities on household health, demonstrating that PFTs with waste treatment are correlated with improved health outcomes.

The results of this study indicate the need for government intervention, especially in providing communal wastewater treatment plants (WWTPs) in densely populated low-income areas. Several factors support the recommendation for communal WWTPs. First, there is the health impact. Our empirical evidence shows that PFTs positively affect health only when waste treatment facilities are present. The second factor is urban vulnerability. While access to PFTs is high in urban areas (approximately 90%), many households lack adequate waste treatment facilities. Given the greater vulnerability to sanitation issues in urban areas, communal WWTPs can mitigate pollution impacts. The third factor is land efficiency. Compared with individual septic tanks, communal WWTPs are more land-efficient. They reduce environmental pollution and free up land previously used for waste disposal, decreasing exposure to pollution in serviced residential areas.

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Author Contribution and Competing Interest

Lenindo and Vid Adrison both contributed to the research design, data collection, quantitative analysis, and writing. Both authors have declared no competing interests in this research.

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