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Community-Based Drinking Water And Sanitation Provision (Pamsimas) In Preventing Outbreaks

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ABSTRACT

This study aims to provide empirical evidence regarding the impact of the Community-Based Drinking Water and Sanitation Program (Pamsimas) in preventing outbreaks. The research is based on the critical importance of drinking water and sanitation for human life, particularly in the field of health. Using a difference-in-differences (DID) approach with a staggered implementation design, the study finds that the Pamsimas program has not yet demonstrated a significant impact at the level of reducing outbreak probabilities. The effects of the program remain limited to the outcomes level, including changes in community behavior such as a decreased likelihood of using rivers/lakes/ponds/irrigation channels for drinking water, an increased likelihood of individuals using private latrines, and a reduced probability of water contamination in a village.

INTRODUCTION

Water is an essential element for life. According to Jerven (2013), water plays a crucial role in the economy, contributing to production, agriculture, and energy sectors. Access to clean water also enhances economic productivity by reducing workdays lost due to illnesses (Glaeser & Gottlieb, 2009). In public health, the burden of diseases associated with poor water and sanitation can be reduced through improved access to clean water and sanitation (WHO, 2017). Additionally, WHO (2017) reports that every dollar invested in clean water yields significant economic returns. Contamination of urban drinking water supplies can trigger outbreaks, affecting economic activities and long-term public health (Ailes et al., 2013).

Given its urgency, water-related issues have become a major concern at both national and international levels. One of the Sustainable Development Goals (SDGs) aims to ensure availability and sustainable management of clean water and sanitation for all by guaranteeing proper access and promoting efficient water use (United Nations, 2015). The Indonesian Ministry of National Development Planning/Bappenas has formulated the National Medium-Term Development Plan (RPJMN) 2020-2024, serving as a reference for improving clean water access in Indonesia. This study aims to explore whether water management (to enhance drinking water and sanitation accessibility) can prevent outbreaks.

As a developing country, Indonesia provides a relevant case study. Unequal access to drinking water and sanitation poses challenges for outbreak control. According to Statistics Indonesia (BPS), access to clean water remains uneven, especially in rural and remote areas, where many still rely on unsafe water sources, increasing health risks (BPS, 2018). In 2020, the Ministry of Health reported that only 11.8% of households had access to safe drinking water services, with the lowest percentage in Maluku (Bappenas, 2023).

Several studies have linked outbreaks to contaminated drinking water and sanitation sources. A study in India found that fecal contamination of drinking water sources led to outbreaks (Dhadwal & Shetty, 2008). Similarly, a survey in Alamosa found that water contamination caused diarrhea among household members (Ailes et al., 2013). Other research highlights that limited access to clean water and proper sanitation increases disease transmission risks, particularly in low- and middle-income countries (Prüss-Ustün et al., 2014). Conversely, improved sanitation access reduces infectious disease risks (Kummu et al., 2016).

The Indonesian government has implemented the Community-Based Drinking Water and Sanitation Program (Pamsimas) to enhance access to clean water and sanitation. Initiated in 2008, Pamsimas has undergone three phases: Phase 1 (2008-2012), Phase 2 (2013-2015), and Phase 3 (2016-2020). By 2021, Pamsimas had reached 35,928 villages (Pamsimas, 2021). Prior research using panel data fixed effects at the district level found a significant negative effect of Pamsimas on outbreak occurrences (Laksana, 2022). This study aims to replicate and refine previous findings by using village-level data and a difference-in-differences (DID) approach.

The staggered implementation of Pamsimas from 2008 to 2021 allows for DID analysis by comparing pre- and post-program outcomes between treatment and control villages. Data from Pamsimas construction will be combined with village potential data (Podes) to assess its impact on outbreak probability. The panel data structure helps control for time-invariant unobserved factors that might influence Pamsimas implementation (Karimah, 2020). By using more granular data at the village level, this study aims to provide a more precise and relevant analysis (Gertler et al., 2016).

LITERATURE REVIEW

Many factors can affect the health level in a community. One of the theories that discusses health as the result of a combination of various resources and individual behaviors is the health production theory, pioneered by Michael Grossman (1972). The Grossman model is one of the fundamental theories in health economics. This model defines health as a form of "capital stock" (health capital) that has both intrinsic and instrumental value. The main component of the Grossman model is health production, where individuals act as both producers and consumers of health. Health outcomes are produced from a combination of various inputs, such as time, medical goods and services, and initial health stock.

According to Law No. 23 of 2014 on Regional Governance, drinking water and sanitation services fall under concurrent governmental affairs, shared between the central and regional governments (provincial and district/city levels). In terms of concurrent governmental affairs under regional authority, drinking water and sanitation services are classified as mandatory affairs, particularly those related to basic services. The implementation of concurrent governmental affairs between the central and regional governments must be based on the principles of accountability, efficiency, externalities, and national strategic interests.

To improve access to adequate drinking water and sanitation facilities for rural and peri-urban populations using a community-based approach, the Indonesian government launched a national program (at both central and regional levels) known as the Community-Based Drinking Water and Sanitation Program (Pamsimas). This program aims to enhance sustainable access to drinking water and sanitation services for underserved communities, including low-income populations in rural and peri-urban areas. Additionally, the program seeks to promote hygiene and healthy living behaviors to achieve the Millennium Development Goals (MDGs) related to drinking water and sanitation through mainstreaming and expanding the community-based development approach (Pamsimas, 2013).

Several activities are carried out under Pamsimas, including the provision of water and sanitation infrastructure such as the construction or rehabilitation of drinking water supply systems, including bore wells, pipeline networks, and reservoirs. Other activities include the development of sanitation facilities such as hygienic latrines, handwashing stations, and drainage systems. Community capacity-building activities are also conducted, including training on infrastructure management and maintenance, as well as hygiene and sanitation education campaigns through posters and leaflets. Governance strengthening efforts include establishing community institutions such as the Community-Based Water Supply and Sanitation Management Group (KP-SPAMS) to ensure sustainable facility management.

Several studies have shown a positive relationship between the management or improvement of drinking water accessibility and good sanitation with a decrease in the probability of outbreaks occurring. A study in Lebanon highlighted the importance of managing sanitation infrastructure and waste disposal to prevent outbreaks (Uwishema et al., 2022). Additionally, research in Malawi also showed that improving access to clean water and sanitation can enhance the resilience system for early detection of outbreaks, enabling prevention (Miggo et al., 2023). A study was also conducted on South Bass Island, Ohio, USA, through a case study with environmental investigation to identify disease sources. Groundwater samples showed some indications of contamination caused by microbes from feces, such as E. coli and salmonella. The combination of environmental investigation and epidemiology indicated that groundwater contamination was a major cause of outbreaks. Long-term changes in water and sanitation infrastructure management are necessary on the island (O'Reilly et al., 2007).

The provision of water and sanitation itself can also lead to outbreaks if not properly managed, as it may spread microbes or viruses that cause diseases (Dhadwall & Shetty, 2008). In 2008, a salmonella outbreak caused contamination of the city's drinking water source in Alamosa, Colorado. (Ailes et al., 2013) conducted a study to estimate the economic impact and long-term health effects of the outbreak. This investigation documented the significant economic and health impacts of a waterborne outbreak and emphasized the potential loss of trust in public drinking water systems.

An economic theory that may explain the changes in the Pamsimas program is the supply-side economics theory. In this context, the improvement of infrastructure and the provision of public services (such as access to clean water and sanitation) can encourage changes in community behavior by providing better alternatives compared to traditional resources, such as river water use. This theory can be used to understand how the increase in the supply of public services affects demand and consumption patterns in society. Supply-side economics focuses on how the increase in the capacity and availability of goods or services can influence market and societal behavior. In this context, the provision of clean water and sanitation infrastructure can be seen as a "new supply" that significantly changes the community's choices in meeting their basic needs (Mankiw, 2020). By providing a safer and more hygienic alternative, Pamsimas uses a supply-side approach to create behavior change in the community. Providing adequate clean water facilities improves accessibility, making the community more likely to abandon unsafe traditional water sources. The resulting health impacts, such as the decrease in waterborne diseases, demonstrate the program's effectiveness in improving community well-being. Research by Duflo et al. (2012) shows that the provision of public infrastructure in developing countries, such as drinking water facilities, significantly reduces the use of traditional, health-risking resources. This study also found that better public services reduce the burden of waterborne diseases.

The demand-side economics approach can also be used to explain consumer behavior changes in response to improved accessibility, awareness, and preferences for goods and services, including clean water and sanitation. In the context of the Pamsimas program, this approach can be used to understand how the improvement in clean water and sanitation access affects community demand and its impact on health, particularly in reducing the probability of outbreaks. Pamsimas raises public awareness about the health risks of using unsafe water through the Clean and Healthy Behavior (PHBS) campaign. This awareness can increase demand for safer clean water facilities. According to Hunter, MacDonald, and Carter (2010), increased awareness of the importance of proper sanitation can reduce the prevalence of waterborne diseases. Other research shows that educational programs like PHBS play a significant role in changing community behavior regarding sanitation facility use (Prüss-Ustün et al., 2014). Higher awareness affects the community's preference for choosing safe and hygienic sanitation facilities. This is supported by the community's involvement in the development of Pamsimas clean water infrastructure, which creates a sense of ownership and increases the preference for safer water sources. A study by Prüss-Ustün et al. (2014) shows that improving access to sanitation can reduce diarrhea risk by up to 58%, particularly in rural areas. The reduction in the cost of accessing clean water through local infrastructure development influences community behavior. By reducing the time and costs required to obtain clean water, the Pamsimas program increases clean water consumption, thus reducing the risk of disease transmission. Bloom and Canning (2008) noted that reducing the opportunity cost of accessing clean water significantly impacts increased community productivity.

METHODS

The type of research used in A difference-in-differences (DID) approach with staggered implementation is employed to investigate the impact of the PAMSIMAS program on water usage/consumption, which is expected to reduce the likelihood of outbreaks. This estimation is inspired by the study by Sparrow et al. (2013), which examined the effects of the Askeskin program on healthcare expenditures and utilization, as well as research on the impact of ports on local economic activity (Karimah, I. D., 2020). By comparing pre- and post-implementation conditions of the Pamsimas program and comparing the treatment and control groups, this study aims to identify the causal effects of community empowerment programs on reducing the probability of outbreaks.

Adopting the difference-in-differences approach used by Karimah, I. D. (2020) and Azzahrah, S. (2024), we estimate the difference in outcomes between villages that received and did not receive the Pamsimas program before and after implementation while controlling for time-variant and time-invariant factors (fixed effects and time fixed effects). The model specification is as follows:

$$OutDia_{rt} = \beta_0 + \beta_1 treatment_{rt} + X'_{rt} + \beta_r + \beta_t + \alpha_{st} + \varepsilon_{it} \quad (3.1)$$
$$OutDif_{rt} = \beta_0 + \beta_1 treatment_{rt} + X'_{rt} + \beta_r + \beta_t + \alpha_{st} + \varepsilon_{it} \quad (3.2)$$
$$OutHep_{rt} = \beta_0 + \beta_1 treatment_{rt} + X'_{rt} + \beta_r + \beta_t + \alpha_{st} + \varepsilon_{it} \quad (3.3)$$

Where, OutDiart/OutDifrt/ OutHeprt indicates whether an outbreak occurred in village r at time t, Treatmentrt represents whether village r received the Pamsimas program at time t. β1 measures the probability that a village experienced an outbreak based on Pamsimas implementation, and X'rt is a vector of control variables that may change over time and influence the outcome. These include availability of public sanitation facilities in village r at time t, waste disposal facilities in village r at time t, the primary drinking water source in village r at time t, presence of slum areas in village r at time t, water pollution levels in village r at time t. βr captures village fixed effects to control for individual fixed effects. βt accounts for time trends to control for unobservable time-dependent variations. αst controls for potential biases introduced by provincial-level policies.

Several robustness tests are conducted in this study, including placebo tests and robustness checks using subsample data. A parallel trend test is also performed to ensure that the treatment and control groups had similar conditions before the intervention. This verification ensures that the observed outcomes are genuinely due to the treatment (Angrist & Pischke, 2009). The parallel trend test is conducted based on dynamic impact estimation or event study methods previously applied by Autor (2003), adjusting variables and treatment timing to capture pre- and post-treatment effects.

Additionally, a heterogeneity test is performed to compare effects across subgroups. This approach provides insights into the accuracy of regression results in identifying potentially differing effects among subgroups (Angrist & Pischke, 2009). To address potential issues arising from the DID model, standard errors are clustered at the village level (Bertrand et al., 2004).

RESULTS

Several variables used for regression/estimation in this study have the following statistical descriptions:

Table 1. Descriptive Statistics (Treatment-Control)

Variable	Group									
	Treatment					Control				
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Diarrheal Outbreaks	56427	.022	0.147	0	1	219356	.069	0.254	0	1
Diphtheria Outbreaks	56427	.001	0.037	0	1	140563	.002	0.043	0	1
Hepatitis E Outbreaks	56427	.002	0.046	0	1	140563	.002	0.046	0	1
Pamsimas Development	56427	1	0.000	0	1	219359	0	0.000	0	1
Toilet Facilities	28276	.953	0.213	0	1	129316	.865	0.342	0	1
Main Drinking Water Source	28276	.04	0.196	0	1	129316	.051	0.220	0	1
Water Pollution	28276	.158	0.364	0	1	129316	.137	0.344	0	1

Several regression alternatives were applied to estimate the effect of the Pamsimas program in preventing outbreaks. The study estimated this effect using Difference-in-Differences (DID) with fixed effects, then added fixed effects for villages and years, added provincial fixed effects, and finally included other covariates or control variables.

Table 2 shows several specifications used in this study to estimate the effect of Pamsimas development on the probability of outbreaks, with the dependent variable being the probability of an outbreak occurring. The direct effect of Pamsimas development on the probability of an outbreak in a village was analyzed using a model that includes fixed effects at the village level, time (year), and province-year interactions. The regression results in Table 2.a show that the first regression (1), which only uses village fixed effects, indicates that there is a negative effect or a reduction in the probability of outbreaks in a village with the Pamsimas program of about 0.86%, with statistical significance at the 1% level. This result is consistent with a study by Laksana, B. M. (2022) on the same program at the district level, which found a reduction in disease cases as the ratio of villages with the Pamsimas program increased by 1%.

In the next regression, when controls for the year are added, the treatment coefficient decreases further and becomes statistically insignificant (above 10%). This suggests that there is no relationship between the decrease or increase in the probability of outbreaks in a village and the presence of the Pamsimas program in that village. In other words, the result demonstrates that there might be other factors or variables affecting the probability of outbreaks in a village besides Pamsimas. The same pattern is observed in subsequent regressions when controls for the year and province are added. The regression results show very small values and low significance.

Table 2.a Effect of Pamsimas Development on Preventing Outbreaks (Diarrhea)

	Probability of Outbreak (Yes/No)			
	(1)	(2)	(3)	(4)
treatment (1 built, 0 others)	-0.08580***	-0.00042	-0.00266	-0.00223
	(0.00158)	(0.00182)	(0.00183)	(0.00206)
Observation	275783	275783	275783	185858
R^2	0.172	0.224	0.234	0.271
Control :				
Village FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes
Province-year FE	No	No	Yes	Yes
Covariat	No	No	No	Yes

Note: The dependent variable uses a dummy variable (Yes/No) for the occurrence of diarrhea outbreaks in a village. Standard errors are clustered at the village level and are shown in parentheses. The covariates include the presence of a village head, age of the village head, gender of the village head, education level of the village head, and the GDP per capita at the district level. The estimations use annual panel data in accordance with the PODES period. Data on Pamsimas development comes from the Ministry of Public Works and Housing (Kementerian PUPR). ***, **, *, denote statistical significance at the 1%, 5%, and 10% levels, respectively.

In addition to showing no significant direct relationship between the Pamsimas program and the probability of outbreaks, some of the regression stages above also suggest that there may be unobserved factors in the observation model that cannot be captured by using fixed-effects panel data alone. The addition of time controls (year fixed effects) results in two-way fixed effects (TWFE), which control for two dimensions: individuals and time, useful for managing unobserved factors (Angrist & Pischke, 2009).

Table 2.b Effect of Pamsimas Development on Preventing Outbreaks (Diphtheria)

	Probability of Outbreak (Yes/No)			
	(1)	(2)	(3)	(4)
treatment (1 built, 0 others)	-0.00121***	0.00005	0.00023	0.00029
	(0.00036)	(0.00042)	(0.00042)	(0.00051)
Observation	196990	196990	196990	147042
R^2	0.216	0.216	0.219	0.293

Control :				
Village FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes
Province-year FE	No	No	Yes	Yes
Covariat	No	No	No	Yes
Note: The dependent variable uses a dummy variable (Yes/No) for the occurrence of diphtheria outbreaks in a village. Standard errors are clustered at the village level and are shown in parentheses. The covariates include the presence of a village head, age of the village head, gender of the village head, education level of the village head, and the GDP per capita at the district level. The estimations use annual panel data in accordance with the PODES period. Data on Pamsimas development comes from the Ministry of Public Works and Housing (Kementerian PUPR). ***, **, *, denote statistical significance at the 1%, 5%, and 10% levels, respectively.				

The results were not much different when the estimation was applied to the diphtheria outbreak variable (Table 2.b). In the first regression, using village fixed effects, the result was quite small (-0.001) with good statistical significance (1%). However, after adding additional controls such as time fixed effects and province fixed effects, the coefficient showed very small values with low significance.

Table 2.c Effect of Pamsimas Development on Preventing Outbreaks (Hepatitis E)

	Probability of Outbreak (Yes/No)			
	(1)	(2)	(3)	(4)
treatment (1 built, 0 others)	-0.00022	0.00026	0.00021	-0.00005
	(0.00040)	(0.00047)	(0.00046)	(0.000560)
Observation	196990	196990	196990	147042
R^2	0.208	0.208	0.209	0.277
Control :				
Village FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes
Province-year FE	No	No	Yes	Yes
Covariat	No	No	No	Yes
Note: The dependent variable uses a dummy variable (Yes/No) for the occurrence of Hepatitis E outbreaks in a village. Standard errors are clustered at the village level and are shown in parentheses. The covariates include the presence of a village head, age of the village head, gender of the village head, education level of the village head, and the GDP per capita at the district level. The estimations use annual panel data in accordance with the PODES period. Data on Pamsimas development comes from the Ministry of Public Works and Housing (Kementerian PUPR). ***, **, *, denote statistical significance at the 1%, 5%, and 10% levels, respectively.				

Similarly, for the Hepatitis E outbreak regression (Table 2.c), the coefficient obtained in the first estimation using only village fixed effects was 0.00022 and not significant. This coefficient did not change significantly as time and province fixed effects were added. This indicates no causal relationship between Pamsimas development in a village and the probability of a Hepatitis E outbreak in that village. The non-significant result may be due to an incomplete transmission mechanism within the Pamsimas development scheme.

DISCUSSION

For further understanding of why the direct impact was not significant, additional analysis was carried out in Table 3 to evaluate how Pamsimas development affects changes in community behavior, which could be a mediating pathway leading to the impact of outbreak probabilities. From the regression results, it can be seen that Pamsimas development had a positive impact on the community, though the values were very small. The first regression showed that Pamsimas development reduced the probability of people using river/lake/pond/irrigation water as drinking water by 0.004 with 5% statistical significance. In the next regression, the program is shown to increase the probability of people using proper toilets by 0.029 with 1% statistical significance.

Lastly, the regression results showed that Pamsimas development reduced the probability of water pollution in a village by 0.008 with 1% statistical significance. Pamsimas development resulted in significant changes at the outcomes level related to community behavior and environmental quality. However, these mediating effects were not strong enough to translate into significant impacts on outbreak probabilities at the impact level. This suggests that the transmission of impact may take more time or require a broader scope of intervention. This may provide an explanation that although the Pamsimas program shows positive results at the outcome level, it is not enough to yield a positive impact at the impact level. This indicates that changes at the outcome level require time or additional interventions to achieve a more significant impact.

Therefore, strategies to strengthen transmission mechanisms and expand the program's coverage could be crucial steps to achieving a larger impact. External factors such as program coverage, local characteristics, and epidemiological factors might play a role in determining the success of the program at the impact level.

Table 3 Effects of Pamsimas Development on Changes in Community Behavior

	Drinking Water	Toilet Use	Water Pollution
treatment (1 built, 0 others)	-0.004**	0.029***	-0.008***
	(0.0017)	(0.0028)	(0.0031)
Observation	157592	157592	157592
R^2	0.587	0.514	0.451

Note: The Drinking Water variable uses a dummy (1/0) for the main source of drinking water for most families in the village, with 1 = river/lake/pond, and 0 = others. The Toilet Use variable uses a dummy (1/0) for the toilet facilities in most families in the village, with 1 = own toilet, 0 = others. The Water Pollution variable uses a dummy (1/0) for the presence of water pollution in the village, with 1 = present, 0 = not

The Pamsimas program has a broad reach, targeting over 35,000 villages across Indonesia since its launch in 2008 (Ministry of Public Works and Housing, 2023). However, this policy still faces challenges in achieving an impact, such as reducing waterborne disease outbreaks like diarrhea and hepatitis E. Currently, Pamsimas has more of an effect on outcomes, such as the improvement of community behavior in maintaining clean and healthy living (PHBS), rather than directly addressing public health impacts significantly.Pamsimas has consistently expanded its geographical coverage, focusing on villages with low access to clean water and sanitation. By 2023, the program had benefited over 20 million people, providing clean drinking water and proper sanitation facilities (World Bank, 2020).

However, coverage in some areas remains relatively low compared to the total population, especially in geographically difficult-to-reach areas such as remote regions and border areas. Despite this, based on descriptive statistics comparing conditions before and after the Pamsimas intervention, outbreaks in villages appear to have decreased, although this may not solely be attributed to Pamsimas but also to other factors.

Table 4. Descriptive Statistics-Treatment (Before-After)

Variable	Group									
	Treatment-Before					Treatment-After				
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Diarrheal Outbreaks	60045	.099	0.298	0	1	56427	.022	0.147	0	1
Diphtheria Outbreaks	26768	.003	0.051	0	1	56427	.001	0.037	0	1
Hepatitis E Outbreaks	26768	.002	0.048	0	1	56427	.002	0.046	0	1
Pamsimas Development	60046	0	0.000	0	1	56427	1	0.000	0	1
Toilet Facilities	38280	.808	0.394	0	1	28276	.953	0.213	0	1
Main Drinking Water Source	38280	.047	0.211	0	1	28276	.036	0.187	0	1
Water Pollution	38280	.136	0.343	0	1	28276	.158	0.364	0	1

According to data from the Pamsimas Sustainability Module from 2008 to 2021 (December 2022), there were 3,116,976 household connections (SR) with water meters and 1,363,098 SR without water meters. Assuming one SR serves one household (KK), the proportion of households served by Pamsimas is approximately 17%. This figure, though not large, is still commendable. Additionally, out of the approximately 35,000 villages receiving the Pamsimas program, about 1,400 villages are non-functional, and 1,805 villages are partially functional. This non-functionality may already affect the outcomes, which could also explain the lack of success at the impact level.

The increase in the number of households with access to proper and safe sanitation facilities has been achieved in many implementation areas. Data shows that the proportion of families with basic sanitation facilities increased by 40% in some regions after the Pamsimas implementation (Ministry of Public Works and Housing, 2023). Pamsimas integrates education campaigns on the importance of maintaining clean and healthy behavior (PHBS), gradually increasing public awareness about personal and environmental hygiene (Bappenas, 2021).

Parallel Trend and Dynamic Effects

One assumption that must be met in applying the DID method is the parallel trend assumption. This study attempts to estimate based on a study by Autor (2003) by creating time schemes that represent conditions before, during, and after treatment. From these estimates, we can observe the significance and magnitude of the effects or coefficients generated by the regression, which can be used to measure the impact of a policy over time.

Figure 1.a Parallel Trend Diarrhea

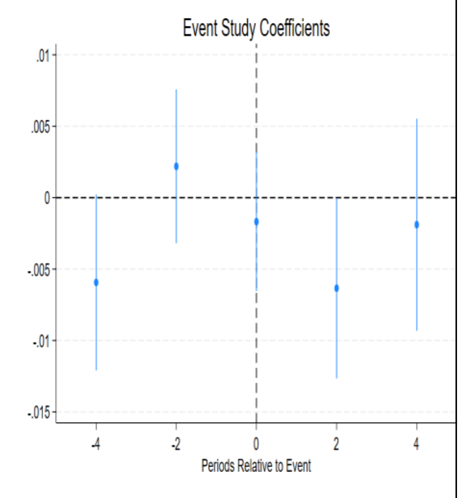


Figure 1.b Parallel Trend Diphtheria

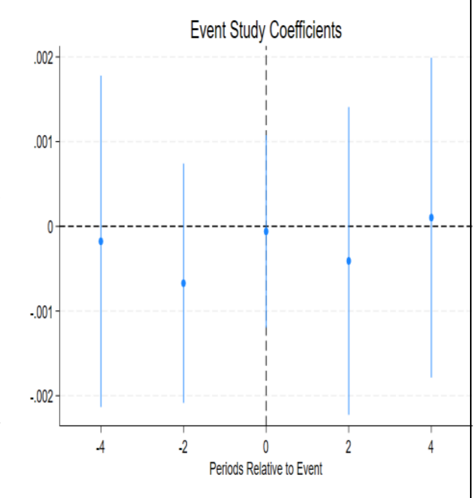
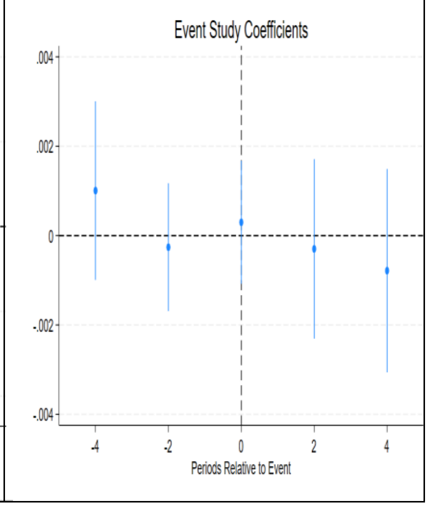


Figure 1.c Parallel Trend Hepatitis E



From the graph above, we can see that the statistical significance before the treatment event is very small or above 10%. This shows that the parallel trend assumption has been met. We also observe that the coefficient after the treatment event is not statistically significant, further confirming that there is no causal relationship between Pamsimas implementation and the likelihood of disease outbreaks.

The same result applies to the estimation of outbreaks of Diphtheria and Hepatitis E. From Figures 1.b and 1.c, we can see that the statistical significance before the treatment event is very small or above 10%, confirming that the parallel trend assumption is met. Furthermore, the coefficients after the treatment event are also not statistically significant. This again proves that there is no causal relationship between Pamsimas development and the likelihood of outbreaks, whether for Diphtheria or Hepatitis E.

Heterogeneity Test

Although the regression results did not show significance, this study still attempts to conduct a heterogeneity test by comparing the effects between subgroups. It is hoped that this can provide insight into the accuracy of regression results in identifying effects that may differ between subgroups (Angrist & Pischke 2009).

Heterogeneity tests are conducted by comparing regression results between two subgroups, specifically the eastern and western regions. The estimation is done using controls such as fixed effects for villages, time, year-province, and other covariates consistent with the regression used earlier. The results of the heterogeneity test are shown in Table 5 below:

Table 5 Heterogeneity Test (East and West)

	Diarrhea		Diphtheria		Hepatitis E	
	East	West	East	West	East	West
	-0.00333	-0.00190	0.00120	0.00002	-0.00204	0.00055
treatment (1 built, 0 others)	(0.004)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Observation	40713	145145	32190	114852	32190	114852
R^2	0.294	0.262	0.271	0.296	0.282	0.275

Note: The East region is represented by provinces in Sulawesi, Maluku, Papua, Nusa Tenggara, and Bali. The West region is represented by provinces in Sumatra, Java, and Kalimantan. The standard errors are clustered at the village level and are shown in parentheses. ***, **, *, denote statistical significance at the 1%, 5%, and 10% levels, respectively.

The regression estimation shows balanced results between the eastern and western regions. There are no coefficients that are statistically significant even at the 10% level. However, the exception is for the diarrhea variable in the eastern region using the specification control of TWFE plus province-year effects. The regression results show a significant relationship at the 10% level, although with a small coefficient. Even though small, this indicates that there is still an impact from Pamsimas activities, particularly in the eastern region. This could be due to the more limited infrastructure and access to clean water and sanitation in the eastern region compared to the western region, making Pamsimas development have a more positive effect, even up to the impact level.

Robustness Test and Placebo Test

In testing the robustness of the estimates, this study uses two approaches: eliminating certain observations or subgroups and conducting placebo tests. As shown in Table 6, robustness tests were performed by running regressions after eliminating certain observations or subgroups, in this case, the Java subgroup.

Table 6 Robustness Test

	Basis			Non-Java		
	Diarrhea	Diphtheria	Hepatitis E	Diarrhea	Diphtheria	Hepatitis E
treatment (1 built, 0 others)	-0.00223	0.00029	0.00005	-0.00166	0.00059	-0.00021
	(0.00206)	(0.00051)	(0.00056)	(0.00237)	(0.00052)	(0.00067)
Observation	185858	147042	147042	114469	90527	90527
R^2	0.271	0.293	0.277	0.279	0.275	0.276

Note: The estimation was carried out by comparing the coefficient values between the base group (all subgroups) and the non-Java subgroup, which consists of provinces outside of Java. Standard errors are grouped at the village level and are shown in the numbers within parentheses. ***, **, *, indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

The regression estimates show that even after eliminating certain observations, the regression coefficients remain consistent with the main regression results. The standard errors are also relatively unchanged, indicating that the estimates are robust across various subgroup levels.

Additionally, this study conducted a placebo test (Table 7) to test the robustness and validate the parallel trend assumption previously tested. To test this assumption, a dummy variable was created for the placebo period (t−5) to avoid potential effects from transitions or anticipation before the treatment was implemented. The placebo test showed no treatment effects, supporting the validity of the parallel trend assumption.

Table 7 Placebo Test

	Diare		Difteri		Hepatitis E	
	Basis	t-5	Basis	t-5	Basis	t-5
treatment (1 built, 0 others)	-0.00223		0.00029		-0.00005	
	(0.00206)		(0.00051)		(0.00056)	
placebo_tr~t		-0.00423		0.00063		-0.00072
		(0.00386)		(0.00094)		(0.00091)
Observation	185858	185858	147042	147042	147042	147042
R^2	0.271	0.271	0.293	0.293	0.277	0.277

Note: The placebo test was conducted by defining the placebo variable as the period t−5, in order to avoid potential transition effects o anticipation before the treatment was applied. Standard errors are grouped at the village level and are shown in the numbers withi parentheses. ***, **, *, indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

CONCLUSION

There are still 785 million, or 11% of the global population, without access to basic water services, with the majority residing in rural areas (UNICEF, 2017). Several studies have shown a correlation between the occurrence of epidemics and contamination in drinking water sources or sanitation systems, which makes access to basic water services critically important. Water and sanitation services are regulated under Law No. 23 of 2014 on Regional Government, which is a concurrent government affair—where the authority is divided between the central government and regional governments (provinces and districts/cities). To address this, the Indonesian Government launched a national program (central and regional) called the Community-Based Drinking Water Supply and Sanitation Program (PAMSIMAS), aimed at improving access to sustainable drinking water and sanitation services for underserved communities, including low-income populations in rural and peri-urban areas (Pamsimas, 2013).

Using a Difference-in-Differences (DiD) model with staged implementation, this study tries to assess the effects of Pamsimas construction, implemented at different times, to observe its impact on the likelihood of epidemic occurrences in villages.

Estimation results using controls such as fixed effects for villages and time (TWFE) show negative values with low statistical significance (above 10%). Adding controls for provincial fixed effects and other covariates yields relatively consistent results, which confirms the robustness of these estimates. The results indicate that there is no significant relationship between the construction of Pamsimas and the probability of epidemic occurrences in a village. In other words, the Pamsimas program does not influence the increase or decrease in the likelihood of epidemics in these villages.

This might be due to a broken transmission mechanism within the Pamsimas development framework. Regression results at the outcome level show that the Pamsimas program had positive effects. However, the coefficient values at that level are relatively small, which suggests that these small effects were not enough to bring about significant changes or impacts at the higher impact level. These findings may contribute to the literature showing that, although infrastructure-based water and sanitation interventions provide benefits at the outcome level, their effects at the impact level still require time or additional interventions.

In heterogeneity tests, regression estimates show balanced results between the eastern and western regions, except for the diarrhea variable, which shows a significant relationship at the 10% level, though with a small coefficient value. Although small, this value suggests that there is still an impact from the Pamsimas program, especially in the eastern regions. This may be because of the more limited infrastructure and access to drinking water and sanitation in the eastern regions compared to the western regions, meaning that the Pamsimas development can provide more positive effects, even up to the impact level.

SUGGESTION

Although the regression results show insignificant findings, the Pamsimas program should not be considered a failure. Through Pamsimas, the Government has succeeded in improving access to clean water by building the infrastructure for clean water and sanitation in approximately 35,000 villages. This aligns with one of the SDGs, which aims to ensure the availability and sustainable management of water and sanitation for all, ensuring access to clean water and adequate sanitation and promoting water use efficiency. Based on the results of this study, several recommendations include:

1. To prevent the occurrence of epidemics, the Government may consider alternative approaches besides the Pamsimas program. The Pamsimas program can still be used to enhance access to drinking water and sanitation in line with the SDG goals.
2. Further research using more reliable data and newer methods that can capture unobserved factors would be greatly supported to reduce potential biases and provide more accurate insights into the relationship between Pamsimas and the likelihood of epidemic occurrences or other variables that need further exploration.

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