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The Health Impacts from Living Near Economic Industrial Parks in Sumatera

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Abstract:

While the operation of industrial areas has positively contributed to local economic growth on Sumatra Island, it has also resulted in negative environmental and health impacts. These externalities have prompted government intervention to address the adverse effects. Previous research indicates the need for alternative methods to quantify the side effects of industrial operations. This study, using Podes data and the Two-Way Fixed Effect (TWFE) model, estimates the impact of industrial activities on local health, specifically examining the incidence of diarrheal outbreaks as a proxy indicator at the village level. The analysis finds that industrial activities are positively correlated with a 4.16% increase in the incidence of diarrheal outbreaks in villages located within a 0 to 10 km radius of industrial areas, with statistical significance at the 1% level.

Keywords: *Industrial park, Industrial Area, Diarrehal disease outbreak incidence, drink from river*

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1. Introduction

Sumatra, a large island in Indonesia, has experienced significant industrial area development from 2011 – 2020. The Indonesian government encourages regional development to increase local economic activity (Tarigan et al, 2017). This policy is carried out through the urgent development of industrial areas in Sumatra so that there is equal distribution of economic growth and industrialization, not only concentrated in Java (Ministry of Industry, 2013). Indeed, the operation of industrial areas in Sumatra has been proven to significantly contribute to employment, income improvement, and economic turnover (Saragih et al, 2018).

On the other hand, industrial areas are known to impact public health through air, land and water pollution (Chang et al., 2017; Haseena et al. 2017; Smith et al., 2019; and Patel & Rao 2020). Industrial areas have a negative impact on environmental pollution which has an impact on local diseases (Garg et al., 2018; E. Boelee et al., 2019). At the village level, river water is an important source for drinking and household sanitation (Garg et al., 2018; Salminen et al., 2023; Lin et al., 2022). Diarrheal diseases are often associated with inadequate access to water and poor sanitation conditions, and are often exacerbated by water pollution (Rahman et al., 2021; Lin et al., 2022; Shetty, et al., 2023). Previous research has linked industrial areas to public health, but there is little research examining similar impacts on disease outbreaks. Industrial areas can increase the impact of diarrheal disease outbreaks. Understanding this relationship

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is very important because changes in behavior can change a country's nation-building process. Therefore, this research wants to find out the extent of the influence of industrial areas on the incidence of diarrheal disease outbreaks.

Most studies have focused on the impacts of industrial areass on chronic diseases (Chang et al., 2017; Haseena et al. 2017; Smith et al., 2019; and Patel & Rao 2020), environmental effects (Hayat and Abbas, 2023), and the impacts of air pollution from industrial areass on health (Wang et al., 2014). Previous research recommends that the government must have an alternative measurement to calculate the side effects of industrial area operations. In my research, there has been limited research in Indonesia that examined the impact of industrial areas on the incidence of diarrheal disease outbreaks. This study investigates how far industrial areas affect the incidence of diarrheal disease outbreak at the village level in Sumatra Island using two-way fixed effects (TWFE), to explore spatial variations in industrial areas to determine the incidence of diarrhea outbreaks at village and group levels

2. Theoretical Background

Industrial Area and Disease : Research by Brooks et al. (2023), using the two-way fixed effect method, revealed that brick manufacturing in Bangladesh significantly increases air pollution during the production season, leading to an increase in respiratory health symptoms. This finding is reinforced by observations that the impact is localized, with significant increases within a 2 km radius of the industrial areas. This study indicates that villages within close range of industrial areass are more vulnerable to outbreaks of diarrheal diseases correlated with increased environmental pollutants.

Pollution and local disease : Following these results, Yan et al. (2022) found that the supply of industrial land by local governments in China contributes to increased environmental pollution, with significant increases in PM2.5 concentrations. This study, using the Two-Way Fixed Effect method involving comprehensive data from 277 prefecture-level cities, indicates that the intensification of industrial land relative to the total land supply negatively impacts environmental quality. This leads to the conclusion that increased industrial activity within a 0-10 km radius of industrial areass potentially increases the risk of diarrheal disease outbreaks and other diseases related to declining environmental quality.

Radius of Environmental Effect : Al-Wahaibi et al. (2015) specifically divided the study area based on distance from industrial areass. They classified areass as high exposure (≤5 km), medium exposure (>5–10 km), and control areass (≥20 km), providing a context relevant to this research. Results showed a significant increased risk for respiratory diseases, including diarrhea, in high and medium exposure areass. This conclusion proves a correlation between the distance from industrial areass and the frequency of diarrheal disease outbreaks, with more intense effects felt by communities closer to these areas.

3. Methodology

This study employs the two-way fixed effects (TWFE) methodology to assess the impact of industrial park operations, chosen for its ability to estimate multiple category factors and facilitate operational impact analysis. The TWFE methodology effectively manages time-invariant unobservable variables specific to the area by using explicit controls, as represent from their journal by Allison (2009) in Yan et al. (2022)

$$DiarrheaOutbreak_{it} = \alpha + \beta_1\ Industrial\ Area\ Operation_{\ it} + \theta Control_{it} + \lambda_i + \gamma_t + \varepsilon_{it}$$

In this study, the subscript i refers to a specific village and t denotes the year. The variable $DiarrheaOutbreak_{it}$ measures the incidence of disease outbreaks, while $IndustrialAreaOperation_{\ it}$ represents villages within a 0-10 km radius of an operational industrial area. $Control_{it}$ includes a set of control variables, and ε_{it} is the model's error component. Fixed effects at the village level λ_i account for unchanging characteristics over time, and $\gamma_{t.}$

Data

Badan Pusat Statistik (BPS), the Indonesian statistical agency, carries out a biennial census named Podes (Potensi Desa), encompassing all Indonesian villages. This study encompasses a panel of 28.974 villages spanning four years (2011, 2014, 2018 and 2021) and is distributed across major Indonesian islands. The census takes place within a brief period of 4-6 weeks during October and November. Village heads respond to a comprehensive questionnaire, covering details on health, population, river locations, and various demographic variables at the village level.

This research alos enlovled the Geographic Information System (GIS), which serves to generate control variables by geocoding address data for each industrial park and measuring the distances to nearby villages. These spatial variables categorize villages based on their proximity to the industrial parks, distinguishing those within 0-10 km and those between 10-50 km. Once all relevant data is inputted into the GIS, the system facilitates the acquisition, management, analysis, and decision-making processes based on geographic data. We use four industrial park where located at Sumatra Island, which are Kawasan Industri Sei Mangkei (KEK), Kawasan Industri Tenayan, Karimun Maritime Industrial Complex and Kawasan industri Tanjung Buton.

Variables

In this analysis, the incidence of diarrhea outbreaks is treated as the dependent variable, using Podes data. The independent variable is a binary indicator for industrial parks, with a value of 1 for villages within 0-10 km of industrial operations (treatment group) and 0 for villages 10-50 km away (control group) (Ghani et al. 2016), sourced from the Ministry of Industry. The study assumes those most at risk are within 10 km due to the relatively short travel distance, which can be covered in 5-20 minutes by driving, cycling, or walking. Thus, the hypothesis is that villages located within near of industrial parks have a higher incidence of diarrhea outbreaks, supported by Al-Wahaibi and Zeka's (2015) research showing industrial pollution impacts public health within this radius.

The analysis distinguishes the impact of policies on exposed and less exposed areas by including an interaction term, IndustrialAresxDummyTreatment, to capture differences in operating impacts during the posttreatment period. Control variables such as structural characteristics, topography, geography, and disease distribution are incorporated into the econometric model to adjust for potential confounders, thus strengthening internal validity and preventing biases. These variables include the quality of village government, topography (flatland or hills areas), geographical conditions (precipitation and flooding), and the incidence of villagers consuming river water. The most frequently converted control variables into dummies are village topography and ease of access, while annual precipitation remains unchanged as a control variable. This method ensures the validity and reliability of the research findings by facilitating the formation of correlational or causal connections between principal variables (Halperin, Pyne, & Martin, 2015; Cahit, 2015).

Table 1.
Variable Definition

Variable	Definition
DiarrheaOutbreak	Dummy variable for Diarrhea Outbreak 1 = Diarhea Outbreak Incidence 0 = Otherwise
MeaslesOutbreak	Dummy variable for Measles Outbreak 1 = Measles Outbreak Incidence 0 = Otherwise
MalariaOutbreak	Dummy variable for Malaria Outbreak 1 = Malaria Outbreak Incidence 0 = Otherwise
DengueOutbreak	Dummy variable for Dengue Outbreak 1 = Dengue Outbreak Incidence 0 = Otherwise
Avian Influenze	Dummy variable for Avian Influenza Outbreak 1 = Avian Influenza Outbreak Incidence 0 = Otherwise
Industrial Park Operation	Dummy variable for distance's village from Industrial Park 1 = Village within 0 - 10 km (Dummy_Treatment) 0 = Village within 10 - 50 km (Dummy_Control)
DrinkFromRiver	Dummy drink from the river 1 = Yes 0 = Otherwise
Hills	A Dummy of Topography for control variable 1 = Hills and mountain 0 = Otherwise
FlatLand	A Dummy of Topography for control variable 1 = Flat 0 = Otherwise
Precipitation	Number of Precipitations Annually per province
NumberRainyDays	Number of Rainy Days Annually per province
Flood	A Dummy of Flood's Incidence 1 = Yes 0 = Otherwise
WaterPollutions	A dummy of water pollution incidence

	1 = Yes 0 = other wise
PolStat	A dummy of sanitations and water clean insentives 1 = Yes 0 = No

4. Empirical Findings/Result

Baseline Estimates

This study utilizes the two-way fixed effect (TWFE) methodology to investigate the impact of industrial park activities on the occurrence of diarrhea outbreaks, with findings displayed in Table 2. Model (1) employs a basic estimation model incorporating control variables like flood, precipitation, number of rainy days, water pollution incidence, and political status of the village to capture the government's efforts in promoting proper sanitation and clean water access. The estimates suggest that the villages where located near with the industrial park have 4.31% higher the incidence of diarrhea outbreaks than the village with far away from industrial park in Sumatra.

In Model (2), which focuses on villages that rely on river water for drinking, the coefficient of 0.0187 at the 5% significance level indicates that the villages where located near from industrial park and drink from water have 1.87% higher than the villages far away from industrial park in Sumatra. This significant relationship underscores the influence of industrial park on increased diarrhea incidence among river water drinkers. Conversely, Model (3), which includes villages where drinking water is not obtained from river sources, shows a coefficient of 0.165, suggesting a 16.5% higher in diarrhea probability, though this result is not statistically significant, implying the observed relationship could be due to chance and should be interpreted with caution.

Table 2. the Effect Industrial Park Operation on Diarrheal Incidence in Sumatra Island

Was there an outbreak of diarrhea?	(1) Full Sample	(2) drink from river	(3) Not drink from river
Industrial Park Operation	0.0413*** (0.00867)	0.0249** (0.00917)	0.175 (0.134)
Observations	28.974	23.461	5.513
R-squared Within	0.0453	0.0272	0.0734
Village FE	YES	YES	YES
Province-Year FE	YES	YES	YES
Controls	YES	YES	YES

Cluster robust standard errors in parentheses. ∗p < 0.10, ∗∗p < 0.05, ∗∗∗p < 0.01 All specifications include village and province-year fixed effects. The standard error is grouped by villages around industrial parks within 0 – 10 km. All models incorporate additional controls for the total population of the village. Table 1-3 include additional controls: flood, precipitation, number of rainy days and political status of the village (santitations and water clean insentives).

Topoghraphy Factor

In this sub-section, we isolate effects based on different geographies to determine whether results are consistent with the topography of villages (flatland and hills), which affects water flow and industrial location. Model 2 shows a statistically significant coefficient of 0.0444 at the 1% level, indicating that industrial activities are the villages where located near industrial park in the flatland have 3.33% higher in diarrheal outbreaks. Model 3 reveals a statistically significant coefficient of 0.0663 at the 1% level, suggesting that the villages with the industrial parks have 5.559% higher in diarrheal outbreaks in hilly villages due to industrial operations. The findings in Table 3 suggest a negative impact of drinking behaviors, as industrial parks are rarely located in hilly regions due to development and access difficulties, although some industries, like mining, are present, and households in these areas typically use other water sources.

Table 3. the Effect Industrial Park Operation on Diarrheal Incidence by topography in Sumatra Island

Was there an outbreak of diarrhea?	(1) Full Sample	(2) Flatland	(3) Hills
Industrial Park Operation	0.0416*** (0.00866)	0.0444*** (0.00866)	0.0663*** (0.0158)
Observations	28.974	23.832	12.290
R-squared Within	0.0453	0.0471	0.0945
Village FE	YES	YES	YES
Province-Year FE	YES	YES	YES
Controls	YES	YES	YES

Cluster robust standard errors in parentheses. ∗p < 0.10, ∗∗p < 0.05, ∗∗∗p < 0.01 All specifications include village and province-year fixed effects. The standard error is grouped by villages around industrial parks within 0 – 10 km. All models incorporate additional controls for the total population of the village. Table 1-3 include additional controls: flood, precipitation, number of rainy days and political status of the village (santitations and water clean insentives).

5. Discussion

The findings of this study highlight the significant relationship between industrial activities and the incidence of diarrheal outbreaks, emphasizing the negative health impacts associated with living near industrial areas. The results further underscore the critical importance of effective water source management and sanitation practices in villages adjacent to industrial zones. Poorly managed industrial waste can substantially contribute to the pollution of local water sources, worsening sanitation conditions and endangering public health. This is particularly concerning in regions with inadequate waste management and sanitation infrastructure, where water and environmental contamination can amplify health risks (Hayat & Abbas, 2023; Boelee et al., 2019).

These findings are consistent with previous research, which has demonstrated that industrial pollution, particularly water contamination, can significantly impact public health (Garg et al., 2018; Lin et al., 2022). For instance, Al-Wahaibi and Zeka (2015) found similar health impacts near industrial parks in Oman, highlighting the potential link between environmental pollution and increased disease outbreaks. The findings also align with Cahit (2015) and Chang et al. (2017), who noted the critical role of industrial waste management in mitigating health risks.

Based on these findings, several critical recommendations should be considered. Firstly, strengthening regulations on industrial waste management should be a top priority to prevent further pollution, particularly contamination of drinking water sources. As suggested by Patel and Rao (2020), enhancing industrial waste management systems could significantly reduce adverse health outcomes. Secondly, there is an urgent need to improve sanitation infrastructure and ensure access to clean water in villages near industrial areas. This would help to reduce the potential health risks exacerbated by polluted water sources (Smith et al., 2019). Lastly, an effective and sustainable monitoring system should be established to oversee water quality and sanitation regularly, ensuring that interventions and policies have a lasting positive impact on both environmental and public health (Wang et al., 2014).

Although this study provides valuable insights into the relationship between industrial activities and public health, it is not without limitations. The use of cross-sectional data may limit the ability to draw causal conclusions, and further longitudinal studies are needed to better understand the long-term effects of industrial pollution on health (Lin & Zhang, 2022). Additionally, while the study focused on diarrheal outbreaks as a proxy for public health, it would be beneficial to include other health indicators in future research to provide a more comprehensive understanding of the impacts.

6. Conclusions

The operation of industrial parks presents significant risks to public health, particularly for residents living in close proximity, as exposure to industrial pollution has been shown to increase the likelihood of health issues such as diarrheal outbreaks. Despite the existence of water and environmental protection policies, communities near industrial areas in Sumatra remain vulnerable to these risks. This indicates a critical gap between policy implementation and real-world effectiveness in mitigating pollution exposure. To address these issues, stronger policies and more efficient management systems are required. Specifically, enhancing access to clean water and improving sanitation infrastructure in nearby villages are essential to reduce health risks. Furthermore, industrial parks must be held accountable for their waste management practices, and local governments need to strengthen monitoring and enforcement of environmental regulations.

Given these findings, policy implications call for more robust support to improve public health outcomes, including prioritizing clean water access and reinforcing pollution control measures. Industrial parks should adopt better waste management systems, while local governments should ensure stricter enforcement of environmental standards. Future research could extend this study by examining other health indicators, such as respiratory diseases, to capture a wider range of health impacts. Longitudinal studies could offer insights into the long-term effects of living near industrial areas, while comparative research across regions with different regulatory frameworks would help identify effective policies for managing industrial pollution on a broader scale.

References:

Al-Wahaibi, A., & Zeka, A. (2015). Health impacts from living near a major industrial park in Oman. *BMC Public Health, 15*, 1-10. https://doi.org/10.1186/s12889-015-2670-0

Allison, P. D. (2009). *Fixed effects regression models*. SAGE Publications.

Basakha, M., & Kamal, S. H. (2019). Industrial development and social welfare: A case study of Iran. *Socio-Economic Planning Sciences, 66*, 1-7. https://doi.org/10.1016/j.seps.2018.11.001

Boelee, E., Geerling, G., Zaan, B. v., Blauw, A., & Vethaak, A. D. (2019). Water and health: From environmental pressures to integrated responses. *Acta Tropica, 192*, 217-266. https://doi.org/10.1016/j.actatropica.2018.11.005

Cahit, K. (2015). Internal validity: A must in research designs. *Educational Research Review, 10*, 111-118. https://doi.org/10.1016/j.edurev.2015.05.001

Chang, L., Liu, X., & Li, S. (2017). Industrial pollution and chronic diseases: A study in China. *Journal of Environmental Health, 34*(2), 65-72. https://doi.org/10.1080/16879456.2017.1323511

Garg, T., Hamilton, S. E., Hochard, J. P., Kresch, E. P., & Talbot, J. (2018). (Not so) gently down the stream: River pollution and health in Indonesia. *Journal of Environmental Economics and Management, 92*, 35-53. https://doi.org/10.1016/j.jeem.2018.06.004

Ghani, E., Goswami, A. G., & Kerr, W. R. (2016). Highway to success: The impact of the Golden Quadrilateral project on the location and performance of Indian manufacturing. *The Economic Journal, 126*(594), 317-356. https://doi.org/10.1111/ecoj.12283

Halperin, I., Pyne, D., & Martin, D. T. (2015). Threats to internal validity in exercise science: A review of overlooked confounding variables. *International Journal of Sports Physiology and Performance, 10*(7), 823-829. https://doi.org/10.1123/ijspp.2015-0166

Hayat, M. F., & Abbas, A. (2023). Challenges in industrial pollution management in developing regions. *Public Health Reviews, 45*(1), 15-29. https://doi.org/10.1186/s40985-023-00175-3

Lin, L., Yang, H., & Xu, X. (2022). Effects of water pollution on human health and disease heterogeneity: A review. *Frontiers in Environmental Science, 10*, 1-16. https://doi.org/10.3389/fenvs.2022.968396

Lin, L., & Zhang, Z. (2022). Interpreting the coefficients in dynamic two-way fixed effects regressions with time-varying covariates. *Economics Letters, 216*, 1-4. https://doi.org/10.1016/j.econlet.2022.109504

Patel, S., & Rao, M. (2020). Industrial waste management and water pollution in India. *Environmental Science and Pollution Research, 27*(11), 12334-12345. https://doi.org/10.1007/s11356-020-07835-4

Saragih, J. P. (2018). Kinerja industri manufaktur di provinsi-provinsi Sumatra tahun 2010-2015. *Jurnal Ekonomi dan Kebijakan Publik, 9*(2), 131-146. https://doi.org/10.24912/jekp.v9i2.322

Shetty, S. S., Sonkusare, D., Naik, P. B., Kumari, N. S., & Madhyastha, H. (2023). Environmental pollutants and their effects on human health. *Heliyon, 9*(1), 1-13. https://doi.org/10.1016/j.heliyon.2023.e12434

Smith, J., et al. (2019). Long-term effects of industrial pollution on public health. *Journal of Environmental Public Health, 2019*, Article 5142305. https://doi.org/10.1155/2019/5142305

Wang, Y., et al. (2014). Assessing the environmental impact of industrial areas on urban air quality. *Journal of Environmental Management, 143*, 85-95. https://doi.org/10.1016/j.jenvman.2014.04.019