JOURNAL LA MEDIHEALTICO

VOL. 05, ISSUE 05 (1163-1170), 2024
DOI: 10.37899/journallamedihealtico.v5i5.1671

The Effect of Residence in Highlands and Industrial Areas on the Incidence of Hypertension

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Article Info

Article history:
Received 30 September 2024
Received in revised form 23 November 2024
Accepted 16 December 2024

Keywords:
Highlands,
Industrial Area
Residence
Hypertension
Pollution
Blood Pressure

Abstract

Hypertension is a measurement of systolic blood pressure (SBP) ≥140 mmHg and/or diastolic blood pressure (DBP) ≥90 mmHg. According to WHO data, the number of adults with hypertension has doubled from 650 million in 1990 to 1.3 billion in 2019. The prevalence in Indonesia in 2018 was around 34.1% and in Kendal it continues to increase every year. People who live in the highlands are at risk of developing hypertension due to differences in the body's physiological processes with people who live in the lowlands. Various types of air pollutants such as particulate matter (PM) are widely recorded as being associated with cardiovascular disease, especially in industrial areas and big cities. This study is to analyze the effect of proximity to highland residences and industrial areas on the incidence of hypertension in Kendal Regency. This study uses observational analytics with a cross-sectional research design. The sampling technique used is purposive sampling. Univariate and bivariate analysis using Chi-Square test. Significant results were obtained based on the Chi-Square test on the effect of residence in the highlands and industrial areas on the occurrence of hypertension with a p-value of 0.000 (p-value <0.05). This study shows the effect of proximity to residence in the highlands and industrial areas on the occurrence of hypertension in Kendal Regency.

Introduction

Hypertension is one of the common chronic diseases that can be characterized by a continuous increase in arterial pressure. Blood pressure has two measurements, namely systolic pressure (pressure when the heart contracts and pumps blood into the arteries) and diastolic pressure (pressure when the heart rests between beats). Hypertension is said to be present if systolic pressure is more than 130 mmHg and diastolic pressure is more than 80 mmHg (Nurochman et al., 2024; Rahmatillah et al., 2020; Katuuk & Masi, 2018; Laura et al., 2020).

Globally, according to WHO data, the number of adults with hypertension has doubled from 650 million in 1990 to 1.3 billion in 2019 (World Health Organization, 2023). Based on SKI 2023, the prevalence of hypertension was still high at 30.8%, but decreased compared to the previous year at 34.1% (Kementerian Kesehatan, 2023). Meanwhile, in Central Java Province, hypertension still occupies the largest proportion of all reported NCDs, which is 72.0% (Dinas Kesehatan Provinsi Jawa Tengah, 2023).The prevalence of hypertension in Kendal Regency always increases every year. In 2021, there were 304,315 people, in 2022 around 310,815 people, and in 2023 around 314,884 people (Dinas Kesehatan Kabupaten Kendal, 2023).

ISSN 2721-1215 (Print), ISSN 2721-1231 (Online)

Kendal Regency is one of 35 regencies/cities in the territory of Central Java Province. The topography of Kendal Regency varies from plains, hills, to mountains with land heights varying between 0 m to more than 500 m above sea level (Dinas Komunikasi dan Informatika Kabupaten Kendal, 2018). In people who live in the highlands, hypoxia will occur which will trigger the process of adaptation of physiological responses to maintain body functions called acclimatization (Storz & Scott, 2019; Mallet et al., 2023). When hypoxia occurs, it will be followed by a compensatory mechanism, such as hyperventilation and increased cardiac output, where increased tissue ventilation and cardiac output can prevent a decrease in inspiratory O2 pressure so that it can increase alveolar O2 pressure and arterial O2 pressure in (Salipadang et al., 2022). In the study Salipadang et al. (2022), significant significance test results were obtained between the highland area and hypertension respectively on changes in systolic and diastolic blood pressure $p = 0.000 < \alpha$ and $p = 0.048 < \alpha$, ($p < 0.005$). Long-term exposure to air pollutants in the form of nitrogen dioxide pollutants and short-term exposure to sulfur dioxide exhaust gas and particulates such as dust can have a risk of hypertension (Zahra et al., 2021; Zhang, 2020). In contrast to research conducted by Zahra et al. (2021), in the study Kephart et al. (2020)that the results of increased CO exposure caused a decrease in systolic blood pressure of 0.17 mmHg (95% CI = -2.38, 2.03) and CO was not associated with diastolic blood pressure (- 0.06 mmHg, 95% CI -1.48 to 1.35) (Kephart et al., 2020).

Based on this background, there are differences in research results so that researchers are interested in conducting this research to prove whether there is an influence related to residence in the highlands and industrial areas with the occurrence of hypertension in Kendal Regency.

Methods

The method used is observational analytic with a *cross-sectional approach*. This study was conducted at the Plantungan Health Center (Highland Area), Brangsong Health Center (Industrial Area Area), and Patebon Health Center (Area far from the highlands and industrial areas). The sample was participants of the Integrated Development Post (Posbindu) in May to July 2024 who lived in the highland areas (Plantungan Health Center), industrial areas (Brangsong Health Center), and not both (Patebon Health Center). The sample size was calculated using the lemeshow formula and a minimum of 96 samples were obtained in each health center. Sampling was carried out using a *purposive sampling type* where the samples were taken based on certain criteria. The inclusion criteria for this study were s all posbindu participants in the highland areas (Plantungan Health Center), industrial areas (Brangsong Health Center), and not both areas (Patebon Health Center), all posbindu participants aged ≥40 years, and have complete health records (address and blood pressure). The type of data used in this study is secondary data. The variables studied were residence in the highland area with the criteria of residential altitude , as well as residence in the industrial area with the criteria of near industry and far industry which will be measured with Google Earth, and blood pressure variables with the criteria of no hypertension (systolic <140 mmHg or diastolic <90 mmHg) and hypertension (systolic ≥140 mmHg or diastolic ≥90 mmHg). Data analysis was carried out univariately and bivariately. The statistical test used was the *Chi-Square test* with a confidence level of 95% (0.05). The researcher has obtained a research permit from the Faculty of Medicine, Muhammadiyah University of Surakarta No.4378./C.4-III/FK/VIII/2024 and research approval from the Head of the National Unity and Politics Agency of Kendal Regency No. 000.9/1537/VIII/2024.

Result and Discussion

Secondary data in this study are residential address, blood pressure, gender and age. The research data were analyzed using *SPSS 25.0 for Windows software* consisting of univariate analysis to determine the frequency distribution and bivariate analysis using the *Chi-Square test* . The following are the results of the data analysis:

Respondent Characteristics

The following univariate t analysis shows that the description of the characteristics of the respondents in this study can be seen in the following table:

Table 1. Characteristics of respondents' residential areas

Region Category	Frequency	Percentage
Plateau	109	26.5%
Industrial area	110	26.7%
Far from the highlands and industrial areas	193	46.8%
Total	**412**	**100%**

Source: Secondary Data (2024)

Based on univariate analysis using SPSS version 26 on the category of area, it is known that there are 109 people with a percentage of 26.5% who live in the highlands, there are 110 people with a percentage of 26.7% who live near the industrial area, and there are 193 people with a percentage of 46.8% who live far from the highlands and industrial areas. The following univariate analysis on the gender variable can be seen in the following table:

Table 2. Gender of respondents

Gender	Frequency	Percentage
Man	56	13.6%
Woman	356	86.4%
Total	**412**	**100%**

Source: Secondary Data (2024)

Based on univariate analysis using SPSS version 26 on gender, it is known that there are 56 people with a percentage of 13.6% who are male and there are 356 people with a percentage of 86.4% who are female. The following are the results of univariate analysis on blood pressure variables can be seen in the following table:

Table 3. Respondents' blood pressure characteristics

Blood pressure	Frequency	Percentage
Normal	250	60.7%
Hypertension	162	39.3%
Total	**412**	**100%**

Source: Secondary Data (2024)

Based on univariate analysis using SPSS version 26 on blood pressure, it is known that there are 250 people with a percentage of 60.7% who suffer from hypertension and there are 162 people with a percentage of 39.3% with normal blood pressure. The following univariate analysis on the age variable can be seen in the table

Table 4. Characteristics of respondent age distribution

Age	Frequency	Percentage
Pre-Elderly and below	282	68.4%
Elderly	130	31.6%
Total	**417**	**100%**

Source: Secondary Data (2024)

Based on univariate analysis using SPSS version 26 regarding age, it is known that there are 282 people with a percentage of 68.4% who are classified as pre-elderly and there are 130 people with a percentage of 31.6% who are classified as elderly.

Bivariate Analysis

The influence of proximity to residential areas in the highlands and industrial areas on the incidence of hypertension.

Table 5. Blood Pressure Distribution by Regional Category

Region category	Blood pressure		total	X^2	p
	Normal (n/%)	Hypertension (n/%)			
Plateau	50 (45.9)	59 (54.1)	109	26,385	0,000
Industrial area	58 (52.7)	52 (47.3)	110		
Control areas (not highlands and industrial areas)	142 (73.6)	51 (26.4)	193		

Source: Secondary Data (2024)

Significant results were obtained based on the *Chi-Square test* on the effect of residence in the highlands and industrial areas on the occurrence of hypertension with a p-value of 0.000 (*p-value* <0.05). In the bivariate analysis above, respondents with residences in the highlands were more likely to have hypertension, as many as 59 samples (54.1%). While respondents with residences in industrial areas were more likely to have normotensive conditions, as many as 58 samples (52.7%).

The Effect of Proximity of Residence to the Highlands on the Incidence of Hypertension

Based on the study, it is known that there is an influence of residence in the highlands on the occurrence of hypertension. This is evidenced by the large p-value obtained of 0.000 (0.000 <0.05). So it can be concluded that there is an influence of residence in the highlands on the occurrence of hypertension in Kendal Regency. Hypertension or high blood pressure is an increase in systolic blood pressure of more than 140 mmHg and diastolic blood pressure of more than 90 mmHg in two measurements with an interval of five minutes in a state of sufficient rest or calm (Apipin & Winarti, 2021). The occurrence of hypertension is influenced by various factors, one of which is the geographical location in the form of the height of the place of residence (Kartikasari, 2012; Bhatnagar, 2017).

The altitude of a person's residence affects the physiological condition of the body (Honigman et al., 1993). The higher the altitude, the lower the temperature and the thinner the oxygen content in the air. This has an impact on the physiological process of the body in the form of hypoxia (Budihartono & Afriliana, 2019; Chen et al., 2020). The occurrence of hypoxia will trigger the process of adaptation of physiological responses to maintain body functions called acclimatization. In addition, the occurrence of hypoxia will be followed by the occurrence of a compensation mechanism, such as hyperventilation and increased cardiac output, where increased tissue ventilation and cardiac output can prevent a decrease in inspiratory O2 pressure so that it can increase alveolar O2 pressure and arterial O2 pressure in, so that it will increase tissue O2 saturation. Increased cardiac output as a result of the compensation mechanism for tissue hypoxia is mainly due to an increase in heart rate regulated by the autonomic nervous system (Salipadang et al., 2022; Amann & Kayser, 2009; Arjamaa & Nikinmaa, 2011).

The results of this study are in line with the results of a study conducted by Verratti et al. (2020) which found that there is an influence of residential altitude characteristics on the incidence of hypertension (P <0.05). The results of another study conducted by Salipadang et al. (2022) also

found that there is a unidirectional, real and meaningful relationship between differences in altitude and changes in systolic and diastolic blood pressure. Different results are shown by the results of a study conducted by which Prihanto et al. (2024) concluded that there is no relationship between residential area and the incidence of hypertension. This is evidenced by the results of a study which found that there was no difference between the systolic blood pressure of residents of the Gurabunga area and the coastal area of Maitara Island.

The Influence of Proximity of Residence to Industrial Areas on the Incidence of Hypertension

The results of this study also found that there is an influence of residence in an area near industry with the prevalence of hypertension. This is evidenced by the large p-value obtained of 0.000 (0.000 <0.05). So it can be concluded that there is an influence of residence in an area near industry with the prevalence of hypertension in Kendal Regency. Kendal Regency is one of the areas chosen to be processed into an industrial area because of its strategic location and flat topography and is located in the coastal area of the north coast of Java Island (Fadhlurrohman et al., 2020; Rudiarto et al., 2018).

Based on Government Regulation No. 85 of 2019, it is stated that the Kendal Industrial Area (KIK) is the only holder of Special Economic Zone (KEK) status in the industrial sector on the island of Java. KIK is also known as the developer of the largest private industrial area in Central Java with a development area of around 2,200 hectares (Ayatullah et al., 2023). Along with the development of Kendal Regency as an industrial area, various pollutants that can have a negative impact on health have also increased. One example of a pollutant that has a negative impact on health is carbon monoxide. Carbon monoxide is an odorless, tasteless, and colorless compound produced from the incomplete combustion process of carbon-containing fuels such as burning oil, coal, wood, or kerosene. When CO is inhaled and absorbed by the lungs, CO can bind to hemoglobin to form carboxyhemoglobin (COHb) which can interfere with the absorption of oxygen in the blood (Zahra et al., 2021; Pan et al., 2020).

The results of this study are in line with the results of research conducted by Zahra et al. (2021), found that long-term exposure to air pollutants in the form of nitrogen dioxide pollutants and short-term exposure to sulfur dioxide exhaust gas and particulates such as dust can have a risk of hypertension. Another risk factor is exposure to carbon monoxide, with the highest concentrations found in heavy traffic and industrial combustion. The results of other studies conducted by Xu et al. (2022) which found that the higher the level of air pollution, the stronger the relationship with hypertension. Different results were found in Kephart's study (2020) which concluded that increased exposure to CO in people living in industrial areas can cause a decrease in systolic and diastolic blood pressure. So it can be concluded that there is no relationship between air pollution in industrial areas and the incidence of hypertension.

Research Limitations

This research is not free from several weaknesses which are limitations of the research, the limitations in this research are: 1) Not all risk factors for Hipertensi can be found in this study, because the analysis conducted was only based on the data found; 2) This study uses a *cross-sectional research design*, where the data collection process is carried out at one time. So that researchers cannot provide a causal explanation and only show the relationship between variables.

Conclusion

Based on the results of the study and discussion on respondents at Plantungan Health Center, Brangsong Health Center, and Patebon Health Center, it can be concluded that there is a significant relationship between the proximity of residence in the highlands and the incidence of hypertension in Kendal Regency with *a p-value* of 0.000 (<0.05 means very significant),

and there is a significant relationship between the proximity of residence to the industrial area and the incidence of hypertension in Kendal Regency with *a p-value* of 0.000 (<0.05 means very significant), and the number of respondents who experience hypertension is greater in the industrial area. The implications of this study indicate that the proximity of residence in the highlands and industrial areas is a risk factor for hypertension in Kendal Regency.

Acknowledgement

The author would like to thank the Faculty of Medicine, Muhammadiyah University of Surakarta for providing supporting facilities for this research. The author would also like to thank the National Unity and Politics Agency of Kendal Regency (Kesbangpol) and the Plantungan Health Center, Brangsong Health Center, and Patebon Health Center for granting permission to conduct the research.

References

Amann, M., & Kayser, B. (2009). Nervous system function during exercise in hypoxia. *High Altitude Medicine & Biology*, *10*(2), 149-164. https://doi.org/10.1089/ham.2008.1105

Apipin, & Winarti, R. (2021). Penerapan Terapi Dzikir untuk Menurunkan Tingkat Kecemasan pada Pasien Hipertensi di Desa Bago. *Jurnal NERS Widya Hussada.* [e-journal]. https://journal.uwhs.ac.id/index.php/jners/article/view/585

Arjamaa, O., & Nikinmaa, M. (2011). Hypoxia regulates the natriuretic peptide system. *International Journal of Physiology, Pathophysiology and Pharmacology*, *3*(3), 191.

Ayatullah, M. A., Syafrudin, S., & Sarmingsih, A., 2023. Analisis Manajemen Waktu Pada Proyek Pembangunan Jalan Parang Garuda East Kawasan Industri Kendal. *Jurnal Profesi Insinyur Indonesia*, [e-journal] 1(3), pp 88–92. https://doi.org/10.14710/jpii.2023.17193

Bhatnagar, A. (2017). Environmental determinants of cardiovascular disease. *Circulation research*, *121*(2), 162-180. https://doi.org/10.1161/CIRCRESAHA.117.306458

Budihartono, E., & Afriliana, I. (2019). Monitoring Ketinggian Plateau Berbasis Mikrokontroler Menggunakan Atmega 328 Dan Sensor Altimeter. *Sebatik*, *23*(2), 440-446.

Chen, P. S., Chiu, W. T., Hsu, P. L., Lin, S. C., Peng, I. C., Wang, C. Y., & Tsai, S. J. (2020). Pathophysiological implications of hypoxia in human diseases. *Journal of biomedical science*, *27*, 1-19. https://doi.org/10.1186/s12929-020-00658-7

Dinas Kesehatan Kabupaten Kendal, 2023. *Profil Kesehatan Kabupaten Kendal 2023*. (pdf) www.dinkes.kendalkab.go.id [Accessed 8 September 2024]

Dinas Kesehatan Provinsi Jawa Tengah. 2023. *Profil Kesehatan Jawa Tengah Tahun 2023*. (pdf) www.dinkes.jatengprov.go.id [Accessed 8 September 2024]

Dinas Komunikasi dan Informatika Kabupaten Kendal. (2022). *Potret Wilayah Kabupaten Kendal 2022*. (pdf) https://diskominfo.kendalkab.go.id/wp-content/uploads/2022/10/POTRET-WILAYAH-KABUPATEN-KENDAL-2022.pdf [Accessed 21 Oktober 2024]

Fadhlurrohman, B., Prasetyo, Y., & Bashit, N., 2020. Studi Penurunan Muka Tanah di Kawasan Industri Kendal Dengan Metode Permanent Scatterer Interferometric Synthetic Aperture Radar (PS InSAR) Menggunakan Citra Sentinel 1-A Tahun 2014-2019. *Jurnal Geodesi Undip*, [e-journal] 9(2), pp 155–166. https://ejournal3.undip.ac.id/index.php/geodesi/article/view/27177 [Accessed 13 September 2024]

Honigman, B., Theis, M. K., Koziol-McLain, J., Roach, R., Yip, R., Houston, C., & Moore, L. G. (1993). Acute mountain sickness in a general tourist population at moderate altitudes. *Annals of internal medicine*, *118*(8), 587-592. https://doi.org/10.7326/0003-4819-118-8-199304150-00003

Kartikasari, A. N. (2012). Faktor Risiko Hipertensi pada Masyarakat di Desa Kabongan Kidul, Kabupaten Rembang. *JURNAL MEDIA MEDIKA MUDA*, [e-journal]. https://media.neliti.com/media/publications/115982-ID-faktor-risiko-hipertensi-pada-masyarakat.pdf

Katuuk, M. E., & Masi, G. M. (2018). Hubungan aktivitas fisik dengan derajat hipertensi pada pasien rawat jalan di wilayah kerja Puskesmas Tagulandang Kabupaten Sitaro. *Jurnal Keperawatan*, *6*(1). https://doi.org/10.35790/jkp.v6i1.25228

Kephart, J. L., Fandiño-Del-Rio, M., Koehler, K., Bernabe-Ortiz, A., Miranda, J. J., Gilman, R. H., Checkley, W., Checkley, W., & Checkley, W., 2020. Indoor Air Pollution Concentrations and Cardiometabolic Health Across Four Diverse Settings in Peru: A cross-sectional study. *Environmental Health: A Global Access Science Source*, [e-journal] 19(1), pp 1–13. https://doi.org/10.1186/s12940-020-00612-y

Laura, A., Darmayanti, A., & Hasni, D. (2020). Evaluasi Penggunaan Obat Antihipertensi Di Puskesmas Ikur Koto Kota Padang Periode 2018. *Human Care Journal*, *5*(2), 570-576. http://dx.doi.org/10.32883/hcj.v5i2.712

Mallet, R. T., Burtscher, J., Pialoux, V., Pasha, Q., Ahmad, Y., Millet, G. P., & Burtscher, M. (2023). Molecular mechanisms of high-altitude acclimatization. *International journal of molecular sciences*, *24*(2), 1698. https://doi.org/10.3390/ijms24021698

Nurochman, M. A., Sudaryanto, W. T., & Debi, S. S., 2024. Penyuluhan Hipertensi Kepada Pengunjung Posyandu RW 14 Kelurahan Sumber. *Cakrawala: Jurnal Pengabdian Masyarakat Global*, [e-journal] 3(1), pp 126–132. https://doi.org/10.30640/cakrawala.v3i1.2122

Pan, K. T., Leonardi, G. S., & Croxford, B. (2020). Factors contributing to CO uptake and elimination in the body: A critical review. *International journal of environmental research and public health*, *17*(2), 528. https://doi.org/10.3390/ijerph17020528

Prihanto, E. S. D., Giringan, F., Fahira, R. J., & Kamal, R. M. (2024). Perbandingan Hipertensi pada Masyarakat Yang Tinggal di Pesisir Pulau Maitara dan Daerah Dataran Tinggi Gurabunga Tidore. *Syntax Idea*, *6*(2), 783-793. https://doi.org/10.46799/syntax-idea.v6i2.2930

Rahmatillah, V. P., Susanto, T., & Nur, K. R. M. (2020). Hubungan Karakteristik, Indeks Massa Tubuh (IMT) dengan Tekanan Darah pada Lanjut Usia di Posbindu. *Media Penelitian Dan Pengembangan Kesehatan*, *30*(3), 233-240. https://doi.org/10.22435/mpk.v30i3.2547

Rudiarto, I., Handayani, W., & Sih Setyono, J. (2018). A regional perspective on urbanization and climate-related disasters in the northern coastal region of central Java, Indonesia. *land*, *7*(1), 34. https://doi.org/10.3390/land7010034

Salipadang, F. P., Danes, V. R., & Moningka, M. E. W., 2022. Hubungan Perbedaan Ketinggian dengan Perubahan Tekanan Darah pada Pelaku Perjalanan dari Dataran Rendah ke Dataran Tinggi dan dari Dataran Tinggi ke Dataran Rendah. *EBiomedik*, [e-journal] 10(1), pp 20–28. https://doi.org/10.35790/ebm.v10.i1.37820

Storz, J. F., & Scott, G. R. (2019). Life ascending: mechanism and process in physiological adaptation to high-altitude hypoxia. *Annual Review of Ecology, Evolution, and*

Systematics, *50*(1), 503-526. https://doi.org/10.1146/annurev-ecolsys-110218-025014

Verratti, V., Ferrante, C., Soranna, D., Zambon, A., Bhandari, S., Orlando, G., Brunetti, L., & Parati, G. (2020). Effect of high-altitude trekking on blood pressure and on asymmetric dimethylarginine and isoprostane production: Results from a Mount Ararat expedition. *Journal of Clinical Hypertension*, *22*(8), 1494–1503. https://doi.org/10.1111/jch.13961

World Health Organization. (2023). *Global report on hypertension The race against a silent killer*. (pdf) https://iris.who.int/handle/10665/372896 [Accessed 26 September 2024] Rahmadhani, M., 2021.

Xu, J., Niehoff, N. M., White, A. J., Werder, E. J., & Sandler, D. P. (2022). Fossil-fuel and combustion-related air pollution and hypertension in the Sister Study. *Environmental Pollution*, *315*. https://doi.org/10.1016/j.envpol.2022.120401

Zahra, H. R., Budiyono, B., & Nurjazuli, N., 2021. Systematic Review: Paparan Karbon Monoksida Dan Gangguan Tekanan Darah Pada Dewasa Dan Lansia. *Jurnal Kesehatan Lingkungan: Jurnal Dan Aplikasi Teknik Kesehatan Lingkungan*, [e-journal] 18(2), pp 97–110. https://doi.org/10.31964/jkl.v18i2.305

Zhang, X. (2020). Particles Matter, Nitrogen Dioxide and Sulfur Dioxide. *Indoor Environmental Quality and Health Risk toward Healthier Environment for All*, 217-235. https://doi.org/10.1007/978-981-32-9182-9_11