MICROBIOLOGICAL INFECTION RISKS AMONG CHILDREN IN SUB-URBAN SETTLEMENT OF MAKASSAR

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Abstract:

Microbiological infections in children are still a significant health problem, especially in sub-urban environments with suboptimal sanitation infrastructure. Environmental factors and hygiene habits play a big role in increasing or decreasing the risk of infection. This study aims to analyze the relationship between home sanitation conditions, housing density, children's hygiene habits, and the incidence of microbiological infections in children in Bontote'ne Housing, Makassar. This study uses an analytical descriptive study design with a cross-sectional approach. A total of 50 children aged 5–12 years and their parents participated as respondents. Data were collected through questionnaires regarding environmental factors, children's hygiene habits, and history of microbiological infections. The analysis was performed using Chi-Square tests and logistic regression to identify the relationship between independent variables and bound variables. The results showed that poor sanitation, high residential density, and inadequate handwashing practices were significantly associated with increased rates of gastrointestinal, respiratory, and diarrhoeal infections. Handwashing with soap was identified as a key protective factor.This study confirms that environmental factors and hygiene habits have an important role in the incidence of microbiological infections in children. Public health interventions such as improving sanitation infrastructure, improving access to clean water, and ongoing hygiene education are needed to reduce the risk of infection in sub-urban environments.

Keywords*: Children, Microbiological Infections, Sanitation, Sub-urban.*

Abstrak:

Infeksi mikrobiologi pada anak-anak masih menjadi permasalahan kesehatan yang signifikan, terutama di lingkungan sub-urban dengan infrastruktur sanitasi yang kurang optimal. Faktor lingkungan dan kebiasaan kebersihan memainkan peran besar dalam meningkatkan maupun menurunkan risiko infeksi. Penelitian ini bertujuan untuk menganalisis hubungan antara kondisi sanitasi rumah, kepadatan hunian, kebiasaan kebersihan anak, dan kejadian infeksi mikrobiologi pada anak-anak di Perumahan Bontote'ne, Makassar. Studi ini menggunakan desain penelitian deskriptif analitik dengan pendekatan *cross-sectional*. Sebanyak 50 anak berusia 5–12 tahun beserta orang tua mereka berpartisipasi sebagai responden. Data dikumpulkan melalui kuesioner mengenai faktor lingkungan, kebiasaan kebersihan anak, dan riwayat infeksi mikrobiologi. Analisis dilakukan dengan uji Chi-Square dan regresi logistik untuk mengidentifikasi hubungan antara variabel bebas dan variabel terikat. Hasil penelitian menunjukkan bahwa sanitasi yang buruk, kepadatan hunian yang tinggi, dan praktik mencuci tangan yang tidak memadai berhubungan secara signifikan dengan peningkatan kejadian infeksi saluran cerna, infeksi pernapasan, dan diare. Mencuci tangan dengan sabun diidentifikasi sebagai faktor protektif utama. Penelitian ini menegaskan bahwa faktor lingkungan dan kebiasaan kebersihan memiliki peran penting dalam kejadian infeksi mikrobiologi pada anak. Intervensi kesehatan masyarakat seperti perbaikan infrastruktur sanitasi, peningkatan akses terhadap air bersih, dan edukasi kebersihan yang berkelanjutan diperlukan untuk menurunkan risiko infeksi di lingkungan sub-urban.

Kata kunci: *Anak-anak, Infeksi mikrobiologi, Sanitasi, Sub-urban.*

INTRODUCTION

Microbiological infections are one of the major challenges in children's health, especially in areas with environmental conditions that lack optimal sanitation and hygiene. Children are more susceptible to infection due to their not yet fully developed immune systems as well as lifestyle habits that often increase exposure to pathogenic microorganisms (Pires, S. M., et al., 2018). Epidemiological studies show that infectious diseases such as diarrhoea, acute respiratory tract infections, as well as skin and parasitic infections, are more prevalent in children living in environments with poor sanitation and inadequate hygiene practices (Freeman et al., 2014). This condition is further exacerbated by socio-economic factors that often limit access to clean water, sanitation facilities, and adequate hygiene education (Prüss-Ustün, A. et al., 2019).

Environmental factors have a very significant role in the spread of infectious diseases in children. According to a WHO report, about 58% of cases of diarrhoea in children in developing countries are directly related to a lack of access to clean water and poor sanitation (WHO, 2020). Children who live in areas with poor drainage systems, environmental pollution, and limited availability of clean water are at higher risk of infections caused by bacteria, viruses, and parasites (Haque, M. A. et al., 2020). In addition, environmental factors that include population density, air quality, and living conditions can also affect children's exposure levels to infectious pathogens (Schwarzenberg et al., 2018).

In addition to environmental factors, hygiene habits are also the main determinant of the risk of microbiological infections in children. Habits such as washing hands with soap, the use of footwear, and body and clothing hygiene are strongly related to the incidence of infectious diseases, especially among school-age children (Aiello et al., 2018). A study found that the habit of washing hands with soap can reduce the incidence of diarrhoea in children by up to 48% (Luby et al., 2015). However, in many areas, especially in sub-urban settings with limited access to sanitation facilities and hygiene education, hygiene awareness and practices are still often ignored (Wolf et al., 2018). Gender differences are also a factor to consider, with some studies showing that boys tend to have lower hygiene habits than girls, which can increase their risk of infection (Scott, N. et al., 2019).

Sub-urban areas, such as in Bontote'ne Housing, Makassar, often face sanitation and hygiene-related challenges that lie between urban and rural conditions. Despite having better infrastructure than rural areas, many sub-urban areas still experience limitations in access to clean water, sewage systems, and effective health education (Garn et al., 2016). Studies conducted in various sub-urban areas show that children in these regions have a fairly high risk of infection due to a combination of less supportive environmental factors and suboptimal hygiene habits (Biswas, R. et al., 2019; Verma & Bajpai, 2021). Bontote'ne Housing was purposively selected as the research location because it typifies transitional sub-urban settlements in Makassar, where rapid population growth has not been matched with proportional improvement in sanitation and hygiene infrastructure. Local health records from community health centers (Puskesmas) and neighborhood reports indicate a recurring incidence of diarrheal and

respiratory infections among children in recent years, making it a representative context for examining infection risks linked to environmental and behavioral factors. Therefore, it is important to understand how these two factors contribute to the risk of microbiological infections in children in sub-urban settings, particularly in Makassar, to formulate more effective prevention strategies.

Based on these problems, this study aims to analyze the relationship between environmental factors and hygiene habits and the risk of microbiological infection in children living in residential areas in the sub-urban area of Makassar. This research is expected to provide deeper insights into infection risk factors based on gender and provide recommendations for efforts to improve child hygiene and health in sub-urban environments.

LITERATURE REVIEW

This literature review discusses various aspects that support research, including microbiological infections in children, environmental factors that affect the risk of infection, hygiene habits, and public health challenges in suburban areas. With a strong theoretical foundation and empirical evidence, this study is expected to provide a new perspective on the relationship between environmental factors, hygiene habits, and the incidence of microbiological infections in children.

Microbiological Infections in Children

Microbiological infections in children are one of the global health challenges that continue to be a major concern in the medical and public health world. Children's immune systems that have not been optimally developed make them more susceptible to various pathogens, whether from the environment, food, or direct contact with other infected individuals (Pires, S. M., et al., 2018). In addition, children's exploration activities such as playing on the ground, sharing toys, and lack of awareness in maintaining personal hygiene further increase the likelihood of transmission of pathogenic microorganisms.

The most common diseases found due to microbiological infections in children are gastrointestinal tract infections, respiratory tract infections, and skin infections. Diarrhea, which is often caused by *Escherichia coli*, *Salmonella* spp., and Rotavirus, is still the leading cause of child morbidity and mortality, especially in developing countries (Li, L. L. et al., 2016). In addition, pneumonia due to *Streptococcus pneumoniae* and *Haemophilus influenzae* are also the leading causes of deaths under five in the world, especially in areas with poor access to sanitation and health services (Walker et al., 2013).

Previous research has shown that environmental factors, such as water hygiene and sanitation, have a significant influence on the incidence of these infections. A study found that children who live in areas with poor sanitation are more likely to develop gastrointestinal infections than those who have access to proper hygiene facilities (Freeman et al., 2014). Therefore, understanding the relationship between the environment and hygiene habits and the incidence of microbiological infections is important to design more effective interventions in reducing the incidence of infectious diseases in children.

Environmental Factors Affecting the Risk of Infection

The living environment is one of the main factors that determine the level of exposure of children to pathogenic microorganisms. Areas with poor sanitation conditions, limited access to clean water, and inadequate sewage disposal systems tend to have higher incidence rates of infection. WHO reports that 23% of child deaths in the world are caused by modifiable environmental factors, such as contaminated water, air pollution, and unhealthy housing (WHO, 2020).

In the context of sub-urban areas, environmental challenges often lie between urban and rural conditions. On the one hand, rapid urbanization leads to increased population density, while on the other hand, sanitation infrastructure is not necessarily adequate to support the growing needs of the community (Haque, M. A. et al., 2020). For example, a study conducted by Wolf et al. found that children who lived in areas with poor drainage systems and inefficient waste management were more likely to develop diseases due to microbiological infections compared to those who lived in environments with better sanitation (Wolf et al., 2018).

Other environmental factors that are no less important are air pollution and climate change. Schwarzenberg et al. showed that children who are exposed to air pollution in the long term have a higher risk of developing respiratory tract infections, especially pneumonia and bronchitis (Schwarzenberg et al., 2018). Likewise, climatic factors, such as humidity and air temperature, can affect the survival of pathogenic microorganisms as well as infection rates in an area (Scott, N. et al., 2019). Therefore, this study is important to understand how specific environmental factors in the sub-urban area of Makassar contribute to the risk of microbiological infections in children.

Hygiene Behavior and Its Impact on Children's Health

In addition to environmental factors, children's hygiene habits also have a significant role in determining the risk of infection. Good hygiene practices, such as washing hands with soap, maintaining nail hygiene, bathing regularly, and maintaining clean clothing, have been shown to reduce the likelihood of infection in children (Aiello et al., 2018). Luby et al. (2015) in their research found that handwashing behavioural interventions can reduce the incidence of diarrhoea in children by up to 48%, which suggests that this simple habit has a great impact on children's health.

Awareness of the importance of cleanliness is often influenced by a variety of factors, including economic factors, parental education, and social norms. A study by Scott et al. found that boys were more likely to have poor hygiene habits than girls, which had an impact on the high incidence of infection in this group (Scott, N. et al., 2019). In addition, limited resources are also the main obstacle for poor families in maintaining cleanliness, for example, due to the difficulty of accessing clean water and hygiene products (Garn et al., 2016).

In the context of this study, it is important to understand how the hygiene habits of children in the sub-urban areas of Makassar affect the risk of microbiological infections they face. Thus, a more effective intervention strategy can be proposed based on local socio-economic conditions.

Research Gaps and Contributions of This Study

Although many studies have addressed environmental and hygiene factors regarding microbiological infections in children, few studies have specifically highlighted sub-urban areas in Indonesia. Most research focuses more on high-density urban areas or rural areas with limited sanitation infrastructure, while the unique challenges in sub-urban areas are often overlooked (Prüss-Ustün, A. et al., 2019).

This study aims to fill this gap by examining the relationship between environmental factors, hygiene habits, and the incidence of microbiological infections in children in Makassar sub-urban housing. By understanding the specific risk factors that contribute to the spread of infection in these areas, it is hoped that this study can provide more targeted policy recommendations in efforts to prevent infectious diseases in children in sub-urban areas.

METHODS

This study was designed to analyze the relationship between environmental factors, hygiene habits, and risk of microbiological infection in children in Makassar sub-urban housing. The approach used in this study is quantitative with questionnaire-based survey methods and interviews to obtain comprehensive data on the factors that contribute to the incidence of microbiological infections in children.

Research Design

This study uses an analytical descriptive study design with a cross-sectional approach. This approach allows data collection in a given time to evaluate the relationship between independent variables, i.e. environmental factors and hygiene habits, and bound variables, i.e. the incidence of microbiological infections in children. This method was chosen because it is efficient in identifying risk factors and providing an epidemiological picture of a health problem in the community in a shorter time compared to the longitudinal method. In addition, this approach is also commonly used in public health research to explore the relationship between risk factors and disease incidence in specific populations (Setia, 2016).

Population and Sample

The population in this study is all children aged 5 to 12 years who live in Bontote'ne Housing, Tamangapa Village, Manggala District, Makassar City. This age group was chosen because children in this age range already have more independent hygiene habits but are still under parental supervision. In addition, this age group is also susceptible to microbiological infections due to the high level of activity in the surrounding environment.

Sample selection was carried out using the purposive sampling method by considering certain criteria to obtain relevant and representative data. The inclusion criteria in this study include children aged 5 to 12 years who have been domiciled in Bontote'ne Housing for at least six months. Respondents who participated in this study were parents or guardians of children who were willing to provide information about

their child's hygiene habits and health history. Meanwhile, the exclusion criteria include children with congenital diseases that can affect the immune system, such as immunodeficiency disorders, as well as parents or guardians who are unwilling to provide complete information.

The number of samples was determined using the Slovin formula to ensure a sufficient number of respondents to obtain representative data. Slovin formula with a set margin of error of 5%. The results of the calculation of the number of samples obtained were adjusted to the response rate and the possibility of invalid data (Creswell, J. W. & Creswell, J. D., 2018).

Data Collection Techniques

Data collection was carried out using structured questionnaires distributed to parents or guardians of children, along with semi-structured interviews conducted with local health workers and selected parents. The questionnaire was developed based on an extensive review of relevant literature and adapted from previously validated instruments commonly used in public health assessments. It consisted of four major sections: the first section collected demographic data, including the child's age, gender, parental education level, and household size; the second section explored environmental sanitation conditions such as the quality of drinking water, toilet and waste systems, house density, and proximity to health facilities; the third section measured hygiene-related behaviors, including handwashing frequency, bathing habits, use of footwear, food handling, and snacking habits; and the final section documented the history of infections reported within the last three months, including gastrointestinal, skin, and respiratory tract infections.

To ensure the quality of the instrument, the questionnaire underwent a process of content validation conducted by a panel of three experts: two public health specialists and one pediatric epidemiologist. They assessed the clarity, relevance, and representativeness of each item based on the study objectives. Revisions were made based on the panel's recommendations to improve the construct integrity of the instrument. Following validation, a pilot test was carried out involving 10 respondents from a comparable sub-urban neighborhood. The purpose of the pilot was to assess the reliability of the questionnaire. Cronbach's alpha values obtained from this pilot ranged between 0.72 and 0.81 across the four sections, indicating acceptable to good internal consistency. Based on these results, the final version of the questionnaire was deemed reliable and used for full-scale data collection.

In addition to the quantitative survey, semi-structured interviews were carried out with health workers and several purposively selected parents. These interviews aimed to capture deeper insights into hygiene practices, environmental challenges, and community health concerns. The inclusion of qualitative interviews also served as a triangulation strategy, enabling the researchers to cross-check and confirm the consistency of data obtained from the questionnaires. This integration of data sources helped to strengthen the validity of the findings and provided richer contextual

understanding for interpreting patterns of microbiological infections in the study population.

Data Analysis Techniques

The data obtained from the questionnaire were analyzed using descriptive and inferential statistical methods. Descriptive analysis was used to describe respondent characteristics, environmental factors, and children's hygiene habits in the form of frequency distributions and diagrams. Meanwhile, inferential analysis was used to test the relationship between environmental factors and hygiene habits and the incidence of microbiological infections in children.

The Chi-Square test is used to test the relationship between environmental factors and hygiene habits and the incidence of microbiological infections. If a significant association is found, logistic regression analysis is performed to determine the factors that have the greatest influence on the incidence of microbiological infections. Data analysis is performed using statistical software such as SPSS to ensure accurate and reliable results.

Triangulation was used to enhance data credibility by comparing patterns emerging from the quantitative analysis of questionnaires with qualitative data from interviews. This helped confirm consistency between self-reported hygiene practices and observations made by health professionals, thereby strengthening the interpretation of key findings.

Research Ethics

This research was carried out by paying attention to the ethical principles of research involving humans. Before data collection, the parents or guardians of each child participating in the study were provided with complete information about the objectives, benefits, and risks of the study. Consent to participation is given in writing through an informed consent form.

The confidentiality of the data is strictly maintained, where the identity of the respondents is kept confidential and only used for research purposes. This research also received permission from relevant institutions, including from the local government and the health research ethics committee. Thus, the entire research process is carried out by applicable research ethics standards.

Research Limitations

Although this study was designed with a systematic method, some limitations need to be considered. This study did not involve laboratory tests, so data on microbiological infections were based only on reports from parents and health workers, which could potentially lead to bias in disease reporting. In addition, data collection through questionnaires is self-reported, so the accuracy of answers depends on the memory and perception of respondents.

This study also has limitations in the scope of the area, as it only focuses on one sub-urban housing complex in Makassar. Therefore, the results of this study may not be

generalized to all other sub-urban areas. Nevertheless, this study still makes a significant contribution to understanding the relationship between environmental factors, hygiene habits, and the risk of microbiological infections in children in suburban environments.

FINDINGS AND DISCUSSION

This study reveals the relationship between environmental factors, hygiene habits, and the risk of microbiological infection in children in Bontote'ne Housing, Makassar. The results were analyzed descriptively and inferentially to identify patterns of relationships between variables and compared with previous studies to provide a more in-depth interpretation.

Responsive Features

This study involved 50 children aged 5 to 12 years living in Bontote'ne Housing, Makassar. Of the total respondents, there were 28 boys and 22 girls The composition of respondents by gender is shown in Figure 1. The majority of respondents came from families with more than four members, while a small percentage came from small families with three or four family members. In terms of parents' educational backgrounds, 60% have secondary education (junior high school/high school), 30% only complete basic education, and 10% have higher education.

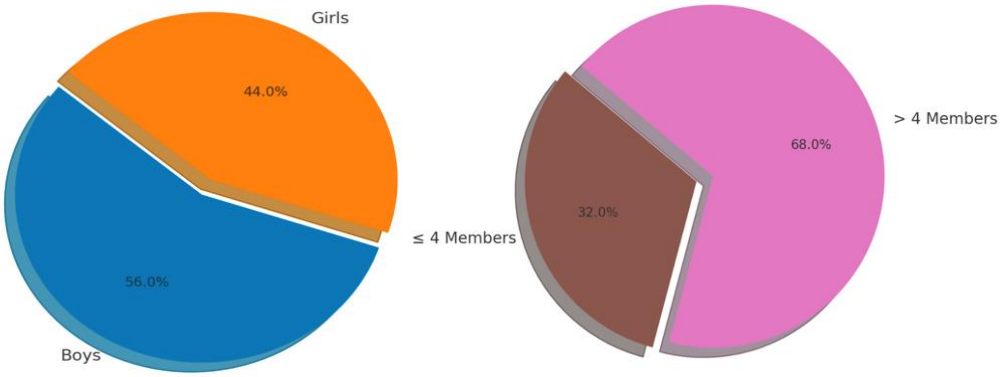

Figure 1. Gender Distribution and Household Size of Respondents

Economically, 56% of families are in the lower middle economic category. This shows that most of the respondents come from neighbourhoods with limited access to adequate sanitation facilities and hygiene education. A study by Prüss-Ustün et al. shows that socio-economic factors and parental education levels play an important role in children's hygiene habits and access to a healthy environment (Prüss-Ustün, A. et al., 2019).

In addition to gender distribution, the composition of the number of family members is also a factor that can affect children's health and hygiene patterns. Of the total respondents, 34 children came from families with more than four members, while 16 children lived in small families with four or fewer members.

The density of family members in a single home can have an impact on sanitation and hygiene, especially if resources such as clean water and sanitation facilities are

limited. Research by Schwarzenberg et al. showed that children who lived in homes with a larger number of occupants tended to have a higher risk of infection due to increased contact with pathogens in a crowded domestic environment (Schwarzenberg et al., 2018).

Parents' education level also plays a role in shaping children's hygiene and health habits. Of the total respondents, 30% of parents only have basic education, 60% complete secondary education (junior high school/high school), and only 10% have higher education. The composition of the education level of parents can be seen in Figure 2.

Parents' education level often correlates with parenting and understanding of good hygiene practices. A study by Freeman et al. shows that parents with higher levels of education tend to have a better awareness of the importance of hygiene and sanitation for children's health (Freeman et al., 2014). In contrast, families with lower levels of education often have limited access to information, increasing the risk of disease exposure due to suboptimal hygiene. This condition is further aggravated when combined with economic limitations. Most of the families in the study, 56%, were in the lower middle economic category, which could affect their access to proper sanitation facilities and clean water.

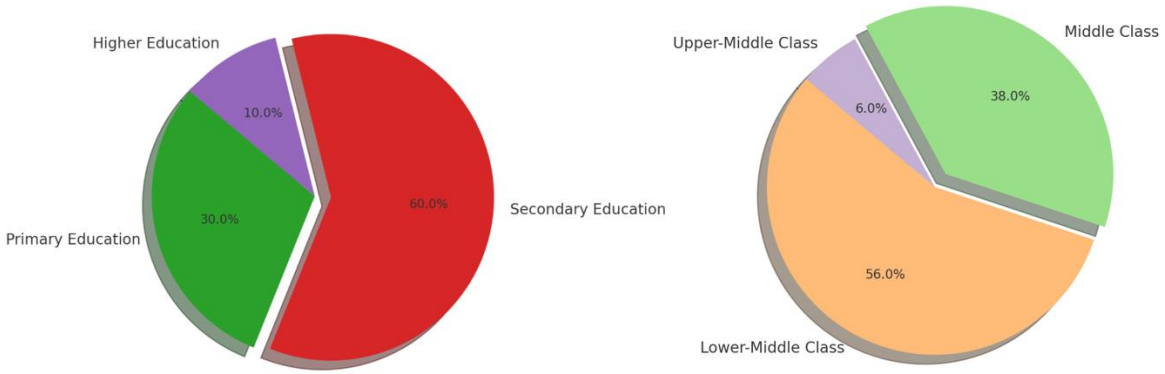

Figure 2. Parental Education Level and Socioeconomic Status of Respondents

The family's economic condition also affects access to proper health and sanitation facilities. Of the total respondents, 56% came from families with lower middle economic status, 38% from middle economic families, and only 6% came from upper middle economic families as illustrated in Figure 2. A family's economic status affects their ability to provide clean water, sanitation facilities, and hygiene products such as soap and antiseptics. Studies by Prüss-Ustün et al. show that economic limitations are often associated with the low quality of the living environment as well as the lack of effective hygiene education (Prüss-Ustün, A. et al., 2019). As a result, children from economically disadvantaged families are more susceptible to infectious diseases due to exposure to pathogens from the surrounding environment.

Environmental Factors and Risk of Infection

The living environment has a significant role in increasing or decreasing the risk of microbiological infections in children. One of the most influential environmental factors is the quality of home sanitation. Of the total respondents, 60% of children lived

in homes with poor sanitation, while 40% lived in homes with better sanitation. This proportion can be seen in Figure 3.

Poor home sanitation, such as the use of flushed toilets without a good drainage system and inadequate drainage systems, can increase the risk of spreading pathogenic microorganisms (Noorhidayah et al., 2023; Palando et al., 2022; Rasma et al., 2023; Sacharum, 2024). The results of the analysis showed that children who lived in homes with poor sanitation were more likely to develop gastrointestinal infections than those who had better sanitation (<0.05). These findings are in line with the study of Wolf et al., which found that environments with poor sanitation systems correlated with a high incidence of diarrhoea and parasitic infections due to faecal contamination of water and soil surfaces (Wolf et al., 2018). In addition, Haque et al.'s (2020) research also showed that the use of contaminated water increases the risk of diarrhoea and other infectious diseases in children in areas with limited access to clean water.

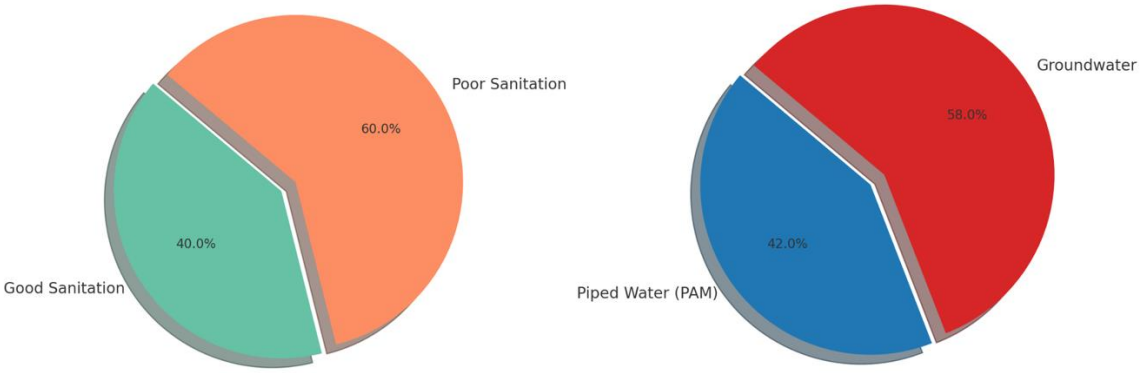

Figure 3. Household Sanitation Conditions and Household Water Sources

Water sources used by households are also an environmental factor that contributes to the risk of microbiological infections in children (Garn et al., 2016; Prüss-Ustün, A. et al., 2019; Wolf et al., 2018). Of the total respondents, 58% of families rely on groundwater that has not been tested for quality, while 42% use water from the PAM network. This proportion can be seen in Figure 3. The source of water used in the household greatly determines the cleanliness and safety of the water consumed by children. The analysis showed that children who used groundwater had a higher incidence of gastrointestinal infections than those who used PAM water (p<0.05). This is due to the possibility of bacterial and parasitic contamination in groundwater, especially in areas with poor sanitation systems.

Research by Prüss-Ustün, A. et al. 2(019)shows that the use of poorly treated water increases the risk of developing infections such as diarrhoea and worms in children. In addition, WHO reports that access to safe drinking water can reduce the incidence of water-based diseases by up to 60% (WHO, 2020).

Hygiene Habits and Incidence of Infection in Children

There are differences in hygiene behaviours between boys and girls that contribute to the rate of microbiological infections. Of the total 50 children studied, 19

boys and 11 girls had poor handwashing habits. A total of 14 boys and 8 girls rarely bathe regularly, while 13 boys and 7 girls often play barefoot. This difference is presented in Figure 4. These results show that boys tend to have worse hygiene habits than girls. These findings are consistent with the study of Scott et al. which stated that boys are more likely to ignore hygiene practices than girls, resulting in a higher risk of infection (Scott, N. et al., 2019).

Children who rarely wash their hands have a higher incidence of gastrointestinal infections than those who wash their hands frequently. Of the 30 children who had poor handwashing habits, 21 of them had diarrhoea in the last three months. Statistical analysis showed a significant relationship between handwashing habits and the incidence of gastrointestinal infections (0.015).

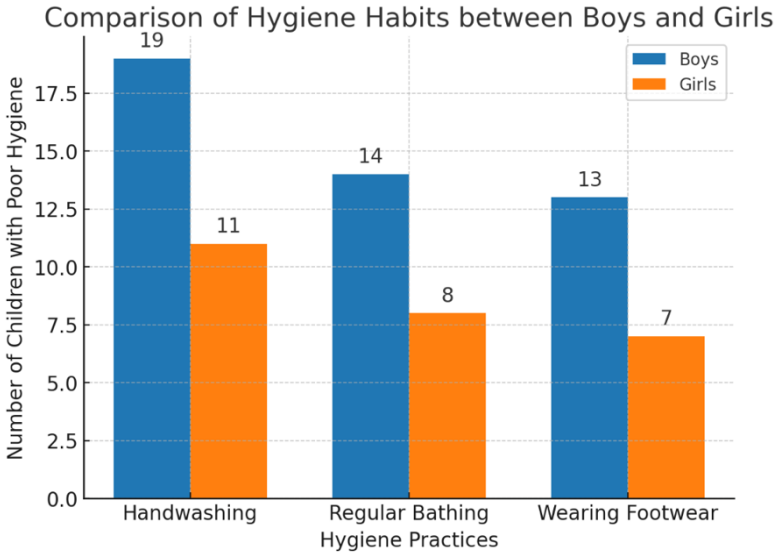

Figure 4. Comparison of Hygiene Habits between Boys and Girls

These findings are in line with the research, which showed that washing hands with soap can reduce the incidence of diarrhoea by up to 48% (Aiello et al., 2018). Studies by Luby et al. (2015) also show that the habit of washing hands is one of the main protective factors in the prevention of microbiological infections in children. In addition to washing hands, other hygiene habits such as bathing regularly and using footwear are also closely related to the risk of infection. In addition to washing hands, regular bathing also plays an important role in maintaining children's health. Of the total respondents, 28 children bathed regularly twice a day, while 22 children had irregular bathing habits. Children who rarely shower tend to have skin infections more often. Of the 22 children who did not bathe regularly, 17 developed skin infections such as hives, rashes, or ulcers in the past three months. Studies by Biswas, R. et al. (2019) show that regular bathing can reduce the risk of skin infections by removing bacteria and impurities that stick to the body.

In addition to washing hands and bathing regularly, the habit of using footwear also plays a role in preventing infections due to soil contamination. Of the total respondents, 30 children always wore footwear when they were outside the house, while 20 children were often barefoot. Children who are often barefoot have a higher incidence

of worm infections and skin diseases than those who use footwear regularly. Of the 20 children who were not used to wearing footwear, 14 of them had a worm infection in the past year. A study by (Biswas, R. et al., 2019) shows that the use of footwear can reduce the risk of hookworm infections and diseases caused by soil contamination. In addition, research by Freeman et al., (2014) also confirms that children who are often barefoot are more susceptible to parasitic infections than those who use footwear well.

The Relationship between Environmental Factors, Hygiene Habits, and Incidence of Infection

Statistical analysis showed a significant relationship between environmental factors, hygiene habits, and the incidence of microbiological infections in children in Bontote'ne Housing. The results of the Chi-Square test revealed that poor home sanitation had a strong correlation with an increase in cases of gastrointestinal infections ($p=0.003$). Children who live in homes with inadequate sewage systems and limited access to clean water have a higher risk of developing diarrhoea compared to those who live in neighbourhoods with better sanitation. These findings support research by several research, which showed that children in environments with poor sanitation systems are more likely to be exposed to diarrhoea-causing pathogenic bacteria due to water and food contamination (Li, L. L. et al., 2016; Walker et al., 2013; Wolf et al., 2018).

In addition, indoor occupancy density was also shown to have a significant relationship with the incidence of respiratory tract infections ($p=0.021$). From the results of this study, children who lived in homes with more than four occupants had a higher incidence of respiratory infections compared to children who lived in homes with fewer occupants. This is due to the increased risk of transmission of respiratory pathogens in denser and poorly ventilated spaces. A study by Schwarzenberg et al., (2018) also found that homes with a high number of occupants often have poor air circulation, thus increasing the likelihood of spreading bacteria and viruses that cause respiratory tract infections.

Hygiene habits also play an important role in preventing microbiological infections. The results of the Chi-Square test showed that the habit of washing hands with soap had a significant relationship with the incidence of diarrhoea in children ($p=0.015$). From the data obtained, children who are not used to washing their hands before eating and after urinating have a greater likelihood of experiencing diarrhoea compared to those who wash their hands regularly. Logistic regression analysis showed that hand washing was the main protective factor against gastrointestinal infections (OR=2.54; CI95), which means children who are not used to washing their hands have more than twice the risk of developing diarrhoea compared to those who maintain regular hand hygiene.

These findings are in line with research conducted by Aiello et al. (2018), which found that washing hands with soap can reduce the incidence rate of diarrhoea by up to 48%. In addition, WHO (2020) reports that improved access to clean water and adequate sanitation can significantly reduce the incidence of gastrointestinal infections, especially in areas with poor water management systems.

This study shows that environmental factors such as sanitation and occupancy density, as well as individual hygiene habits such as hand washing, have a huge role in determining the risk of microbiological infections in children. By understanding these relationships, public health interventions can be focused on improving sanitation infrastructure, providing access to clean water, and hygiene education for children and their families. These quantitative patterns were further illuminated by insights gained from the qualitative interviews. Health professionals from the local community health center (Puskesmas) confirmed that gastrointestinal infections and acute respiratory illnesses were among the most frequently reported conditions affecting children in the area, aligning with the patterns revealed by the survey. Moreover, several parents reported challenges in maintaining daily hygiene due to inconsistent water supply, lack of proper drainage, and limited understanding of basic hygiene practices. These narratives provided contextual depth to the statistical associations found in the quantitative data, particularly regarding the role of environmental constraints and behavior in infection transmission. The interviews also revealed gendered patterns in hygiene supervision, with boys often allowed more freedom in outdoor play and less monitored in personal cleanliness than girls, supporting the observed differences in hygiene-related infections. By triangulating these perspectives, the study offers a more nuanced interpretation of how structural and behavioral factors interact to shape children's vulnerability to microbiological infections in sub-urban settings.

Implications of Research Results

The results of this study carry substantial implications for public health, particularly in the prevention of infectious diseases among children living in sub-urban environments. The association between inadequate sanitation and increased incidence of gastrointestinal infections emphasizes the urgency of prioritizing sanitation infrastructure in local health agendas. Local governments and relevant agencies must improve access to essential sanitation services, including the development of effective sewage disposal systems and the provision of safe, reliable water sources. As underscored by the World Health Organization, access to clean water and proper sanitation can reduce the burden of waterborne diseases by up to 60%, reinforcing the necessity of sustained infrastructural interventions.

Beyond sanitation, housing density emerged as a critical factor contributing to respiratory infections among children. Households with a high number of occupants often experience limited air circulation and poor ventilation, which increase the risk of airborne disease transmission, particularly of pathogens such as *Streptococcus pneumoniae* and *Haemophilus influenzae* (Jeni et al., 2022). These findings underscore the need to promote public awareness of healthy housing environments and to integrate housing policy reforms into broader public health strategies, especially in sub-urban areas facing rapid population growth.

In terms of hygiene practices, this study reaffirms that simple behaviors, especially handwashing with soap is among the most effective, low-cost strategies to reduce diarrhoeal diseases and other microbiological infections. However, observational

data and parental interviews indicate that hand hygiene remains inadequate among many children, particularly boys. Prior studies, such as those by Aiello et al. (2018), have shown that continuous hygiene education can significantly increase compliance and thus reduce infection rates. Therefore, sustained hygiene promotion at schools and community levels must be institutionalized as part of long-term public health initiatives.

An important secondary finding of this study concerns the role of gender in hygiene behavior. Boys were observed to have poorer hygiene habits compared to girls, correlating with higher infection rates in male children. This gender-based disparity calls for differentiated health promotion strategies that take into account behavioral tendencies and social norms affecting boys and girls differently. Based on the findings, the following strategic recommendations are proposed:

- Improving Sanitation and Clean Water Infrastructure: Strengthen the development of sewage systems and ensure equitable access to safe drinking water, especially in sub-urban housing clusters.
- Sustained Hygiene Education: Implement school- and community-based programs to reinforce essential hygiene behaviors such as handwashing, regular bathing, and footwear use.
- Gender-Sensitive Health Campaigns: Design health education initiatives that recognize and respond to differing hygiene behaviors among boys and girls to ensure inclusive impact.
- Promotion of Ventilation and Healthy Housing: Encourage proper home ventilation practices and support housing upgrades to minimize respiratory infection risks.
- Monitoring and Evaluation of Public Health Programs: Establish routine assessments of sanitation and hygiene interventions to ensure relevance and responsiveness to the evolving needs of sub-urban communities.

Importantly, this research offers more than just academic insight, it provides a practical, evidence-based foundation for local policymaking. By highlighting the intersection of environmental, behavioral, and demographic determinants of child health, the study offers actionable guidance to agencies such as the Makassar City Health Office and the Department of Human Settlements. Findings can be leveraged to design neighborhood-specific sanitation upgrades, expand hygiene education in schools, and inform health outreach tailored to socio-economic realities. By aligning empirical evidence with the lived conditions of vulnerable populations, this research contributes to the formulation of localized, preventive, and participatory public health strategies aimed at improving child health outcomes in transitional sub-urban environments like Bontote'ne Housing, Makassar.

CONCLUSION

This study shows that environmental factors and hygiene habits have a large role in determining the risk of microbiological infections in children. Poor home sanitation is associated with an increased incidence of gastrointestinal infections, housing density contributes to the incidence of respiratory infections, and poor handwashing habits are major factors in the incidence of diarrhoea. These findings underscore the importance

of public health interventions that focus on improving sanitation infrastructure, hygiene education, and gender-based prevention strategies. With coordinated efforts between governments, health institutions, and communities, the risk of microbiological infections in children can be minimized, thereby improving their well-being in the sub-urban environment.

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