Correlational effect of the management of sanitation services to mortality, undernourishment, and government effectiveness

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Abstract

Individual human health is the basic foundation of a strong community. Such aspect can be directly correlated with issues on the management of sanitation services, mortality, undernourishment and government effectiveness. This study explored the significant impact of sanitation services management to mortality among children under five years old, prevalence of undernourishment, and government effectiveness worldwide. Web-based numeric data and information from 120 countries have been downloaded, summarized, and analyzed using multivariate clustering and correlation analysis. The findings of this study showed that safely managed sanitation services and the prevalence of undernourishment were found to have a negative correlation. It signifies that as sanitation services are enhanced, the prevalence of undernourishment decreases. Meanwhile, safely managed sanitation services and mortality rates are negatively correlated, which means that as the former improves, the mortality rate drops. In addition, the relationship between safely managed sanitation services and government effectiveness is found to have a strong positive correlation, indicating that safely managed sanitation services depend on effective governance.

Keywords: Government effectiveness, mortality, sanitation services, undernourishment.

JEL Classification Codes: C38, C55.

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1. Introduction

Sanitation services is a critical issue that affects all of humanity and enforcing sanitation and hygiene policies for the population's benefit is the government's responsibility. This concern may necessitate approaches to reduce the sixty percent (60%) sanitation facilities' deficiency as purported in the study conducted by Andersson, Otoo, and Nolasco (2018) thereby improving its positive impacts on health and the environment. In fact, billions of people lack access to safely managed sanitation services, which results to thousands of annual deaths among children under five years old (Hubbard et al., 2020). On the other hand, the status report presented by the Philippines' Department of Environment and Natural Resources (DENR), Environmental Management Bureau (EMB), and National Solid Waste Management Commission (NSWMC), and the World Health Organization (WHO) in 2015 identified poor water quality as one of the hindrances in providing adequate sanitation services. And this prompted international agencies and national governments to increase their efforts to address the issue (Armah et al.,2018).

Partnership between communities and the urban government are effective in creating healthier cities (Satterthwaite, 2016) which means investing in water and sanitation, improving government assistance, and increasing public spending on health are significantly important. Thus, (Ortega, Sanjuán, & Casquero, 2017) fewer health inputs are required to countries with an effective government. Ruolahti-Virtanen, Mujjukizi, and Adhiambo (2014) also found out that poor hygiene, water quality, sanitation, and malnutrition are directly significant to children's health well-being. So, inadequate sanitation systems and water quality not only harm natural resources but also poses health risks to many human beings (Nansubuga et al., 2016).

In this light, this study sought to investigate the relationship between the management of sanitation services, mortality of children under five years old, undernourishment, and the government effectiveness. Specifically, it aimed to: (1) describe the profile of 120 countries in terms of the four variables; (2) determine the correlation between properly managed sanitation services and mortality; properly managed sanitation services and prevalence of undernourishment; properly managed sanitation services and government effectiveness. This paper offers the policymakers relevant inputs in strengthening their efforts to improve the health and safety of their citizens.

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2. Conceptual Framework

Willetts et al. (2020) claimed a long term and sustainable sanitation infrastructure is essential for providing safe sanitation for all. Thus, (Baker et al., 2016) sanitation and hygiene interventions leads to a reduction in diarrheal risk among young children by 48%. Howard (2021) emphasized that water and sanitation services are crucial for public health, as reflected in Sustainable Development Goal (SDG) 6 and its associated targets. He stated that to increase the world's ambition, we must strive to achieve universal access to safe, sustainable, and resilient services and protect public health.

In this study, the researcher analyzed data from 120 countries on safely managed sanitation services, the death rate and undernourishment of children under five years old, and government effectiveness. The researcher used Minitab software to cluster these variables using a dendrogram. They also conducted a correlation analysis to determine the relationship between management of sanitation services and the death rate of children under five years old, undernourishment, and government effectiveness.

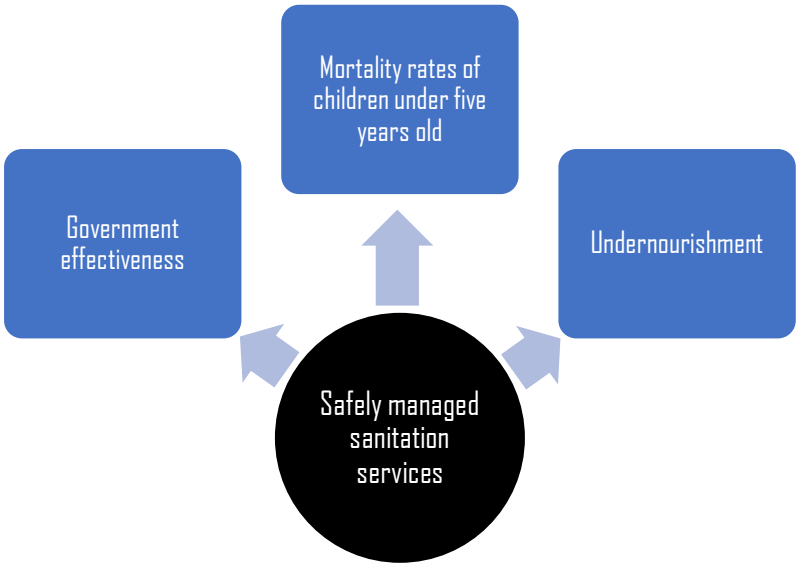

Figure 1. *The conceptual framework*

3. Methodology

The data on safely managed sanitation services, mortality rates, undernourishment, and government effectiveness were obtained from the World Bank. The study employed a web mining approach in the data gathering of information on the management of sanitation services, death rates among children under five years old, undernourishment, and government effectiveness in 2018. The researchers used Minitab to conduct a hierarchical cluster analysis, using the squared Euclidean distance as the similarity metric and the complete linkage method for cluster fusion. A correlation analysis was also performed.

4. Results and Discussions

4.1 Clustering of countries with well-managed sanitation services, death rate of children below five years old, undernourishment, and government effectiveness

Clustering is a data analysis technique used to group similar observations based on criteria. Typically, clustering organizes data on varying scales by constructing a cluster tree or dendrogram. A dendrogram is a graphical representation of the clusters produced by the clustering method. It shows how the observations are grouped at each level of similarity.

In this study, the researcher used clustering to group observations related to four variables. The researcher used the dendrogram to determine the optimal level or scale of clustering for the data application. The dendrograms produced by the cluster analysis were examined to determine the appropriate degree of similarity to set as the graph's cutoff. The cutoff point determines how many clusters are produced by the analysis. In this case, the researcher determined that four clusters would be appropriate for their analysis. The clustering results can be seen in Figure 2, where the observations are grouped into four distinct clusters. This information can be used to draw conclusions about the relationships between the studied variables and also identification of trends on gathered data.

The distribution of the 120 countries into four distinct groups is presented in Table 1. Each cluster represents countries with similar characteristics or attributes, such as safely managed sanitation services, mortality under 5, undernourishment, and government effectiveness. The first cluster contains 41 individual countries, meaning that these 41 countries share similar characteristics that differentiate them from the other 79 countries that are not part of this cluster.

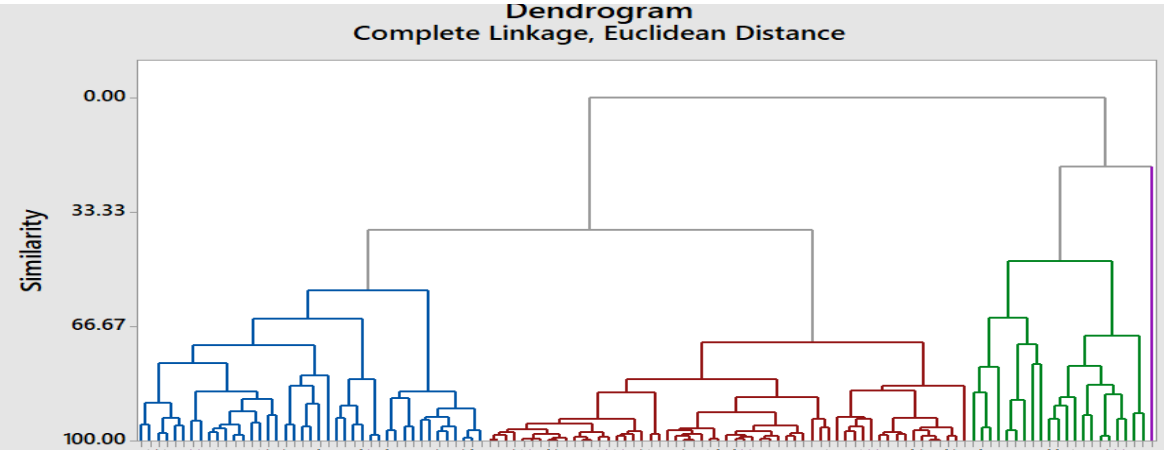

Figure 2. *Resulting dendrogram of the 120 clustered countries in the world*

The second cluster consists of 57 countries, meaning that these countries have different characteristics that differentiate them from the other 63 countries that are not part of this cluster. Cluster three has 21 countries, while cluster four has only one, Somalia. The clustering process is often used in data analysis to identify similarities and differences between different groups of observations. The purpose of creating these clusters is to find trends and relationships within the data that might not immediately apparent when looking at the entire dataset. By examining the characteristics of each cluster, researchers can gain understanding into the underlying structure of the data and identify factors that may be driving the observed patterns.

Table 1. *Resulting clusters of the 120 clustered countries in the world*

	Number of observations	Within cluster sum of squares	Average distance from centroid	Maximum distance from centroid
Cluster 1	41	18073.9	19.2381	36.7779
Cluster 2	57	9366.8	11.2144	28.7409
Cluster 3	21	20.633.8	30.0238	47.5801
Cluster 4	1	0.0	0.0000	0.0000

Cluster 1	Albania, Algeria, Azerbaijan, Bangladesh, Bhutan, Bolivia, Bosnia-Herzegovina, Brazil, Colombia, Costa Rica, Cuba, Ecuador, Arab Republic of Egypt., Georgia, Honduras, India, Iraq, Lao PDR, Lebanon, Libya, Mexico, Mongolia, Montenegro, Morocco, Myanmar, Nepal, North Macedonia, Paraguay, Peru, Philippines, Samoa, Sao Tome and Principe, Serbia, Solomon Islands, Spain, Switzerland, Thailand, Turkey, Tuvalu, United States, Venezuela RB

Cluster 2	Andorra, Armenia, Australia, Austria, Bahrain, Belarus, Belgium, Bulgaria, Canada, Chile, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Jordan, Korea Rep., Kuwait, Kyrgyz Republic, Latvia, Liechtenstein, Lithuania, Luxembourg, Malaysia, Malta, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Qatar, Romania, Russian Federation, San Marino, Saudi Arabia, Singapore, Slovak Republic, Slovenia, Suriname, Sweden, Tonga, Tunisia, Ukraine, United Arab Emirates, United Kingdom
Cluster 3	Central African Republic, Chad, Congo Dem. Rep., Djibouti, Ethiopia, Gambia, The, Ghana, Guinea-Bissau, Kiribati, Lesotho, Madagascar, Malawi, Mali, Niger, Nigeria, Senegal, Sierra Leone, Tanzania, Togo, Yemen Rep., Zimbabwe
Cluster 4	Somalia

4.2 Within-cluster sum of squares

A *within-cluster sum of squares* measures data points within each cluster that vary from the cluster center (Hastie et al., 2009). In other words, it indicates the total sum of the squared distances between each data point and its assigned cluster center. A lower WSS value typically indicates better clustering which suggests that the data points within each cluster are more similar and different from other clusters (Tibshirani et al., 2001). As seen in Table 1, Cluster 2 has the lowest within-cluster sum of squares which means that countries in this cluster possess a high similarity.

4.3 Average distance from a data point to its assigned centroid

The *average distance from a data point to its assigned centroid* measures the tightness of a clustering solution (Kaufmanc& Rousseeuw, 2009). Mean calculation of the distances between each data point is assigned as centroid. A smaller average distance generally indicates a more compact and well-defined cluster. In contrast, a more considerable average distance implies that the data points within the cluster are more dispersed and less clustered around their centroid (Jain et al., 1999). This measure can be used to evaluate the quality of clustering and can also be used to compare different clustering algorithms or parameter settings. Of the 4 clusters, Cluster 2 is more compact while the cluster is more dispersed than the other clusters.

4.4 Maximum distance from the centroid

The *maximum distance from the centroid* is defined as the maximum distance between any data point and its assigned centroid within a cluster. This measure is also known as the cluster's diameter and provides measure of the spread of the data points in a cluster. A more considerable maximum distance from the centroid generally indicates that there are some data points in the cluster that are much farther from the centroid than others (Jain et al., 1999), suggesting that the cluster may not be as compact or well-defined as it could be (Han & Kamber, 2012). This measure can also be used to evaluate the quality of clustering (Alpaydin, 2010) or to compare different clustering algorithms or parameter settings. Cluster 3 is more dispersed and less compact than Clusters 1 and 2 as it has the highest maximum distance from the centroid, meaning there is a higher variability or spread of the dataset from the countries in Cluster 2.

4.5 Relationship between the management of sanitation services and mortality

Table 2 portrays the relationship between the management of sanitation services and the mortality rates of children under five years old, prevalence of undernourishment, and government effectiveness. As presented in the table, the correlation results show significant relationship between the management of the sanitation services and the mortality rates of children under five years old, prevalence of undernourishment, and the government effectiveness.

Table 2. *Correlation between the management of sanitation services and mortality under five, undernourishment and government effectiveness*

			r-value
Management of sanitation services	⟶	Mortality rate	-0.527*
Management of sanitation services	⟶	Undernourishment	-0.376**
Management of sanitation services	⟶	Government effectiveness	0.610*

*Note: *p< 0.05; **p< 0.01; ns not significant*

Table 2 shows a moderately negative correlation (r=-.527, p<.0005.) between safely managed sanitation services and mortality rate under five in 120 countries. This result shows that the mortality rate dropped as the sanitation services improved. Sanitation services refers to (Oxford Dictionary) the provision of clean drinking water and adequate disposal of sewage.

When these services are well-managed, they can help minimize the spread of diseases that can lead to death. However, when poor sanitation proliferates, it causes transmission of diarrheal diseases, which remains a significant killer but is largely preventable by better water, sanitation, and hygiene (Manetu & Karanja, 2021). It significantly contributes to disease outbreaks and the spread of waterborne illnesses, leading to increased mortality rates (Cisse, 2019; Tulchinsky, 2018).

4.6 Relationship between the management of sanitation services and undernourishment

The relationship between the management of sanitation services and the prevalence of undernourishment ($r = -0.376$, $p = 0.000$) found a negative correlation which signifies that as the sanitation services enhanced, the prevalence of undernourishment decreased. Undernourishment is a widespread problem in many developing countries. It is caused by lack of access to adequate food and clean drinking water which can make it difficult for individuals to digest and absorb the nutrients they need. One of the critical ways that safely managed sanitation services can reduce undernourishment is by preventing the spread of waterborne diseases, such as diarrhea, cholera, and typhoid fever (Amicizia et al., 2019). These diseases can cause dehydration, leading to malnutrition by preventing the body from properly absorbing nutrients. In addition, diarrhea and other related illnesses can prevent individuals from being able to work, which can further impact their ability to access food and other necessities.

4.7 Relationship between the management of sanitation services and government effectiveness

The relationship between the safely managed sanitation services and government effectiveness ($r = 0.610$, $p < .0005$) was found to have a strong positive correlation, which means the more the sanitation services are safely managed, the more influential the government. A government that effectively implements policies and regulations can ensure that providing safe and sustainable sanitation services is a priority. In turn, access to safe and well-managed sanitation services can significantly impact a population's health, the environment, and the economy.

Improved sanitation services led to better public health outcomes (WHO, 2018). When toilets and waste management systems function correctly, the spread of diseases caused by poor sanitation practices is reduced. It can prevent cholera, dysentery, and typhoid fever outbreaks, which are common in areas with inadequate sanitation facilities. In addition to improving public health, effective and safe sanitation services can positively impact the environment. Properly managed waste treatment systems can prevent contaminated water from entering rivers and groundwater, reducing the risk of waterborne diseases and preserving drinking water quality. They can also help reduce greenhouse gas emissions by managing methane emissions from wastewater and reducing the amount of organic waste that goes to landfills.

Governments can significantly promote these services by implementing policies and regulations that prioritize their provision and management. Investment in the sanitation sector can have far-reaching benefits for communities, the environment, and the economy, making it a critical priority for governments worldwide.

5. Conclusion and Recommendations

In clustering the countries, cluster 3, composing 21 countries, is more dispersed than clusters 1 and 2. Thus, these countries are characterized by higher variability in managing their sanitation services, reduction of mortality rates, and prevalence of undernourishment among children five (5) years old and below; also, their governments have different levels of effectiveness. Cluster 2 (57 countries) shows a contradictory characteristic and is more compact, which demonstrates that these countries have high similarity on how their sanitation services are being managed, how mortality and undernourishment of children under five (5) years old are reduced, and also how their governments implement policies to address such concerns.

Further, the negative correlation between sanitation services, mortality, and undernourishment can be concluded that improved sanitation services, providing clean water and hygiene, contribute to nutrient absorption, thereby preventing malnutrition. These factors are closely linked since malnourished children mainly lead to death and are susceptible to diseases. Additionally, these concerns strongly correlate to the government's effectiveness in implementing policies and regulations in adequately managed sanitation services.

Policymakers may draft legal bases to increase budget allocation for the investment of sanitation services infrastructure and equipment for the global communities' well-being.

Generally, government authorities should address and prioritize sanitation services so that malnutrition and mortality rates of children under five years old will be reduced. The local and national governments may consider the results of this study to improve the policies, programs, and activities, particularly on sanitation services. Strategizing the right pathway toward attaining sustainable long-term sanitation services may be focused on achieving the international development goal of public health.

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