Environmental Factors Perpetuating Infant Mortality Rate in Chepalungu Sub-County, Bomet County, Kenya

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Abstract: Abstract: It has been observed that infant mortality in Chepalungu Sub County, Bomet County is higher at 57 per 1000 compared with the National average of 54 per 1000. Therefore, to achieve the sustainable development goal (SDG) target of reducing infant mortality to 25 deaths per 1000 live births, the study conducted a descriptive survey research design to establish the factors perpetuating high infant mortality rates in Chepalungu Sub-County. Descriptive survey research design describes the distribution of and relationship among variables. The study targeted all household mothers in the reproductive ages 18-49 and key informants. Purposive and stratified simple random sampling techniques were used to select 381 mothers and 4 key informants. Data was collected using questionnaires and interview schedules. Quantitative data was analyzed using frequencies, percentages, and Chi-square test while qualitative data was coded, transcribed and organized thematically. The study concluded that environmental factors perpetuated and had a great bearing on infant health. Specifically, source of drinking $\chi2 = 38.442$ (p < .001), safety of drinking water $\chi2 = 21.884$ (p < .001), treating drinking water $\chi2 = 39.119$ (p < .001), type of toilet facility $\chi2 = 36.268$ (p < .001), washing hand after visiting toilet $\chi2 = 24.761$ (p < .001) and type of cooking fuel $\chi2 = 18.040$ (p = .021) had statistically significant difference. The study recommends the need to conduct an environmental education program targeting the mothers on the human waste disposal, safe drinking water and safe cooking fuel.

Keywords: Infant mortality Rate, Environmental Factors, Neonatal mortality, Perinatal mortality, Post neonatal mortality, Chepalungu Sub-County.

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1. Introduction

Infant mortality is the death of under one year of age. The death toll is assessed by the infant mortality rate (IMR), which is the number of deaths of infants for every 1000 live births. Reno, & Reno and Hyder, (2018) discovered that there are many factors that contribute to infant mortality across the world. These factors include the mothers' level of Education, environmental conditions, political and health conditions among others. According to Kumar, *et al.,* (2020), infant mortality is by far the most sensitive indicator of population health as well as reflects the country's adverse social, environmental and economic conditions. The (MDGs) of the United Nations Millennium Declaration also focused on the financial dimension and

quality of life of a nation and description of the population wellbeing as an attribute of infant mortality.

World Health Organization (WHO) (2017), reported that risks of an infant dying under one year of age was highest in the African Region (51 per 1000 live births), compared to six European Regions (8 per1000 live births). In Kenyan context, the Population and Housing Census 2019 enumerated the population at 38.6 million where data trend indicated that total population tripled between 1969 and 1999 with an increase of 1 million infants born yearly as echoed by the data from National Council for Population Development (NCPD) (Peters, 2020). Migration of residents from rural to Urban in some areas of Kenya, Chepalungu included has been stirred by search for employment and settlement which has resulted to urban growth. This rapid migration has to some extend created disparities in the economic, social, cultural and environmental status of the people in the Country as acknowledged by boundary changes and classifications of the society.

The up-coming metropolitan setting however in the Kenyan counties- Chepalungu integrated is characterized by critical effects both negative and positive as indicated by the WHO (2018). There have been increased imbalances that have led to problems in rural areas have increased poverty and inadequate services especially among the less fortunate members. According to Kimani-Murage, *et al.,* (2016), there was enough evidence which revealed that explosion of urban population in a region has been found to go together with high rates of poverty and poor health conditions. It further contributes to high infant mortality in slums and rural areas than in more urban centers.

Globally, IMR has been decreasing from 65 deaths per 1000 live births in 1990 to 29 deaths per 1000 live births in 2017 (WHO, 2017). The present condition of infant mortality in Africa is becoming a critical factor. High rates of mortality levels have been frequently documented, especially infant mortality, whichhasd been a critical challenge in the continent of Africa. Tichenor, & Sridhar, (2019) indicated that African infant mortality is a significant problem that has caused worries among people particularly over the pace at which it is increasing. This influences the achievement of the Sustainable Development Goals (SDGs) in many developing countries.

Reno and Hyder (2018) is concerned about the need to sustain the rate of infant mortality because it can affect the economy of the country. This is a great concern as it arises from the belief that demanding technologically sophisticated public health interventions could bring about sustained mortality only with limited improvements in third world living standards. Kenya where Bomet County

is found as an individual country in Sub Saharan Africa has seen very critical trends of infant mortality.

In order to implement the 2030 Agenda for Sustainable Development Goals (SDG) on objectives to guarantee sound lives for all at all ages and advance to world leaders embraced prosperity. According to Buse and Hawkes (2015), measures to end unnecessary death of infants and reduce to 25 and below for every 1,000 live births by 2030). In this way urgent efforts are required in all those nations that are left behind, (UNIGME 2017).

According to WHO (2018) report, Mali had the highest IMR in Africa with 100 deaths per 1,000 live births and became the second country in the world after Afghanistan. According to the report, this is a threatening situation on the economy and general development of a Country if no quick measures are taken. On the contrary Berríos, (2018) found out that IMR in Japan has been decreasing gradually from 1967 which was 16.2, in 1970 it was 13.4, it was 2.3 in 2010 and in 2018 it was 1.8 per thousand live births. According to the statistics, this made Japan to have the lowest IMR in the world. Despite the considerable advancement in decreasing IMR in the preceding decades, inconsistencies in infant survival still exist across regions and countries. As Kiross, *et al.,* (2020) put it, Sub-Saharan Africa remains the region with the most astonishing IMR in the world. However, the infant survival rate of every country change with variables, such as the fertility rate and income circulation.

Tesfaye, *et al.,* (2020) discovered that attributes of infant health rates in Ethiopia had differences between the proximate trend and hidden determinants of interests on the ground. The first attribute of infant health leads directly to death, while environmental and social barriers prevent access to basic medical resources and thus contribute to an increase in IMR where 99 per cent of infant mortality deaths occur in developing countries and 86 per cent of such deaths are due to infections, premature deaths and complications during childbirth and birth injuries. Birth injuries have an indirect impact on infants (Tesfaye, *et al.*, 2020; Singh, *et al.*, 2017). However, according to Singh, *et al.,* (2017) malformations have such a massive effect on child mortality, accounting for 5% of infant deaths in developed countries, while malnutrition and infectious diseases are the main causes of high infant mortality in developing countries.

WHO (2018) report indicated that infant mortality in the United States, Sweden and Germany were affected by the high preterm infant mortality rates compared to other European countries. Report also defined the differences in reporting between the United States and Europe. However, it noted that France, Czech Republic, Ireland, Netherlands and Poland do not report all live births of babies under 500 g and/or 22 weeks of gestation. In Russia, infant death,

which was extremely premature, accounted for only 0.5 per cent of all live born children (Wolowyna, 2020).

Yohannes, *et al.,* (2017) indicated that IMR in the United States was approximately 2.3 per cent to a historic low of 582 infant deaths per 100,000 live births in 2014. In 1850, rates were estimated at 216.8 per 1,000 white-born babies. However, there were 340.0 per 1,000 African Americans. The rates have declined significantly in modern times. The decline was due to modern improvements in basic health care, technology and medical advances. Overall, there is a dramatic decrease from 20 deaths in 1970 to 6.9 deaths (per 1000 live births) in 2013.

While developing countries are forging forward in harnessing the application of modern facilities to decline infant mortality in health sectors, the adoption is slow and costly (Gostin, *et al.,* 2019). Despite several interventions, new policies put in place by the Government, campaigns to create awareness and new strategies by the ministry, few of the technologies have been implemented for adoption by society (Theobald, *et al.,* 2018).

In Kenya, the Kenya Service Provision Assessment Survey (KSPA) revealed that most health care providers are not taking care of sick children holistically but rather are treating children only for the presenting illness (Wando, 2017). It established the factors that are associated with the promotion of child health using a holistic approach, such as the Integrated Management of Childhood Illness (IMCI) strategy to manage a sick child. The IMCI strategy aims to reduce morbidity and infant and child mortality by implementing three main components: improving health workers' skills in case management; improving the health systems; and improving family and community childcare practices (Theobald, *et al.,* 2018). In addition, Vision 2030 aims to end preventable deaths of newborn and children under 5 years of age. This can help to reduce neonatal mortality to as low as 12 per 1000 live births and under -5 mortality as low as 25 per1000 live births.

As per the previous literature it is exceptionally clear that critical strategies and projects are set up to improve IMR in Chepalungu Sub-County to achieve Sustainable Development Goals (SDGs) by 2030**.** In Bomet, Wando, (2017) indicates IMR was 57 deaths per 1000 live births in the county while the National IMR was 54 deaths per 1000 live births. This is a critical scenario since Chepalungu is in the County of Bomet and no research has been done in the area.

1.1Research Objectives

The study aimed at establishing factors perpetuating high infant mortality rates in Chepalungu Sub-County, Bomet County, Kenya. The specific objectives were:

1.   Examine the prevalence of infant mortality in Chepalungu, Bomet County, Kenya.

2.   To establish the effect of environmental factors on high infant mortality rate in Chepalungu, Bomet County, Kenya.

1.2 Research Questions

The elicited questions for scholarly investigation were fragmented into the following:

1.   How common is infant mortality Chepalungu, Bomet County, Kenya?

2.   What are the effects of environmental factors on high infant mortality rate in Chepalungu, Bomet County, Kenya?

2. Literature Review

Research has shown that environmental and social barriers prevent access to basic medical resources which contribute to a high level of IMR. According to Domnariu (2015), infant mortality in developing countries was due to infections, premature births, complications during delivery, prenatal asphyxia as well as birth injuries. However, Domnariu (2015) observes that many of these causes can be prevented with very low costs.

The WHO (2018) report indicated that among the ten leading mortality risks that contribute to high infant mortality in developing nations are: dirty water, sanitation and smoke from carbon fuels. Vakili *et al* (2015) on a different observation reported that diseases of infant mortality are linked to several common trends, scientific development and social programs. The scholars felt that the trends for its decline could include improvement of sanitation, and especially access to safe drinking water which would dramatically help in the decrease of high infant mortality fatal_disease. Pasteurization of milk and other living standards in the urban settings would also assist in the increase of education and awareness regarding infant mortality in regions.

Currier and Widness, (2018) noted that traditional practices pose risks associated with poverty. These include lack of safe water, lack of sanitation, transfer of waste and indoor air contamination in a disorganized ecological perimeter. Other risks, such as rural air contamination and agro-industrial chemicals as well as disposables that require environmental protection, should also be organized and implemented (Sumankuuro, *et al.,* 2017).

Similarly, Heft-Neal, *et al.,* (2018) noted in a related report that there is a relationship between infant mortality, family quality and network conditions in rural countries affected by environmental hazards. Their findings, among others,

show that the use of clean cooking fuels, access to safe water and sanitation reduces the risk of infant mortality. However, the study recommended that women who are exposed to pollution daily when pregnant should be closely monitored by their physicians. Their physicians should also monitor them and their infants after birth. It was also noted that children living in environments with more air pollution, high population density, high crime rate and low level of income will have high IMR.

Research by Mokgaga, *et al.,* (2020) on environmental determinants of infant mortality in urban Kenya, found out that those families that had flush toilets in their area of residence had lower IMR than those without any such facilities. A study by Mwambire, (2020) on Determinants of Infant and child Mortality in Kenya showed that there was 20% increase in infant deaths in family units with no latrine contrasted with those who had.

In another study, Anele, *et al.,* (2020) on factors influencing infant mortality in Kenya projected the mortality discrepancies according to maternal education, marital status and place of residence. She used a multivariate regression analysis and reported a significant relation between the ratios of observed to anticipated deaths and length of breast feeding, age of weaning, water treatment, maternal literacy and attendance of antenatal clinics by expectant mothers. Education appeared to be very important and significant in affecting ratio of observed to expected deaths. There was also a significant

relationship between toilet facilities, source of water, and treatment of ordinary water and percentage of the expected deaths.

2.1 Conceptual Framework

This study adopted a modified conceptual framework developed by Subramaniam in 2018 (Figure 1). The conceptual framework helps in demonstrating relationship between independent and dependent variables. Each component of independent variable is critical in determining infant mortality rate among the communities living in Chepalungu Sub County.

In this conceptual framework, the independent variables considered for this study were first. This study examined economic determinants (occupation, income level) which also play a critical role in determining level of IMR within the study area. Additionally, the study examined environmental determinants such as sources of water, sanitation and air pollution which has an impact on IMR level within the study area. They are all considered as the direct influencers of IMR in study. The moderating variables that influence independent variables on infant mortality rate were maternal reproductive health and attitude towards primary health services. They indicated that good maternal reproductive health and positive attitude towards primary health services lowers IMR whereas reverse is true.

Independent Variable

Intervening Variable
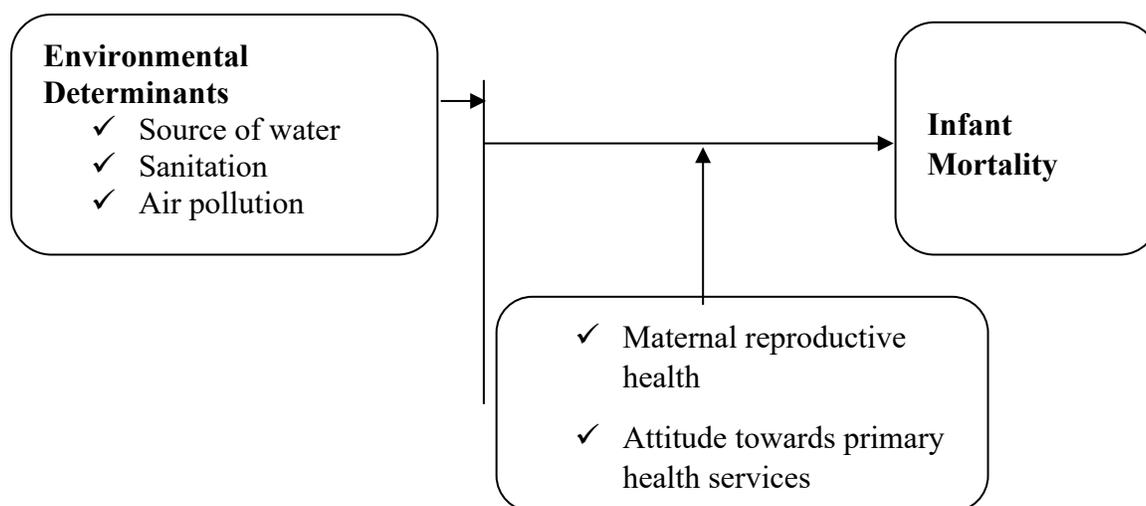
Dependent Variable

Figure 1: A conceptual framework showing the relationship between the underlying factors and infant mortality.
Source: Modified from Subramaniam (2018)

3. Methodology

3.1 The Study Setting

This study was conducted in Chepalungu Sub-County in Bomet County, Kenya, which lies between latitudes 0º29′ South to 0º03′ and between longitudes 35º05′ South to 35º35′ East. The county is divided into five Sub-Counties namely Bomet central, Konoin, Chepalungu, Sotik and Bomet central. It is bordered by Narok County to the south, Nyamira to the West, Nakuru to the North East and Kericho to the North (Figure 2). Chepalungu Sub-County covers an area of 539.8 Km^2 with a population of 163,759 individuals (Bomet County Government 2018). The population density is 387 persons per km squared.
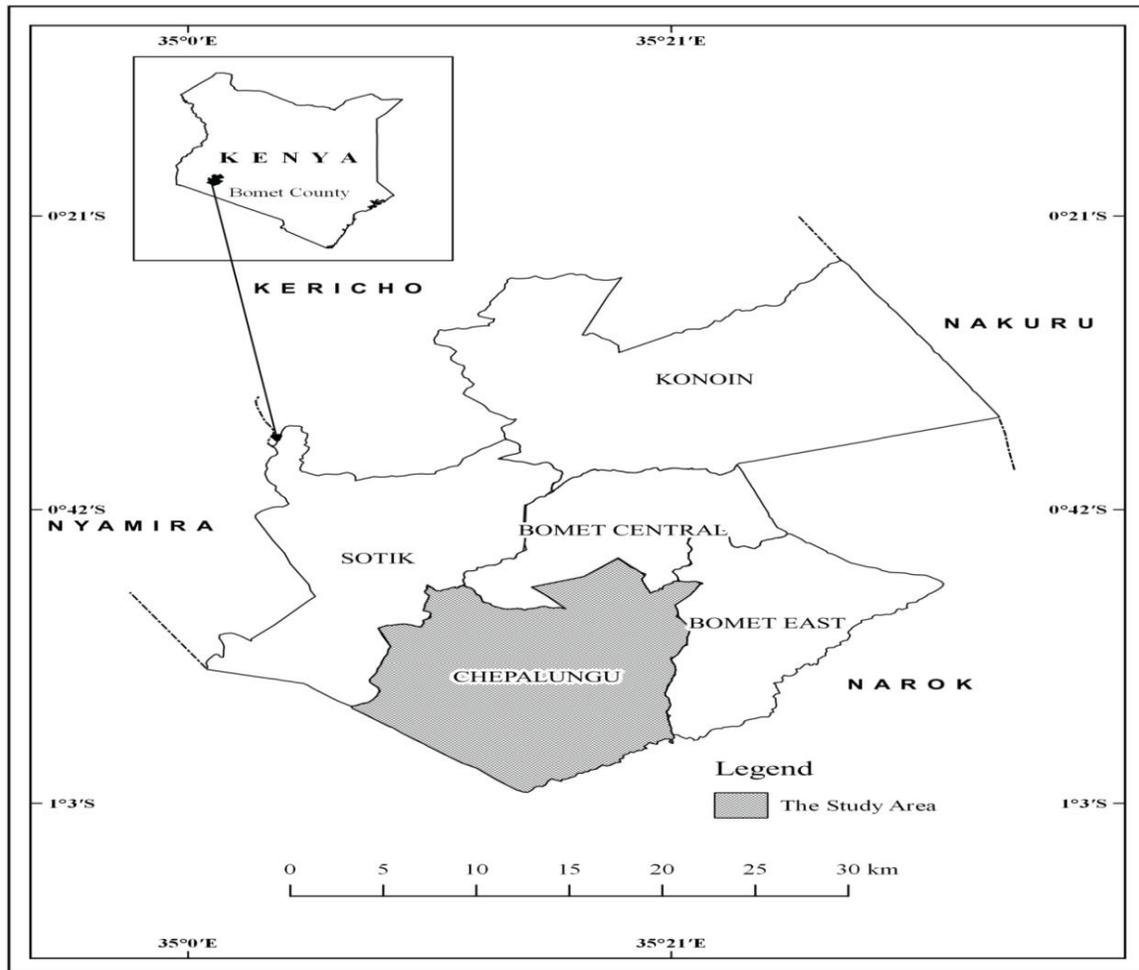

Figure 2: Location of Chepalungu Sub-County in the Kenyan Context

Source: Kenya Demographic and Health Survey Bomet County (2013/2014).

3.2 Research Design, Sample Size and Data Collection

This study used both descriptive survey and naturalistic phenomenology design to assess the infant mortality. The descriptive survey research design enables a researcher to collect data at a particular point in time with the intention of describing the nature of existing conditions and identifying the standards against which existing conditions can be compared and determined (Vaske, 2019). Further Celis Sierra, (2020), posits that descriptive survey research determines and reports things describing behaviour, attitudes, opinions, values, perceptions and attributes as precisely as possible. It also deals with the frequency, allocation and interrelation of variables.

According to Englander, (2020) phenomenology examines the world as it appears to individuals when all the prevailing understanding of the phenomena is laid aside and revisit the immediate experience of the phenomena. In this case the characteristic of phenomenology is an

emphasis on the participants' responses, interpretations and experiences. According to Anyon, *et al.,* (2018), a systematic phenomenological study strengthens a study and entails the use of several sources of data. The study used health workers and mothers to collect data on the factors perpetuating infant mortality. The researcher also used two different forms of data collection tools (a self-administered questionnaire and an interview guide) to collect information from the participants.

This study targeted about 58,000 mothers in the reproductive age of 18-49 years and Health officials (clinical officers/nurses in charge) who were the Key informants from Chepalungu Sub County. This is because they had significant information on the causes of infant mortality in the study area. An optimum sample size of 385 was estimated using the formula suggested by Smith (2013). Upon these three hundred and eighty-one (381) households and four (4 key) informants drawn from Chepalungu Sub-County Health Centres added up to three hundred and eight five participants (385). The key informants were selected such that only those with information on infant mortality were sampled.

3.3 Analytical Approach

Computer software, Statistical Package of Social Sciences (SPSS) version 22.0 was utilised to code, enter and analyse results of the study. A descriptive statistical summary was used to analyse various items in the questionnaire in terms of frequencies, percentages, means, and standard deviations (Mishra, *et al;* 2019).

Inferential statistics (Pearson's Chi-square statistic, χ2) (equation 3.1) was used to test relationship between the independent variables; economic and environmental determinants and the dependent variable (infant mortality rate) at 95.0% confidence level (Schober, *et al.,* Schwarte, 2018).

$$\chi^2 = \sum_{i=1}^{k} \sum_{j=1}^{n} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$
……….………………………………….. (3.1)

Where O_{ij} is the number of individuals observed in the ith row and j^{th} column cell;

E_{ij} is the number of individuals expected in the ith row and j^{th} column cell.

3.4 Research Ethics

The research ethical clearance was approved by the Ministry of Higher Education, Science and Technology through the National Commission for Science, Technology and Innovation (NACOSTI). Research ethics included issues such as informed consent, respect for individual rights, privacy, anonymity, confidentiality, and ethical clearance (Clark-Kazak, 2017; Kumar, et al., 2020).

4. Results and Discussion

4.1 Demographic Information

The background and demographic information of the study respondents included current age, age at first birth as well as number of children one had.

4.1.1 Age of the Respondents

The current age and age at first birth of the respondents were captured (Table 1). This enabled the researcher to have enabled an understanding into the child bearing stage at which the participants were at.

Table 1: Age of Participants

Variable	Age Group	Frequency	Percent
	Below 20 years	5	1.5
	20 - 29 years	83	24.3
Current age	30 - 39 years	77	22.5
	40 and above years	177	51.7
	Total	**342**	**100.0**
	Below 19 years	92	26.9
Age at first birth	20 years and above	250	73.1
	Total	**342**	**100.0**

At the time of the study, majority of the respondents (51.7%) were aged 40 years and above with another 22.5% aged between 30 and 39 years while 24.3% were aged 20 to 29 years. However, only 5 (1.5%) of the participants were aged below 20 years. This shows that cumulatively, 98.5% of the women were in the active child bearing age and were expected to have at least experienced child bearing.

When it came to age at first birth, the study found that majority of the women (73.1%) had their first births when they were more than old. However, 26.9% (29) of the women had first birth before being 19 years old. This

shows that there is teenage pregnancy and motherhood to the extent of 26.9%. This demonstrates that for every 100 women, there are 27 cases of teenage pregnancies.

4.1.2 Number of Children

The researcher sought information on whether the women had any children at the time of the study. The findings are cross tabulated in Table 2 below.

Table 2: Number of children

	Number of children			
	Base	0 - 3 children	4 - 5 children	More than 5 children
Base	342	100	89	153
	100.0%	29.2%	26.0%	44.7%
Have children				
Yes	336	94	89	153
	98.2%	27.5%	26.0%	44.7%
No	6	6	0	0
	1.8%	1.8%	0.0%	0.0%

The finding shows that 336 (98. 2%) of the women participants had had children at the time of the study with only 6 (1.8%) reporting that they did not have children. Further, of the 336 who had children, majority (44.7%) had more than 5 children while another 89 (26.0%) had 4 – 5 children and another 94 (27.5%) of the mothers had up to 3 children.

4.2 Infant Mortality

In this study, the variable of investigation was infant mortality which was considered as the dependent variable.

Infant mortality was measured by establishing whether there were dead infants aged 1 and below at the time of their death, gender of dead infants, birth position of dead infants and age at death.

4.2.1 Dead Infants at age ≤ 1 year

The researcher sought information from the participating women whether; they had in their history, an infant who died within one year of birth. The findings are presented in Table 3.

Table 3: Any dead infant aged ≤ 1 Year

	Frequency	Percent	Valid Percent
Yes	276	80.7	80.7
No	66	19.3	19.3
Total	342	100.0	100.0

From the findings, majority of the women participants, 276 (80.7%), reported having lost an infant aged less than 1 year with only 66 (19.3%) saying that they had never had the experience. This shows that the respondents' pool was sufficient and had the information regarding infant mortality since more than 80% had experienced infant mortality at one time in their child bearing life.

4.2.2 Infant Mortality by Birth Order

Birth order could be influencing infant mortality. Thus, the researcher captured information regarding birth position of the dead infants so as to establish infant mortality for various birth positions. The findings are presented in Table 4.

Table 4: Birth Order of Dead Infant

	Infant Mortality (No. of Deaths)				
	Base	**1st**	**2nd**	**3rd**	**4th**
Base	342	282	48	6	6
	100.0%	82.5%	14.0%	1.8%	1.8%
Birth Position					
1st	168	168	-	-	-
	49.1%	49.1%			
2nd	72	72	-	-	-
	22.8%	22.8%			
3rd	55	44	11	-	-
	16.1%	12.9%	3.5%		
4th	24	24	-	-	-
	7.0%	7.0%			
6th	18	-	6	6	6
	5.7%		1.8%	1.8%	1.8%
10th	5	-	5	-	-
	1.5%		1.5%		

The finding shows that a total of 342 infant deaths were reported. Of this total, majority of the reported deaths 168 (49.1%) were for the first births with another 72 (21.1%) being for second born. Thus, there is high infant mortality where 282(82.5%) of the infants were first and second births.

4.2.3 Age at Infant Deaths

The researcher sought to establish infant mortality at various ages and stages of infancy. Thus, information on age at infant death was captured, analyzed and presented in Table 5.

The study found that of the 342 reported cases of infant deaths, majority of the infant deaths 153 (44.7%) occurred within the first six months after delivery, followed by 113 (33.0%) infant deaths that occurred at delivery or less than a month from birth while another 76 (22.2%) occurred from 7 to 12 months. Similar findings were arrived at by Yeung, et al., (2017) who found out that one out of ten infants don't live to see their first birthday celebration. Death during delivery could be attributed to place of delivery and proper prenatal care as well as distance from health facility and transport logistics. Similarly, Blencowe, et al., (2021) in a study which was done in Bangladesh, Ethiopia, Ghana, Guinea Bissau and Uganda showed that 2.7 million infants die within their first month of life. About 50% of them die within the first 24 and three quarters die within the principal week.

Table 5: Age at Infant Death

	Infant Mortality (No. of Deaths)				
	Base	1st	2nd	3rd	4th
Base	342	216	77	45	4
	100.0%	63.2%	22.5%	13.2%	1.2%
Age at Death					
At delivery or less than	113	48	16	45	4
1 month	33.0%	15.2%	5.1%	6.0%	1.3%
1 - 6 months	153	113	40	-	-
	44.7%	33.0%	11.7%		
7 - 12 months	76	55	21	-	-
	22.2%	16.1%	6.1%		

4.3 Environmental Factors and Infant Mortality

The fourth study objective investigated the effect of environment related factors on infant mortality. Thus, various factors of environment related to general public health were considered and their interplay within the families in Chepalungu Sub-County. Thus, the researcher sought information on the main source of drinking water, whether the source was safe, whether the water was treated before drinking, type of toilet used, washing hands after using the toilet as well as the type of cooking fuel. The findings are presented in the subsequent sub-sections.

4.3.1 Source of Drinking Water and Infant Mortality

The participants were asked to indicate where they obtained the drinking water for their households. This was given in terms of 4 choices such as: river/stream, borehole, tap and water pan. The findings were cross tabulated against the number of infant deaths reported by the participants as presented in Table 6.

The source of drinking water for households in Chepalungu Sub-County was mainly water pan/reservoir (29.8%) followed closely by borehole (27.0%) and river/stream (23.4%). However, access to tap water is least available (19.8%). This was also revealed by the nurse in charge who explained that:

> *Majority of the households use water from the water pans in the village with tap water only accessible to those in urban areas. Moreover, the water is not treated, leading to waterborne diseases like typhoid among the infants. [Interview: Nurse in Charge].*

Table 6: Source of Water for Drinking versus Number of Infant Deaths

	Infant Mortality (No. Deaths)					
	Base	0	1st	2nd	3rd	4th
Base	342	63	191	63	18	7
	100.0%	18.4%	55.8%	18.4%	5.2%	2.0%
Source of Drinking Water						
River/Stream	80	21	42	15	2	0
	23.4%	6.1%	12.3%	4.4%	0.6%	0.0%
Borehole	92	13	56	18	5	0
	27.0%	3.8%	16.4%	5.3%	1.5%	0.0%
Tap	68	25	35	6	2	0
	19.8%	7.3%	10.23%	1.8%	0.6%	0.0%
Water pan (reservoir)	102	4	58	24	9	7
	29.8%	1.2%	17.0%	7.0%	2.6%	2.0%

On the frequency of infant deaths in relation to source of drinking water, 15 (4.4%) of those who use river/stream reported 2 infant deaths, while cumulatively 23 (6.8%) of those who use borehole water reported more than 1 infant death. Similarly, 40 (11.6%) of participants who use water pan/ reservoir cumulatively had lost more than 1 infant each. However, for households which use tap water as their source of drinking water, only 8 (2.4%) lost more than 1 infant with a significant 25 (7.3%) having not lost an infant child. Thus, infant mortality was highest among households using water pan as a source of drinking water (28.6%), followed by borehole (23.3%), river/stream (17.3%) with those using tap water having the least prevalence at (12.6%). This shows that the water sources are less safe, and this might affect the overall health of the infants. This is because water from the river, water pan, and boreholes are open to pollution with disease causing organisms while tap water is treated against such organisms.

4.3.2 Safe Drinking Water and Infant Mortality

The study participants were asked to indicate whether they considered their drinking water to be safe for drinking. This was cross tabulated against the number of reported infant deaths to establish whether there was an evident pattern on association between safe drinking water and infant mortality. The findings are presented in Table 7.

The study found that majority of households, 229 (67.0%) do not have safe drinking water with only 113 (33.0%) indicating that their source of drinking water is safe. For those who reported that their drinking water was safe, 72 (21.1%) reported exactly 1 infant death while another 30 (8.8%) indicated that they had no infant deaths. However, for those households whose drinking water was not safe, only 30 (8.8%) reported that they had not experienced any infant death with majority 136 (39.8%) reported exactly one infant death.

Table 7: Safe Drinking Water Source versus Number of Infant Deaths

	Infant Mortality (No. Deaths)					
	Base	0	1st	2nd	3rd	4th
Base	342	60	208	52	16	6
	100.0%	17.5%	60.8%	15.2%	4.7%	1.8%
Safe Drinking Water						
Yes	113	30	72	6	5	0
	33.0%	8.8%	21.1%	1.8%	1.5%	0.0%
No	229	30	136	46	11	6
	67.0%	8.8%	39.8%	13.5%	3.2%	1.8%

Further, 63 (18.5%) of mothers from households who consider their drinking water not to be safe had lost more than one (1) infant compared to only 11 (3.3%) who had lost more than 1 infant among those who use safe drinking water. This shows that infant mortality is higher when drinking water is not safe. Moreover, this appears to be the case in Chepalungu Sub County where majority of the households (67%) do not have safe drinking water.

4.3.3 Treating Drinking Water and Infant Mortality

The researcher sought information on the additional efforts the households make to ensure that the water is safe for drinking. Thus, the method of treating drinking water was probed with respondents indicating whether this was done by use of water guard, boiling or just leaving it to settle. Cross tabulation was done between methods of water treatment and number of infant deaths with a view to establishing any patterns. The findings are presented in Table 8.

Table 8: Treat Drinking Water versus Number of Dead Infants

	Infant Mortality (No. Deaths)					
	Base	0	1st	2nd	3rd	4th
Base	342	82	154	6	11	0
	100.0%	24.0%	45.0%	1.8%	3.2%	0.0%
Treating Drinking Water						
Water Guard	41	12	24	0	5	0
	12.0%	3.5%	7.0%	0.0%	1.5%	0.0%
Boiling	183	64	107	6	6	0
	53.5%	18.7%	31.3%	1.8%	1.8%	0.0%
Leave Water to Settle	29	6	23	0	0	0
	8.5%	1.8%	6.7%	0.0%	0.0%	0.0%

Majority of the study participants treat their drinking water by boiling (53.5%) while another 12.0% use water guard for treatment of drinking water with another 8.5% just leaving the water to settle. The study found that majority of households which use water guard for water treatment (7.0%) had exactly 1 infant death with another 1.5% having 3 infant deaths. However, 3.5% of households using only water guard for treatment had not experienced any infant deaths.

In the case of households who boil their drinking water to make it safe, a significant proportion (18.7%) had not experienced any infant deaths despite 107 (31.3%) reporting that they had experienced exactly 1 infant death. However, 6 (1.8%) households who boil drinking water experienced 2 infant deaths while 6 (1.8%) had

experienced 3 infant deaths. Thus, a cumulative total of 12 (3.6%) of households who treat drinking water by boiling had experienced more than 1 infant death.

Of those who only leave drinking water to settle, 6.7% had experienced 1 infant death while only 1.8% had not experienced any infant death. The findings show that 18.7% of those who boil drinking water had not experienced infant death, while 3.5% who use water guard for treatment had also not experienced infant with only 1.8% of those who leave water to settle had not experienced infant death. These findings show that infant mortality is lowest among households who boil drinking water compared to other methods of water treatment. This is because boiling water eliminates disease causing germs which might eventually affect the health of the infants and other members of the household.

4.3.4 Type of Toilet Facility and Infant Mortality

The type of toilet facility available to people in a household is an indication of hygiene level and possible disease and infection prevention mechanisms. Thus, the researcher sought information on the available toilet facility which was cross tabulated against the number of infant deaths recorded as o deaths, 1 death, 2 deaths, 3 deaths and 4 deaths at infant age to establish any relationship. The findings are presented in Table 9.

Table 9: Type of Toilet Facility versus Number of Infant Deaths

| | Infant Mortality (No. Deaths) | | | | | |
	Base	0	1st	2nd	3rd	4th
Base	342	55	211	54	16	6
	100.0%	16.1%	61.7%	15.8%	4.7%	1.8%
Type of Toilet Facility						
Pit latrine	318	48	196	52	16	6
	92.9%	14.0%	57.3%	15.2%	4.7%	1.8%
In-door toilet/flush toilet	18	6	12	0	0	0
	5.3%	1.8%	3.6%	0.0%	0.0%	0.0%
Bush	6	1	3	2	0	0
	1.8%	0.3%	0.9%	5.8%	0.0%	0.0%

Majority of the participants, 318 (92.9%) came from households using pit latrine as their toilet facility with another 18 (5.3%) with access to indoor flush toilet. However, the study found that only 6 (1.8%) of the participants use the bush as their toilet facility. The findings show that 5 (6.8%) of those who use the bush had experienced infant deaths as well as 79.0% for those who use pit latrine, with a significant 0.3% of those who use indoor flush toilets having not experienced any infant death.

Further, of the participants who use pit latrine as toilet facility, 196 (57.3%) had experienced exactly 1 infant death, 52 (15.2%) had experienced 2 infant deaths, 16 (4.7%) had experienced 3 infant deaths while 6 (1.8%) had experienced 4 infant deaths. However, for those using indoor flush toilets, 12 (3.6%) had experienced exactly only 1 infant death. Thus, infant mortality was higher among users of pit latrine and bush compared to those using indoor flush toilets with none of the families reporting multiple number of infant deaths.

Concurrent to this view, Perry, *et al.,* (2019) saw that family units with flush toilets in Kenya had infant mortality of 13 per thousand and those with pit lavatories had 31 per thousand. Thus, infant mortality is prevalent among families using bush and pit latrine for toilet facilities. This is attributable to waste disposal and vector insects as houseflies which transmit disease causing organisms. The nurses in charge also noted that use of open latrine contributes to the witnessed high IMR where one of them said that:

> *Most residents use an open pit latrine while in some extreme cases, the bushes are used as the toilet facility which leads to infections with diarrhea symptoms due to poor quality of care offered to the infants. [Interview: Nurse in Charge].*

The finding shows that human waste disposal could contribute to diseases and contamination which affect health especially of infants in Chepalungu Sub County. The predominant use of pit latrines and bush as toilet facilities leaves the households vulnerable to such infections transmitted by vector insects, wind and fellow human beings.

4.3.5 Wash Hands after Visiting Toilet and Infant Mortality

Washing hands after using toilet facilities is a practice considered healthy in prevention of infection causing germs. Children are vulnerable to infection thus handling them requires higher standards of hygiene such as washing of hands after using toilet facilities. Consequently, the researcher sought information from the participating mothers whether they wash their hands after using the toilet facilities. Cross tabulation of the findings was done against the number of infant deaths reported as presented in Table 10.

From the findings, majority of the mothers in Chepalungu Sub County 319 (93.3%) wash their hands after using toilet facilities with only 23 (6.7%) indicating that they do not always wash their hands. Further, although a higher proportion of mothers who wash their hands after using the toilet reported having not experienced infant deaths (59.1%).

Table 10: Wash hand after visiting the toilet versus Number of Infant Deaths

	Infant Mortality (No. Deaths)					
	Base	0	1st	2nd	3rd	4th
Base	342	60	208	52	16	6
	100.0%	17.5%	60.8%	15.2%	4.7%	1.8%
Wash Hand After Visiting The Toilet						
Yes	319	202	54	41	16	6
	93.3%	59.1%	15.8%	12.0%	4.7%	1.8%
No	23	6	6	11	0	0
	6.7%	1.8%	1.8%	3.2%	0.0%	0.0%

Cumulatively, 17 out of 23 mothers who do not wash their hands after using toilet facilities recorded at least 1 infant death. This shows that there are more cases of infant mortality where mothers do not wash their hands after using toilet facilities. This could be due to the increased chances of transmitting disease-causing organisms to the infants during feeding as a result of the unwashed hands.

4.3.6 Type of Cooking Fuel Used and Infant Mortality

The type of cooking fuel is crucial in the hygienic handling of food which might influence the transfer of germs for those who use the food or the safety of the food. The researcher sought information on the cooking fuel used in their households and the number of infant deaths within the household through cross tabulation. The findings are presented in Table 11.

Table 11: Cooking fuel versus Number of Infant Deaths

	Infant Mortality (No. Deaths)					
	Base	0	1st	2nd	3rd	4th
Base	342	60	208	52	16	6
	100.0%	17.5%	60.8%	15.2%	4.7%	1.8%
Cooking Fuel						
Firewood	312	48	190	52	16	6
	91.2%	14.0%	55.5%	15.2%	4.7%	1.8%
Pressurized gas	18	6	12	0	0	0
	5.3%	1.8%	3.5%	0.0%	0.0%	0.0%
Charcoal	12	6	6	0	0	0
	3.5%	1.8%	1.8%	0.0%	0.0%	0.0%

According to the households 312 (91.2%) use firewood as their main fuel type for cooking while 18 (5.3%) use pressurized gas with another 12 (3.5%) using charcoal. Of those households who use firewood, only 48 (14.0%) reported that they had not experienced any infant deaths, while 6 (1.8%) of those who use pressurized cooking gas had not experienced infant deaths with 6 (18%) of those who use charcoal as fuel having not experienced infant deaths.

The trend in fuel use and infant mortality emerged with regards to multiple deaths where households using firewood as the preferred fuel type reported multiple infant deaths while those using pressurized cooking gas and charcoal did not report any multiple infant deaths. Specifically, 52 (15.2%) of households using firewood reported 2 infant deaths, 16 (4.7%) had experienced 3 infant deaths while 6 (1.8%) had experienced 4 infant deaths. Thus, cumulatively 74 (21.7%) of households using firewood as cooking fuel had more than 1 infant deaths.

This shows a variation in fuel type used for cooking and infant mortality. The higher infant mortality for households using firewood and charcoal as fuel is attributable to the dust and smoke inherent in the fuel type which ends up contaminating the food which may be consumed by the infant leading to disease transmission. On a similar note, Khan, *et al.,* (2017) demonstrated that the utilization of clean cooking fuels, access to safe water and sanitation decreases the dangers of infant mortality.

4.3.7 Relationship between Environmental Factors and Infant Mortality

In order to establish the relationship between the indicators of various environmental factors and infant mortality, Chi-Square analysis was run between each indicator of environmental factors (Source of drinking water, safety of drinking water, method of treatment of drinking water, type of toilet facility used, washing hands after using toilet as well as the type of cooking fuel) and infant mortality measured by the number of infant deaths reported ordered as 0, 1, 2, 3 and 4. The findings are summarized in Table 12.

Table 12: Chi Square output for Environmental Factors and Infant Mortality

Variable	Chi-Square Value	df	Asymp. Sig. (2-sided)
Source of drinking water	38.442[a]	12	.000
Safety of drinking water	21.884[a]	4	.000
Treat drinking water	39.119[a]	8	.000
Type of toilet facility	36.268[a]	8	.000
Wash hand after visiting toilet	24.761[a]	4	.000
Type of cooking fuel	18.040[a]	8	.021
N of Valid Cases	342		

The study found that all the indicators of environmental factors investigated had significantly influenced infant mortality. Specifically, source of drinking χ^2 = 38.442 (p < .001), safety of drinking water χ^2 = 21.884 (p < .001), treating drinking water χ^2 = 39.119 (p < .001), type of toilet facility χ^2 = 36.268 (p < .001), washing hand after visiting toilet χ^2 = 24.761 (p < .001) and type of cooking fuel χ^2 = 18.040 (p = .021) had statistically significant difference with infant mortality in Chepalungu Sub County. This shows that environmental factors influence infant mortality with p < .05. Thus, environmental factors have a greater bearing on infant health and as such explain infant mortality. Polluted environment from drinking water, toilet facility and cooking fuel lead to higher infant mortality in Chepalungu Sub County. Similarly, WHO (2017) reports that among 10 distinguished major causes of high IMR in developing countries, dirty water, and poor sanitation were positioned second, while indoor smoke was rated fourth.

5. Conclusion and Recommendations

5.1 Conclusion

The study considered various environmental factors including main source of drinking water, whether the source was safe, whether the water was treated before drinking, type of toilet used, washing hands after using the toilet as well as the type of cooking fuel. The study shows that water sources were less safe and might affect the overall health of the infants. This was because water from the river, water pan and boreholes are open to pollution with disease causing organisms while tap water was covered and treated for such organisms. This was because; infant mortality was higher when drinking water was unsafe.

Infant mortality rate was lowest among households who boiled drinking water compared to those who used other methods of water treatment. Further, the study concluded that infant mortality was prevalent among families using

bush and pit latrine for sanitary purposes and that there were more cases of infant mortality where mothers did not wash their hands after using toilet facilities compared to cases where there was hand washing after using toilet facilities. The study also concluded that there was a relationship between fuel type used for cooking and infant mortality. Overall, environmental factors have a greater bearing on infant health and as such explain infant mortality. Polluted drinking water, poor sanitation and use of firewood as main source of cooking fuel led to high infant mortality rate in Chepalungu sub county.

Overall, the study established that source of drinking $\chi^2 = 38.442$ (p < .001), safety of drinking water $\chi^2 = 21.884$ (p < .001), treating drinking water $\chi^2 = 39.119$ (p < .001), type of toilet facility $\chi^2 = 36.268$ (p < .001), washing hand after visiting toilet $\chi^2 = 24.761$ (p <.001) and type of cooking fuel $\chi^2 = 18.040$ (p = .021) statistically significant influence on infant mortality rate.

5.2 Recommendations

As a measure and strategy to reduce infant mortality rate, the study recommends the need to conduct environmental education program targeting the mothers on the human waste disposal, safe drinking water and safe cooking fuel. This can be done through forums in the women groups, pre-natal clinics and Barazas as well as church forums.

5.3 Suggestions for Further Research

Future research should be conducted to include: causes of infant mortality, biological factors influencing infant mortality and climatic determinants of infant mortality by region.

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