World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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The effect of distance covered to the nearby medical facility on the death of infants in rural and urban areas of Kakamega Central Sub-County, Kakamega County, Kenya

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World Journal of Advanced Research and Reviews, 2023, 17(03), 842–852

Publication history: Received on 15 February 2023; revised on 25 March 2023; accepted on 27 March 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.17.3.0489

Abstract

Purpose of the study: At the backdrop of the third sustainable development goal, Kenya's infant mortality rate is 36 while that of Kakamega is 37. This study assessed the effect of distance covered to the nearby medical facility on the death of infants in rural and urban areas of Kakamega Central Sub-County, Kakamega County, Kenya.

Data and Methods: A cross-sectional research design was employed to collect data from a sample of women population within childbearing ages of 15 to 49 years in Kakamega Central Sub-County. Analyses were done on the Statistical Package for Social Sciences computer program at descriptive and inferential levels.

Results: Straight-line distance covered to the nearby medical facility was significantly related to urban neonatal mortality. A straight-line distance of 1.1 to 3.9 kilometres from one's residence to the nearby medical facility had a 1.127 higher likelihood of neonatal mortality in comparison to an at most 1 kilometre straight-line distance. Further, an increase in travel-time was associated with an increase in the likelihood of infant mortality. The adjusted odds ratios of infant mortality increased by 167.2 percent and 643.6 percent for a 30 minutes' and 60 minutes' increase in travel time in urban and rural areas, respectively.

Conclusion: Straight-line distance influenced infant mortality in urban areas but not rural areas. Travel-time influenced both rural and urban infant mortalities. There is need observe equitable geospatial distribution of medical facilities and proper equipment of the same in Kakamega Central Sub-County in order to observe the acceptable density of medical facilities in correspondence with the population.

Keywords: Straight-line distance; Travel-time; Rural areas; Urban areas; Death of infants; Kakamega Central Sub-County

1. Introduction

The rate of death of babies between birth and the eleventh month of life is an excellent pointer to the health standing of children and the life expectancy at birth of a given society. High infant mortality is undesirable and a reflection of poor health status of a society. This is because infant mortality robs a country of the much needed human capital besides increasing maternal mortality as women try to get pregnant to replace dead infants before their bodies fully recover from the lost births. It also increases fertility as women tend to have more children as a result of the fear of losing some along the way. Infant mortality thus retards development.

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Generally, the number of children dying at tender ages is still high. The world has however advanced incredible developments in decreasing childhood mortality over decades. A report by [1] noted that the world-wide rate of under-five mortality dropped from 93 (in 1990) through to 38 (in 2019) deaths for every 1,000 live births. Among the under-five deaths, 47 percent took place in the first month of life (neonate deaths), 28 percent at ages 1 to 11 months (post-neonate deaths), and 25 percent at ages 1 to 4 years (child deaths). The rates were 17, 11 and 10 deaths for every 1,000 live births for neonatal, post-neonatal and child mortality, in that order. The foremost roots of these deaths were pneumonia and complications occurring preterm and intra-partum such as birth asphyxia [2][3]. A study carried out by [2] on the causes of child mortality established that the observed reductions in global childhood mortality were mainly a result of reductions in such communicable diseases as pneumonia, diarrhoea and measles. These studies and reports addressed the causes of death and but did not assess whether infant mortality differed based on the distance covered to reach the nearby medical facility.

According to Kenya demographic and health surveys, 1989 through to 2014, Kenya's infant mortality has shown an erratic pattern over time as follows: 60 (1989), 62 (1992), 74 (1998), 77 (2003), 52 (2008/09) and 39 (2014). It was not until 2008 that there was a reversal in infant mortality based on the type of place of residence. Before, the rate had been higher in rural compared to urban areas of Kenya. In 2008/09, infant mortality rate was 58 and 63 in rural and urban areas, respectively. The rate declined to 40 and 43 deaths for every 1,000 live births in rural and urban areas, respectively, in 2014. According to the analytical report on mortality based on the 2019 Kenya population and housing census, rural and urban areas of Kenya had a similar infant mortality rate of 36 deaths for every 1,000 live births in 2019 [4]. The analysis in this report was however based on the entire birth and death histories of mothers unlike the current study that has a well-defined time-frame.

Regional disparities exist in the death of infants in Kenya. In 2009, Kenya's infant mortality rate was 54 while that of Kakamega County was 65 [5]. This improved to 39 and 40 deaths for every 1,000 live births for Kenya and Kakamega County, respectively [6]. According to the 2019 Kenya population and housing census report, Kenya's infant mortality rate is 36 while that of Kakamega County is 37 [4]. In their study in Kenya, [7] established that Kakamega County ranked fifth among fifteen counties with the poorest maternal, new-born, child and adolescent health indicators.

In 2015, nations pledged to terminate avertable deaths of children under the age of 60 months of life. They also pledged to lower the death of neonates to at least 12 for every 1,000 live births and that of children under the age of 60 months to at least 25 for every 1,000 live births come the year 2030 [8]. To achieve this goal, each country is expected to understand the local factors influencing infant mortality and implement appropriate interventions to address the elevated risk of mortality and the existing differentials. This study assessed the effect of distance covered to the nearby medical facility on the death of infants in rural and urban areas of Kakamega Central Sub-County, Kakamega County, Kenya. It was guided by the hypotheses that: (1) straight-line distance covered to the nearby medical facility has a significant relationship influence on the death of infants in rural and urban areas of Kakamega Central Sub-County, and (2) travel-time taken to reach the nearby medical facility has a significant relationship influence on the death of infants in rural and urban areas of Kakamega Central Sub-County Such an assessment helps in fast-tracking the United Nation's Sustainable Development Goal on early childhood mortality. Reducing infant mortality allows new-borns to live out their social and economic potential in their families and societies at large.

2. Literature Review

A number of studies have identified the distance covered to reach the nearby medical facility as a factor related to childhood mortality. Poor geographical access to a health facility affects maternal service usage and increases the risk of new-born mortality [9]. Distance negatively affects antenatal care, facility delivery and postnatal counselling services. When compared with women who lived less than a kilometre from a facility, the odds of receiving at least 4 antenatal care visits for women living more than 10 kilometres from a facility were 38.8 percent lower (OR = 0.612; 95% CI = 0.559 – 0.671). The odds of in-facility delivery were lower at greater distances with the odds ratio for delivery for women living more than 10 kilometres being 55.3 percent lower (OR = 0.447; 95% CI = 0.394 – 0.508) relative to women living less than a kilometre away [10]. A different study by [11] found greater distance to be associated with higher mortality, lower healthcare utilisation, increased home deliveries, reduced number of antenatal care visits, and a reduction in skilled aid in the course of childbirth delivery.

Some studies found out that relative distance from medical facilities accounted for high childhood mortality [9][12][13][14]. [12] explained that the distinct childhood mortality differentials in Zimbabwe were due to differences in regional health arrangement, an observation that points to the distribution of medical facilities. A study done in rural areas of Tanzania found the rate of mortality for infants who lived within 5 kilometres to the nearby medical facility to be 72.4 for every 1,000 person years while that of those living greater than 5 kilometres from the health facility was

82.3 for every 1,000 person years [15]. In Ethiopia, [16] reported that there were insignificantly high odds ratios for the distance to the medical facility not being problematic with reference to it being problematic.

In low - and middle - income countries, [10] used multivariable logistic models and meta-analysis regressions to estimate the association between facility distance, child mortality, and health care utilisation. The study found children born in households that were located within 2 kilometres, 3 kilometres and 5 kilometres from a health facility to have 7.7 percent, 16.3 percent and 25 percent higher odds ratio of dying in the neonatal period, respectively, when compared with children born in households that were within a kilometre from a health facility. Further, being more than 10 kilometres from a health facility increased the odds of neonatal mortality in five surveys, decreased the odds of neonatal mortality in one survey, and there was no effect in the remaining 23 of the 29 demographic and health surveys.

Other studies have reported contradicting results [17][18]. [17] did a study on distance to care, facility delivery and early neonatal mortality in Malawi and Zambia. The study found no association between distance and neonatal mortality in Malawi, while in Zambia, a ten kilometre further distance was associated with lower neonatal mortality. A study done in India by [18] found neonatal mortality to decrease with increase in distance from home to the primary healthcare services.

Children born and raised in communities with reduced access to health facilities more likely suffers social and economic deficiency that affects their health outcomes [19][20]. In rural areas of Burkina Faso, [21] established that the death of children under the age of five years was greater when a time duration of 4 hours was needed to reach to the nearby medical facility as likened to when the nearby medical facility was village-based. A study by [22] established that people living in remote areas had greater risks of childhood deaths. According to the study findings, living at least 90 minutes from the nearby medical facility was associated with a double larger risk of the death of children than living within 90 minutes from the nearby medical facility. A different study by [10] found children born to households that were located more than 60 minutes from a health facility to have a 25.6 percent (OR: 1.256; $p < 0.05$; CI: 1.105 – 1.429) higher odds ratio of dying in the neonatal period than children who were born to households that were within 10 minutes from a health facility. [16] explained that those people who live in the inaccessible mountainous and remote areas end up spending many hours trekking in search of maternal and infant health services. This might discourage some mothers from visiting health facilities and delay access of treatment in case of infant sickness.

Having insufficient resources at disposal limits the reach to and uptake of current health care more so given the pay-and-take system operating in several sub-Saharan countries [23]. In selected districts of Kenya, [24] projected that roughly 63 percent of the people were able to reach a government medical centre within in an hour. Yet still, accessing a health facility does not necessarily guarantee access to proper infant care services. In Kenya at large, [25] noted that only 75 percent of the assessed medical centres were well-stocked with family planning and vaccine commodities. The study further established that childbirth delivery services were available in below 50 percent of the assessed medical centres.

A study done on the effect of health systems context on infant and child mortality in Sub-Saharan Africa from 1995 to 2015 found infant and child survival to be related to the cost of care [26]. Moving from the first to the third quartile of prevalence of delivery fee (10 – 77 percent) was associated with an 11 percent increase in the risk of infant death. A similar scaled increase in the proportion of facilities charging immunization fee (from 27.5 to 73.1 percent of facilities charging fee) was associated with a 20 percent increase in the risk of child mortality. Therefore, the current study postulated that the distance covered to reach the nearby medical facility might be influencing infant mortality in Kakamega Central Sub-County either through travel time or straight-line distance, or through other pathways.

3. Material and methods

This study employed a cross-sectional research design. The study data was gathered from a sample of mothers within the childbearing ages of 15 to 49 years who had an experience of a childbirth between 2013 and 2022 in Kakamega Central Sub-County, Kakamega County, Kenya. Kakamega Central Sub-County had 52,015 households [4] from which a sample size of 384 respondents was drawn. The sample population was arrived at through a formula developed by Fisher et al. [27] of whom a questionnaire was presented. Systematic random sampling technique was used to arrive at households which were involved in the study. Half of the respondents (cases) were mothers with an experience of an infant death in the study period 2013 to 2022. The other half of the respondents (controls) were mothers without an experience of an infant death in the study period 2013 to 2022. [28] recommended matching of cases and controls in order to adjust for confounding at the data analysis stage.

This being a research involving people, the study observed research ethics of minimising the risk of psychological and social harm especially on recall of events of death, confidentiality, anonymity, informed consent and honesty. A research licence was gotten from the National Commission for Science, Technology and Innovation (NACOSTI), license number NACOSTI/P/22/22577. With the research licence, the researchers visited the Kakamega County Secretary's Office to ask for permission to conduct research in Kakamega Central Sub-County, and were granted a research authorization reference number CGK/OCS/GEN.CRR./04/(621). An informed consent was sought from all the targeted respondents after describing to them what the study entailed at the point of gathering data. Each willing participant was asked to append a signature on the participation agreement form at the verge of the interview. The willing participants voluntarily participated in the study without coercion or inducement.

Data analyses were conducted on the Statistical Package for Social Sciences (SPSS) version 25 computer software program at descriptive and inferential analyses levels. At descriptive level, cross-tabulation analysis was done to obtain the prevalence of infant mortality in rural and urban areas by study variables. Inferential analysis engaged multinomial logistic regression modelling at univariate and multivariate analytical levels to assess the effect of distance covered to the nearby medical facility (straight-line distance and travel-time) on the death of infants in rural and urban areas using logistic regression analysis.

At univariate analysis level, data on straight-line distance and travel-time taken to reach the nearby medical facility were separately fitted in a logit function logistic curve in order to estimate the occurrence of an outcome as a result of each explanatory variable. The findings, in terms of crude odds ratios, were arrived at by considering the exponential function of appraised coefficients of regression. At multivariate analysis level, both exposure variables were fitted in the multinomial logistic regression model controlling for covariates (geographical, socioeconomic and demographic factors) in order to study the independent effect of each one of them on neonatal, post-neonatal and infant mortality in terms of adjusted odds ratios. The analyses were segmented at neonatal level, post-neonatal level, and the infant level and hypotheses tested at 95% significance level.

Survival analysis, basically Kaplan-Meier survival curve was estimated to obtain the probability of surviving within the first 11 months of life based on the study variable that was found to be the most significant contributor to the death of infants in rural and urban areas in Kakamega Central Sub-County. The Kaplan-Meier estimate involves computing probabilities of occurrence of an event at a certain point in time [29]. The event, in this case, is death. Survival is thus remaining free of death over time. For each time interval, survival probability was calculated by the number of subjects surviving divided by the number of patients at risk. That is,

S_t = {(Number of subjects living at the start – Number of subjects who died) ÷ Number of subjects living at the start}

Subjects who have died, dropped out or move out are not counted as being at risk. This means that subjects who are lost are considered censored and thus excluded from the denominator. A flat survival curve suggested good survival while a sharply-dropping survival curve suggested poor survival [30].

4. Results

4.1. Results of descriptive analysis

Descriptive analysis was conducted to bring out the percentage distribution of infant deaths according to distance factors in rural and urban areas of Kakamega Central Sub-County. The results are presented in Table 1.

Majority of the infants who died were to mothers who covered a distance of between 1.1 and 3.9 kilometers in rural areas (42.31 percent) and at most 1 kilometer in urban areas (50.76 percent) to reach the nearby medical facility. Those mothers who took at most half-an-hour to reach the nearby medical facility recorded the highest proportion of infant deaths both in rural and urban areas (rural – 51.28 percent; urban – 84.09 percent). Mothers who took at least an hour to reach the nearby medical facility recorded the least proportion of infant deaths (rural – 19.23 percent; urban – 3.03 percent). There was a common trend with the proportion of infant deaths reducing from an at most 30 minutes' travel-time through a 31 to 60 minutes' travel-time to an at least 60 minutes' travel-time taken by a mother to reach the nearby medical facility. The reduction was however steeper in urban areas than in rural areas. This is well illustrated on Figure 1.

Table 1 Distribution of deaths according to distance factors

	RURAL			URBAN		
Exposure variable	**Neonate**	**Post-neonate**	**Infant**	**Neonate**	**Post-neonate**	**Infant**
Straight-line distance (in km)						
x≤1	32.26	10.64	19.23	46.15	53.75	50.76
1.1≤x≤3.9	41.94	42.55	42.31	44.23	35.00	38.64
x≥4	25.81	46.81	38.46	9.62	11.25	10.61
Travel-time (in minutes)						
x≤ 30	61.29	44.68	51.28	88.24	81.48	84.09
31≤x≤60	25.81	31.91	29.49	9.80	14.81	12.88
x>60	12.90	23.40	19.23	1.96	3.70	3.03

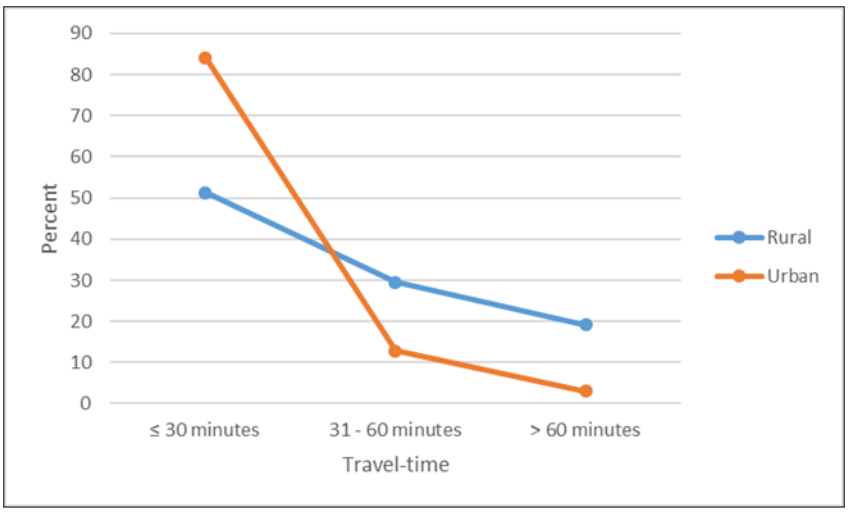

Figure 1 A comparative line graph showing distribution of infant deaths against travel time in rural and urban areas of Kakamega Central Sub-County

The descriptive statistics showed that there was a higher prevalence of infant mortality amongst mothers who lived/stayed at a distance of between 1.1 and 3.9 kilometers to the nearby medical facility (42.31 percent) while it was lowest amongst mothers who lived/stayed at an at most 1 kilometer distance to the nearby medical facility (19.23 percent) in rural areas. Shorter straight-line distance to the nearby medical facility increases utilization of health services in terms of antenatal care visits, hospital delivery, post-natal care visits and in case of infant sickness, all of which contribute to reduced prevalence of infant mortality. In urban areas, there was a high prevalence of infant mortality amongst mothers who lived/stayed at a distance of at most 1 kilometer to the nearby medical facility (50.76 percent) and lowest amongst mothers who lived/stayed at a distance of at least 4 kilometers to the nearby medical facility.

The higher prevalence of infant mortality amongst infants who resided at reduced distances to the nearby medical facilities in urban areas might be as a result of the choice of public vis-à-vis private medical facilities. Private medical facilities might be closer to a client yet the client is unable to afford the hospital charges. Of course there is higher number of medical facilities in urban areas than in rural areas. With the small land-size area of urban areas, then the physical distance from one medical facility to the other is not that large. So is the general straight-line distance from one's area of residence to the nearby medical facility.

Mothers and their infants who took at most 30 minutes to reach the nearby medical facility had a higher prevalence of infant mortality (rural - 51.28 percent; urban – 84.09 percent) when compared to their counterparts who took beyond

an hour to reach the nearby medical facility (rural - 19.23 percent; urban – 3.03 percent). It is possible that people closer to medical facilities in terms of travel-time might wait until their sick infants reach critical conditions before taking them for medication. People far away from medical facilities in terms of travel-time do not take risks: they avail their sick infants to hospitals once they notice some abnormal symptoms. A medical facility might be near in terms of travel time yet not well-equipped with the rightful medical infrastructure for maternal and infant care: frequent stock-outs of drugs, shortage and/or absence of qualified medical personnel to offer the required services and absence of equipment needed to diagnose the expectant mothers and sick infants.

4.2. Results of univariate analysis

The distance factors of straight-line distance and travel-time taken by a mother and her infant to reach the nearby medical facility were fitted in the multinomial logistic regression model to obtain the crude odds ratios on the effect of distance covered to the nearby medical facility on neonatal, post-neonatal and infant mortality. The results are presented in Table 2.

Table 2 Crude odds ratios on the effect of distance factors on neonatal, post-neonatal and infant mortality

	RURAL			**URBAN**		
Exposure variable	**Neonatal**	**Post-neonatal**	**Infant**	**Neonatal**	**Post-neonatal**	**Infant**
Straight-line distance (in km)						
x≤1[a]	1.000	1.000	1.000	1.000	1.000	1.000
1.1≤x≤3.9	0.284*	2.183	0.746	1.799	0.956	1.407
x≥4	0.495	0.953	0.653	1.220	1.248	1.359
Travel-time (in minutes)						
x≤ 30[a]	1.000	1.000	1.000	1.000	1.000	1.000
31≤x≤60	0.763	1.267	1.076	0.705	3.797	3.399
x>60	0.990	1.442	1.395	1.812	3.842	5.929

*ρ<0.05; [a] Reference category

Straight-line distance between one's residence and nearby medical facility was found to significantly contribute to rural-urban differentials in infant mortality in Kakamega Central Sub-County. In rural areas, mothers and their infants who travelled between 1.1 kilometres to 3.9 kilometres to reach the nearby medical facilities were less likely to experience neonatal mortality when compared to their counterparts who travelled at most 1 kilometre to reach the nearby medical facility (cOR = 0.284; ρ<0.05; CI = 0.086 – 0.939). There was a general insignificant increase in the likelihood of infant mortality with increase in straight-line distance covered to reach the nearby medical facility in urban areas. Travel-time taken to reach the nearby medical facility did not significantly influence infant mortality both in rural and urban areas.

The findings in Table 2 show that the crude odds ratios of neonatal mortality decreased by 71.6 percent for a 1.1 to 3.9 kilometre distance to the nearby medical facility in comparison to an at most 1 kilometre distance to the nearby medical facility in rural areas. This observation can be explained by differences in the quality health care services offered from one health facility to the other in rural areas of Kakamega Central Sub-County. A near-home health facility might be offering low-quality healthcare services with a distant one offering better healthcare services. It is also possible that the near-home health facilities do not stay open throughout the day and seasons making them occasionally inaccessible.

4.3. Results of multivariate analysis

The results in the final model that incorporated both the study variables and confounders showed that both straight-line distance and travel-time taken to reach the nearby medical facility were significantly related to infant mortality in Kakamega Central Sub-County (Table 3).

From Table 3, the study noted that the significance of straight-line distance on rural neonatal mortality observed in the univariate regression analysis level disappeared in the full model. On the flip-side, there were higher adjusted odds ratios of neonatal mortality for urban mothers and infants who travelled between 1.1 kilometers to 3.9 kilometers to reach the nearby medical facility in reference to their counterparts who travelled at most 1 kilometer to reach the

nearby medical facility (aOR = 2.127; ρ<0.05; CI = 1.197 – 3.781). Travel-time taken to reach the nearby medical facility significantly influenced both rural and urban infant mortality. There was a general increase in the likelihood of infant mortality with increase in travel-time. In rural areas, the adjusted odds ratios of infant mortality were higher among infants who took at least an hour to reach the nearby medical facility compared to infants who took at most half-an-hour to reach the nearby medical facility (aOR = 7.436; ρ<0.05; CI = 0.948 – 5.834). There were higher adjusted odds ratios of infant mortality for urban infants who took between 31 to 60 minutes to reach the nearby medical facility in reference to their counterparts who took at most 30 minutes to reach the nearby medical facility (aOR = 2.672; ρ<0.05; CI = 0.534 – 1.340).

Table 3 Adjusted odds ratios on the effect of distance factors on neonatal, post-neonatal and infant mortality controlling for all other study factors

	RURAL			**URBAN**		
Exposure variable	**Neonatal**	**Post-neonatal**	**Infant**	**Neonatal**	**Post-neonatal**	**Infant**
Straight-line distance (in km)						
x≤1[a]	1.000	1.000	1.000	1.000	1.000	1.000
1.1≤x≤3.9	0.499	0.912	0.495	2.127*	0.926	3.978
x≥4	1.122	0.416	0.592	3.588	1.499	2.852
Travel-time (in minutes)						
x≤ 30[a]	1.000	1.000	1.000	1.000	1.000	1.000
31≤x≤60	7.336	3.137	5.747	6.524	9.278	2.672*
x>60	14.957	2.581	7.436*	18.28	13.44	6.257

*ρ<0.05; [a] Reference category

Urbanites travelling 1.1 to 3.9 kilometers to reach a nearby medical facility experienced a 112.7 percent higher likelihood of neonatal mortality than those who travelled for a kilometer to reach a medical facility. This might be due to unaffordability of transport expenses and low utilization of antenatal, perinatal, delivery and postnatal care services, yet the uptake of these services influence infant mortality. Distance influences accessibility to healthcare services, causes delays to care, and influences the ability of a mother to use health services during pregnancy, at birth and during postnatal period. In low income areas and households, long distance to the nearby health facility is out of reach and this is aggravated by the limited infrastructure.

An increase in travel time was associated with an increase in the likelihood of infant mortality. The odds of infant mortality increased by 167.2 percent and 643.6 percent for a 30 minutes' and 60 minutes' increase in travel time in urban and rural areas, respectively. A sick infant might be in a critical condition which worsens with increase in travel time making them to die before getting medical attention. The effect of travel time on infant mortality is exacerbated by poor road infrastructure, absence of quicker means of transport and fear of insecurity in some parts of the study area.

Kaplan-Meier survival curve was estimated for the specific variable that was found to be the most significant predictor of infant mortality in a single type of place of residence in Kakamega Central Sub-County. A straight-line distance of 1.1 to 3.9 kilometres from one's residence to the nearby medical facility had a 1.127 higher likelihood of neonatal mortality in comparison to an at most 1 kilometre straight-line distance in urban areas. The risk of infant survival according to straight-line distance in urban areas is presented in presented in Figure 2. As can be seen, the sharpest drop in survival probability at neonatal (0 months') level was in the 1.1 to 3.9 kilometres straight-line distance category. This depicted higher risks of neonatal mortality amongst urbanites residing at a mileage of 1.1 to 3.9 kilometres from the nearby medical facility in comparison to their colleagues residing at a mileage of at most 1 kilometre from the nearby medical facility. A general observation is that there was a lower risk of mortality between the third month of life to the eleventh month of life for infants residing at least 4 kilometres from the nearby medical facility. This is evidenced by the flat curves in that time span.

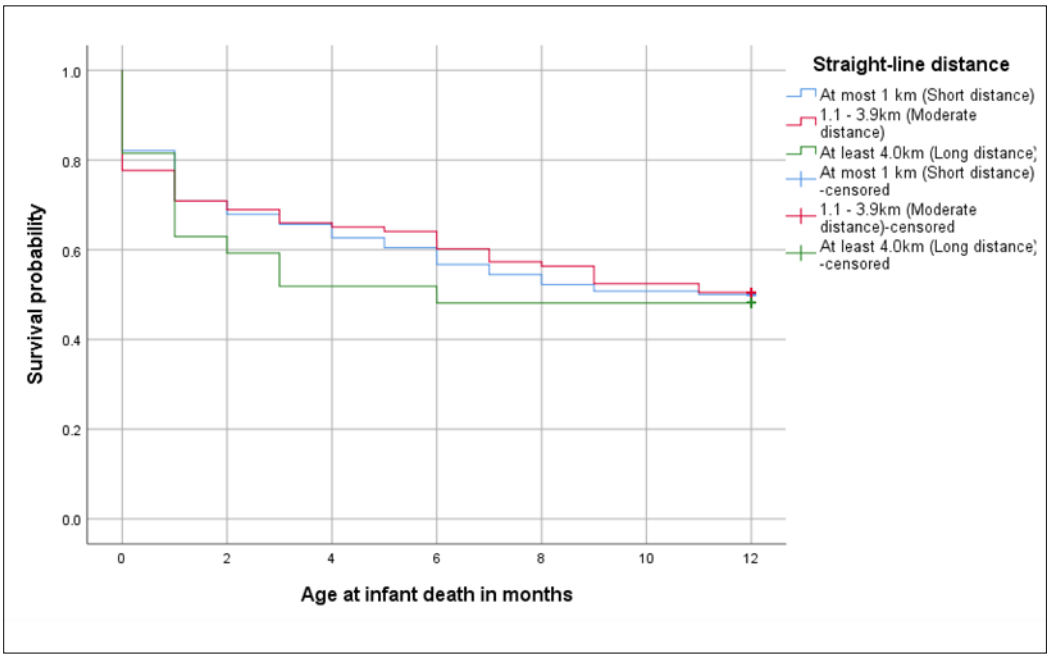

Figure 2 Kaplan-Meier survival graph of infants by straight-line distance in urban areas of Kakamega Central Sub-County

5. Discussion

This study sought to assess the effect of distance covered to the nearby medical facility on the death of infants in rural and urban areas of Kakamega Central Sub-County. There existed rural-urban differentials in the prevalence of infant death according to straight-line distance covered to reach the nearby medical facility. As explained by [12], distinct differentials in childhood mortality exist due to differences in regional health arrangement. The current study found 50.76 percent of infant deaths to occur to mothers who resided within a kilometer to the nearby medical facility in urban areas while 42.31 percent occurred to mothers who resided within a distance of 1.1 to 3.9 kilometers to the nearby medical facility in rural areas. Majority of deaths were to infants who lived relatively close to a medical facility. 61.54 percent and 89.39 percent of infants died in households that lived within 3.9 kilometers from a medical facility in rural and urban areas, respectively. This is confirmed by the findings of a study by [10] that found 52.2 percent of children to live within 3 kilometers from a health facility. The findings in the current study might be due to the observed economic development as a result of devolution.

Straight-line distance to the nearby medical facility was a significant contributor to rural-urban differentials in infant mortality. The results in Tables 2 and 3 showed that a straight-line distance of between 1.1 kilometers to 3.9 kilometers was significantly associated with neonatal mortality in comparison to a distance of at most 1 kilometer. However, the association was divergent in the there was a lower likelihood of neonatal mortality in rural areas (cOR = 0.284) whereas there was a higher likelihood of neonatal mortality in urban areas (aOR = 2.127). The findings in rural areas are in agreement with other studies that found neonatal mortality to decrease with increase in distance from home to health facilities [31]. In line with the urban findings were the findings of other studies [9][10][11][19]. Compared to children who lived within a kilometer to a facility, children who lived within 2 kilometers, 3 kilometers and 5 kilometers to a facility had a 7.7 percent ($\rho<0.05$; CI = 0.927 – 1.251), 16.3 percent ($\rho<0.05$; CI = 1.020 – 1.327), and 25 percent ($\rho<0.05$; CI = 1.087 – 1.439) higher odds of neonatal mortality, respectively [10].

A most recent study in Ethiopia by [9] found a ten kilometer increase in distance to a health facility to increase the odds ratios of neonatal mortality by 1.33 percent (95%CI = 1.06 – 1.67). In support of the findings of this study, a study by [10] found straight-line distance covered to the nearby medical facility to have no significant effect on infant mortality after the neonatal period. These findings are however inconsistent with those of a study that showed no significant association between distance and neonatal mortality in Malawi and a greater distance to be associated with significantly lower neonatal mortality in Zambia [17]. A key informant was asked on how distance covered to the nearest medical facility influence infant mortality. The response from the interview was as presented:

Distance compromises accessibility for those who need healthcare services. If the health facility is far off, this is likely to lead to delays in deciding or availing of transport costs to access the healthcare services. Distance can also force a healthcare seeker to decide to seek services of a Traditional Birth Attendant instead of a skilled birth attendant putting the life of a mother and her infant at risk should any complication arise.

(Senior Population Programmes Officer, National Council for Population and Development, Kenya)

Pertaining travel-time taken to reach the nearby medical facility, this study found an inverse relationship between the prevalence of infant mortality and the travel-time taken to reach the nearby medical facility both in rural and urban areas. There were more infants dying to mothers who took a shorter travel time to reach the nearby medical facility than to mothers who took a longer travel-time to reach the nearby medical facility. Travel-time to the nearby medical facility might be shorter but medication costs be unaffordable or hospitals suffer frequent stock-outs of medical equipment and drugs, absent and limited medical personnel. These findings are unlike the findings of a rural-based study done in Burkina Faso by [21] that found lesser death of children when the nearby medical facility was village-based than when a time duration of 4 hours was needed to reach the nearby medical facility.

Results of inferential analysis showed a common pattern on the influence of travel-time on infant mortality in rural and urban areas. An increase in travel time was associated with an increase in the likelihood of infant mortality. In comparison to an at most 30 minutes' travel-time, a travel-time of 31 to 60 minutes was associated with higher adjusted odds ratios of infant mortality in urban areas. Furthermore, a travel-time of beyond an hour was associated with higher adjusted odds ratios of infant mortality in rural areas. These findings are consistent with other findings of related studies [10][21][22] that found the threat of mortality to be directly proportional to distance.

A study done in rural areas of Burkina Faso found greater under-five mortality when a time duration of four hours was needed to reach the nearby medical facility in reference to a village-based medical facility [21]. Another study by [22] found living at least 90 minutes from the nearby medical facility to be associated with a double larger risk of death of children than living within 90 minutes from the nearby medical facility. In a study done in low and middle income countries, [10] found neonates born in households located at a travel time of beyond an hour from a health facility to have higher odds ratio of dying than neonates born in households that were within a ten minutes' travel time from a health facility (OR – 1.256; $\rho<0.05$; CI = 1.105 – 1.429).

Straight-line distance and travel-time relate to each other. Straight-line distance might be short but the road impassable and thus lengthen the travel-time taken to reach the nearby medical facility. Conversely, straight-line distance might be long but the road passable making a patient to take a shorter time to reach the nearby medical facility. [24] indicated that about 63 percent of people were able to reach a government medical centre within an hour in some districts in Kenya. On their side, [16] explained that residents of inaccessible mountainous and remote areas spent many hours trekking in search of maternal and infant health services, something that delays access to treatment in case of infant sickness.

In the least economically stable homes, mothers might be discouraged from visiting distant medical facilities for childcare-related services because of unaffordability of travel expenses involved. A study by [23] noted that having insufficient resources at disposal limits the reach to and uptake of current healthcare exacerbated by the pay-and-take system operating in several sub-Saharan countries. [31] noted that people experienced difficulties in accessing emergency new-born care with only 46.5 percent of all births in Ethiopia having access to emergency neonatal care facilities within two hours of travel-time. This is an indication that pregnant women experience long distances of travel and challenging transportation conditions to access child care services.

6. Conclusion

This study aimed at assessing the effect of distance covered to the nearby medical facility on infant mortality in Kakamega Central Sub-County, Kakamega County, Kenya. The study found straight-line distance to be significantly associated with rural neonatal mortality at univariate analysis level and urban neonatal mortality at multivariate analysis level. Specifically, the study found a straight line distance of 1.1 to 3.9 kilometres to a health facility to be less likely to experience neonatal mortality in rural areas (cOR – 0.284) and more likely to experience neonatal mortality in urban areas (aOR – 2.127) relative to an at most 1 kilometre straight line distance. The influence of travel time on infant mortality was insignificant at univariate analysis level but significant at multivariate analysis level. A travel time of 31 to 60 minutes significantly influenced infant mortality in urban areas (aOR – 2.672) while that of beyond an hour significantly influenced rural infant mortality (aOR – 7.436) when compared to a travel time of an at most 30 minutes.

It is possible that travel-time influenced infant mortality through the confounders of geographical, socioeconomic and demographic factors.

From the study findings, we accepted the following research hypotheses: (1) Straight-line distance covered to the nearby medical facility had a significant relationship influence on the death of infants in urban areas of Kakamega Central Sub-County, and (2) Travel-time taken to reach the nearby medical facility had a significant relationship influence on the death of infants in rural and urban areas of Kakamega Central Sub-County.

The study recommends for equitable geospatial distribution of medical facilities in Kakamega Central Sub-County to ensure an acceptable density of medical facilities. The medical facilities need to open-up on daily basis and not having some stay closed over weekends and public holidays as was observed by the researchers. Sickness does not book an appointment with a patient.

Compliance with ethical standards

Acknowledgments

We acknowledge the community of Kakamega Central Sub-County for willingly participating in the data collection process and thus making this publication a success.

Disclosure of conflict of interest

The authors of this publication declare no conflict of interest in the work. The authors further declare that they did not receive any support from any organization for the submitted work.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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