World Journal of Public Health
2025; 10(3): 389-397
http://www.sciencepublishinggroup.com/j/wjph
doi: 10.11648/j.wjph.20251003.30

Frailty Modeling of Child Stunting in Coast Province, Kenya: Analysis Using KDHS 2022 Data

Ombaka Ogolla[1, *], Richard Simwa[2], Cheruiyot Kipkoech[1]

[1]School of Mathematics and Actuarial Sciences, Technical University of Kenya, Nairobi, Kenya
[2]Department of Science, Daystar University, Nairobi, Kenya

Email address:

eombaka2000@gmail.com (Ombaka Ogolla), simwa@daystar.ac.ke (Richard Simwa),
Wycliffe.cheruiyot@tukenya.ac.ke (Cheruiyot Kipkoech)
[*]Corresponding author

To cite this article:

Ombaka Ogolla, Richard Simwa, Cheruiyot Kipkoech. (2025). Frailty Modeling of Child Stunting in Coast Province, Kenya: Analysis Using KDHS 2022 Data. *World Journal of Public Health, 10*(3), 389-397. https://doi.org/10.11648/j.wjph.20251003.30

Received: 24 July 2025; **Accepted:** 8 August 2025; **Published:** 5 September 2025

Abstract: Child stunting reduction is the first of 6 goals in the Global Nutrition Targets for 2025 and a key indicator in the second Sustainable Development Goal of Zero Hunger. The prevalence of undernutrition is decreasing in many parts of the developing world, but challenges remain in many countries. For instance,the prevalence of stunting is 30.7% in Africa - higher than the global average of 22.0%. In Kenya, more than a quarter of children under the age of five, or two million children, have stunted growth. Stunting is the most frequent form of under-nutrition among young children. If not addressed, it has devastating long-term effects, including diminished mental and physical development.Child under-nutrition in Kenya has decreased in recent years. Levels of child stunting fell from 35.2% in 2009 to 26% in 2014 and wasting from 7% in 2009 to 4% in 2015. In Kenya, Coast Province has the highest stunting rate with (30.8%) and the lowest in Nairobi Province (17.2%). Despite this advancement, the world is still unlikely to achieve that goal in the global nutrition targets. Our study intends to investigate on crucial prognostic factors influencing child stunting in Coast, Kenya. The principal objective of this paper is to determine the effect of socioeconomic and demographic variables on child stunting in presence of dependencies in clusters and households. The study then uses variable selection technique which is an artificial intelligence techniques to select covariates with the highest predictive power from the robust KDHS 2022 data. Additionally, a proportional hazards assumption test was carried out for the chosen covariates. Those covariates that satisfied the proportionality assumption were finally included in the frailty model to takes care of the presence of dependencies within the households. Data used was based on the Kenya Demographic and Health Survey (KDHS 2022), which was collected by use of questionnaires. Child stunting from the, KDHS 2022 data, was analyzed in an age period: stunting from the age of 12 months to the age of 60 months, referred to as "child stunting". from the age of 12 months to the age of 60 months, referred to as "child stunting".

Keywords: Frailty Models, Stunting, Nutrition, Correlated Data, *lmer* Function, AIC, Best Linear Unbiased Predictors (BLUP)

1. Introduction

Stunting is a process that can affect the development of a child from the early stages of conception until the third or fourth year of life, when the nutrition of the mother and the child are essential determinants of growth. Stunting is defined as the percentage of children whose 'height-for-age' is below minus two standard deviations for moderate and minus three standard deviations for severe stunting from the median of the 2006 WHO Child Growth Standards [6].

Similarly, children are considered severely stunted if their length/height is below -3 SDs from the WHO child growth standards median for the same age and sex.

Nutritional stunting is caused by insufficient maternal nutrition, intrauterine undernutrition, lack of breastfeeding until 6 months of age, late introduction of complementary feeding, inadequate (quantity and quality) complementary feeding, and impaired absorption of nutrients owing to infectious diseases [7, 8]. Stunting has long-term effects on individuals and societies, including poor cognition and educational performance, low adult wages, lost productivity and, when accompanied by excessive weight gain later in childhood, an increased risk of nutrition-related chronic diseases in adult life [9].

A high stunting rate generally signify unmet human health needs in education,medical care,nutrition and sanitation. The desire to understand the determinants of Child stunting poses a very important aspect of research. Today, it is an indicator in the second sustainable development goal of zero hunger.

The Demographic and Health Surveys (DHS) program has been very instrumental in obtaining and disseminating authentic, national representative data on family planning, fertility, maternal and child health, among other health issues [10]. The most recent DHS survey conducted in Kenya was KDHS 2022.

This study aims at identifying the determinants of Child stunting in the Coastal region of Kenya. We chose a range of covariates obtained from three different publications based on Demographic health survey data in those three countries [1, 2, 11]. Those covariates were exceptional in determining child stunting. In the study, we then test for normality assumption using residual plots and analysis for purposes of diagnostics on the best fit from those specified covariates. We ultimately built a frailty model that takes care of the dependence within clusters and households.

A frailty model is a random effects model for time variables, where the random effect (the frailty) has a multiplicative effect on the hazard. It can be used for univariate (independent) failure times, i.e. to describe the influence of unobserved covariates in a proportional hazards model [12].

2. Methods

2.1. Data Description and Ethical Approval

In this paper, we use the Kenya Demographic Health Survey data *KDHS* 2022. It is the sixth Demographic and Health Survey (DHS) conducted in Kenya since 1989. KDHS is a national research undertaking conducted every five years with an intention of collecting a wide range of data with a strong interest on indicators of reproductive health, fertility, mortality, maternal and child health, nutrition and self-reported health habits among adults [13]. It is a household sample survey data with a national representation where households are selected at random from Kenya National Bureau of Statistics (KNBS) sampling frame. The survey procedures, instruments and sampling methods used in the KDHS 2022 acquired ethical recommendation from the Institutional Review Board of Opinion Research Corporation (ORC) Macro International Incorporated, a health, demographic, market research and consulting company situated in New Jersey, USA. We sought official registration on the DHS website and got permission to use the KDHS 2022 data.The data was downloaded in SPSS format and constituted 1,099 variables and 20,964 observations. Using package foreign, the data was imported to R software version 4.2.2 for analysis. KDHS data is a national survey data which is classified into 8 regions, constituting former provinces in Kenya. In this study, we analyzed data only for Coast region, being a region with the highest child stunting in Kenya. A set of dependant variables are chosen from literature given that they were profound in explaining child stunting. Survival time and status variables which are important considerations when analyzing survival data were calculated and included in the dataset.

2.2. Ethical Approval

The study did not require any approvals because it was secondary data.

3. Data Analysis

3.1. Application to KDHS 2022 Data Sets

3.2. Descriptive Statistics

Table 1, gives the distribution of stunted children in Kilifi County, Kenya. Children who had gotten that condition accounted for $123(35.45\%)$ while those who had not were $224(64.55\%)$.

Table 1. *Stunted Children.*

	Frequency	Percentage
Yes	123	35.45
No	224	64.55
Total	347	

Table 2, Male children were almost the same as their female counterparts with $192(49.87\%)$ and $193(50.13\%)$ respectively.

Table 2. *Sex of children.*

	Frequency	Percentage
Male	192	49.87
Female	193	50.13
Total	385	

Table 3, showed that most children resided in the rural areas $272(70.65\%)$ while $113(29.35\%)$ did live in the urban areas.

Table 3. *Place of residence.*

	Frequency	Percentage
Urban	113	29.35
Rural	272	70.65
Total	385	

Table 4, below gives the scenario of those households with electricity. 1957(74%) houses did not have access to electricity while 602(23%) had electricity, 89(0.03%) who were gotten in those households were not the rightfull owners of those houses.

Table 4. *Household has electricity.*

	Frequency	Percentage
No	1957	0.74
Yes	602	0.23
Not de jure resident	89	0.03
Total	2648	

Table 5, shows those women with Primary education were the majority with 228(59.22%) while those with higher education were 26(6.75%) which is comparatively a small number.

Table 5. *Maternal education level.*

	Frequency	Percentage
No education	61	15.84
Primary	228	59.22
Secondary	70	18.18
Higher	26	6.75
Total	385	

Table 6, shows that the poorest households were the majority with 199(551.69%). This is more than half of the population interviewed. Those with middle-level capability were 52(13.51%). The richest population has a proportion of 37(9.61%).

Table 6. *Household wealth index.*

	Frequency	Percentage
Poorest	199	51.69
Poorer	36	9.35
Middle	52	13.51
Richer	61	15.84
Richest	37	9.61
Total	385	

Table 7, we realised that 101(26.23%)households had a flush to septic tank kind of toilet facility. Nevertheless, 88(22.86%) did not have a toilet facility at all or used bushes or field. Again, 74(19.22%) and 73(18.96%) had pit latrine with slab and and without slab/open pit toilets respectively. A few households had proper toilet facilities e.g. Flush toilets or flush to piped sewer system only amounted to 11(2)%.

Table 7. *Type of toilet facility.*

	Frequency	Percentage
Flush toilet	0	0.00
Flush to piped sewer system	1	0.26
Flush to septic tank	101	26.23
Flush to pit latrine	29	7.53
Flush to somewhere else	3	0.78
Flush,to don¡¯t know where	0	0.00
Pit toilet latrine	0	0.00
Ventilated improved pit latrine	9	2.34
Pit latrine with slab	74	19.22
Pit latrine without slab/open pit	73	18.96
No Facility	0	0.00
No Facility/bush/field	88	22.86
Composting toilet	0	0.00
Bucket toilet	0	0.00
Hanging toilet/latrine	0	0.00
Other	0	0.18
Not a dejure resident	7	1.82
Total	385	

Table 8, most households used public tap/stand pipe with a 78(20.26%) , while those whose water source was from river/dam/lake/ponds/stream/canal/irrigation channel were 87(22.6%).

Table 8. *Source of drinking water.*

	Frequency	Percentage
Piped water	0	0.00
Piped into dwelling	26	6.75
Piped to yard/plot	47	12.21
Public tap/stand pipe	78	20.26
Tube well water	0	0.00
Tube well or borehole	21	3.12
Dug well(open/protected)	0	0.00
Protected well	13	3.38
Unprotected well	5	1.30
Surface water	0	0.00
Protected spring	0	0.00
Unprotected spring	6	1.56
River/dam/lake/ponds/stream/canal/irrigation channel	87	22.60
Rainwater	1	0.26
Tanker truck	12	3.12
Cart with small tank	0	0.00
Bottled water	12	3.12
Other	0	0.00
Not a dejure resident	7	1.82
Total	385	

Table 9, depicts that there were more births in the rural as compared to urban areas. Furthermore, those stunted were 104(84.55%) and 19(15.45%) in the rural and urban respectively. The p-value shows that there was a statistical significance in the association between child stunting and place of residence.

Table 9. Association between Child Stunting and Place of residence.

	Child_Stunted		
	No	Yes	Total
Urban	73	19	92
Rural	151	104	255
Total	224	123	347

3.3. Kaplan-Meier Curves

Figure 1, gives the overall survival probabilities for all children with respect to time in days.Upto almost 205 days, the probability of surviving from being stunted is still 1. As time progresses, the probability reduces. For instance, the chance of living until 400 days without stunting is 0.6 or 60%.The 2 dotted lines are the 95% confidence interval for the survival curve.

Figure 2, holds two curves for survival between male and female children across time. It shows that female children have a slightly higher chance of not getting stunted as compared to their male counterparts. In the second plot,it is clear that children born in urban places had a higher survival probabilities as compared to those in the rural areas. At 500 days, the chances of surviving from child stunting for those born in urban places was 50% as compared to those in rural with 30%.

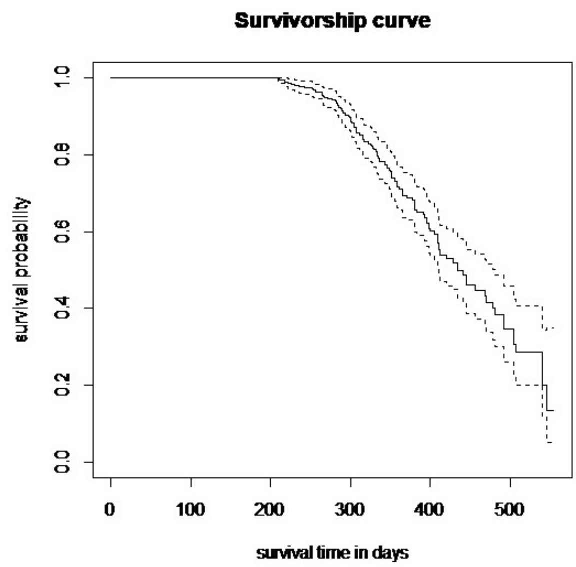

Figure 1. Kaplan-Meier without a covariate.

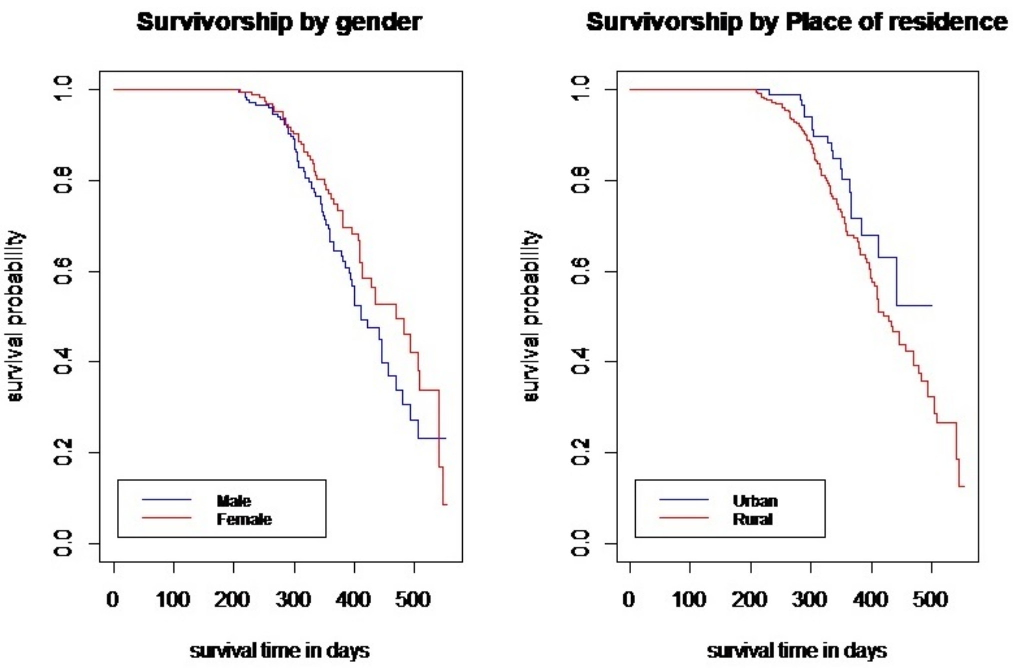

Figure 2. Survivorship for Gender and Residence.

3.3.1. Log-rank Test

The log -rank test is a naive technique though, it is the most frequent method for comparing survival between two groups.
Hypotheses on Gender -
H_o: There is no survival difference between the two groups.
H_a: There is a survival difference between the two groups.

Table 10. Log rank by Sex of Child.

	N	Observed	Expected	(O-E)$\hat{2}$/E	(O-E)$\hat{2}$/V
Male	175	68	59.7	1.17	2.31
Female	172	65	63.3	1.10	2.31
Chisq=2.3	df=1	p=0.1			

Table 10 above, the $p - value = 0.1$ implies that we fail to reject our null hypothesis and conclude that there is no statistical significance in survival difference between the males and females children at $\alpha = 0.05$.

Hypotheses on type of place of residence -
H_o: There is no survival difference between urban and rural areas.
H_a: There is a survival difference between urban and rural areas.

Table 11. *Log rank by place of residence.*

	N	Observed	Expected	(O-E)2̂/E	(O-E)2̂/V
Urban	92	19	26.9	2.308	3.08
Rural	255	104	96.1	0.645	3.08
Chisq=0	df=1	p=0.08			

Table 11, the $p - value = 0.08$ which implies that we fail to reject our null hypothesis and infer that there was no statistical significance in survival difference between the place of residence $\alpha = 0.05$.

3.4. Variable Importance

Table 12, below shows covariates and their corresponding mean decrease gini. The values depict how important that variable is in explaining child stunting. The higher the value, the more important or valuable that covariate is to the response variable.

Table 12. *Variable importance.*

	MeanDecreaseGini
Size_of_child_at_birth	2.918202
Duration_of_breastfeeding	2.764845
Age_of_child	3.318298
Sex_of_child	2.792797
Working_status	2.023692
Household_wealth_index	4.713942
Frequency_of_reading_newspaper	1.4385
Frequency_of_listening_to_Radio	3.871723
Frequency_of_watching_TV	4.153732
Maternal_Education_level	3.536206
Source_of_drinking_water	5.962577
Type_of_toilet_facility	5.421072
Place_of_residence	2.314856

In Figure 3 is the order of importance predictors. We can clearly see that Source of drinking water,type of toilet facility and household wealth index are the first three covariates, toping the list.

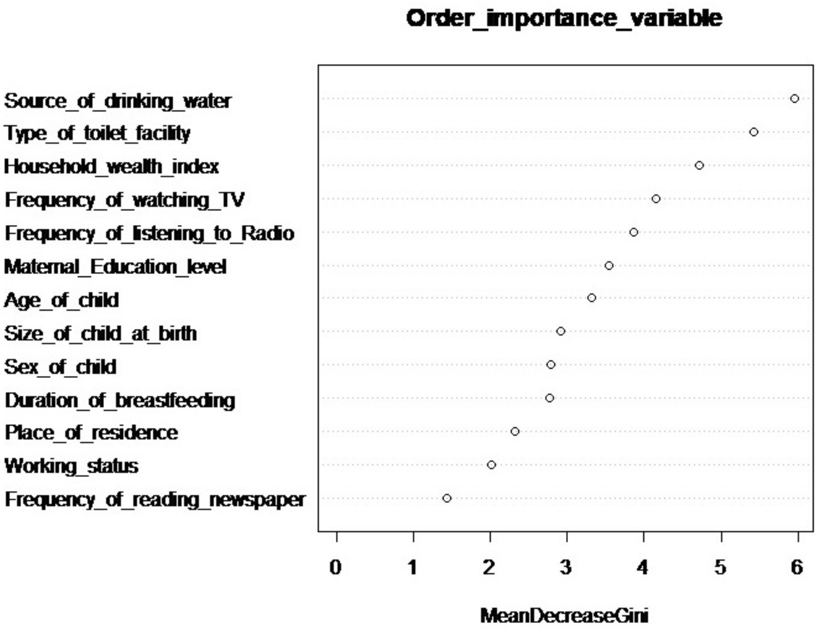

Figure 3. *Variable importance.*

3.5. Proportionality Testing Among Covariates

Table 13, gives a comprehensive impression of proportional hazards test of whether there is a violation or not. The Global *p-value* $>$ *0.05*,implying that there was not even one or more violations [10]. On that exposition, we do not need to narrow down into individual covariates to confirm if proportional hazards assumption was met. Therefore we can assume the proportional hazards.

Table 13. *Proportionality test.*

	chisq	df	p
Size_of_child_at_birth	0.25082	1	0.616
Duration_of_breastfeeding	0.11782	1	0.731
Age_of_child	0.60958	1	0.435
Sex_of_child	0.21579	1	0.642
Working_status	0.29322	1	0.588
Household_wealth_index	0.11561	1	0.734
Frequency_of_reading_newspaper	3.43289	1	0.064
Frequency_of_listening_to_Radio	0.12483	1	0.724
Frequency_of_watching_TV	0.15584	1	0.698
Maternal_Education_level	0.15053	1	0.698
Source_of_drinking_water	3.55717	1	0.059
Type_of_toilet_facility	0.43216	1	0.511
Place_of_residence	0.00475	1	0.945
GLOBAL	16.00829	13	0.249

Figure 4, is the scaled schoenfeld residuals against time. The broken lines represent a standard error band around the fit while the continuous line represents a smoothing spline fit to the plot. The line of fit is expected to stay close to the horizontal axis within the whole stretch of time ,so that we conclude that the proportional hazard assumption holds or not. In general, we have symmetry along zero - line and have no fear for existence of influential observations in the data or outliers. Accessing all the variables in the plot, it is evident that all of them had a smooth line begining around zero. This then implies that they all satisfied the proportional hazard assumption.

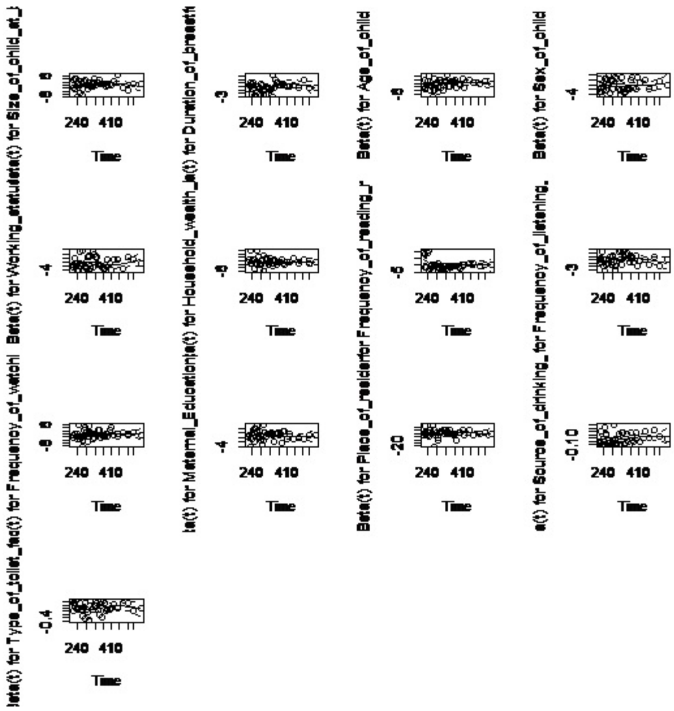

Figure 4. *Schoenfeld residuals.*

3.6. Frailty Model

In the Frailty regression model, the output shows how our covariates predict our response variable which is child stunting.

Out of 14 variables, we had 7 that turned out to be statistically significant.They were, Type of place of residence with a p-value = 0.00401, Households that had electricity with p-value = 0.03052, Maternal age with p-value = $5.8 * 10^{-13}$, Maternal height with p-value = 0.00588, Sex of child with p-value = 0.01072, Preceding birth interval with p-value = $2.6 * 10^{-11}$ and Duration for breastfeeding with p-value = 0.05384 (marginally significant).

Association within the household was also statistically significant as depicted by the extremely remarkable Frailty(household_number) p-value = 0.018.

Apart from just the statistical significance, we proceed to check performance of our covariates. Those children born in the rural areas had a reduced chance of getting stunted by a factor of 0.59869.

Families with the richest wealth index were 55.46% less likely to have their children stunted as compared to the poorest families.

As maternal age increases by one year, the odds of having a stunted child is reduced by 13.23%.

Female children were less likely to be stunted by a factor of

0.730.

As a child grew older by one year,they were 6.27% less likely to be stunted.

As preceding birth interval increased, chances of getting child stunting decreased by 2.322%.

Again, as duration for breastfeeding increased ,the chances of having a stunted child were less likely by 0.4878%.

Women with normal body mass index were 23.43% less likely to have stunted children as compared to those in the reference category who were underweight.

Table 14. *Frailty model.*

	coef	se(coef)	se2	Chisq	DF	p	exp(coef)	exp(-coef)
frailty(Household_number)				0	0	0.018		
as.factor(Socab)2	1.22248	1.3932	1.3932	0.77	1	0.38	3.40E+00	2.95E-01
as.factor(Socab)3	0.54349	1.1551	1.1551	0.22	1	0.64	1.72E+00	5.81E-01
as.factor(Socab)4	1.18047	1.2167	1.2167	0.94	1	0.33	3.26E+00	3.07E-01
as.factor(Socab)5	7.2674	2.5444	2.5444	8.16	1	0.0043	1.43E+03	6.98E-04
as.factor(Dobr)94	-9.22806	2298.826	2298.826	0	1	1	9.82E-05	1.02E+04
as.factor(Dobr)95	0.05422	0.7498	0.7498	0.01	1	0.94	1.06E+00	9.47E-01
Aoc	-0.0937	0.5049	0.5049	0.03	1	0.85	9.11E-01	1.10E+00
as.factor(Soc)2	0.26716	0.5007	0.5007	0.28	1	0.59	1.31E+00	7.66E-01
as.factor(Ws)1	-0.98736	0.5664	0.5664	3.04	1	0.081	3.73E-01	2.68E+00
as.factor(Hwi)2	-0.28312	0.8399	0.8399	0.11	1	0.74	7.53E-01	1.33E+00
as.factor(Hwi)3	-3.07051	1.5238	1.5238	4.06	1	0.044	4.64E-02	2.16E+01
as.factor(Hwi)4	-0.29354	1.7397	1.7397	0.03	1	0.87	7.46E-01	1.34E+00
as.factor(Hwi)5	-20.9181	63.0752	63.0752	0.11	1	0.74	8.23E-10	1.22E+09
as.factor(Frn)1	1.71955	0.8767	0.8767	3.85	1	0.05	5.58E+00	1.79E-01
as.factor(Frn)2	-3.67217	119.9347	119.9347	0	1	0.98	2.54E-02	3.93E+01
as.factor(Flr)1	0.844	0.622	0.622	1.84	1	0.17	2.33E+00	4.30E-01
as.factor(Flr)2	-1.27494	0.5636	0.5636	5.12	1	0.024	2.79E-01	3.58E+00
as.factor(Fwtv)1	-0.47058	0.9102	0.9102	0.27	1	0.61	6.25E-01	1.60E+00
as.factor(Fwtv)2	-0.78426	0.9844	0.9844	0.63	1	0.43	4.57E-01	2.19E+00
as.factor(Mel)1	13.78596	37.6323	37.6323	0.13	1	0.71	9.71E+05	1.03E-06
as.factor(Mel)2	14.19862	37.6355	37.6355	0.14	1	0.71	1.47E+06	6.82E-07
as.factor(Mel)3	14.20387	37.6903	37.6903	0.14	1	0.71	1.48E+06	6.78E-07
as.factor(Por)2	0.94611	1.2304	1.2304	0.59	1	0.44	2.58E+00	3.88E-01
as.factor(Sow)12	8.90112	72.3705	72.3705	0.02	1	0.9	7.34E+03	1.36E-04
as.factor(Sow)13	7.07005	72.3675	72.3675	0.01	1	0.92	1.18E+03	8.50E-04
as.factor(Sow)14	6.19184	72.3681	72.3681	0.01	1	0.93	4.89E+02	2.05E-03
as.factor(Sow)21	6.72688	72.3773	72.3773	0.01	1	0.93	8.35E+02	1.20E-03
as.factor(Sow)31	-5.23006	292.868	292.868	0	1	0.99	5.35E-03	1.87E+02
as.factor(Sow)42	5.36628	72.3774	72.3774	0.01	1	0.94	2.14E+02	4.67E-03
as.factor(Sow)43	6.24477	72.3691	72.3691	0.01	1	0.93	5.15E+02	1.94E-03
as.factor(Sow)61	-4.51188	135.4626	135.4626	0	1	0.97	1.10E-02	9.11E+01
as.factor(Sow)71	10.95221	72.4022	72.4022	0.02	1	0.88	5.71E+04	1.75E-05
as.factor(Sow)97	-5.36118	1650.914	1650.914	0	1	1	4.70E-03	2.13E+02
as.factor(Totf)13	-1.16777	1.4126	1.4126	0.68	1	0.41	3.11E-01	3.22E+00
as.factor(Totf)14	2.66646	1.6131	1.6131	2.73	1	0.098		
as.factor(Totf)21	-11.1487	142.8547	142.8547	0.01	1	0.94		
as.factor(Totf)22	-0.56833	0.9553	0.9553	0.35	1	0.55		
as.factor(Totf)23	0.50113	1.2342	1.2342	0.16	1	0.68		
as.factor(Totf)31	0.34928	1.2297	1.2297	0.08	1	0.78		
as.factor(Totf)97		0	0		1			

4. Discussion

The study attempts to understand the determinants of child stunting using survey data from KDHS. In this case, Kenya DHS survey 2022 dataset was used for the analysis. For this work, we analysed data for Coast province only being a region with the highest child stunting prevalence in Kenya [5].

A high stunting rate generally signify unmet human health needs in education,medical care,nutrition and sanitation. Therefore, aspiration to understand the determinants of Child stunting gives rise to a very important aspect of research. Many studies have employed different techniques to explore the determinants of child stunting. Those methods include systematic reviews [1, 14]. Multiple linear regression and general linear model have also been used by other researchers [2, 11].

In our discovery, using a shared frailty model we realised that the following covariates; The Type of place of residence, Maternal age, Maternal height,Sex of Child, Preceding birth interval and Duration for breastfeeding were statistically significant at $\alpha = 0.05$.

Furthermore, Children in rural areas, Households with richest or richer wealth indexes ,children born to mothers with older age,Sex of child, were found to have lower chances of getting stunted. In comparison with other studies that were published, there was no great mismatch in that findings showed that child stunting was associated with variables related to: child characteristics at birth (such as age at birth), reproduction factors of the mother (such as number of children born before), better educated mothers, households with electricity, higher wealth index, proper breastfeeding feeding characteristics and anthropometric measurements were less likely to get child stunting.

In our work, we had a large sample of 2650 observations and 1132 variables which was statistically sufficient. Nevertheless, there was a limitation of missing cases which we ignored and just used complete cases in our analysis.

Another limitation was that we did not use any scientific method on choosing the covariates we worked on. That, was just choosen from literature.

The study is of significance in that it will help the government,Non-governmental organisations to get information to guide them on how to intervene in order to ultimately achieve the global target on Child stunting.

Furthermore, students who are actively engaged in doing research in child mortality may not only fill the gap but also add on the already existing bank of knowledge.

5. Conclusion

Correlated data arises from numerous health fields especially where participants are in a cluster or household sharing the same prognostic factors. In this research, we have managed to present a framework for determination of child mortality using the 2022 KDHS data from Coast Province in Kenya.

Majorly, the framework involved checking which covariates were notable in explaining child stunting. Additionally, based on this research, child stunting is associated with variables related to mother‘s age, Preceding birth interval, breastfeeding nutrition, Type of place of residence.

ORCID

0009-0004-8649-6752 (Ombaka Ogolla)
0000-0002-2136-1433 (Richard Simwa)

Acknowledgments

We acknowledge the anonymous reviewers whose remarks revamp the standard of this paper outstandingly.

Author Contributions

Ombaka Ogolla: Conceptualization, Data curation, Investigation, Resources, Validation, Writing - review & editing

Richard Simwa: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing - review & editing

Cheruiyot Kipkoech: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing - review & editing

Conflict of Interest

The authors declare no conflicts of interest.

References

[1] Beal, T., Tumilowicz, A., Sutrisna, A., Izwardy, D., & Neufeld, L. M. (2018). A review of child stunting determinants in Indonesia. Maternal & child nutrition, 14(4), e12617.

[2] Hoffman, D., Cacciola, T., Barrios, P., & Simon, J. (2017). Temporal changes and determinants of childhood nutritional status in Kenya and Zambia. Journal of Health, Population and Nutrition, 36(1), 1-13.

[3] Global Nutrition report: https://globalnutritionreport.org/resources/nutrition-profiles/africa/ (2014).

[4] Unicef report: https://www.unicef.org/kenya/nutrition:2019

[5] Kenya National Bureau for Statistics report: KNBS. Kenya National Bureau for Statistics (KNBS) (2015) Demographic and health Survey 2014. Nairobi, Kenya: KNBS, Ministry of Health, NACC, KEMRI, NCPD, 2015.

[6] Soliman, A., De Sanctis, V., Alaaraj, N., Ahmed, S., Alyafei, F., Hamed, N., & Soliman, N. (2021). Early and long-term consequences of nutritional stunting: from childhood to adulthood. Acta Bio Medica: Atenei Parmensis, 92(1).

[7] Kramer, C. V., & Allen, S. (2015). Malnutrition in developing countries. Paediatrics and child health, 25(9), 422-427.

[8] Prendergast, A. J., & Humphrey, J. H. (2014). The stunting syndrome in developing countries. Paediatrics and international child health, 34(4), 250-265.

[9] Dewey, K. G., & Begum, K. (2011). Long-term consequences of stunting in early life. Maternal & child nutrition, 7, 5-18.

[10] Wanjiru, W. H. (2021). Improved balanced random survival forest for the analysis of right censored data: application in determining under five child mortality (Doctoral dissertation, Moi University).

[11] Takele, K., Zewotir, T., & Ndanguza, D. (2019). Understanding correlates of child stunting in Ethiopia using generalized linear mixed models. BMC Public Health, 19(1), 1-8.

[12] Hougaard, P. (1995). Frailty models for survival data. Lifetime data analysis, 1(3), 255-273.

[13] Corsi, D. J., Neuman, M., Finlay, J. E., & Subramanian, S. V. (2012). Demographic and health surveys: a profile. International journal of epidemiology, 41(6), 1602-1613.

[14] Keino, S., Plasqui, G., Ettyang, G., & van den Borne, B. (2014). Determinants of stunting and overweight among young children and adolescents in sub-Saharan Africa. Food and nutrition bulletin, 35(2), 167-178.