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Infant Mortality Decline in Zambia: To What Extent Did Maternal Education Influence Infant Mortality Rate Decline for the Period 1992 to 2018?

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Abstract

Purpose: In Zambia, infant mortality has reduced from 107 per 1000 live births in 1992, to 42 per 1000 live births during the 2018 period. Across the Globe, it is argued that maternal education (ME) contributes to the reduction in infant mortality (IM). However, the extent to which maternal education influenced the decline in infant mortality in Zambia for the period 1992 to 2018 was not clear. Therefore, this study sought to investigate the extent to which ME influenced the decline in IM in Zambia from 1992 to 2018.

Materials and Methods: This study was a secondary data analysis (Trend Analysis). Zambia Demographic and Health Survey (ZDHS) data sets: 1992 to 2018 were used in the analyses. The unit of analysis was IM with sample sizes: 6169, 7066, 6526, 6025,12916 and 9959 respective to the ZDHS years. All analyses were done using SPSS version 25.0. Univariate analysis was done for descriptive statistics. Bivariate analysis, Chi-square was used at 5% level of significance for associations. Point Bi-serial Correction was done between ME and IM at 1% and/or 5% levels of significance. Binary logistic regression at 5% level of significance was used to determine the influence of predictors on IM.

Findings: It was found that ME was (negatively) related to IM from 1992 to 2001-2. The correlation coefficients were smaller negatives indicating a very weak negative relationship between ME and IM. In multivariate analysis ME was found to be negatively associated with IM, from 1992 to 2001-2 only. Among the interactions, only the interactions between ME and contraceptive use; ME and preceding birth interval; ME and breast feeding; and ME and antenatal care (visits) significantly influenced the decline in IM from 1992 to 2018. Singularly, ME influenced the decline in IM rate to a lesser extent (only marginally). When interacted with contraceptive use, preceding birth interval, breast feeding and antenatal care, ME influenced the decline in IM to a larger extent.

Implications to Theory, Practice and Policy: in order to come up with more robust interventions to further reduce IM in the country, these interactions should be considered in the planning and implementation of child health programs such as the child health nutrition, national partnership for maternal, new-born and child health, child health week, Integrated Community Case Management of Childhood Illnesses (ICCM), and the Support to Safe motherhood and New-born Health among others.

Keywords: *Infant Mortality, Maternal Education, Trend Analysis, Infant Mortality Decline, Influence*

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1.0 INTRODUCTION

Infant mortality (IM) is the term used to describe any deaths arising in children who are born alive but die before their first birthday (Mathews, MacDorman, & Thoma, 2015). Infant mortality is said to be a sensitive measure of the overall health of a population as it reflects the apparent association between the causes and other factors that are likely to influence the health status of whole populations (Reidpath and Allotey, 2003). These include factors such as economic development, general living conditions, social well-being, rates of illness, and the quality of the environment in which they live (Basumatary, 2016). Basumatary (2016) further postulates that infant mortality rate is exceedingly responsive to changes in these factors and as such, it is said to be an important index of economic development and social-health status of every society. Globally, infant mortality has decreased from an estimated rate of 65 deaths per 1000 live births in 1990 to about 29 deaths per 1000 live births in 2017(Mohammadi et al., 2017). In addition, annual infant deaths have declined from 8.8 million in 1990 to 4.1 million in 2017 (WHO and Mathers, 2017). Sub-Saharan Africa (SSA) continues to record the highest levels of infant deaths and this therefore, calls for more efforts from African governments including Zambia, to effectively invest in infant mortality reduction (Gwatkin, 2000). In Zambia, IM reduced by 57.9% (107 to 42 per 1000 live births) from 1992 to 2018 (CSO: ZDHS,2018). See Figure 1.

Infant Mortality Trend: Zambia (ZDHS: 1992 to 2018)

Figure 1 shows the trends in the decline of infant mortality in Zambia from 1992 to 2018.

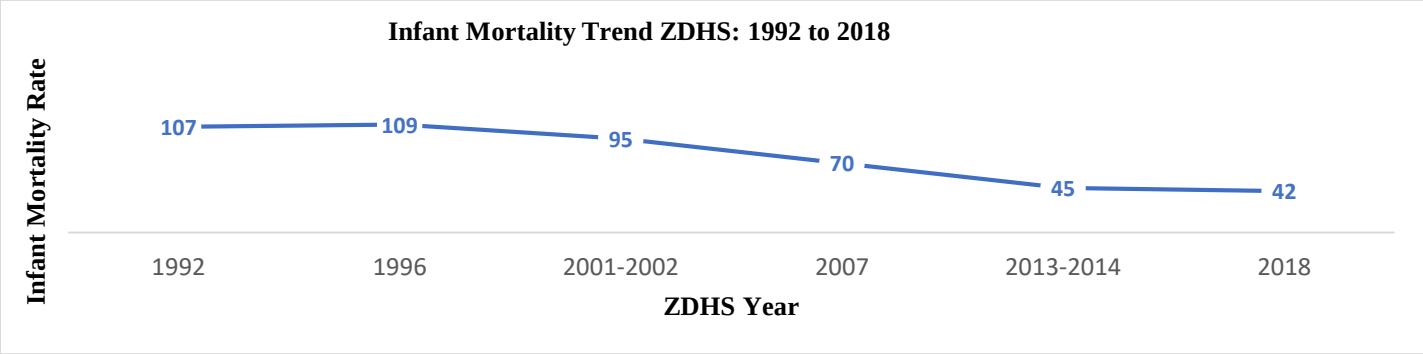

Figure 1: Infant Mortality Trend: Zambia (ZDHS: 1992 to 2018)

Source: (CSO: ZDHS, 2018)

One important ingredient in the reduction of infant mortality is maternal education (Shoham-Yakubovich & Barel, 1988). Maternal education is internationally recognized as one of the strongest determinants of infant survival in developing countries, and mass primary education for women is a common policy recommendation to improve infant health in developing countries (Basu and Stephenson, 2005; Huffman, 1984; Pamuk et al., 2011). Most demographic research indicates that there is a strong association between maternal education and infant mortality (Abuqamar et al., 2011 & Kalipeni, 1993). These findings have led some researchers, Caldwell (1979; 1994) to conclude that there is a causal relationship between mothers' education and infant mortality. However, other researchers incliding Desai & Alva, (1998) reject the existence of a strong causal relationship arguing that the nature of disease to which the children are exposed during the first year of life is such that mothers (whether educated or not) cannot do much to prevent the deaths of their infants. Therefore, the causal relationship between ME and IM remained unclear.

Infant mortality remains a big problem in Zambia (CSO: ZDHS, 2018). The government of Zambia and several Non-Governmental Organizations (NGOs) such as Campaign for Female Education (CAMFED) are investing in

the education of girls and consequently, ME has been improving since 1992 to date, with many more women attaining tertiary education (CSO: ZDHS, 2018). See Table 1.

Table1: Trends in Maternal Education: Zambia (ZDHS: 1992 to 2018)

Year	1992		1996		2001-2002		2007		2013-2014		2018	
Education Level	**Women**	**%**	**Women**	**%**	**Women**	**%**	**Women**	**%**	**Women**	**%**	**Women**	**%**
No Education	1217	16.3	1093	14.3	925	12.1	744	10.4	1,375	8.4	1054	7.7%
Primary	4443	59.4	5033	65.7	4439	58.0	3,891	54.4	7,685	46.8	6059	44.3%
Secondary	1654	22.2	2130	27.8	2061	26.9	2,140	29.9	6,521	39.7	5816	42.5%
Tertiary	154	2.1	230	3	234	3.1	371	5.2	830	5.1	755	5.5%

Source: (CSO: ZDHS 1992-2018)

However, the extent to which ME influenced the decline in IM in Zambia from 1992 to 2018 was not known. This study therefore, investigated the extent to which ME influenced the decline in IM from 1992 to 2018. The paper investigated the relationship between ME and IM and examined how the interactions between ME and selected social-economic, demographic, mother and child health and water and sanitation factors influenced the decline in IM during the period 1992 to 2018.

Data and Methods

The study design adopted in this study was a secondary analysis (trend analysis)(Cheng and Phillips, 2014). This study employed the ZDHS kids' records data sets for the years 1992, 1996, 2001/02, 2007, 2013-14 and 2018 in the analyses. The outcome variable (Unit of analysis) was infant mortality extracted using variables; B3- Date of birth, B5-Child is alive, B7-Age at death in months, V008-Date of interview, by use of the predictive software; SPSS vision 25.0. Each woman (15-49) provided the information for her infant (s) as to whether the infant/infants died between age 0 and 1 year (CSO: ZDHS, 2018). This study only included infants who died within the first twelve month of life for the purpose of capturing infant mortality. The sample sizes for all the surveys were: 6169, 7066, 6526, 6,025, 12916 and 9957 respective to the ZDHS years (CSO: ZDHS, 2018). The selected independent variables were grouped into four macro categories: socio-economic, demographic, mother and child health and water and sanitation (Bhandari et al., 2019). However, the key independent variable in this study was maternal education. Methods of analysis used were univariate, bivariate and multivariate (Burdenski Jr, 2000). However, this paper only presents part of the Bivariate and the second, and third models of multivariate analyses. At bivariate level Pearson Point Bi-Serial Correlation was done between ME in single years and the dependent variable to examine how it correlated with IM from 19192 to 2018 (Kornbrot, 2014). Binary logistic regression was used to determine the influence of all the predictors on the outcome variable (Tranmer and Elliot, 2008). The Mosley and Chain (1984) child survival conceptual framework was adapted to underpin the analyses performed in this study. The study was ethically cleared by all relevant bodies.

The Model

Binary logistic regression was used to estimate the (Log Odds**)** of a child dying before reaching one year of age. The binary logistic regression equation was estimated as below:

$$\text{Logit}(P) = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + ... + b_pX_p + E$$

P: - denotes the probability of the risk of infant mortality.

Where P is a dichotomous dependent variable with values 0 (did not die before

the first birthday) or 1 (died before first birthday)

$b_1 ... b_p$: - denotes the coefficients of the independent variables.

$X_1...X_p$: - denotes the independent variables. All dichotomous variables were converted into dummies before they could be entered in the model (Tranmer and Elliot, 2008). The model was built using the **Enter Method** in which all the predictors were entered at once regardless of whether they were significant or not (Tranmer and Elliot, 2008).

2.0 FINDINGS

Bivariate Analysis

A Correlation Test Between ME in Single Years and IM was done to determine how infant mortality correlated with ME single years for the period 1992 to 2018 using point-biserial correlation at 0.01 or 0.05 levels of significance.

Table 2: Pearson Point-Biserial Correlations between ME in Single Years and IM: 1992 to 2018

ZDHS Phase			Education in single years	Infant Death
ZDHS1992	ME in Single Years	Pearson Correlation	1	-.037**
		Sig. (2-tailed)		.003
	IM	Pearson Correlation	-.037**	1
		Sig. (2-tailed)	.003	
ZDHS1996	ME in Single Years	Pearson Correlation	1	-.029*
		Sig. (2-tailed)		.013
	IM	Pearson Correlation	-.029*	1
		Sig. (2-tailed)	.013	
ZDHS2001/02	ME in Single Years	Pearson Correlation	1	-.027*
		Sig. (2-tailed)		.028
	IM	Pearson Correlation	-.027*	1
		Sig. (2-tailed)	.028	
ZDHS2007	ME in Single Years	Pearson Correlation	1	-.006
		Sig. (2-tailed)		.642
	IM	Pearson Correlation	-.006	1
		Sig. (2-tailed)	.642	
ZDHS2013/14	ME in Single Years	Pearson Correlation	1	-.014
		Sig. (2-tailed)		.111
	IM	Pearson Correlation	-.014	1
		Sig. (2-tailed)	.111	
ZDHS2018	ME in Single Years	Pearson Correlation	1	-.005
		Sig. (2-tailed)		.594
	IM	Pearson Correlation	-.005	1
		Sig. (2-tailed)	.594	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 2 presents the correlations between ME in single years and IM from 1992 to 2001-2 and as indicated in the table, increase in ME years was associated with a decrease in IM with Point-Biserial correlation coefficients of -.037**, -.029* and -.027* which were statistically significant at the P = 0.003, P = 0.013 and P = 0.028 respectively.

Multivariate Analysis

By use of Binary Logistic Regression, three models were fitted using the ENTER method to determine the influence of ME and its interaction with the selected explanatory variables on IM. In the first model all the predictor variables were entered to determine their single general influence on IM. However, the first model is not presented in this paper because the main aim of the paper was to determine how ME related with IM and how this key independent variable with its interactions influenced IM for the period under study. In the second model, ME as a single variable and its interactions with other predictor variables were entered to determine their general interaction influence on IM. In this model however, only variables which were found to be associated with ME

were included. In the third-final model, ME as a single (key independent) variable and the interactions which influenced IM throughout the period under study were entered. The goodness-of-fit of the final model was done for prediction accuracy at -2 log likelihood, Cox & Snell R squared and Hosemer and Lemeshow tests. Results are presented with respect to the macro-variables: social-economic, demographic, mother and child health and water and sanitation factors.

Second Model

Table 3: Interaction Influence of ME and Other Predictors on IM

Variables in ZDHS	ZDHS1992		ZDHS1996		ZDHS2001/2		ZDHS2007		ZDHS2013/14		ZDHS2018	
	B	Sig.	B	Sig.	B	Sig.	B	Sig.	B	Sig.	B	Sig.
M.E / Me * Social-EC- Factors												
ME in single years	-.21	.011*	-.35	.031*	-.41	.023*	-.27	.346	-7.10	.921	-.571	.100
ME * Province		.000*		.001*		.000*		.031*		.019*.		.004*
Copperbelt (1)	-.17	.099	-.04	.703	-.01	.892	-.00	.982	-.23	.085	-.033	.324
Eastern (2)	-.24	.014*	-.13	.153	-.03	.808	-.05	.708	-.15	.236	-.008	.796
Luapula (3)	-.07	.459	-.14	.125	-.11	.303	.27	.032*	.08	.533	.041	.156
Lusaka (4)	.12	.216	.12	.207	.30	.001*	.24	.075	-.12	.360	-0.74	.025*
Muchinga (5)									-.04	.33	.032	.302
Northern (6)	-.03	.740	-.04	.631	.07	.463	.12	.323	-.05	.763	-.018	.611
North Western (7)	-.10	.459	-.07	.564	-.16	.239	-.02	.882	.14	.342	-.093	.021*
Southern (8)	-.28	.003*	-.26	.010*	-.24	.027*	-.01	.047*	-.10	.032*	-.051	.115
Western (9)	-.24	.062	.01	.879	-.04	.743	-.03	.855	-.12	.018*	-.012	.988
ME by Lived in Urban (1)	.05	.469	.00	.974	-.01	.912	-.11	.223	-.06	.469	.018	.385
ME by Used Contraceptive (1)	-.19	.001*	-.22	.000*	-.26	.000*	-.12	.036*	-.11	.025*	-.069	.000*
M.E *Demographic Factors												
M. E * M. Age In 5-Year		.035*		.004*		.378		.022*		.001*		.000*
(20-24)(1)	-.23	.318	.12	.618	-.19	.286	-.24	.274	-.09	.709	-.019	.002*
(25-29)(2)	-.07	.744	.14	.527	-.26	.122	-.34	.082	-.41	.055	-.095	.001*
(30-34)(3)	-.07	.723	.10	.660	-.13	.444	-.28	.152	-.42	.046*	-.088	.005*
(35-39)(4)	-.07	.738	.06	.794	-.18	.292	-.47	.018*	-.53	.013*	-.109	.002*
(40-44)(5)	-.18	.390	-.22	.350	-.16	.345	-.33	.099	-.53	.015*	-.064	.118
(45 - 49)(6)	-.09	.694	-.08	.753	-.22	.243	-.26	.229	-.32	.166	-.122	.173
ME by Pre-Birth Interval24+(1)	-.20	.000*	-.15	.001*	-.15	.002*	-.09	.016*	-.15	.007*	-.107	.000*
M.E * Environmental Factors												
ME By Sourced from Pipe (1)	-.01	.824	-.03	.676	-.02	.810	-.15	.098	-.04	.612	.052	.170
ME By Flushable Toilet (1)	.07	.205	.06	.294	.04	.662	-.02	.862	.16	.037	-.05	.070
M.E * M.C Health Factors												
ME By Breastfed (1)	-1.49	.000*	-1.82	.000*	-1.81	.000*	-1.66	.000*	-7.26	.019*	-.460	.000*
ME By Delivered from Hospital (1)	-.09	.077	-.04	.439	-.04	.441	-.08	.222	-.00	.954	.34	.067
ME By Received Antenatal Care (1)	-.23	.000*	-.00	.02*	-.22	.000*	-.24	.000*	-.05	.046*	-.159	.000*
ME By Received Tetanus Injection (1)	-.01	.822	-.05	.195	.03	.600	.03	.615	.09	.188	-.003	.900
Intercept	**2.03**	**.000***	**1.95**	**.000***	**2.12**	**.000***	**2.23**	**.000***	**.09**	**.001***	**3.107**	**.000**

In Table 3, the intercepts (constants) show that from 1992 to 2018 infant mortality increased by [2.0, 2.0, 2.1, 2.2 .1 and 3.1 log odds, P < 0.05: CI: 95%] respectively, holding all predictor variables constant.

When ME (single years) was added to the second model some reductions in the coefficients were observed compared to the first model (table 3). Results show that, overall, the interactional effect between ME and Province contributed significantly to the reduction in IM throughout the period under study. However, holding everything else constant, disaggregated effects from 1992 to 2018 shows that the interaction between ME and being in Eastern Province reduced infant mortality (the least) by [.2 log odds, P < 0.05: CI: 95%] in 1992 only. The interaction between ME and Luapula and Lusaka Provinces increased infant mortality by [.3 log odds, P <0.05: CI: 95%] in 2007and 2001-02 respectively. The interaction between ME and Southern Province reduced infant mortality (the most) from 1992 to 2013/14 by [.3, .3, .2, .0, and .1 log odds, P < 0.05: CI: 95%] respectively. The interaction between ME and place of residence was found to have no significant effect on IM throughout the period 1992 to 2018. Throughout the period under study, the interaction between ME and contraceptive use was found to reduce infant mortality by [.19, .2, .2, .1, .1 and .07 log odds, P < 0.05: CI: 95%] respectively.

Overall, the interaction between ME and maternal age significantly contributed to the model in 1992, 1996, 2007 and 2013/14. However, holding all other variables constant, from 1992 to 2018 the interaction between ME and maternal age group 35-39 reduced IM the most by [.5, .5 and .02 log odds, P < 0.05: CI: 95%] in 2007, 2013-14 and 2018 respectively. The interaction between ME and maternal age groups 20-24 and 40-44 reduced IM the least by [.02 and.5 log odds, P <0.05: CI: 95%] in 2013-14 (for age group 40-44) and 2018 (for age group 20-24) respectively. Additionally, from 1992 to 2018, the interaction between ME and birth interval reduced IM by [.2, .2, .2, .1, .2 and .12 log odds, P < 0.05: CI: 95%] respectively.

Holding all other variables constant, for the periods from 1992 to 2018, the interaction between ME and source of drinking water and, type of toilet facility did not significantly affect infant mortality. From 1992 to 2018, holding other variables constant, the interaction between ME and breastfeeding, significantly reduced infant mortality by [1.6, 1.8, 1.8, 1.7, 7.3 and .46 log odds, P < 0.05: CI: 95%] respectively. The interaction between ME and place of delivery and tetanus injection did not affect infant mortality. The interaction between ME and antenatal care, significantly reduced infant mortality by [.2, .00, .2 .2, .1 and .16 log odds, P < 0.05: CI: 95%] from 1992 to 2018 respectively.

Third Model (Final Model)

Table 4: Binary Logistic Regression Final Model

Variables in ZDHS	ZDHS1992		ZDHS1996		ZDHS2001/2		ZDHS2007		ZDHS2013/14		ZDHS2018	
	B	Sig.	B	Sig.	B	Sig.	B	Sig.	B	Sig.	B	Sig.
ME/ M.E * Social-Economic and Demographic Factors												
ME Single Years	-.01	.041*	-.05	.051*	-.18	.025*	-.32	.346	-7.00	.911	-.186	.120
ME By Used Contraceptive (1)	-.65	.001*	-3.2	.000*	-1.7	.000*	-.62	.016*	-.91	.025*	-.071	.000
ME By Pre-birth_Interval_24+(1)	-.80	.000*	-.75	.001*	-.56	.002*	-.98	.016*	-.57	.007*	-.101	.000
M.E * Mother and Child Health and Water and Sanitation Factors												
ME By Breastfed (1)	-2.49	.000*	-.91	.000*	-3.81	.000*	-1.88	.000*	-8.62	.019*	-.434	.000
ME By Received Antenatal Care (1)	-1.23	.000*	-.07	.002*	-.72	.000*	-.94	.000*	-.65	.046*	-.153	.000
Intercept	6.03	.000*	2.65	.000*	.61	.000*	1.23	.000*	.19	.001*	-3.111	.000

When ME single years was added to the third-final model further reductions in the coefficients were observed compared to the coefficients in the first and second models (Table 4). Variables which significantly contributed

to the reduction in infant mortality throughout the period under study, (in the second model), including maternal education as the key independent variable, were advanced to the final (third) model. Table 4 shows the model with ME, ME by use of contraceptives (1), ME by preceding birth interval 24+ months (1), ME by breastfeeding (1) and ME by received antenatal care (1). Apart from ME which only influenced to the reduction in IM from 1992 to 2001-02, all the interactions in the model significantly reduced IM throughout the period under study.

Goodness-of-Fit of the Model

From 1992 to 2018 model 3 illustrated 91.4%, 92.4%, 93.7%, 95.1%, 96.5% and 96.2% accuracy of data prediction, respectively. The model indicates that variations of 8.4% (Cox & Snell R^2: 0.084) 12.9% (Cox & Snell R^2: 0.129) 14.7% (Cox & Snell R^2: 0.147), 13.8% (Cox & Snell R^2: 0.138), 21.2% (Cox & Snell R^2: 0.212) and 6.9% (Cox & Snell R^2: 0.212) correspondingly, (in IM) were explained by the model. Hosmer and Lemeshow goodness of fit model of [.058, .098, .276, .091, .070 and .197 ($P > 0.05$)], respectively, showed that the model estimates were acceptable and the -2 Log Likelihood values of 1512.26a, 1355.74b,1098.33c, 1172.71d, 1083.017e and 2656.024_f, correspondingly, gave an indication of a good model fit.

Discussion

To address objective one, point-biserial correlation was done between ME in single years and IM from 1992 to 2018. It was found that ME was significantly (negatively) correlated to IM from 1992 to 2001-02. That is, increase in ME years was associated with a decrease in IM. However, the correlation coefficients were very weak negatives indicating that there is a very weak negative relationship between ME and IM. This could imply that ME has less direct effect on IM and this maybe for the reason that, education only exposes women to accessing other factors which may have more direct or indirect effects on the infants' survival (Desai & Alva, 1998). Therefore, having received education alone does not guarantee the survival of infants ((Desai and Alva, 1998). These results are consistent with what other researchers argue, that the relationship between ME and IM is very week when socio-economic, environmental, community and health characteristics of mothers are controlled for. They argue that the socio-economic, environmental, community and health characteristics may be the pathways through which ME influences IM (Desai and Alva, 1998).

Maternal education is internationally recognized as one of the strongest determinants of infant survival in developing countries and girl child education is a common policy recommendation to improve infant health in developing countries (Hannum and Buchmann, 2005). Literature shows that the education of women in Zambia has been greatly improving with more women attaining higher education in recent times compared to the past years (CSO: ZDHS, 2018). However, in this study, ME was found to be negatively associated with IM from 1992 to 2001-02 only. This confirms with the correlation results in which ME and IM were negatively related from 1992 to 2001-02. However, it was expected that ME would be negatively associated, with IM throughout the period 1992 to 2018. This scenario is in line with literature which explains that; in recent years more women, worldwide, have been attaining higher education which subsequently, makes them become very busy with economic activities and in instances where they have infants, their attention on their infants probably reduces as most of them would leave their infants in the hands of maids/nuns among others who may have little or no education at all (Heinrich, 2014). Faced with economic challenges, coupled with more widespread gender equality perspectives which have driven men away from the idea of sole responsibility for provision in homes, it has meant that women, or mothers, have less time to focus their attention and care on infants (Flood, 2015). Other women, due to their busy schedules may have little or no time to prepare nutritional sound foods for their infants (Kaygamba, 2015). These results however, are in contradiction with most demographic research which shows that there is a strong statistical association between maternal education and infant mortality (Abuqamar et al., 2011; Kalipeni, 1993 and Caldwell, 1979; 1994). Nonetheless, the results are in line with other researchers (Desai & Alva, 1998) who reject the existence of a strong causal relationship between ME and IM arguing that the nature

of disease to which the children are exposed during the first year of life is such that mothers cannot do much in order to prevent their deaths.

Among the interactions of ME by social-economic and demographic factors, only the interactions between ME and contraceptive use and ME and preceding birth interval significantly affected IM throughout the period under study. From 1992 to 2018, the interaction between ME and contraceptive use significantly influanced IM. It is argued that educated women may know the importance of the usage of contraceptives and this allows them to have wanted children at their own convenient time and this makes them prepared psychologically physically, and financially with regards to the raising of the children (Stanfors and Larsson, 2014). A possible explanation for this could be that significant strides have been made in the improvements in access to education for women, subsequently resulting in their knowledge of sex rights, and use of contraceptives (Stanfors and Larsson, 2014). As such, in the recent past, the average use of contraceptives in Zambia has been improving and this is probably helping women to have health children at the right time and age (CSO: ZDHS, 2018). At the second level of analysis, maternal education was significantly associated with contraceptive use throughout the period under study. Other scholars argue that maternal education is the best contraception adding that many countries are now supporting and improving education levels of women to achieve multiple goals including the reduction in fertility levels as well as infant, and child mortality through a single policy (Boehmer & Williamson, 2006; Hannum & Buchmann, 2005; Mason, 2007). Education does not only increase the use of contraceptives but is itself a contraceptive technique, therefore combining it with actual contraceptive use knowledge, women will bear children at the right (safe and healthy) time, and ensure that they care for their infants wholeheartedly (Craig, 2009; Miller et al., 1992; Nath, Land, & Singh, 1994; Norton, 2005).

Additionally, from 1992 to 2018, the interaction between ME and birth interval Influenced the decline in IM. Educated mothers usually have fewer and well-spaced children (Hazan and Zoabi, 2015). Smaller families help them to plan well and manage their families within their timed amounts of resources and as such their infants are usually well provided for (Hazan and Zoabi, 2015). This can possibly be explained by the indication in the ZDHS that the average number of months for child spacing in Zambia has been increasing (ZDHS, 2018). In addition, the spacing of children of 24+ months equally helps women to be well prepared physically, mentally and financially and this makes them be able to provide enough required care and resources for their infants (Miller et al., 1992; Nath, Land, & Singh, 1994; Norton, 2005).

Among the interactions of ME with environmental and mother and child health factors, only the interactions between ME and breast feeding and ME and antenatal visits significantly affected IM throughout the period under study**.** As indicated**,** from 1992 to 2018 the interaction between ME and breastfeeding, significantly effected infant mortality. Educated women may have enough nutritional foods to provide their infants with and, this coupled with breastfeeding makes their infants even healthier because breast milk provides even more natural nutrition and antibodies which protects the infants from certain acute diseases (Jackson and Nazar, 2006). According to the 2018 data, about three-quarters (74%) of Zambian children age 0-23 months are breastfed appropriately for their age and this includes exclusive breastfeeding for children aged 0-5 months and continued breastfeeding along with complementary foods for children age 6-23 months (CSO: ZDHS, 2018). About 80% of children under age 6 months are predominantly breastfed but this percentage includes children who are exclusively breastfed and those who receive breast milk and only plain water or non-milk liquids such as juice (CSO: ZDHS 2018). Therefore, these factors coupled with increased education among women may explain why this interaction contributed significantly to the decline in IM. Many researchers have found similar results that breast milk is nature's perfect baby food: it contains immunity-boosting antibodies and healthy enzymes which protects against allergies and many infant diseases including virus infections among others (Rubin, 2005; Saputo and Faass, 2010; Stengler, 2001; Thomas, 2008).

The interaction between ME and antenatal visit significantly influenced the decline in IM throughout the period under study. Antenatal visits help women to gather information on how best they need to care for their infants and this therefore, helps the women to provide good care for their infants (Simkhada et al., 2010). The possible explanation for this maybe that educated women know the importance of receiving antenatal care and utilize this information very well as advised by the health personnel and there is improved observable, utilization of antenatal care services in Zambia (CSO: ZDHS, 2018). During antenatal care visits various issues are addressed including HIV, the general health of the mother, and the health of the child in the womb, among others to ensure that quality health is provided for the protection of the unborn child. After delivery, women are expected to report to the hospitals for check-ups on both the mother and the infant for prevention and treatment of alarming problems (Mathole et al., 2004; Nyblade and Field, 2000; Organization, 1994; Varga and Brookes, 2008). In agreement with this finding are similarly study findings of other researchers who postulate that antenatal care increases awareness of maternal and newborn health needs and self-care during pregnancy and the postnatal period, including the need for social support during and after pregnancy (Simkhada et al., 2010; Varga and Brookes, 2008). It promotes healthy behaviors in the home, including healthy lifestyles and diet, safety and injury prevention, support and care in the home, such as advice and adherence support for preventive interventions like iron supplementation among other things (Chan, 2015; Faso, 2007).

3.0 CONCLUSION AND RECOMMENDATIONS

Conclusion

In this study a very weak negative relationship between ME and IM was found. An increase in the number of years spent in school was found to be associated with a very minimal influence on the decline in IM from 1992 to 2001-2. This may imply that ME has less direct effect on IM for the reason that education only exposes women to accessing other factors which may have more direct effects on the infants' survival. When interacted with social-economic and demographic factors it was found that only the interactions between ME and contraceptive use and, ME and preceding birth interval, ME and breastfeeding and, ME and antenatal visit (care) significantly influenced the reduction in IM from 1992 to 2018. Therefore, it can be stated that on its own, ME influenced the decline in IM to a lesser extent as evidenced by the very weak negative relationship found between the two variables. However, when interacted with contraceptive use, preceding birth interval, breastfeeding and antenatal visit (care), ME influenced the decline in IM to a larger extent. Consequently, in order to come up with more robust interventions to further reduce IM in the country, these interactions should be considered in the planning and implementation of child health programs such as the child health nutrition, national partnership for maternal, new-born and child health, child health week, Integrated Community Case Management of Childhood Illnesses (ICCM), and the Support to Safe motherhood and New-born Health among others.

Recommendations

The interactions between ME and socio-economic, demographic, and mother and child health factors are found to have played a bigger role in the reduction of IM. Zambia has committed herself to the Agenda 2063-Sustainable Development Goals (SDGs). To achieve this goal, policy should be directed towards among others things, the presented factor interactions associated with IM; ME and contraceptive use, ME and preceding birth interval of 24+, ME and breastfeeding, ME and antenatal care, and ME and living in Southern Province. Therefore, this study may inform policy in this direction.

i. While the sexual reproductive health school program has a component on contraception, the subject should be broadened enough to include lessons on the importance of using contraceptives, spacing births for 24+ months, breast feeding and receiving antenatal care. This subject should be made compulsory in Zambian

schools up to tertiary level for more women in the country to have adequate knowledge on how to have health infants.

ii. During the implementation of such programs as child health nutrition, national partnership for maternal, newborn and child health, child health week, Integrated Community Case Management of Childhood Illnesses (ICCM), Support to Safe motherhood and Newborn Health, among others, government and the cooperating partners in the implementation of these programs should provide more Knowledge and emphasis on the importance of, girl child education, using contraceptives, spacing children for 24+ months, breast feeding and antenatal care during pregnancy and after birth to make women have a better understanding of the health needs of their infants in the country.

iii. The study indicated that coupling with ME, living in Southern Province which is known for abundancy production of various agro-products as well as livestock, influenced the reduction in IM throughout the period under study. Therefore, government should, continue to promote the girl child education and through the farmer support programs like Farmer Input Support Program (FISP); promote and increase the production of abundant agro-products and livestock in all the other provinces. This will continue to help women have a better understanding of the health of their infants and be able to provide for them the required nutritional foods such as meat and milk.

iv. Future research may be done to find out the actual numbers (counts) of infant deaths which were averted in each year (from 1992 to 20013/14) by the observed improvements in maternal education in Zambia considering interactions with other variables left out by this study which may include, wealth index, occupation, HIV, and employment status among others.

Limitations of the Study

i. The data sets used in the analysis were not collected for the purpose of this study and therefore, the analysis was done based on the nature of the data and as such, the study may have left out certain key variables, such as HIV, wealth index, employment, vaccinations, diarrhea treatment, malaria treatment and prevention among others, which may have been very important to the study.

ii. Data were weighted, some variables were collapsed (manipulated) this may have, to some extent affected the results of the analysis. For example, the collapsing of the many response categories for source of drinking water and type of toilet facility made some categories fall in the responses which were not exact of their representation. To deal with this, such variables were dichotomised to only allow effect analysis for the higher categories.

iii. When generating the dependent variable (Infant Mortality), the process did not account for the 'lost to follow up' and this inflated the denominators thereby making infant mortality rates smaller than as reported in the ZDHS of which however, the study did not intend to reproduce.

iv. Despite the conceptual framework showing many interactions, the study only focused on the interactions between maternal education and other explanatory variables.

v. The use of cross-sectional secondary data did not allow the control over how the data was collected when accessing it in a secondary way and could not provide data for causal relationships.

vi. By the use of binary logistic regression, the study did not factor in the censoring aspect and was not able to produce the quantifiable contribution of ME to the reduction in IM which however, the study did not intend to investigate.

List of Acronyms

CAMFED	Campaign for Female Education
CL	Confidence Level
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
IM	Infant Mortality
ME	Maternal Education
NGOs	Non-Governmental Organizations
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
ZDHS	Zambia Demographic and Health Survey

Declarations

Ethics Approval and Consent to Participate

This study was approved by the directorate of research and graduate studies (DRGS) University of Zambia and the Demographic and Health Survey Programme. There was no individual consent required in this study because the study was pure based on secondary data.

Consent for Publication

This study did not involve direct human participants. However, consent to make publications on the secondary ZDHS data was sought from Demographic and Health Survey Programme.

Availability of Data and Materials

The six ZDHS data sets which were employed in the analyses in this study are available at the Demographic and Health Survey Programme: (https://dhsprogram.com/data/).

Competing interests

The authors declare that they have no competing interests.

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Authors' Contributions

The main author is the pioneer and writer of the manuscript while the core author provided all the technical guidance and specialty-subject editorials/reviews to the paper.

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