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Levels and Trends of Under-Five Mortality in South Africa from 1998 to 2012

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Abstract**—**Childhood mortality is a key sign of the coverage of child survival interventions, social and economic progressions. Although the level of under-five mortality has been declining, it is still unacceptably high. The primary aim of this paper is to establish and analyse the levels and trends of under-five mortality for the periods 1998, 2003 and 2012 in South Africa. Methods: The data used for analysis came from the 1998 SADHS, the 2003 SADHS and the 2012 SABSSM which collected information on the survival status of children. The Kaplan-Meier estimate of the survival function method was used to determine the probabilities of failure (death) from birth up to 59 months. Results and Conclusion: The overall U5MR declined by 28.2% from 53.1 in 1998 to 38.1 in 2012. The U5MR of male children declined from 59.2 in 1998 to 46.2 in 2003 and dropped further to 41.4 in 2012. The U5MR of children of mothers aged 40 years and older increased from 64.0 in 1998 to 89.0 in 2003 and rose further to 129.9 in 2012. The U5MR of children of mothers with education level of 12 years or more increased from 32.2 in 1998 to 35.2 in 2003 and declined substantially to 17.5 in 2012.

Keywords**—**Demographic and health survey, Kaplan-Meier, levels and trends, under-five mortality.

I. Introduction

CHILDHOOD mortality is generally a concern for many countries and the reduction of childhood mortality levels will be good for all countries. It is a key sign of the coverage of child survival interventions, social and economic progressions [1]. In 2000, the Millennium Development Goals (MDGs) set out targets to reduce under-five mortality rate (U5MR) by two-thirds in 2015 with 1990 as a base period [2]. Although the global U5MR dropped by 53% from 91 deaths per 1,000 live births in 1990 to 43 deaths per 1,000 live births in 2015, the U5MR was still high in South Africa by 2015. By 2015 the U5MR of South Africa was 41 deaths per 1,000 live births [3]. This level of under-five mortality is unacceptably high. For the sake of this paper all U5MRs are reported as deaths per 1,000 live births [4].

The global U5MR decreased substantially between 1990 and 2015 [3]. It declined from 91 in 1990 to 76 in 2000 and dropped further to 52 in 2010, and by 2015 it was 43 [3]. In 1990 the U5MR of sub-Saharan region was 180 and for developed regions it was 15 and by 2015 the sub-Saharan region's U5MR was 83 and that of the developed regions was only six [3]. Clearly, between 1990 and 2015 the highest U5MR had been in sub-Saharan Africa and South Africa is part of this region [3].

Nannan et al. studied the levels and causes of child mortality in South Africa for the period between 1990 and 2007 [5]. The data used for analysis came from the three South African Demographic and Health Surveys (SADHS) conducted during 1988, 1998 and 2003, the 1996 and 2001 Census data, the 2007 Community Survey and vital registration data [5]. The U5MR from the SADHS data indicated a downward trend in U5MR from the late 1970s until 1990 and it levelled off at least until the year 2000 [5]. Adjusted levels of U5MR from the 1996 Census showed the steady downward trend of U5MR from the early 1980s to the early 1990s [5].

Oni and Adetoro examined the levels, trends and patterns of U5MR in Nigeria for the period between 2003 and 2013 [6]. The data from the three Nigerian Demographic and Health Surveys that were carried out in 2003, 2008 and 2013 were used for analysis [6]. It was found that the U5MR declined from 187 in 2003 to 128 in 2013 [6]. In Zimbabwe, the levels and trends in childhood mortality were investigated [7]. The data used for analysis came from the four Zimbabwean Demographic and Health Surveys conducted between 1988, 1994, 1999 and 2005-2006 [7] and the additional data came from population censuses and inter-censal demographic surveys conducted in Zimbabwe [7]. The results revealed that U5MR increased from 75 from the period of 1984-1988 to 102 during the period of 1995-1999 and then decreased to 82 during the period of 2001-2005 [7]. The primary objective of this paper is to establish and analyse the levels and trends of under-five mortality for the periods 1998, 2003 and 2012 in South Africa.

II. Methods

A. Data

The data used for analysis came from the three nationally representative household surveys, the 1998 SADHS, the 2003 SADHS and the 2012 South African National Human Immunodeficiency Virus, Behaviour and Health Survey (SABSSM). From the 1998 SADHS, a total of 11 735 women aged 15-49 years from 12 247 households were interviewed [8] whereas from the 2003 SADHS information was collected

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from a total of 7 041 women aged 15-49 years from 7 756 households [9]. In the 2012 SABSSM, data were collected from a sample of 15 000 households [10] and 40 000 individuals throughout the country [11]. Among others, the scope of the SABSSM survey was expanded to collect demographic and health indicators including fertility, morbidity and mortality [11]. Information on the survival status of children was also collected through the 1998 and 2003 SADHSs [8], [9].

B. Estimation of the U5MR

Direct and indirect methods are the two main types of estimation methods for calculating childhood mortality rates [12]. On one hand, computations of direct methods are applied directly on the data [13] as direct methods require data on the date of birth of children, their survival status and the date of death or ages at death of deceased children [12]. On the other hand, indirect methods, pioneered by Brass and Coale, estimate child mortality rate from information on aggregate numbers of children ever born and children still alive (or dead) reported by women classified by age group (15-19, 20-24, …, 45-49) or alternatively grouped by time since first birth, or marital duration [14]. Unlike the direct methods, the indirect methods are very dependent upon several assumptions that may or may not hold true [12]. One method of indirect methods is to make assumptions about the underlying pattern of fertility and mortality [5]. Another method is based on calculating life table indices using model life tables based on several assumptions [5]. Both types of methods can suffer from errors in data [12]. Estimation of child mortality using direct method depends on the correct reporting of date of birth, date of death or age at death [12].

Estimations of indirect methods can be incorrect if maternal age and ages and dates of births and/or deaths of children are wrongly reported [12]. Stillbirths and may be included in the response to the question ever born, thus leading to overestimates of mortality rates [12]. In this paper direct estimation method was chosen over the indirect estimation method due to the number of assumptions that may or may not necessarily be true but need to be made in indirect methods and the limited amount of information that they provide [4], [12].

The Kaplan-Meier (K-M) estimate of the survival function method was used to calculate the probabilities of failure (death) from birth up to 59 months. The estimator of K-M is a non-parametric estimate of the survivor function $\hat{S}(t)$, which provides the probability of the child surviving beyond time *t* [15]-[17]. The advantage of this method is that it considers censoring and other characteristics of survival data [18]. For a dataset with observed failure times, $t_1,....,t_k$, where k is the number of distinct failure times observed in the data, the K-M estimate at any time t is given by:

$$\hat{S}(t)=\prod_{j|t_j\le t}\left(\frac{n_j-d_j}{n_j}\right) \quad (1)$$

where n_j is the number of children at risk at time t_j and d_j is the number of failures (children who died during the stated period interval) at time t_j with $\hat{S}(t)=1$ for $t<t_{(1)}$ [15], [17]. The product is over all observed failure times less than or equal to t [15].

C. Biodemographic and Socioeconomic Factors

It has been reported in other studies that there are biodemographic and socioeconomic factors that impact survival chances of children [19], [20]. Amongst others, sex of the child, type of birth of the child, maternal age, population group, main source of water, main type of toilet facility, access to electricity, maternal education level, place of residence and province were considered for analysis.

III. Results

Fig. 1 presents neonatal mortality, post-neonatal, infant, child and under-five mortality levels and trends for the periods 1998, 2003 and 2012. The results show that neonatal mortality rates, post-neonatal mortality rates, infant mortality rates and U5MR have declined steadily from 1998 to 2012. However, child mortality rate declined between the periods 1998 and 2003 and increased in 2012. The infant mortality rate declined by 75.3% from 44.6 in 1998 to 11.0 in 2012. The overall U5MR declined by 28.2% from 53.1 in 1998 to 38.1 in 2012.

A. Under-Five Mortality Levels and Trends by Sex

Fig. 2 presents under-five mortality levels and trends by sex. The results show that U5MR of both males and females declined consistently from 1998 to 2012 although male children experienced higher under-five mortality levels than female children. The U5MR of male children declined from 59.2 in 1998 to 46.2 in 2003 and it dropped further to 41.4 in 2012 while for female children it declined from 46.8 in 1998 to 43.8 in 2003 and dropped further to 34.6 in 2012.

B. Under-Five Mortality Levels and Trends by Type of Birth

Fig. 3 presents under-five mortality levels and trends by type of birth. The results show that U5MR of singleton birth children declined from 1998 to 2012. However, multiple birth children experienced higher under-five mortality levels than singleton children during the three periods under study. The U5MR of multiple birth children declined from 206.1 in 1998 to 94.3 in 2003 and then it increased to 99.0 in 2012.

C. Under-Five Mortality Levels and Trends by Maternal Age

Fig. 4 presents under-five mortality levels and trends by maternal age. The U5MR of children of mothers aged 15-19 years and those of mothers aged 20-24 years declined substantially between 1998 and 2003, but their respective U5MRs increased between the periods 2003 to 2012. The U5MR of children of mothers aged 15-19 years declined from 65.3 in 1998 to 26.1 in 2003 and then it increased to 30.2 in 2012. The U5MR of children of mothers aged 20-24 years fell from 55.9 in 1998 to 27.1 in 2003 and it rose to 29.7 in 2012.

The U5MR of children of mothers aged 25-29 years declined consistently during the three periods under study. It declined from 55.1 in 1998 to 43.6 in 2003 and it dropped further to 29.0 in 2012. The U5MR of children of mothers aged 30-39 years increased from 44.8 in 1998 to 51.8 in 2003 and then it declined to 30.1 in 2012. The U5MR of children of mothers aged 40 years and older increased constantly from 1998 to 2012 and has been the highest throughout the three periods under consideration as compared to the U5MRs of other maternal age groups. The U5MR of children of mothers aged 40 years and older increased from 64.0 in 1998 to 89.0 in 2003 and it rose further to 129.9 in 2012.

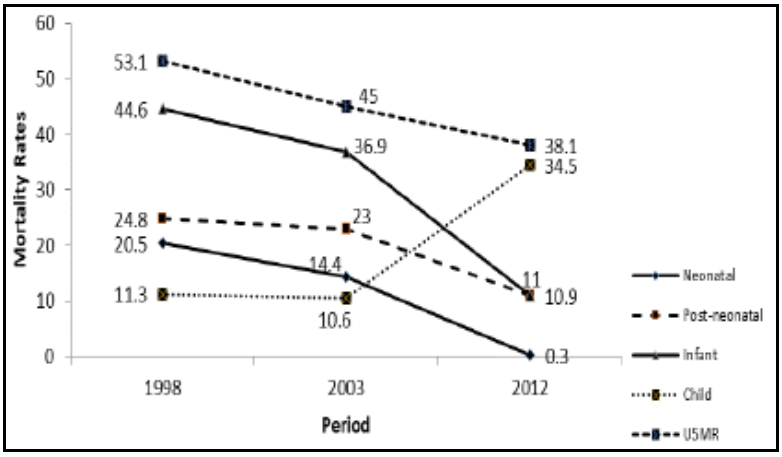

Fig. 1 Childhood mortality levels and trends: 1998, 2003 and 2012

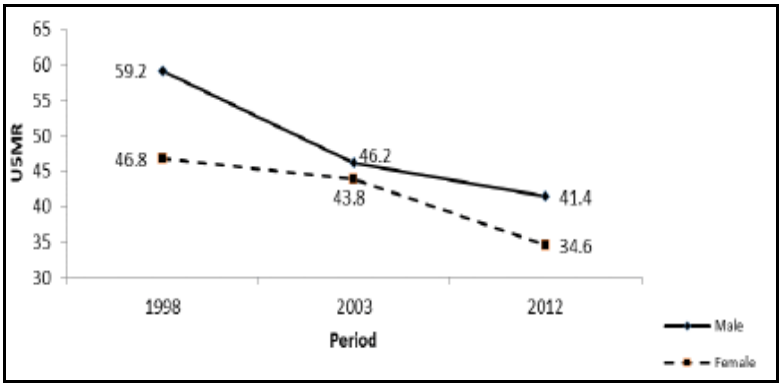

Fig. 2 Under-five mortality levels and trends by sex

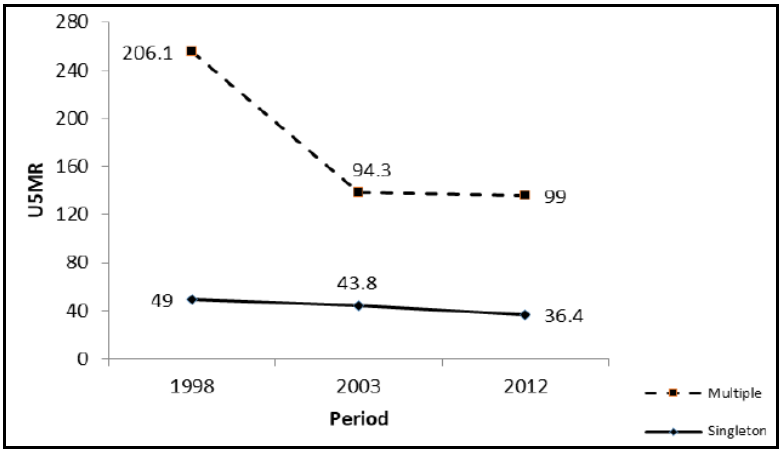

Fig. 3 Under-five mortality levels and trends by type of birth

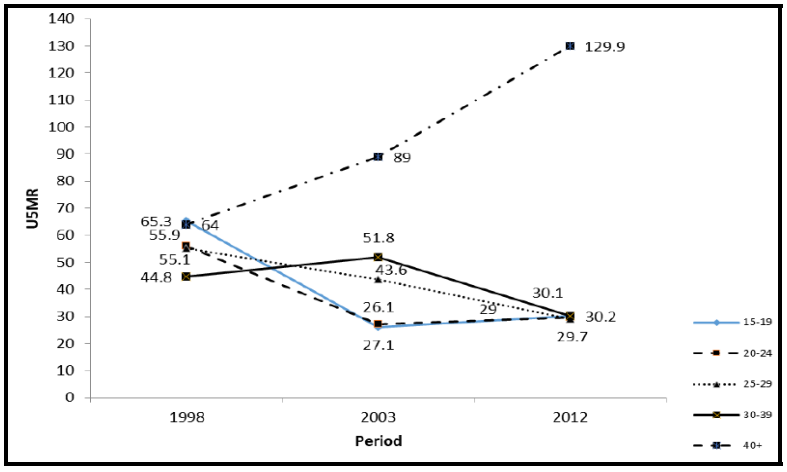

Fig. 4 Under-five mortality levels and trends by maternal age

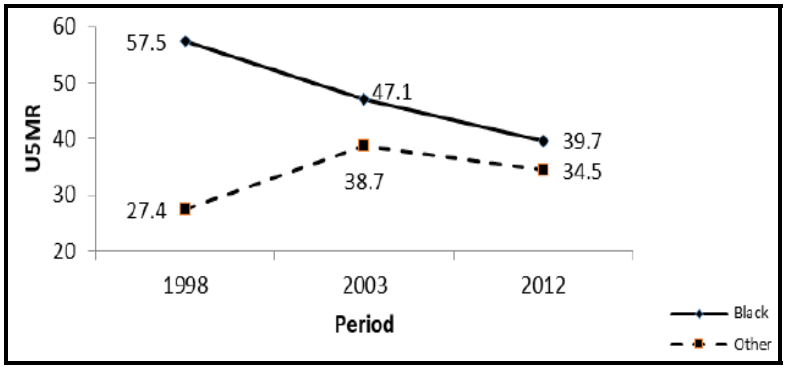

Fig. 5 Under-five mortality levels and trends by population group

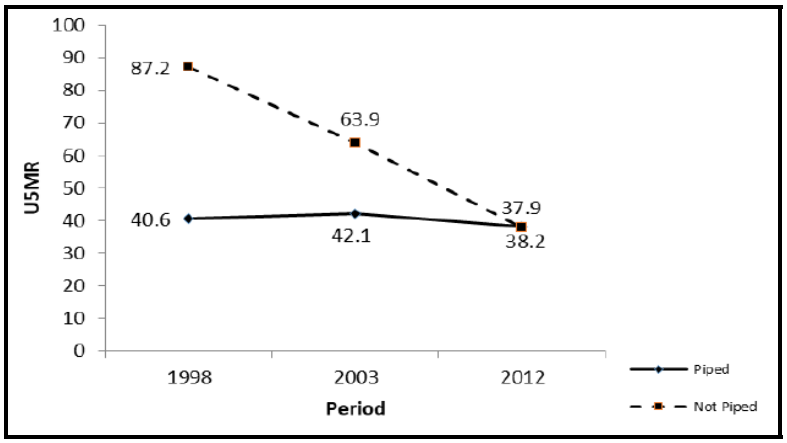

Fig. 6 Under-five mortality levels and trends by main source of water

D. Under-Five Mortality Levels and Trends by Population Group

Fig. 5 presents under-five mortality levels and trends by population group. The U5MR of black children declined consistently from 1998 to 2012. It declined from 57.5 in 1998 to 47.1 in 2003 and dropped further to 39.7 in 2012. However, the U5MR of non-black children increased from 27.4 in 1998 to 38.7 in 2003 and then it declined to 34.5 in 2012. The U5MR of black children has been the highest for the three periods under study although the gap of the U5MR between the black and non-black children has been narrowing during the same period.

E. Under-Five Mortality Levels and Trends by Main Source of Water

Fig. 6 presents under-five mortality levels and trends by

main source of water. The U5MR of children from households without access to piped water declined substantially from 1998 to 2012. The U5MR of children from households without access to piped water declined from 87.2 in 1998 to 63.9 in 2003 and dropped further to 37.9 in 2012. However, the U5MR of children from households with access to piped water increased from 40.6 in 1998 to 42.1 in 2003 and then it declined to 38.2 in 2012.

F. Under-Five Mortality Levels and Trends by Type of Toilet Facility

Fig. 7 presents under-five mortality levels and trends by type of toilet facility. The results show that U5MR of children from households without access to formal toilet facilities declined from 89.3 in 1998 to 86.8 in 2003 and it dropped further to 41.5 in 2012. The U5MR of children from households with access to bucket/pit latrine toilet facilities declined from 53.2 in 1998 to 46.2 in 2003 and it remained 46.2 in 2012. Surprisingly, the U5MR of children from households with access to flush toilet facilities increased from 33.1 in 1998 to 35.2 in 2003 and to 46.2 in 2012.

G. Under-Five Mortality Levels and Trends by Access to Electricity

Fig. 8 presents under-five mortality levels and trends by access to electricity. The results, on one hand, show that the U5MR of children from households without access to electricity declined from 68.7 in 1998 to 55.0 in 2003 and dropped further to 42.8 in 2012. On the other hand, the U5MR of children from households with access to electricity increased from 39.4 in 1998 to 42.3 in 2003 and then it dropped to 36.8 in 2012. The U5MR of children from households without access to electricity has been higher than that of children from households with access to electricity during the three periods under study.

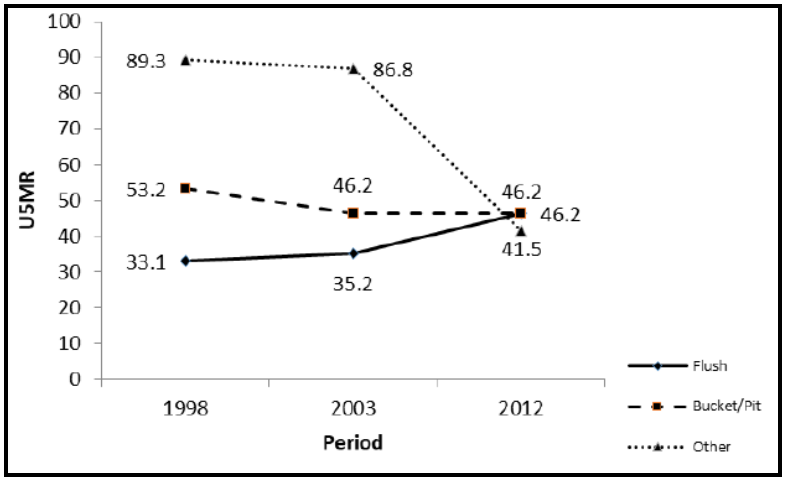

Fig. 7 Under-five mortality levels and trends by type of toilet facility

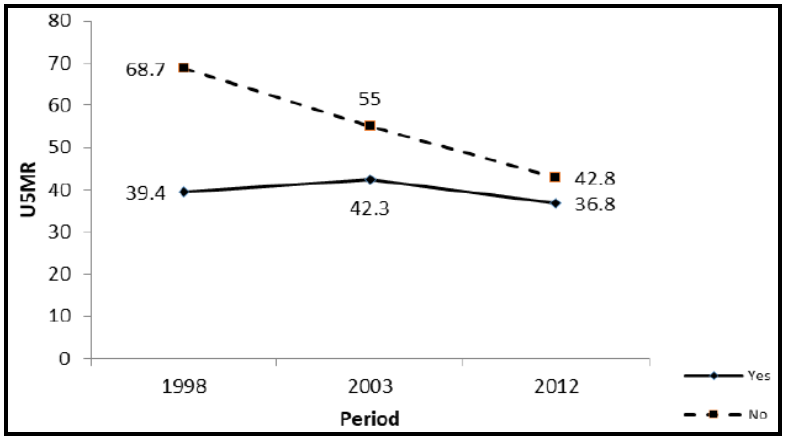

Fig. 8 Under-five mortality levels and trends by access to electricity

H. Under-Five Mortality Levels and Trends by Level of Education

Fig. 9 presents under-five mortality levels and trends by level of education. The results show that the U5MR of children of mothers with education level of 0 to 7 years declined from 1998 to 2012. The U5MR of children of

mothers with education level of 8 to 11 years declined from 48.5 in 1998 to 44.7 in 2003 and then it rose to 50.1 in 2012. The U5MR of children of mothers with education level of 12 years or more increased from 32.2 in 1998 to 35.2 in 2003 and then it declined substantially to 17.5 in 2012.

I. Under-Five Mortality Levels and Trends by Place of Residence

Fig. 10 presents under-five mortality levels and trends by place of residence. The results show that the U5MR of children who resided in rural areas declined from 63.9 in 1998 to 51.3 in 2003 and it dropped further to 30.6 in 2012. However, the U5MR of children who resided in urban areas increased gradually from 39.6 in 1998 to 40.0 in 2003 and it increased to 42.3 in 2012. Surprisingly, by 2012 the U5MR of children who resided in rural areas was lower than that of children who resided in urban areas.

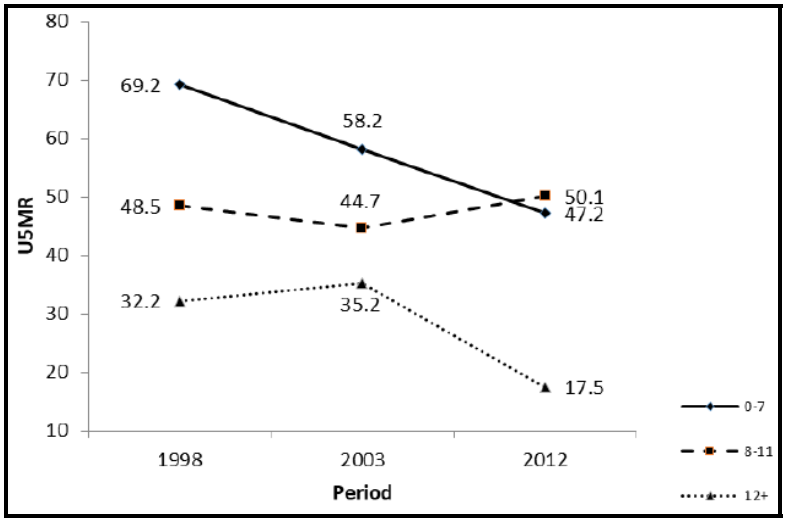

Fig. 9 Under-five mortality levels and trends by level of education

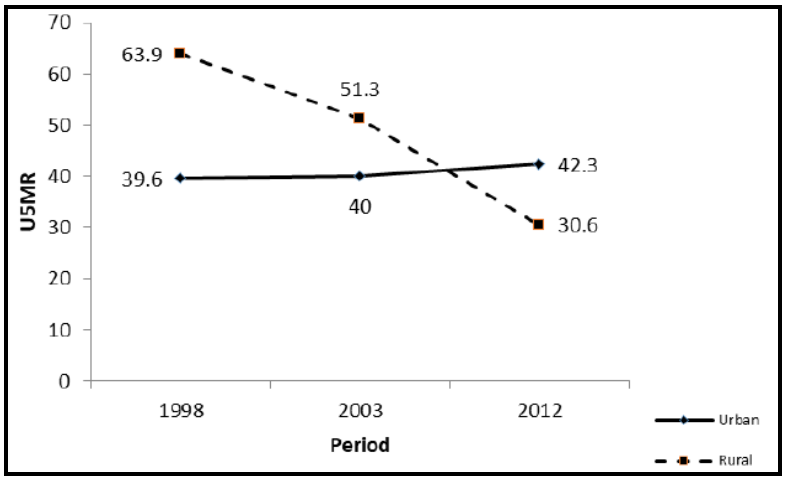

Fig. 10 Under-five mortality levels and trends by place of residence

J. Under-Five Mortality Levels and Trends by Province for 2012

Fig. 11 presents under-five mortality levels by province for 2012. In 2012, the Northern Cape province recorded the highest U5MR (53.6) followed by North West province (50.5), Gauteng province (47.5), Free State province (46.9) and Western Cape province (43.4) whereas Limpopo province had the lowest U5MR (19.4) followed by Mpumalanga province (21.4), Eastern Cape province (28.0) and KwaZulu-Natal province (36.6).

K. Under-Five Mortality Levels for 2012

Fig. 12 presents under-five mortality levels for 2012 by different factors. The highest U5MR occurred amongst the children of women aged 40 years and older (129.9) followed by the one of multiple birth children (99.0) and it was lowest among the children of women with the education level of 12 years or more (17.5) followed by that of children who resided in Limpopo province (19.4).

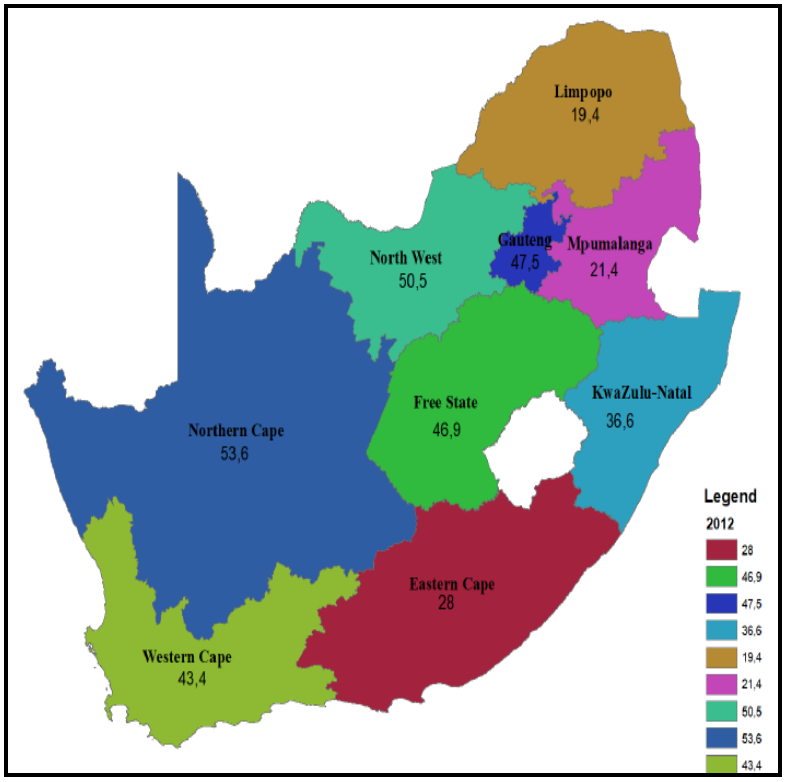

Fig. 11 Under-five mortality levels for each province, 2012

IV. Discussions

Under-five mortality levels were established using the direct estimate method of Kaplan-Meier estimator. In addition, the trends of U5MRs from 1998 to 2012 were analysed. The results revealed that the overall U5MR declined by 28.2% from 53.1 in 1998 to 38.1 in 2012. This decline could be attributed to the increased supply and use of antiretroviral treatment drugs (ARVs) that were made available to the public from 2004 [21]. Also, the roll out of the Prevention of Mother-To-Child Transmission (PMTCT) may have contributed immensely to the reduction of U5MR. The improvement of access to basic services such as clean water, flush toilet facilities and electricity may have also contributed to the reduction of U5MR. For instance, the percentage of households that have access to piped water increased from 80.3% in 1996 to 91.2% in 2011, the percentage of households that have access to flush toilets increased from 82.9% in 1996 to 90.6% in 2011 and the percentage of households that have access to electricity increased from 58.2% in 1996 to 84.6% in 2011 [22].

Globally, male children experience higher under-five mortality than female children [3]. The findings of this study revealed that the U5MR of male children have been highest for the periods 1998, 2003 and 2012 in South Africa. The results are in agreement with the results of UNICEF whereby it was reported that in 2015 male children had higher U5MR (44) than female children (41) [3]. Other reasons attributing to the male children experiencing higher under-five mortality than female children could be that female children have high vigorous immune response and greater resistance to infections and respiratory illnesses than male children [23]. Furthermore, findings showed that the U5MR was highest amongst children of multiple births for the three periods under study. These results are in line with the findings of other studies. In Cambodia, it was found that multiple birth children experienced higher risks of under-five mortality than singleton children [20]. The majority of multiple births occur at infant stage [24] and this contributes towards high under-five mortality levels. The greater risk of under-five deaths in multiple birth children may be attributed to complications at birth [25]. Lack of affordability for private health and food may also be contributing factors towards under-five mortality of multiple birth children.

Previous studies have shown that the risk of under-five mortality was high among young and old women [26]. In this study, it was discovered that in 2003 and 2012 the U5MR was highest amongst the children of women aged 40 years and older. Old women may lack the physical strength and/or physiological fitness to give birth to healthy children and mental fitness/strength to raise the children in a proper manner.

The U5MR of black children has declined constantly from 1998 to 2012 and was the highest for the three periods under assessment as compared to the U5MR of non-black children. The greater risk of under-mortality in black children may be attributed to the differences in economic factors such as lower

education levels of their parents, lack of affordability to private healthcare and nutrition as compared to non-black children. The majority of black children reside in townships (black community areas) and rural areas where there is a lack of decent infrastructure, sanitation and electricity.

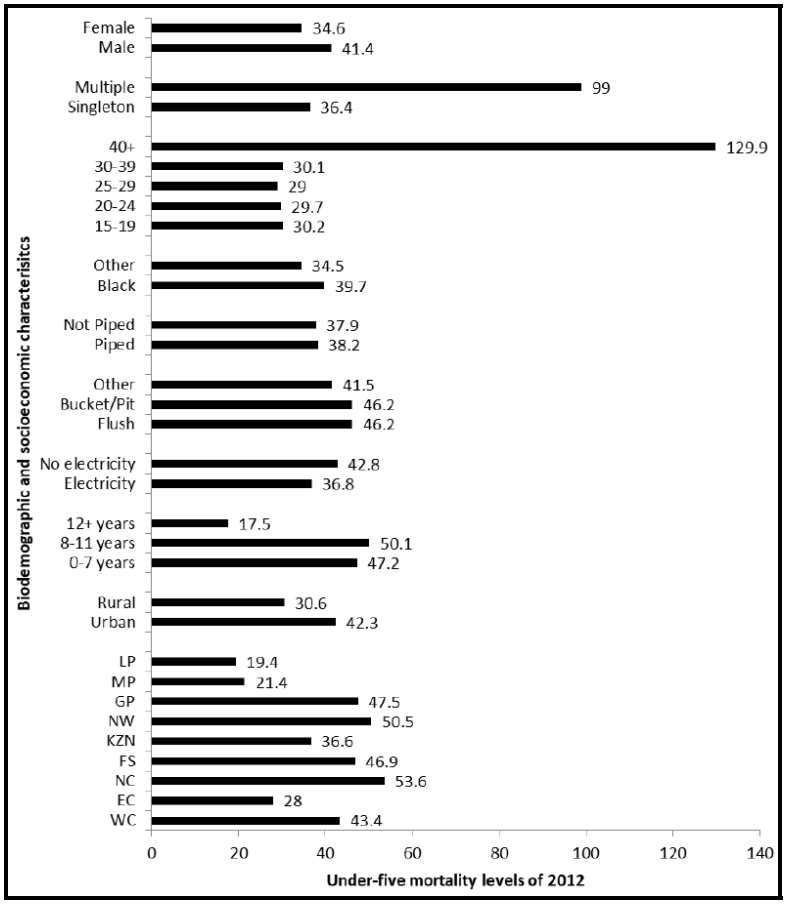

Fig. 12 Under-five mortality levels for 2012

High level of maternal education is associated with child survival [19]. The results of this study showed that children of mothers with the education level of 12 years or more had the lowest U5MR of the periods under study. These results are in agreement with what is reported in literature that higher education levels are largely associated with lesser under-five mortality risks [19]. It has been explained that a well-educated mother has a better chance of satisfying important factors that can improve under-five survival, the quality of feeding, household sanitation, and adequate use of preventive and curative health services [24]. Mothers with high levels of education are able to read newspapers and magazines. They can use information learnt from these resources and apply that knowledge they gained in raising their children. Highly educated mothers are likely to be associated with high salaried jobs and can afford expensive medical care.

Normally, rural children are strongly associated with high under-five mortality levels. The results of this study revealed that the U5MRs of rural children were higher than the U5MRs of urban children in 1998 and 2003. Surprisingly, in 2012 the U5MR of rural children was lower than that of urban children. Unexpectedly, the provinces with the lowest U5MR of 2012 were Limpopo and Mpumalanga provinces. These provinces are more rural than Gauteng and Western Cape provinces. The lower U5MRs of Limpopo and Mpumalanga provinces could be related to the lower U5MR of rural children for 2012.

V. Conclusion and Recommendations

The objective of this paper was to establish and analyse the levels and trends of under-five mortality for the periods 1998, 2003 and 2012 in South Africa. It was shown that the U5MR was consistently high amongst male children, children of multiple births, children of mothers aged 40 years and older, black children, children from households without access to electricity and children of mothers with a low level of education. Some of the under-five deaths are caused by the transmission of HIV/AIDS. The government of South Africa should increase the supply of ARVs to all communities, especially in under-developed communities such as the rural areas. Also, the implementation of PMTCT should be spread

equally countrywide. Women who are 40 years and older should be discouraged to fall pregnant. Children should be fully immunized against the common childhood infections such as tuberculosis, diphtheria, whooping cough, tetanus, polio and measles [20].

Maternal education should be enhanced as this would contribute positively to the under-five survival in South Africa. Women should be supported to continue with education up until they can complete post-matric qualifications. More funding should be made available, especially for women so that they can study at institutions of higher learning. Keeping the women at school and increasing their education level will reduce teenage pregnancy levels and the risks of under-five mortality in South Africa. The United Nations developed and launched Every Woman Every Child strategy to boost the global momentum in improving new-born and under-five survival [1]. In September 2015 the government of South Africa adopted this strategy [27]. The efficient implementation of this strategy will help the government of South Africa towards maintaining the well-being of children. The implementation of this strategy will boost the country towards achieving the Strategic Development Goal target 3.2 of reducing U5MR to as low as 25 by 2030 of by 2030 [28].

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