Levels of Infant Mortality in a Context Perspective: A Focus on Africa

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Abstract: *The world under-five mortality rate declined by 56 per cent, from 93 deaths per 1,000 live births in1990 to 41 in 2016. However, Africa remains the region with the highest global burden of child mortality. The study intends to describe the transition to lower infant mortality of most African countries in the last decades. Applying a cluster analysis on DHS data representing the levels of infant mortality and the values of some covariates regarding health, woman's status and economic situation, we found four scenarios ranging from a lowest-low to a medium development. Related to these differences, we found a reduction of infant mortality from 96.8to 42.2, a decline of fertility from 6.0 to 4.2 birth per woman, an increase of the woman's median age at first marriage from 17 to 20 years, and an increase of the percentage of women with a diploma from 13 to 43%.*

Key words: *Infant mortality, African countries, Cluster analysis, Woman's status, Health condition.*

1. INTRODUCTION AND AIM OF THE STUDY

The world has made substantial progress in child survival since 1990. The global under-five mortality rate declined by 56 per cent, from 93 deaths per 1,000 live births in1990 to 41 in 2016. The majority of the regions in the world and142 out of 195 countries at least halved their under-five mortality rate. Among all countries, more than a third (67) cut their under-five mortality by two thirds – 28 of them are low or lower-middle-income countries, indicating that improving child survival is possible even in resource-constrained settings (UNICEF, WHO, World Bank Group and United Nations, 2018).

However, Africa remains the region with the highest global burden of under-five deaths(INDEPTH Network, 2001).Children of sub-Saharan African nations are seven times more likely to die under the age of five than children in Europe do. In 2016, the region had an average under-five mortality rate of 79 deaths per 1,000 live births. This translates to 1 child in 13 dying before his or her fifth birthday – 15 times higher than the average ratio of 1 in 189 in high-income countries, or 20 times higher than the ratio of 1 in 250 in the region of Australia and New Zealand.

But, what about the contextual conditions which supports the mortality trends in Africa? Literature agrees that the reduction of child mortality is part of a larger process of societies' development, which refers to the populations' life conditions, the quality and accessibility of the health services for mothers and children, the role of the woman into the society (Frost and Pratt, 2014; Hanmer et al., 2003; Hill, 1991).

Several studies have indeed analysed the relationship between health care, including health services, and child survival (Liù et al., 2015).Accessible health care and services are the first aid to reduce the incidence of preventable diseases that may lead to death children aged less than five.

Poverty is highly associated with child mortality too (O'Hare et al., 2013). The latest mortality estimates by wealth quintile reveal that in 99 low-and middle-income countries, under-five mortality among children born in the poorest households is on average twice that of children born in the wealthiest households. The burden of under five deaths is also disproportionally concentrated among poorer households, with the two poorest quintiles accounting for about half of the under 5 deaths but

only for 40 per cent of the births. Eliminating the gaps between the poorest and richest households and between countries would save millions of lives.

Finally, women's status. It has been demonstrated that women's status has a positive impact on child survival (Caldwell 1993; Boehmer and Williamson, 1996) and on maternal and child health (Singh et al. 2015).The link between child survival and female status may be explained through different mechanisms. On the one hand, women with more human capital are more aware of possible health risks of their children and more autonomous in deciding the best strategy to cope that risks. On the other hand, the greater control of fertility usually adopted by the women with a higher status has the consequence of both reducing the teenage pregnancies and lengthening the birth intervals, with positive effects on pregnancy outcomes and neonatal mortality (de Jonge et al., 2014; Phipps, 2015).

With this research, we intend to describe the transition to lower infant mortality of most African countries in the last decades, analysing levels and trends in a contextual perspective. Thus, we focus on the deaths occurring in the first twelve months of life, considering them olisticallyas part of a more general process of the societies' development. More explicitly, the aim of our research may be outlined according the following three points:

1) To describe the trend of infant mortality in most African countries, comparing the results of different DHS available surveys and focusing - when possible - on either the final values of rates (preferably 2010-2015) and the target of the Millennium Goal.

2) To analyse how infant mortality levels are associated with some background conditions(health care, poverty, women's status) which are assumed to impact (and maybe to be recursively influenced) on child mortality, in order to identify different phases of transition to the low-infant mortality in a contextual perspective,

3) To classify the countries according the phases identified in the previous point in order to have a synthetic picture of the position occupied by most African countries over the last 20 years.

The paper is organized as follows: next section presents the results of some studies which analysed the relationships between child survival and some relevant background characteristics (health care and services; poverty; woman's status).Section 3 describes both the data (Demographic and Health Survey - DHS) and the methods used to reach our research aims. Section 4 shows the infant mortality rates of most African countries according to the results of the DHS conducted between 1987 and 2016.Section 5 presents the results of the cluster analyses applied to the countries characteristics to verify if in sub-Saharan region some similar groups exist concerning the trend of infant mortality and the covariates. Section 6 comments the results.

2. About the Relationships Between Child Mortality and Background Conditions

a) Economic Conditions

Poverty is clearly positively associated with child mortality. Closing the gap of under-five mortality between the poorest and the richest countries would save millions of lives: if all countries had reached an under-five mortality rate at or below the average rate of high-income countries – 5.3 deaths per 1,000 live births – 87 per cent of under-five deaths could have been prevented, and the lives of almost 5 million children could have been saved in 2016.

Poverty influences infant mortality through several mechanisms (O'Hare et al., 2013). On the one hand, it forces mothers and babies to live in unhealthy environment or to adopt unhealthy lifestyles which are the main responsible of serious children' s diseases due to both poor diet and poor hygiene; on the other hand, the lack of income reduces for mothers and children the opportunities to access to health care, especially those of higher quality (Tabutin and Schoumaker, 2004).

The relationship between nutrition affected by economic condition and infant mortality has been deeply analyzed (UNICEF, LSTM, 2011). The nutrition transition[i] is a period of transition thought to precede or occur simultaneously with the demographic and epidemiological transitions which is resulting from a change in diet and hygienic norms in nutritional habits. At any given time, a country or region within a country may be at a different stage within this transition. Sub-Saharan Africa, made up of low- and middle income countries, is undergoing a health transition causing these countries to experience a double burden of disease. The nutrition transition appears to be accelerating in Sub-Saharan Africa from the receding famine stage to the nutrition related to non-communicable disease

stage. As a result, an increasing number of households are experiencing the dual burden of underweight and obesity occurring simultaneously. At the same time high rates of chronic diseases, like diabetes, cardiovascular disease and cancer are occurring together with infectious diseases such as HIV/AIDS, tuberculosis and malaria.

b) Health care

In the developed and other industrialized economies, several studies have provided empirical evidence on the relationship between public health expenditure and health outcomes. In general, no consensus has emerged on the effect of public health spending on health outcomes in less developed countries (Frankenberg, 1995)

While some studies found that public health expenditure has significant impact on health outcomes, some reported that expenditure on public health does not have an impact on health outcomes. In sub-Saharan Africa, empirical studies on the relationship between government health expenditure and under-five as well as infant mortality rates are just evolving. There is the need for more empirical studies on the effect of health expenditure on child mortality in sub-Saharan Africa countries. This is particularly important considering the high level of under-five and infant mortality rates in the countries (Okeke, and Chari, 2018).

It is shown that government health expenditure has a positive effect on under-five and infant mortality. However, some studies show that GDP per capita, health aid, and immunization have significant negative effects on under-five and infant mortality. The results clearly suggest that health care expenditures have not been translated into improvement in under-five mortality in sub-Saharan Africa. The results possibly reflect the high level of waste and corruption of public health expenditure.

Nevertheless, accessible primary health care, including health services, presents a very important role on development. Their influence on mortality, especially on infant mortality, is undeniable. So far, the reduction in under-five and infant mortality rates has resulted primarily from the prevention of deaths due to diarrhea, pneumonia, measles, and other infectious diseases after the first four weeks of life (Unicef, 2018).

c) Female status

Literature clearly supports the hypothesis of an inverse relationship between the status of women and child mortality. Boehmer and Williamson (1996) argue that nations in which women have higher status will tend to be nations in which women are able to have a greater influence on social policy. Women will tend to favor spending a greater share of family and national resources on basic education, primary health care, and a variety of other social welfare programs that tend to lower infant mortality (Boehmer and Williamson, 1996; IJaz, 2012; Shapiro and Tenikue, 2017).

Caldwell's (1993) found that mother's education is the single most important determinant of Okiroges in family roles giving women greater say with respect to the number of desired children (Kaplan et al., 2015) and of care of their children. (2) A more educated mother tends to be less fatalistic about her sick child. She tends to be more prone to seek medical treatment and more prone to make use of modem medical facilities. (3) More highly educated mothers are in a better position (are therefore more autonomous) (Sripad et al., 2019) to demand the attention of health providers and more likely to ask for explanations as to the cause of the problem and what can be done to prevent it. Gender stratification theory would suggest that such behavior would be even more likely in countries in which women have more autonomy, more political influence, and greater control over economic resources. In addition, educated women are more able to control their fertility with respect to the onset of the first pregnancy as well as the distance between the pregnancies, with undeniable positive effects on the mothers' health and the survival of newborn (de Jonge et al., 2014). Singh et al. (2015), in their study carried out in African countries on DHS data, show protective associations between the gender equality measures and the children's health outcomes studied, indicating that gender equality is a potential strategy to improve maternal and child health in Africa. (Singh, Bloom and Brodish, 2015).

In summary, according to the literature, the ways through which gender equality influences on child survival, health and nutrition are several. Firstly, the extent to which women are able to influence decision-making within the household influences how resources are conducted to children in terms of both nutrition and health inputs. Secondly, women's ability to access and control the use of resources for their own health and well-being influences significantly their children's survival, health and

nutrition. Overall, women's multiple responsibilities (which often encompass domestic tasks, childcare and paid labor) present a heavy burden on women, which has potentially negative impacts for child health and nutrition outcomes. Thirdly, it was found that socio-culturalvalues which perpetuate certain expectations about women's and men's capacities, characteristics and social behavior reinforce many of the imbalances between women and men. These have serious consequences, especially in contexts where gender bias against girls exists. There are also serious consequences for children exposed to domestic violence, a phenomenon that reflects gender discrimination at its most extreme (Unicef and LSTM, 2011; Wickrama et al., 2003; Lindskog, 2017).

3. DATA AND METHODS

Data we used derive from DHS (Demographic and Health Surveys), national family surveys providing comparable data between countries in reference to indicators such as fertility, health and maternal and child nutrition. We used 147 DHS surveys conducted between 1987 and 2016, referring to 44 African countries (Table 1)[ii]. Obviously, the available DHS Surveys offer a partial coverage of the countries of African continent, as well as the historical series that we can built with successive DHS on the same country may have different length, different years of start and different years of end. However, for the more recent period (2011-16) the surveys refers to a large number of African countries (31) and for most countries we can count at least on more than two surveys.

Table1. *African countries and number of DHS surveys according to the geographic region*

North Africa		Western Africa		Eastern Africa		Central Africa		South Africa	
Egypt	8	Benin	4	Burundi	2	Angola	1	Botswana	1
Morocco	3	Burkina Faso	4	Comores	2	Cameroon	4	Lesotho	3
Tunisia	1	Ivory Coast	3	Eritrea	2	Chad	3	Namibia	4
		Gambia	1	Ethiopia	4	Congo	2	South-Africa	1
		Ghana	6	Kenya	6	Gabon	2	Swaziland	1
		Guinea	3	Madagascar	4	C.Afr. Republic	1		
		Liberia	3	Malawi	5	D.Rep. Congo	2		
		Mali	5	Mozambique	3	São Tomé	1		
		Mauritania	1	Rwanda	6				
		Niger	4	Sudan	1				
		Nigeria	4	Tanzania	6				
		Senegal	9	Uganda	5				
		Sierra Leone	2	Zambia	5				
		Togo	3	Zimbabwe	6				
3	12	14	52	14	57	8	16	5	10

As regards the methods used, we firstly show a descriptive analysis of the infant mortality trends, and secondly we will use techniques of cluster analysis on historical series of infant mortality rates and related variables to describe groups of countries' trajectories in the process of demographic transition .For the cluster analyses, we used 11 variables representing infant mortality (our outcome variable:infant mortality rate) and ten other variables representing three background dimensions: health context (3 variables: % of children having made 8 vaccines, % of children born at the household,% of women with unmet need of contraception); female status (4 variables: Total Fertility Rate, % of women using contraception, that is prevalence of contraceptive use in women ever in union or marriage aged 15-49, % of women with a diploma, median age at the first marriage), economic conditions (3 variables: % of stunted children; % of under-weight children; % of households having electricity in their dwelling).
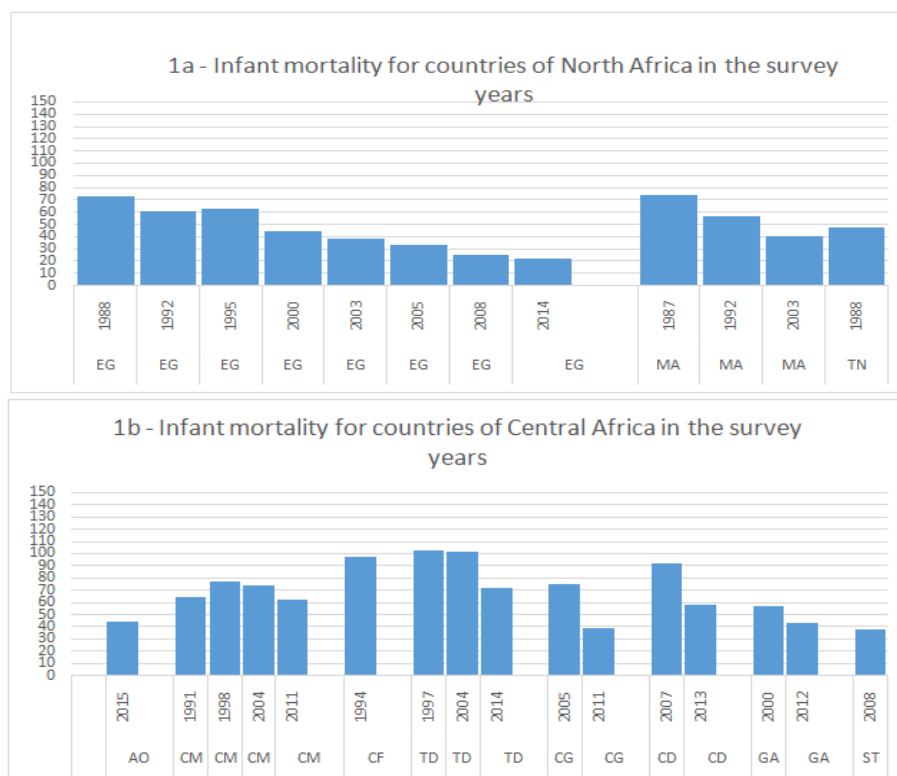
a) Economic conditions

1. Stunted children. It is represented by the percentage of moderately or severely stunted children[iii], aged between 0 and 59 months.

2. Underweight children. It is measured with the percentage of moderately or severely underweight children[iv], aged between 0 and 59 months, to the total number of children living between 0 and 59 months of age. Many countries show high levels of underweight children that are correlated with infant mortality.
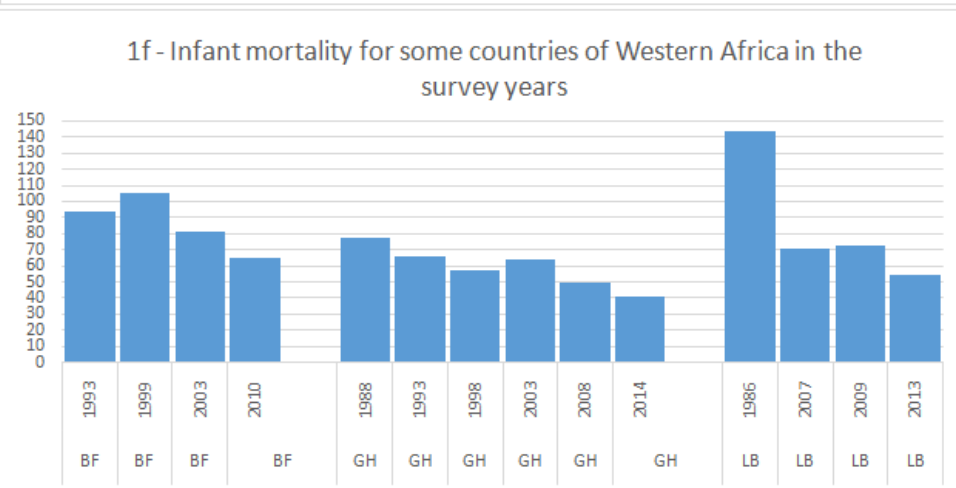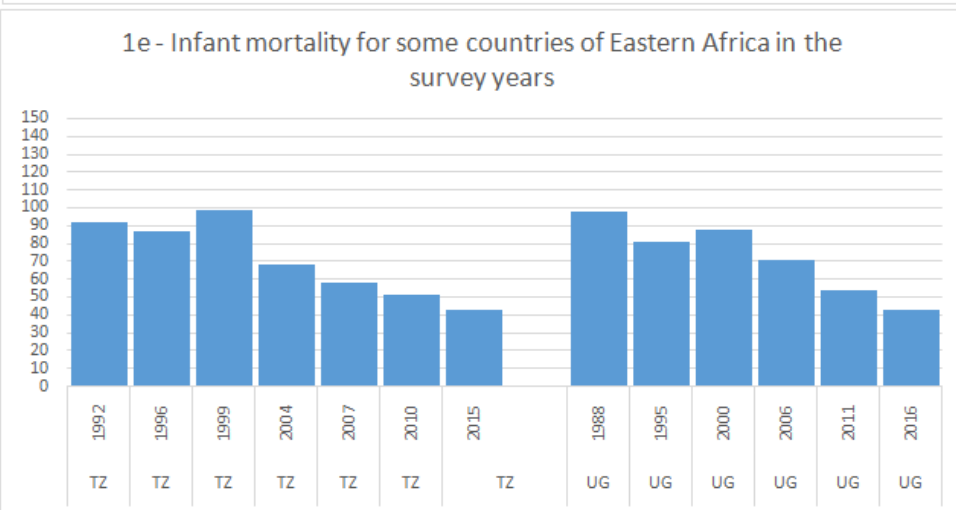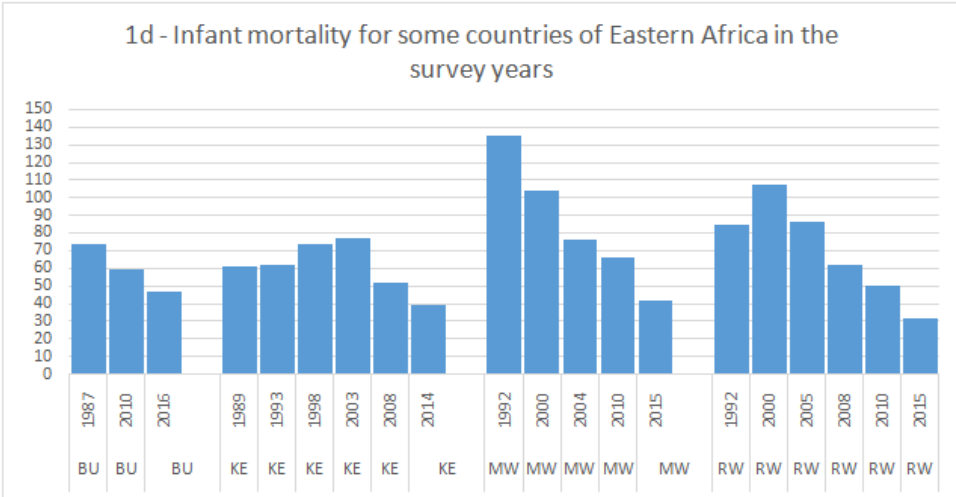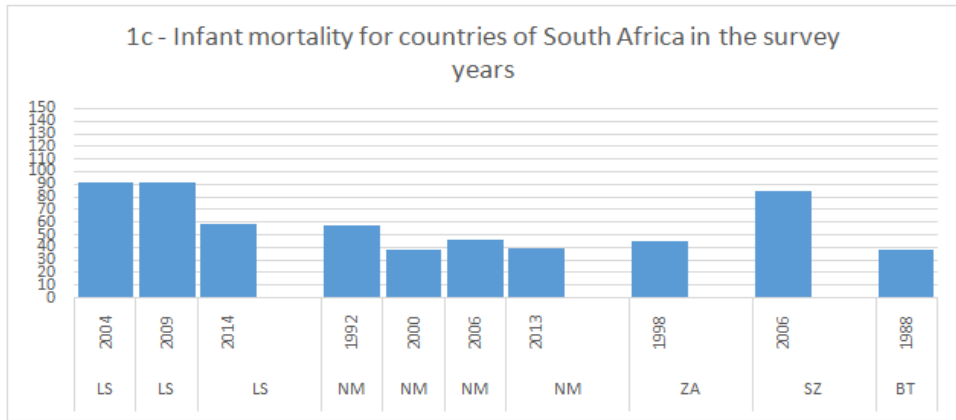
3. Household electricity. It is represented by the percentage of families living in a household with the electricity, that is the ratio of families having electricity and the total of the interviewed families.

b) Health conditions

1. Vaccines. The variable is the percentage of children aged 12 to 23 months who received the eight vaccines among children aged between 12 and 23 months[v].

2. Born in household. It is the percentage of children born in the household and not in a structure.

3. Unmet need, that is defined as the percentage of women of reproductive age, either married or in a union, who have an unmet need for family planning. Women with unmet need are fecund women who want to stop or delay childbearing but are not using any method of contraception.

c) Female status

1. Total Fertility Rate, that is the number of children per woman, calculated as the sum of age specific fertility rates

2. Women using contraception. The variable we used is the percentage of women who use contraception among those aged 15-49 living in a partnership (marriage or cohabitation)

3. Median age at marriage, that is the age that divides by two the distribution of women according to the age at marriage.

4. Women with diploma. It is measured by the ratio of women with a diploma of secondary school and the total number of women.

Through these variables, we perform a technique of aggregative cluster on the 121 DH surveys[vi], which present information on all the 11 background variables.

4. INFANT MORTALITY: THE COUNTRIES OVER THE TIME

A description of infant mortality in the different African regions according DHS data is reported in the figure 2a-g below. The trends are almost always decreasing such as Malawi, but in some cases (Cameroon 1998-2004; Egypt 1992-1995; Lesotho 2004-2009; Namibia 2000-2013; Kenya 1993-2003;) we observe periods of stability and also of increase. Many countries show a mixture of trends: initially infant mortality goes up and down, more recently we observe a decreasing tendency, as in the case of Tanzania and Uganda.
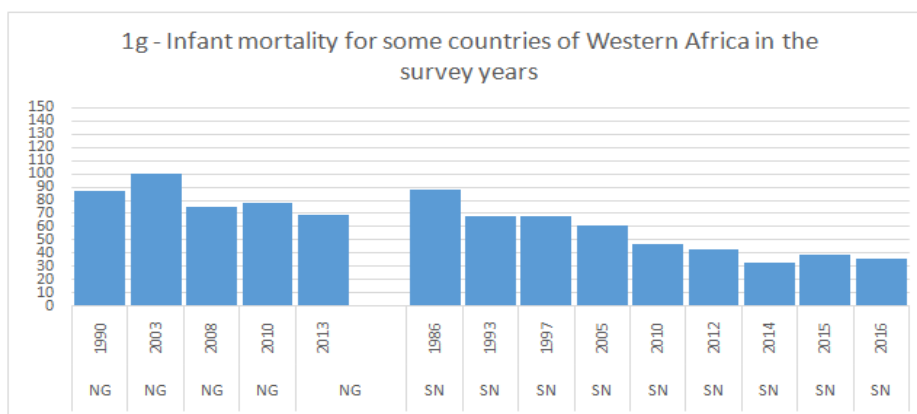
1c - Infant mortality for countries of South Africa in the survey years

1d - Infant mortality for some countries of Eastern Africa in the survey years

1e - Infant mortality for some countries of Eastern Africa in the survey years

1f - Infant mortality for some countries of Western Africa in the survey years

Figure1 (a-g). *Infant mortality in different regions of Africa*

From a descriptive point of view, for example Egypt and Morocco in North Africa have reduced infant mortality respectively of more than two/thirds and a half, so reaching and narrowing the target previewed by the Goals, while the large majority of countries of the other regions of Africa present, at the end of 2010-2015, a value of infant mortality around or higher than the half of late '80s. These are the cases of Malawi, Nigeria and Lesotho, for sub-Saharan Africa. Other countries present a worst pattern, citing firstly Ghana and Burkina Faso.

5. HOW MANY STAGES OF TRANSITION TO LOW INFANT MORTALITY?

From the clusters[vii] on 121 surveys and the 11 variables described in section 3 we identified four different scenarios, where the level of infant mortality is associated with different socio-economic and health contexts: CL1 (lowest-low development - LLD) that is the largest group (42 surveys); CL2 (low development - LD), that includes 33 surveys; CL3 (medium-low development - MLD) with 24 countries; finally CL4 (medium development - MD), the smallest group (22 surveys). Table 2 shows the percentage distributions or averages for the 11 variables according to the four groups.

Each of these groups might also be interpreted as possible stages experienced by African countries in the last 25 years during their transition to a reduction of infant mortality. In this perspective, it seems that the African countries have followed a not linear path towards a low infant mortality: the greatest change of mortality is between CL1 and CL2 where the infant mortality rates decrease by 33%; then, there is the change between CL3 and CL4 (with a decrease by 27%). CL2 and CL3 seem two intermediate stages (moving from CL2 to CL3 the infant mortality rate decreases of 9%).

Table2. *Mean value of variables in the different clusters.*

Infant mortality rate	CL1= LLD	CL2=LD	CL3=MLD	CL4=MD
	96.81	64.24	58.17	42.23
Economic conditions				
% Stunted children	44.95	36.55	37.19	24.31
% Underweigth children	26.55	20.26	13.60	11.30
% Households having electricity at home	11.80	29.58	22.95	73.75
Health context				
% Children born at the household	62.14	50.34	28.54	31.53
% Children aged 12-23 months 8 vaccines	45.90	47.24	71.58	71.09
% Unmet need of contraception	27.56	27.26	21.62	24.26
Woman's status				
TFR	6.04	5.37	4.78	4.17

|				
% Women in union using contraception	15.12	21.38	44.38	35.29
Median age at the first marriage	17.44	18.45	19.55	19.93
% Women with a diploma	12.87	27.25	37.82	42.51
N. of surveys	42	33	24	22

Interesting arealso the scenarios associated to the four clusters.

CL1 represents countries with a *very low social and economic development*: infant mortality is on average almost 100‰; economic conditions are very hard (only 11% of households have on average electricity in their house and almost half of children are stunted); basic health services for mothers and children seem to be little available or accessible (62% of children are born at home andjust under half of children are not vaccinated); in addition, gender equality seems to be totally unknown to this context (only 13% of women have a diploma; age at first marriage is on average less than 18; TFT is over 6 chldren).

With respect to CL1, CL2 shows a significant improvement of infant survival (IM rate declines to 64‰),which is associatedto a general improvement of all the contextual dimensions, but especially of the *economic conditions and ofthe woman's status*. The economic conditions are clearly betterthan CL1: the percentage of households with electricity isstill low (almost 30%) but it is three times that of CL1 (even the percentages of stunted and unweighted children drop by about 20% with respect to those of observed in CL1). In addition, the woman's status registers a market improvement: those with a diploma grow up to one third, with a increse by 112% respect to CL1; the median age at first union is now more that 18 and the TFT decreases to 5.

The slightly lower infant mortality rate which characterized CL3 (58‰) with respect to CL2 is associated to a "further improvement of the woman's condition and of a greater availability of health services".In CL3 women using contrception raise on average to more than 40% and those with a diploma to almost 40%; in addition,the age at first union is now over the age of 19. In addition, this group shows a significant improvement of the health variables with respect to the previous ones:vaccined children are almost two third (72%) as children born outside the householdare the majority (71%).

Finally, with CL4 infant mortality lowers under 50 per thousand (42%).With respect to the scenario examined in CL3, this group of countries is characterized bya general improvement of all dimensionsbut, among these, it is to mention a further strong reduction of household poverty(stunted children lower to 24% and households with electricity increase to 74%).

But what about the position of the countries with respect to this classification? Figure 2 shows the distribution of the countries according to their attribution to the four clusters in the years 1991-2016
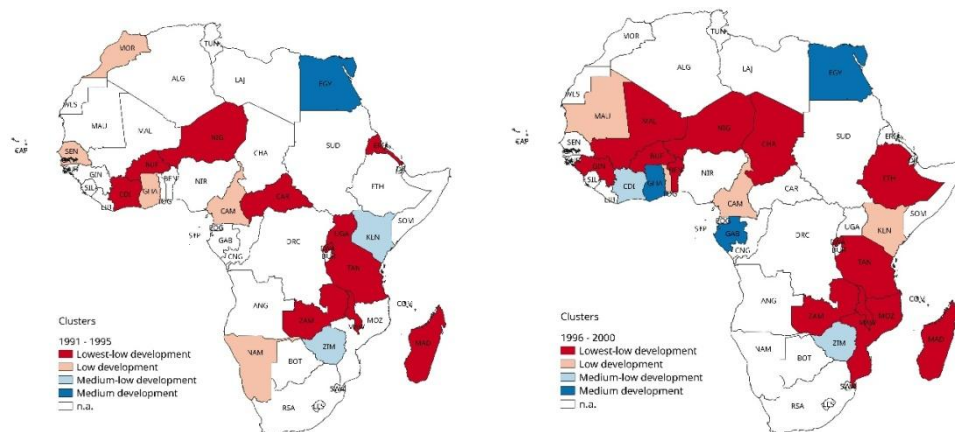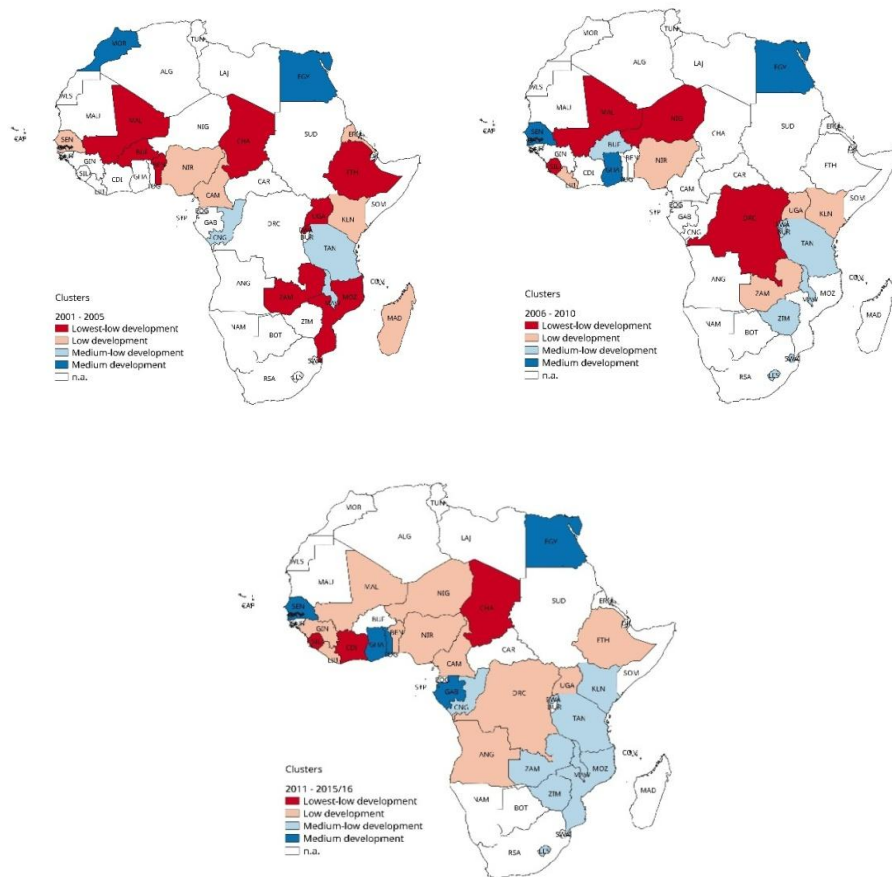
Fig2. *Maps of Africa with countries according to the type of cluster they belong in different5-years'time periods*

Legenda: AO=Angola; CM=Cameroon; CF=Centro-African Rep.; TD= Ciad; CG=Congo; CD= Dem. Rep. of Congo; GA=Gabon; ST= Sao Tome; EG=Egypt; MO=Morocco; TN=Tunisia; LS=Lesotho; NM=Namibia; ZA=SouthAfrica.; SZ=Swaziland; BT=Botswana; BU=Burundi; KE=Kenya; MW=Malawi.; RW=Rwanda; BF=Burkina Faso; GH=Ghana; LB=Liberia; NG=Nigeria; SN=Senegal; TZ=Tanzania; UG=Uganda.

The analysis of the maps over the time shows a general shift of the countries from the worst to the best conditions, that means a slow but clear pattern to the Millennium Goals: infant mortality lowers progressively; population living conditions (particularly: stunted and underweight children, households having electricity) register a significant improvement; changes of the health context (children having made eight vaccines, children born at home) shows that children and mothers are receiving increasing care. Even some variables related to the woman's status, i.e. women in union using contraception and women with a diploma suggest an increasing empowerment of the women, while median age at first marriage and TFR are moving over the time in the expected directions.

In the period 2011-2016,we note a general improvement in social situation of many countries, i.e. Zaire, Nigeria, Mali and Ghana, evidence that – even if sub-Saharan Africa presents many critical issues – also large region are living an improvement of the way of life. On the other side Chad, Ivory Coast and Uganda maintain a critical situation, in child survival and generally in the social context.

Table 3, that shows the frequencies of countries modifying cluster among those with more than one survey, tells us that out of total of 32 countries, 20 improve their position, 10 remain stable.

Countries passing from a cluster to another illustrates generally the passage from a cluster characterized by worse condition to another with a better condition (mainly from 1 to 2, but several even from 1 to 3 or from 2 to 4). Among those that remain in the same position between the first and the last survey we note that Kenya is the only country that moved from cluster 2 to cluster 3 during the period 2008-2014 after a worsening of condition (from 3 to 2) during period 1993-98. Ivory Coast is the only country that moved up to down (from 2 to 1) between 1998 and 2011, certainly because of a conflict verifying in this period; Sierra Leone and Chad remain stable on CL1 even in recent years (2013-15), may be due to the poor conditions of the two countries that up to now have not improved.

Table3. *Countries with 2-plus surveys modifying their cluster from the first to the last survey*

Shifts	N. of countries	Countries /surveys
Passage from 1 to 2	9	Benin, Guinea, Mali, Niger, Eritrea, Ethiopia, Madagascar, Uganda, Dem. Rep. Congo
Passage from 1 to 3	6	Burkina Faso, Malawi, Mozambico, Rwanda, Tanzania, Zambia
Passage from 2 to 4	5	Morocco, Ghana, Senegal, Togo, Comoros
Stable 1	3	Sierra Leone, Chad, Ivory Cost*
Stable 2	3	Liberia, Nigeria, Cameroon
Stable 3	4	Kenia*, Zimbabwe, Lesotho, Congo
Stable 4	2	Egitto, Gabon

* Kenia between 1996-2010 moved to CL2; Ivory Cost between 2006-10 moved to CL2

6. CONCLUDING REMARKS

The risk of a child dying before completing the first year of age was highest in the African Region (51 per 1000 live births), over six times higher than that in the European Region (8 per 1000 live births).More than half of the 10 million children who die globally below the age of five die in Africa. Several reasons facilitate this large numbers, and some of them include lack of access to healthcare facilities and high levels of poverty. Food insecurity and hunger that areotherprimary cause of infant mortality in Africa. Malaria and malnutrition also often lead to early deaths and undeveloped infrastructure also induce deaths of children when born or need medical help.

In this paper we have underlined the different pattern of infant mortality in several African countries, grouped in clusters according to levels of children mortality and some covariates regarding health, woman and economic statuses. We found four clusters, with infant mortality varying from 96.8 (lowest-low development) to 42.2 (medium development). Related to these differences, we found a decline of the fertility from 6.0 to 4.2 birth per woman, an increase of the woman's median age at first marriage from 17 to 20 years, and an increase of the percentage of women with a diploma from 13 to 43%. The improvement of female's status as well as that of economic conditions of population seem to be the contextual changes more associated with a significant reduction of the infant mortality. If cluster 4 (medium development) shows an improvement in every domain of development, the other clusters do not. For example, cluster 2 (low development) includes countries where sanitary services are still weak and cluster 1 (lowest-low development) represents countries where vaccination prevalence is low.

In addition, the study offers the opportunity to examine the infant mortality level in a contextual perspective and classify the position of the different African countries in the last twenty years according to a more general view. Our results show that most of countries have improved their position over the time, moving from the less to more developed clusters, witnessing an improved situation of the societies of sub-Saharan countries. Looking to some specific country, Senegal, for instance, moved to a condition of low development (CL2) experienced until the first five years of the century to a condition of medium development (CL4) since 2010; similarly, Rwanda in the same period moved from a lowest-low development condition (CL1) to a medium low position (CL3).In the more recent period (2010-15) we found 7 countries in the highest development condition and only 3 in the lowest-low development situation, while 20 years before they were respectively 1 and 11, being the others in intermediate positions. Nevertheless, despite the improvements, many are still the aspects on which policy must intervene.

Obviously, the work presents some limits. First, we do not have data for all African countries and for all five-year periods. This impose us to face for each country with incomplete time series and thus sketch a partial – even if not little representative – picture of the African situation. Moreover, we cannot speak about causality between child mortality and covariates but only of association between

the different aspects considered: in fact, we are not interested to capture the causal relationships but only to describe the (multi-faced) context in which infant mortality finds room, being aware that the variables used are inter-related. Finally, we are aware that our considerations regard only aggregate data at national level, even if we know that many countries are strongly heterogeneous at territorial level. Connected to this last point we did not consider important factors such as climate and conflicts that often interest local intra-country areas. In fact, near the variables taken into account in this analysis, two aspects are related to infant mortality regarding the context and that we have not considered in the cluster analysis: climate and conflicts. On the other side, we can consider that the effects of these factors are implicitly included in variables measuring poverty and sanitary conditions (Han and Foltz, 2015; Kudamatzu et al., 2012; Wikipedia, 2019). Infant mortality is directly and indirectly related to conflicts. We remember that since 1989, 75% of non-state armed conflicts have been in Africa (Wagner et al. 2018).In the entire continent, the number of infant deaths related to conflict from 1995 to 2015 was between 3·2 and 3·6 times the number of direct deaths from armed conflicts (Wagner et al., 2018).Moreover, changes in heat and precipitation because of climate change are expected to have adverse effects on health, particularly among the most vulnerable populations, such as children. As conflicts, these changes can affect health both directly, through extreme events and changes in the disease environment, as well as indirectly through its impact on the economic livelihood of the population (Geruso and Spears, 2018).

[1]This transition may be divided in five stages. During the first stage (hunter-gatherer), diets were high in carbohydrates and fibre and low in fat (especially saturated fat). Activity levels were high, and obesity levels low. The second stage (famine) refers to a period where food was scarce and dietary diversity low. While the type of physical activity done may have changed, the activity levels remained much the same. These changes are related to a shift toward settlements and cultivation, first of crops and later also livestock and poultry. During the third stage (receding famine), the amount of carbohydrates in the diet decreased, and fruit, vegetables and protein consumption increased. Physical activity levels started to decrease. This is the development of more technically advanced and productive agriculture. The fourth stage (nutrition-related non-communicable disease) is characterized by a diet high in fat, refined carbohydrates, sugar and cholesterol and low in fibre. Physical activity levels are low, and obesity prevalence high. The final stage (behavioural change) occurs due to a desire to prolong health and delay or prevent degenerative diseases. The consumption of complex carbohydrates, fruit and vegetables increases, while the consumption of fat, processed foods, meat and dairy products are reduced.

[1] For a more detailed list of the DHS surveys considered in the paper see Appendix 1.

[1]A stunted child is a child affected by rickets or childhood disease due to a defect of bone calcification due to vitamin D deficiency that causes an interruption in the development of the child, with serious consequences both in the short (compromising physical growth, motor skills and cognitive abilities) and in the long run. According to the WHO criteria, a child is moderately stunted when its height-per-age is between -2.0 SD and -2.99 SD below the mean in the WHO international reference standard. Severely stunted if its height-for-age is less than -3.0 SD below the average in the WHO international reference standard.

[1]A child, is underweight if its weight is lower than that considered in the norm that is when it weighs 90% compared to the form weight. According to the WHO criteria, a child is moderately underweight when its weight-per-age is between -2.0 SD and -2.99 SD below the mean in the WHO international reference standard.Severely underweight if its weight-per-age is less than -3.0 SD below the average in the WHO international reference standard.

[1]The types of vaccines administered are: a) BCG: anti-tuberculosis received shortly after birth. b) DPT: triple vaccine for diphtheria, pertussis and tetanus given in three doses to the sixth, tenth and fourteenth week after birth; it can also be given as a pentavalent vaccine together with hepatitis B and HIB (Haemophilus Influenza type B). c) Polio: received in three doses usually given together with DPT. d) Measles: given at nine months. Thus, if the child receives all 8 vaccinations, he/she is given one dose of BCG, three doses of DPT, three doses of Polio, and onedose of Measles.

[1]The decrease of the number of surveys by 26 units (from 147 to 121) is due to the lack of information in some DHS surveys on at least one of the variables chosen for the cluster analyses. In this way we have left out 15 surveys conducted in the late '80s and 3 surveys conducted in the second half of the '90s of the past century; in addition, we left out 8 surveys conducted between the 2001 and 2016 (for a detailed list of the countries see Appendix 1).

[1] The clusters are obtained using a hierarchical method (Henning et al., 2016). We used also other techniques of cluster analyses (for example, the k –means method) to test the robustness of the results, that did not significantly change.

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Appendix1. *Surveys and countries by period of survey and African region**

Periods	North Africa	Western Africa	Eastern Africa	Central Africa	South Africa	Tot. Surveys (countries)
1986-90	Egypt 88 Morocco 87 Tunisia 88	Ghana 88 Liberia 86 Mali 87 Nigeria 90 Senegal 86 Togo 88	Burundi 87 Kenia 89 Sudan 89/90 Uganda 88/89 Zimbabwe 88		Botswana 88	15 (15)
1991-95	Egypt 92 -95 Morocco 92	Burkina Faso 93 Ivory Coast 94 Ghana 93 Niger 92 Senegal 92/93	Eritrea 95 Kenia 93 Madagascar 93 Malawi 92 Rwanda 92 Tanzania 91/92 Uganda 95 Zambia 92 Zimbabwe 94	Camerun 91 C. African Rep. 94/95	Namibia 92	20 (19)
1996-00	Egypt 00	Benin 96 Burkina Faso 98/99	Comore 96 Etiopia 00 Kenia 98	Camerun 98 Chad	Namibia 00 South Africa 98	27 (26)

		Ivory Coast 98/99 Ghana 98 Guinea 99 Mali 95/96 Mauritania 95/96 Niger 98 Senegal 97 Togo 98	Madagascar 97 Malawi 00 Mozambico 97 Rwanda 00 Tanzania 96 -99 Zambia 96 Zimbabwe 99	96/97 Gabon 00		
2001-05	Egypt 03-05 Morocco 03/04	Benin 01 Burkina Faso 03 Ghana 03 Guinea 05 Mali 01 Nigeria 03 Senegal 05	Eritrea 02 Etiopia 05 Kenia 03 Madagascar 03/04 Malawi 04 Mozambico 03 Rwanda 05 Tanzania 04/05 Uganda 00/01 Zambia 01/02	Camerun 06 Chad 04 Congo 05	Lesotho 04	24 (23)
2006-10	Egypt 08	Benin 06 Burkina Faso 10 Ghana 08 Liberia 07 Mali 06 Niger 06 Nigeria 08 Senegal 10 Sierra Leone 08	Burundi 10 Kenia 08/09 Madagascar 08/09 Malawi 10 Rwanda 07/08 – 10 Tanzania 10 Uganda 06 Zambia 07 Zimbabwe 10 - 05/06	Dem. Rep. of Congo 07 Sao Tome 08/09	Lesotho 09 Namibia 06/07 Swaziland 06/07	26 (24)
2011-15/16	Egypt 14	Benin 11/12 Ivory Coast 11/12 Gambia 13 Ghana 14 Guinea 12 Liberia 13 Mali 12/13 Niger 12 Nigeria 13 Senegal 12/13 -14 -15-16 Sierra Leone 13 Togo 13/14	Comore 12 Etiopia 11-16 Kenia 14 Malawi 15/16 Mozambico 11 Rwanda 14/15 Tanzania 15/16 Uganda 11 Zambia 13/14 Zimbabwe 15	Angola 15/16 Camerun 11 Chad 14/15 Congo 11/12 Dem. Rep. of Congo 13/14 Gabon 12	Namibia 13 Lesotho 14	35 (31)
Total surveys (countries)	12 (3)	52 (14)	57 (14)	16 (8)	10 (5)	147 (44)

Underlined surveys are not considered in the cluster analysis.