LESSON 7

Mortality Measures and Levels

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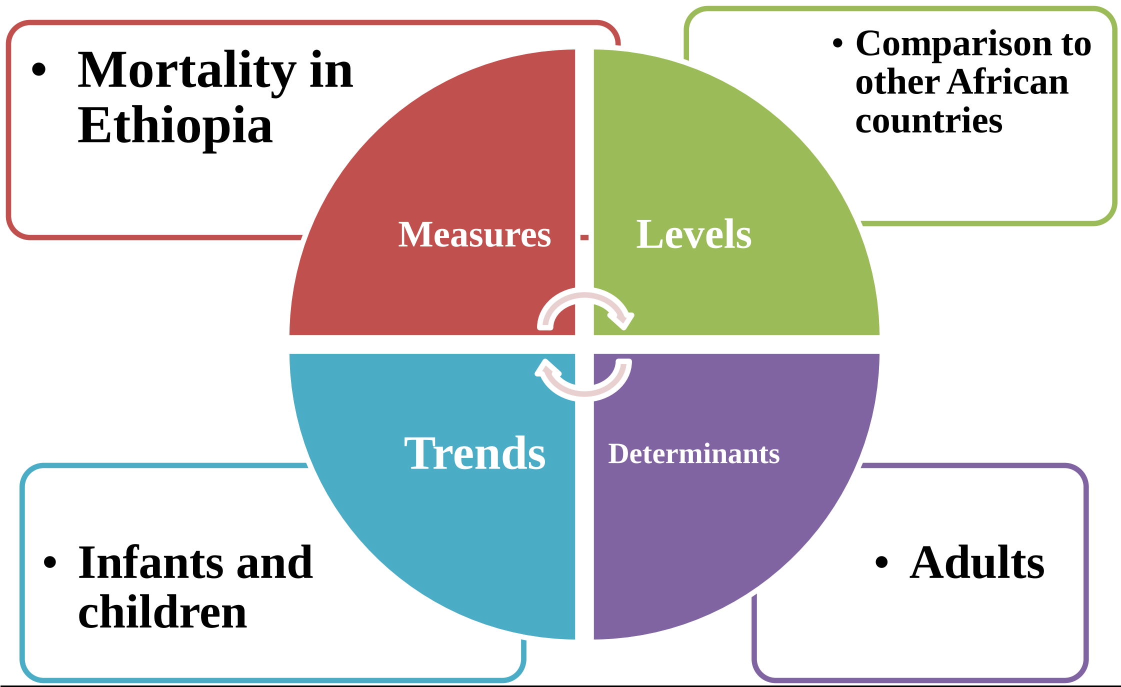
Learning objectives



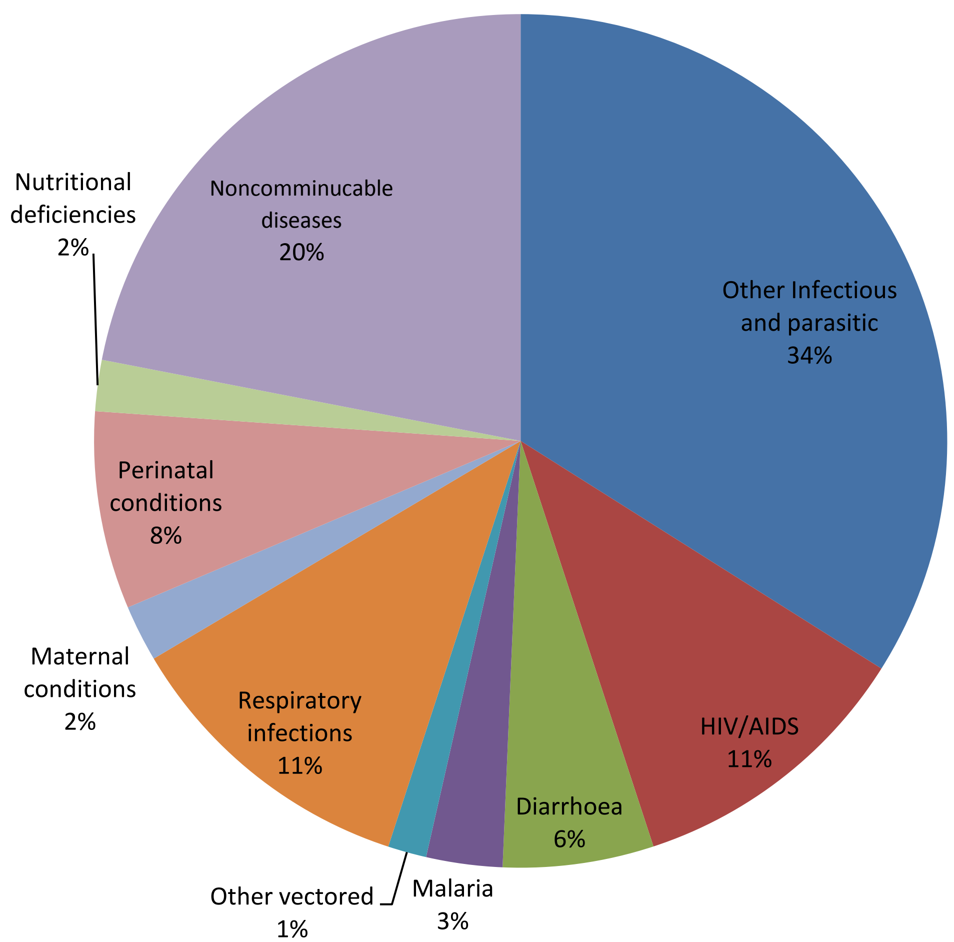
Introduction

There are no vital registration systems or monitoring regimes in Ethiopia to give accurate statistics on the numbers and causes of death. The country's Statistical Authority has been reporting mortality figures on a regular basis, regardless. The numbers come from a series of national demographic surveys and the three censuses the country has had (1984, 1994, and 2007). However, censuses and sample surveys are suffer from reporting errors and typically underestimate mortality. This often results in rosy survival pictures and higher survivorship probabilities and life expectancies than is real.

Causes of death

Three categories of preventable illnesses labeled "infectious and parasitic" "respiratory infections" and "HIV/AIDS" account for almost two-thirds of the yearly deaths in Ethiopia (Fig.7.1). In others words, close to two thirds of the deaths taking place annually are preventable. The total annual number of deaths in Ethiopia was estimated at 1,106,000 by the WHO. This compares favorably (in terms of accuracy), with the total 1,156,500 deaths implied by the reported crude death rate (CDR) of 15 per thousand.

Figure 7.1 Percentage Distribution of the Top Ten Causes of Death in Ethiopia (2002)



Source: Based on [1]

Table 7.1 The number of Deaths by Cause ('000s) - 2002

HIV/AIDS	**121.7**
Other Infectious and parasitic	375.5
Diarrhoea	63.2
Malaria	31.9
Other vectored	16.2
Respiratory infections	126.7
Maternal conditions	23.7
Perinatal conditions	82.8
Nutritional deficiencies	21.4
Noncomminucable diseases	242.8
Total	1105.9

Source: [1]

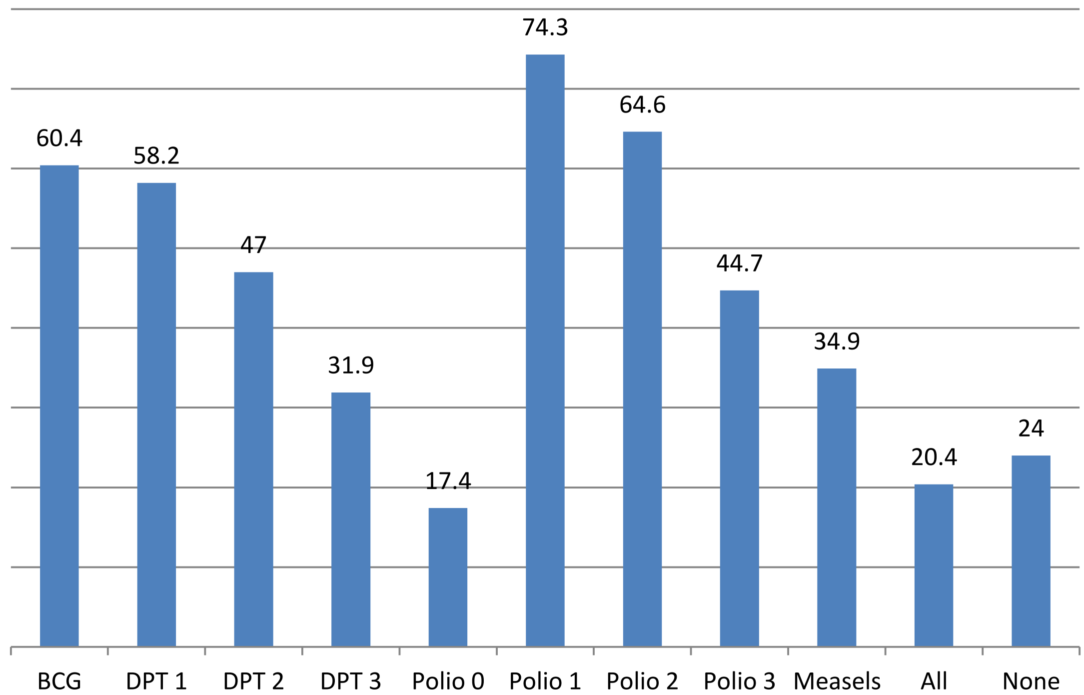
HIV/AIDS infection appears to have reached a plateau in Ethiopia but remains a major public health threat.

> The first AIDS case was detected in Ethiopia in 1986. The prevalence of HIV remained very low in the 1980s but spread quite rapidly during the 1990s. It has been estimated at6.6 percent of the adult population in 2002, and the epidemic is considered generalized in Ethiopia. By the end of 2001, there were 2.1 million children and adults in Ethiopia living with HIV/AIDS. Although Ethiopia constitutes only 1 percent of the world's population, it contributes 7 percent of the world's HIV/AIDS cases, and in terms of the number of infected persons, Ethiopia ranks fifth after South Africa, Nigeria, Kenya and Zimbabwe in SSA. Tuberculosis is also widespread. [2]

With nearly a quarter a million deaths nationally (Table 7.1), non-communicable diseases – malignant neoplasms, cardiovascular diseases, diabetes mellitus, respiratory and digestive diseases, congenital abnormalities and injuries - have been on the rise. Most are diseases, primarily, of the relatively well-off urban residents [2].

The picture regarding the causes of death among children is different. The 2005 Demographic and Health Survey (DHS) report provided data on the health risks Ethiopian children face. Birth weight is the first indicator of the survival chances of a child. The lower the weight is below the ideal - 2.5 kg - the higher the risk. Very small fractions (3%) of births are weighed [3]. The DHS report states that "twenty-three percent of births in rural areas compared with 10 percent in urban areas have a reported birth weight less than 2.5 kg." [3]. After birth weight, the most important predictor of child survival is immunization status. Figure 7.2 shows the percentage of Ethiopian children under five years of age who have received immunization, by type of immunization.

Fig. 7.2 Percentage of children < 5 who have received immunization, by type of immunization.



Source: Based on [2]

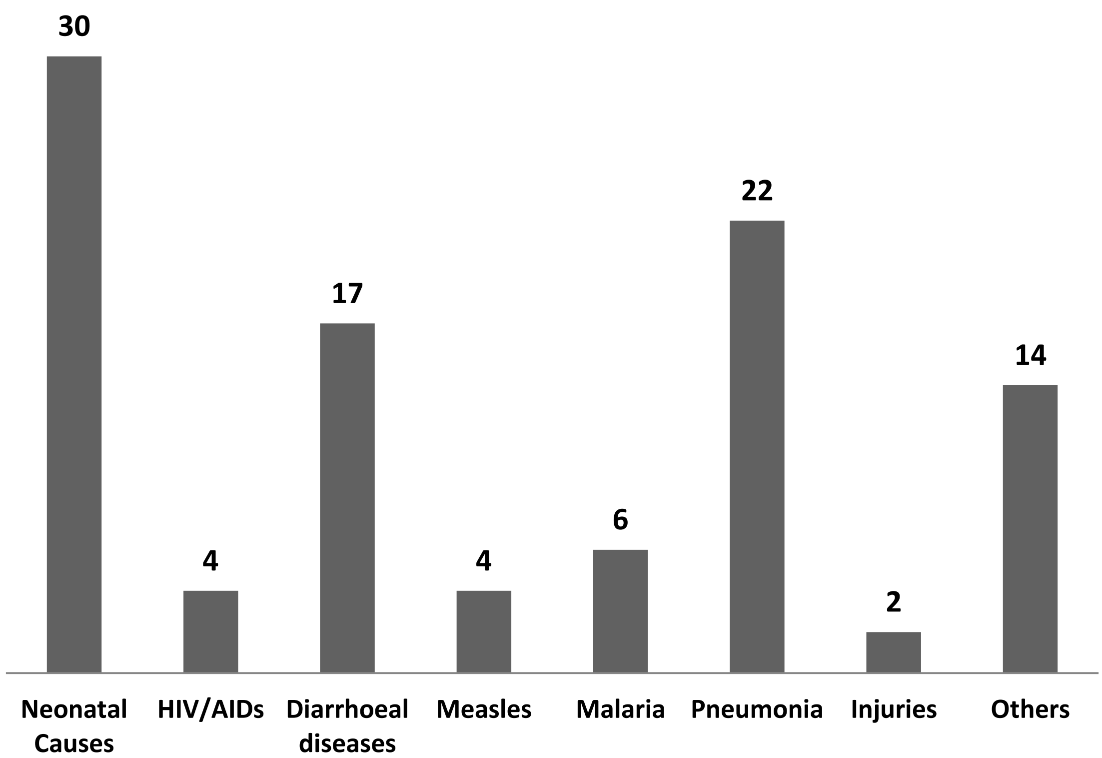
Sixty percent of Ethiopia children under five years of age have received the BCG vaccine which includes "measles, and three doses each of DPT and polio vaccine excluding polio vaccine given at birth" [2]. "Polio 0" on the graph refers to the polio vaccine given at birth. Note the rapid decline in the percentage of children who have taken DPT2 and DPT3 as well as Polio2 and Polio3. This appears to show lack of continuity and due diligence on the part of institutions/parents to ensure full coverage. Only half of the children who received the first DPT vaccine go on to take complete it by taking the second and third. More children start the polio vaccine regime than DPT and a higher proportion – about 60% of those who started the Polio vaccine - go on to complete the program. This might have to do with government support in ensuring a wider coverage, and better adherence to the completion requirements. As a result, more children under five took Polio1 than any other single vaccine (Fig. 1.2). The graph also shows reality where-by only 20 percent of children under five have completed the entire vaccination program as prescribed by the World Health Organization (WHO). Moreover, nearly a quarter of Ethiopian children have not received any vaccination at all.

Causes of childhood mortality (children under 5)

"Nneonatal causes" are the main reason children who did not make it to age 5 failed to do so. According to a WHO report, the neonatal period, although brief (the first thirty days of a human life) accounts for "… more than one in three deaths in children under five" [2]. It goes on to say that on a global level:

> '….. every year over 4 million babies die in the first four weeks of life; 3 million of these deaths occur in the early neonatal period. Moreover, it is estimated that more than 3.3 million babies are stillborn every year; one in three of these deaths occurs during delivery and could largely be prevented. Ninety-eight per cent of the deaths take place in the developing world…In developing countries, the risk of death in the neonatal period is six times greater than in developed countries; in the least developed countries it is over eight times higher. With 41 neonatal deaths per 1000 live births, the risk of neonatal death is highest in Africa; the sub-Saharan regions of Eastern, Western and Central Africa have between 42 and 49 neonatal deaths per 1000 live births. ' [2].

Fig. 7.3 Percentage of Deceased Children Under Five Years of Age by Cause of Death (Ethiopia, 2005).



Source: [2]

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It should be noted that the neonatal mortality includes perinatal deaths (deaths during the first week of life including still births), and those taking place in the remaining three weeks.

The causes of neonatal deaths in less developed countries (LDC) include:

- Low birth weight
- Preterm births
- Absence of obstetric care
- Maternal nutrition and health
- Maternal infections such as malaria, syphilis
- Complications during birth such as obstructed labor, birth asphyxia and trauma
- Infections at birth – especially neonatal tetanus, syphilis, and HIV/AIDS
- Poor and unhygienic feeding practices
- Multiple births
- Infanticide (usually sex selective to the detriment of girls)

The number two cause of under-five mortality in Ethiopia - pneumonia – is a major killer all around the world. According to UNICEF and the World Health Organization (WHO), "pneumonia kills more children than any other illness – more than AIDS, malaria and measles combined." [4].

Pneumonia is a lung illness affecting the respiratory system whereby"… air-filled sacs of the lung responsible for absorbing oxygen become inflamed and flooded with fluid". The pathogen involved could be bacteria, viruses, fungi, or parasites. "The bacterial pathogen *Streptococcus pneumoniae* (also known as pneumococcus) is the world's leading cause of severe pneumonia among children across the developing world. This type of pneumonia is known as pneumococcal pneumonia." [4].

At 17%, diarrheal diseases are the third major cause of childhood deaths in Ethiopia [Fig. 7.3]. Acute diarrhea becomes the leading cause of death during famine [5]. A recent study estimated the number of childhood deaths attributable to diarrhea in Ethiopia at 95,000 [6]. In addition, "the percentage of children with diarrhea who receive ORT in Ethiopia is one of the lowest in the world" and "for all of Sub-Saharan Africa "lack of safe water, basic sanitation and hygiene may account for as much as 88% of the disease burden due to diarrhea" [6].

Malnutrition, a serious health risk in itself, adds to the severity of illnesses mentioned above thereby playing the role of both a primary and secondary cause of illness and death among children.

> About half of all children under five are stunted (about six million children total), and about one-quarter are severely stunted. Eleven percent are wasted and 1% (a small proportion, but representing about 125,000 children) are severely wasted. As expected, rural children fare much

worse than urban children (for severe stunting, 27% versus 19%) as do children of uneducated versus well-educated mothers (28% versus 11%). [7]

A comparison of childhood mortality rates and risk-factors between Ethiopia, Eritrea and Kenya is given in Annexes 1 through 9.

General

Death is a principal vital event. The three censuses and various sample surveys in Ethiopia have attempted to gather information about this event. There are also a few experimental vital registration systems in place to register the event at the time of occurrence, as opposed to the practice in censuses and surveys where death is reported up to a year after it has happened. Death statistics are needed for a number of reasons, including the satisfaction of the public's need to know who dies, from what causes, in what numbers, etc. It also allows knowledge of the correlates and determinants of the levels and trends of mortality in a country. Therefore, the collection, analysis, and publication of information on death is one of the fundamental responsibilities of any government, and a crucial starting point for any institution seeking to improve public health. Last but not least, without statistics on current mortality levels and trends it is not possible to make population projections.

The definition, methodology, and concepts presented below are modeled after two of the most comprehensive books on demographic techniques ever written, "*The Methods and Materials of Demography*", by Shryock and Seigel [9] and "*Demography"* by Preston et. al. [10]. The definition of death does not include deaths taking place before live birth has occurred. These are called ***fetal deaths***, and include ***stillbirths*** or deaths prior to the complete expulsion of the product of conception. The term ***miscarriage*** refers to accidental terminations of fetal life taking place early in the life of the fetus whereas the term ***stillbirth*** is often used as synonym for fetal deaths occurring late in the pregnancy term. The term ***abortion,*** on the other hand, is used to refer to induced early fetal death [9].

Death statistics derived from censuses and surveys in Ethiopia suffer from a number of shortcomings including incomplete coverage of people or geographic areas. Places experiencing civil unrests and conflicts are often excluded, and excess mortality numbers in these areas due to violence and dislocation remain undocumented. Moreover, available financial resources and trained man-power has not been sufficient to achieve full canvassing of the entire country. Besides, Ethiopia is home to a number of nomadic groups who are perpetually on the move thus making it difficult for census takers or survey personnel to reach them. Moreover, a substantial portion of the population reached by censuses and surveys often fail to report a death event out of negligence, or because they do not fully appreciate the value of such information. Even those who make genuine efforts to report death might make errors on dates or place of death, and may not know the true cause of death.

It can be said that the close association between ***age*** and the probability of dying is the single most important determinant of the likely mortality experiences of any population. The gender (***sex***) of the deceased comes second in importance, followed by a number of other variables, including place of residence, marital status, socio-economic status, disability status, and the general characteristics of the community in which the person lived, together with the physical environment surrounding the community.

BASIC MORTALITY MEASURES

Newell [11] argues that “perhaps because death is a precise and easily definable event which occurs just once to each individual, the techniques for analyzing mortality have a longer history and are more developed than those for analyzing fertility”. There are a number of measures we can use, some basic and others very complicated. Our goal here is to focus on simple temporal and geographic measures of levels and variations in death among the various population groups in Ethiopia as well as its linkage to mortality changes over time.

Crude Death Rate

First, we would like to point out the difference between ***reported rates*** calculated directly from actual data, and ***adjusted rates*** in which modifications are made. The modifications involve the use of assumptions and techniques that combine estimates from more than one population. The simplest and most common mortality measure in statistical reports of countries and international agencies is the crude death rate (CDR). The CDR measures the number of deaths in a population in a given year by relating the total number of reported or adjusted deaths (numerator) to the total number of person-years lived by the population in which the deaths took place. CDR is defined as follows [10]:

$$CDR\,[0,T] = \frac{\text{Number of death in a population between time } 0 \text{ and } T}{\text{Person-years lived in the population between times } 0 \text{ ad } T} \times 1000$$

Table 7.2 Calculation of Crude Death Rates for Selected Countries in Africa, 2000.

Country	Population	No. Deaths	CDR	CDR per thousand
1	**2**	**3**	**4** Col. 3 ÷ Col. 2	**5** Col. 4 x 1000
Western Sahara	300,000	5,400	0.018	18
Niger	10,100,000	242,400	0.024	24
Ethiopia*	64,100,000	1,346,100	0.021	21*
Zimbabwe	11,300,000	226,000	0.020	20
Libya	5,100,000	15,300	0.003	3
Egypt	68,300,000	409,800	0.006	6
Nigeria	123,300,000	1,602,900	0.013	13
Reunion	700,000	3,500	0.005	5

Source: Based on [12]
***** *A lower estimate of 15 per thousand is given for the year 2005*** [2]

In Table 7.2 a diverse group of African countries have been chosen to demonstrate the calculation of CDR. Simple calculations shown in the table reveal that a given country (***A)***, with a larger population than another country (***B)***, does not necessary experience deaths in the same proportion as the proportional difference in populations. For example, Libya's population size is seven times as large as that of Western Sahara's, but the number of people dying in Libya annually is only three times as high. Ethiopia's population size is only slightly larger than Egypt's, but the number of annual deaths is three times as large. Nigeria has almost twice the population size of Ethiopia, but the annual number of people dying there is only 19 percentage points higher. This means that even basic mortality measures such as the CDR can bring out spatial differences in mortality rates in various parts of Africa and within Ethiopia. Countries with high CDR such as Niger, Ethiopia, and Zimbabwe, have been selected together with low mortality countries – Libya, Egypt, and the island state of Reunion – to show the CDR's ability to effectively show spatial variations in mortality.

Table 7.3 Reported Crude Death Rates for African Countries in (year 2008)

Contry	CDR	Contry	CDR	Contry	CDR
Swaziland	31	Chad	16	Gambia	11
Lesotho	25	Ethiopia	15	Madagascar	10
Sierra Leone	23	Namibia	15	Eritrea	10
Zimbabwe	22	Burkina Faso	15	Senegal	10
Zambia	21	Mali	15	Togo	10
Angola	21	Tanzania	15	Ghana	10
Mozambique	20	S. Africa	15	Mauritania	9
Guinea Bissau	19	Guinea	14	Comoros	8
C.A. Republic	19	Botswana	14	Sao Tome	8
Somalia	19	Cote d'Ivoire	14	Seychelles	7
Niger	18	Congo	13	Mauritius	7
Western Sahara	18	D.R of Congo	13	Tunisia	6
Liberia	18	Cameroon	13	Egypt	6
Chad	17	Benin	12	Morocco	6
Malawi	16	Djibouti	12	Cape V.	5
Rwanda	16	Gabon	12	Reunion	5
Uganda	16	Kenya	12	Algeria	4
Burundi	16	Sudan	12	Libya	4

Source: Based on [12]

An imortant fact about the crude death rates above is their extreme sensitivity to reporting errors. For instance, a census or survey in which only half the deaths in a population have been reported results in a crude death, which is only 50 percent of what it should be. Underreporting in which half the deaths have been missed is not uncommon in Africa. If we were to assume that the rates in Table 7.3 are true, and that possible departures from the true figure are uniform across the continent, we will note the lighter mortality experience of countries in north of the Sahara. Algeria, Egypt, Libya, Morocco, and Tunisia, have a single digit CDR, Libya's CDR being the lowest mortality in Africa, and one of the lowest in the world. Only Kuwait has a reported CDR less than Libya's (2 deaths per thousand per year) [12]. A sharp contrast is noted when one crosses the southern border of Libya into Niger. Here the CDR is 18 per thousand, one of the highest in Africa, and in the world. In other words, a community of 1000 people in Niger will bury, this year, more than four times as many members as a community in neighboring Libya with identical population sizes. One has to travel further south, to the HIV/AIDS epicenters - Zambia, Zimbabwe, Zimbabwe, Angola, and Mozambique to encounter a similarly high mortality level. In each of these countries, 20 per thousand or more die each. Swaziland has the highest CDR in Africa and in the world – 31 per thousand. A few bright spots, other than Northern Africa, include the island nations of Mauritius, Reunion, Cape Verde, Seychelles, as well as Sao Tome and Principe where CDR is very low.

Age-specific death rate ASDR

In any population, the frequency of a demographic event such as death is highly dependent on the age distribution. The crude death rate provides only a general indication of the level of mortality in a population. For this reason, it is necessary to compute age specific rates which still depend on the "count of events in the numerator and person-years in the numerator. However, the age range within which the events and person-years are to be tallied is restricted often to single-age groups or five-year age groups [10]. The age specific death rate can be defined as:

$$ {}_{n}M_{x}[0,T] = \frac{\text{Number of deaths in the age range } x \text{ to } x+n \text{ between time 0 and } T}{\text{Number of person-years lived in the age range } x \text{ to } x+n \text{ between time 0 and } T} $$

The subscript x in ${}_{n}M_{x}$ refers to the age at the beginning of an age interval, and the subscript n to the length of the interval. For example ${}_{5}M_{45}$ is the age specific death rate between age 45 and 50 (or between ages 45.0000 and 49.9999…., to be precise). This is calculated with the number of annual deaths in that age group as numerator and the person-years lived by members of the population in that group as the denominator. It is important to note, however, that death rates need not be based on yearly totals of deaths and person-years lived. It is possible to calculate quarterly or monthly rates as well. It is also important to recognize the relationship of crude death rates to the underlying age-specific death rates. A crude rate may be viewed as "…the weighted average of a set of age-specific death rates, the weights being the proportion of the total population in each age" [9]. Infant deaths are customarily tabulated separately to produce another measure commonly included in mortality reports - the infant mortality rate (IMR). The United Nations recommends that infant deaths be further broken up to include those taking place in the first 28 days of birth and those happening during the rest of the first year, and that classifications be made on the basis of gender, month of death, and cause of death [9]. Classification by gender is also mandated for deaths at age 1 and greater than 1 due to the dissimilar mortality experiences of male and female babies and children.

The distribution of age-specific death rates typically shows a bimodal pattern (Fig. 7.4) with peaks before the first birthday and a sustained rise starting at ages 65 where the number of survivors falls off rapidly to the upper end of the human life-span. We have chosen to use data from Sweden, and not Ethiopia to draw the ASDR graph. We did so for three reasons:

1) It has been almost a decade and a half since a national data on mortality by age was collected in Ethiopia. Moreover, given the HIV/AIDS epidemic taking place

in Ethiopia over the same period, it would not make much sense to use the 1994 or year 2007 census data.

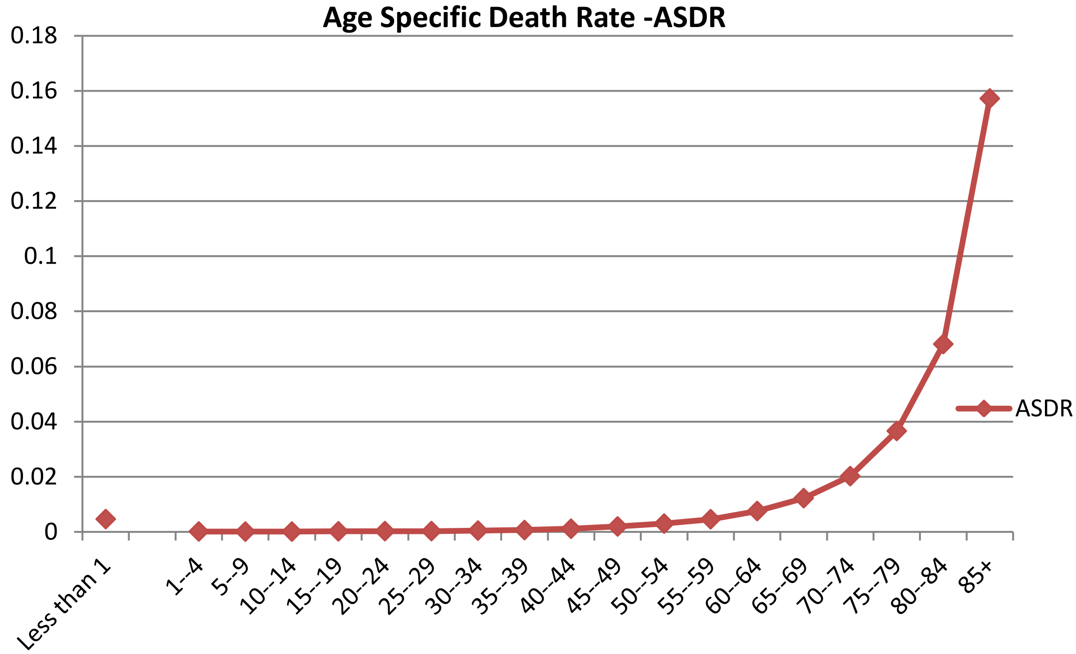
2) There is clear evidence of errors with both the 1994 and census 2007 mortality data due to reporting problems, incompleteness of coverage, and other causes.
3) Sweden has achieved an almost "stable" population status (refer to Lesson 10 for definition of a ***stable population***) with little yearly changes and shifts in age specific birth and death rates. In other words the age specific numbers in column 4 of Table 7.4 are most likely to apply today in their entirety.

Table 7.4 Calculation of Age Specific Mortality Rate and Crude Death Rate (Sweden, Females 1992)

Age Group	Mid-year population	No. Deaths	Age Specific Death Rate
Less than 1	59,727	279	0.00467
1--4	229,775	42	0.00018
5--9	245172	31	0.00013
10--14	240110	33	0.00014
15--19	264957	61	0.00023
20--24	287176	87	0.00030
25--29	311111	98	0.00032
30--34	280991	140	0.00050
35--39	286899	197	0.00069
40--44	308238	362	0.00117
45--49	320172	643	0.00201
50--54	242230	738	0.00305
55--59	210785	972	0.00461
60--64	216058	1640	0.00759
65--69	224479	2752	0.01226
70--74	222578	4509	0.02026
75--79	184102	6745	0.03664
80--84	140667	9587	0.06815
85+	110242	17340	0.15729
All	4,385,469	46256	0.01055
CDR			10.54756

Source: Based on [10]

Fig 7.4 Graph of Age Specific Death Rate (Sweden, Females 1992)



Source: Based on [10]

The crude death rate is determined by two important factors – the set of age specific death rates ${}_nM_x$ discussed above, and the proportions of a country's populations in the various age groups. If the crude death rate depended on age specific death rates alone, the United States would have a much lower crude death rate than Egypt. In reality, however, the US crude death rate – 9 per thousand – is 33 percent higher than Egypt's. The lower CDR for Egypt reflects the effects of the second factor – differences in the proportionate distribution of the populations in the two countries. Egypt has a "young" population, and the US has an "old" or "aging" population. In other words, a very large proportion of Egypt's population is concentrated in the younger age groups where mortality is very low, whereas the US population is heavily represented at the higher ends of the age spectrum where mortality is high. It is also worth noting that the age distribution of a given population is itself shaped, among other things, by past levels of age specific death rates. It is possible, therefore, to separate out the difference between Egypt and US's CDR that is due to differences in levels of mortality, and the part that is due to differences in age structure. The method often employed to achieve this is known as ***standardization***. Standardization involves re-calculating the CDR for one of the two countries by "borrowing" the age structure of the other. The difference between actual CDR and the CDR obtained in this way represents the portion of the mortality difference that is solely an artifact of differences in age structure. There are two types of standardizations - ***direct standardization***, and *indirect standardization*. Direct standardization is simpler and more straightforward. A demonstration is presented in Table 7.5 for females in Oromiya and Sweden.

Table 7.5 Calculation of Age Standardized Crude Death Rate (Direct method)

Age	**Ethiopia**		**Sweden, Population**		**Sweden, Deaths**	
	(Oromia F. 1994)					
Group	Population	Proportion	Actual	Expected	Actual	Expected
1	**2**	**3**	**4**	**5**	**6**	**7**
0	259,446	0.0281	52,727	232,322	79	567
1--4	1,162,628	0.1259	229,775	552,130	42	99
5--9	1,505,140	0.163	245,172	714,832	31	93
10--14	1,304,803	0.1413	240,110	619,667	33	87
15-19	1,014,714	0.1099	264,957	481,945	61	145
20-24	732,536	0.0793	287,176	347,923	87	104
25-29	668,193	0.0724	311,111	317,363	98	102
30-34	534,411	0.0578	280,991	253,822	140	127
35-39	500,521	0.0542	286,899	237,726	197	164
40-44	399,230	0.0432	308238	189,613	362	222
45-49	256,814	0.0278	320,172	121,975	643	245
50-54	280,113	0.0303	242,230	133,041	738	406
55-59	136,644	0.0148	210,785	64,900	972	299
60-64	196,458	0.0212	216,058	93,309	1640	708
65-69	81,931	0.0089	224,479	38,913	2752	477
70-74	96,120	0.01	222,578	45,653	4509	925
75-79	34,575	0.0037	184,102	16,422	6745	602
80-84	44,297	0.0048	140,667	21,039	9,587	1434
85+	24,838	0.0027	110,242	11,797	17340	1856
Total	9,233,412	1	4,385,469	4385469	46256	8662

Sources: [10, 13]

Columns 1 and 2 of Table 7.5 show the population sizes, by age, of Oromiya females and their proportionate distribution (col. 2). Columns 3 and 4 show the actual population distribution by age for Sweden, and the population numbers by age that would be observed in Sweden (col. 4) if it had the proportionate distribution by age of Oromiya females shown in column 2. Columns 5 and 6 show the actual numbers of deaths by age for Sweden, and the numbers that would be observed if Sweden had the same age structure as the Oromo females of Ethiopia respectively. The totals at the bottom for columns 5 and 6 also show the overall number of people dead in the actual count, and the number of deaths that would be observed in Sweden if it had the same age structure as female's in Oromiya in Ethiopia respectively. The difference between the two is enormous, as is the implied difference in the CDRs. If Sweden had the age structure of Oromiya females of Ethiopia its crude death rate would drop from 10.5 per thousand to only 2 per thousand matching Kuwait's CDR which is the lowest CDR for any country in the world. The exercise helped us solve the mystery behind Kuwait's status as the country with the lowest CDR. It, simply, has the best of both worlds – the best health care system money can buy, financed by billions of dollars of petroleum export revenues, and a young age structure composed; 17 percent of Swedes are 65 years or older (only one percent of Kuwaitis are in this category).

Infant Mortality Rate

The infant mortality rate (IMR) measures mortality levels in the first year of life and is defined as the total number of infant deaths (D) in a given in a year per 1000 births (B) that year. Neonatal mortality refers to the death of infants during the first month of life. The constant (k) of 1000 is now universally adopted even though other numbers like 100 could be used. Thus:

$$IMR = {}_1M_0 = (D_0 \div B) \times 1000$$

$$\text{Neonatal mortality rate} = \frac{D_{0\text{-}3\ weeks} \times 1{,}000}{B} \quad \text{or}$$

$$\text{Neonatal mortality rate} = \frac{D_{<1month} \quad X \quad 1{,}0000}{B}$$

The infant mortality rate is a very useful measure of mortality and a powerful indicator of the overall well being of the population it relates to. It is increasingly being used good yardstick in the rating of countries' social progress and well being living. Canada often takes the number one ranking on the social well being index. Generally, infant mortality is high in low-income countries including Sub-Saharan Africa, and low in high income countries - North America and Europe. In other words, there is a strong negative correlation between infant mortality and development. Hence, socio-economic development is an important determinant of infant mortality variations over time. This means that low infant mortality countries of today did not always have such low rates. As late as the 1930s several localities in the United Kingdom had infant mortality rates exceeding 85 deaths per thousand births per year [14]. The rate for the year 2007 in the UK was 10 infant deaths per 1000 births per year [15].

Similarly, the rates in all Sub-Saharan countries have changed over time with most countries registering gains in the numbers and proportions of infants making it to their first birthdays. It is, difficult however, to say with total certainty, or to accurately quantify the magnitude of reductions in IMR in various regions of Africa. A major impediment is the lack of reliable data on both the numbers of infants dying in the first 51 weeks of life, and accurate data on the numbers of births in a population. Very commonly, both the numbers of infant deaths (the numerator), and the births in a given year (denominator) are under reported. This would not cause a great deal of problems if the underreporting of the numerator and denominator took place in the same magnitude everywhere because the errors will, simply, cancel each other out. In reality, however, the proportions are different, and rarely, accurately known.

For the world, in general, infant mortality varies from a low of 2.6, 3.2 and 3.5 in Iceland, Singapore and Japan/Sweden, to 157 per thousand per year in Sierra Leone (the highest in the world). Western Sahara has the second highest infant mortality rate in the world. Half of the Sub-Saharan African countries are reporting triple digit infant mortality rates. Iraq with the crippling economic embargo it is under, Haiti, and the war-torn countries of Afghanistan, Laos, and East-Timor, are the only nations outside of Sub-Saharan Africa with triple digit infant mortality rates. Twenty two of the 27 countries with infant mortality in excess of 100 per thousand births per year, are in Sub-Saharan Africa (Table 7.6).

Table 7.6 Infant Mortality Rates (per 1000 births) in Africa, 2008

Country	IMR	Country	IMR	Country	IMR
Sierra Leone	158	Togo	91	Djibouti	67
Angola	132	Burkina Faso	89	Senegal	61
Guinea Bissau	117	Rwanda	86	Zimbabwe	60
Somalia	117	Swaziland	85	Eritrea	59
Liberia	113	Niger	81	Gabon	58
Guinea	113	Sudan	81	W. Sahara	53
Mozambique	108	Malawi	80	Namibia	47
Burundi	107	Ethiopia	77	South Africa	45
Chad	106	Tanzania	77	Botswana	44
Central Af. R.	102	Mauritania	77	Morocco	43
Cote d'Ivoire	100	Kenya	77	Egypt	33
Zambia	100	Sao T & P.	77	Cape Verde	28
Nigeria	100	Uganda	76	Algeria	27
Benin	98	Congo	75	Libya	21
Mali	96	Madagascar	75	Tunisia	19
Gambia	93	Cameroon	74	Mauritius	15
D.R. Congo	92	Ghana	71	Seychelles	11
Eq. Guinea	91	Comoros	69	Reunion	8
Lesotho	91				

Source: [12]

The island states Reunion is the only independent country in Africa with a single digit infant mortality rate. Four Arab states north of the Sahara – Egypt, Algeria, Libya, and Tunisia - also have a relatively low infant mortality of less than 40 per thousand. In terms of the absolute number of infants dying annually the population giant Nigeria is seeing more infant deaths in the general population than any other country in the world. Even though there were nearly two and a half times as many Americans as Nigerians in 2000, five times as many infants died - close to a million – in Nigeria than in the US where192, 500 infants died. Sierra Leone's population of only 5.2 million, (but with the highest infant mortality rate in the world) will see 816,400 infant deaths this year if the rate remains the same.

Adult Mortality

The Ethiopian Demographic and Health Survey of (2000 and 2005) collected data on sibling mortality to arrive at an indirect mortality estimate of adult Ethiopians between the ages of 15 and 50 [8]. The survey reported an overall improvement in mortality with a modest reduction of 3% for adult females, but a suspicious 26% reduction for males. The authors did not question the validity of such a decline in just five years. The erratic nature of the reported age specific rates (see Table below) also point to inherent data errors with low age specific mortality at older ages than at lower ages. For example, the rate for females aged 45–49, (year 2000) was lower than that of females aged 30-34. The age specific death rates (ASDR) are given in Table 7.4.

Table 7.4 Adult Age Specific Death Rate - ASDR (per thousand), 2000 and 2005.

Age Group	**ASDR Female, 2000**	**ASDR Female, 2005**	**ASDR Male, 2000**	**ASDR Male, 2005**
15 to 19	4.89	3.89	4.89	3.96
20 to 24	6.83	5.33	6.03	4.61
25 to 29	6.15	6.46	6.15	5.58
30 to 34	8.18	8.03	8.18	7.1
35 to 39	8.46	8.15	8.46	6.9
40 to 44	8.26	7.54	8.26	8.01
45 to 49	8.05	9.52	8.05	10.07

Source: DHS 2000, 2005

THE LIFE TABLE

The life table provides a statistical summary of the mortality experiences of a given cohort, usually a birth cohort. In its simplest form, the life table is derived from a set of age-specific mortality rates to measure mortality, survivorship, and life expectancy. Life tables allow, among other things, the combining of age specific mortality rates (and many other rates) into a single statistical model. Moreover, as can be observed from the forthcoming discussions, the effects of differences in the age structure of populations do not distort life table values. Life tables are commonly used in mortality analysis by demographers and other students of population as well as:

> "… public health workers, demographers, actuaries, and many others in the study of longevity, fertility, migration, and population growth, as well as in making projections of population size, and characteristics, and in studies of widowhood, orphanhood, length of married life, length of working life, and length of disability free life." [9]

There are two types of life tables. The first type combines the mortality experience of the population in a particular short period of time to give a cross-sectional view or a snapshot of current mortality. This is known as ***period*** life table (occasionally referred to as *current* life table). The second type known as, ***cohort*** life table or ***generation*** life table is based on real mortality experiences of a real cohort, e.g. all persons born in 1920 [9]. In this approach, the mortality experiences of all members of the cohort would be observed until the last person dies. The major shortcoming associated with latter method is that, it requires data gathering over a period of time lasting several decades just to complete a single table.

Life tables are also classified into two as ***abridged*** and ***unabridged*** (or complete). An unabridged life table contains data by single year of age, whereas an abridged life table presents data by intervals of 5 or 10-year age groups. According to Woods [14] the life table represents

> "… a formalized departure from the concept of age specific mortality rates ${}_{n}M_{x}$. Instead of expressing the number of deaths to a mid-year estimate, the probability that a person aged x will die before reaching age x+n (symbolized by convention as $q_{x,x+n}$ or ${}_{n}q_{x}$) is considered. Thus q_0 is the probability that a newly born child will die during the first year of life; ${}_{5}q_{20}$, the probability that a person aged exactly 20 will die before reaching 25…"

The difference between the age specific death rates (ASDR) or ${}_{n}M_{x}$ and ${}_{n}q_{x}$ is, simply, that with ${}_{n}M_{x}$ the denominator is the population at the *middle* of the year, whereas in ${}_{n}q_{x}$ the population at the *start* of the year is used as a denominator. Generally, ${}_{n}M_{x}$ and ${}_{n}q_{x}$ will be very similar in value with ${}_{n}q_{x}$ slightly smaller in a population that is growing, and slightly higher in a declining population. Therefore, in the construction of life tables we have to adjust ${}_{n}M_{x}$s slightly to produce ${}_{n}q_{x}$s. The process of conversion is explained as follows by Newell (1988: p68, 69):

Let D_x be the number of deaths in the year of persons aged x.

Let N_x be the population age x at the start of the year.

Let P_x be the population aged x at mid-year.

Then:

$$qx = \frac{Dx}{Nx}$$

$$Mx = \frac{Dx}{Px}$$

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In other words, N_x is just P_x plus persons dying between the beginning and the middle of the year. For most populations and most age groups the proportion of persons dying between the start of the year and the middle of the year is half ***(0.5D)*** of the total deaths for the whole year, because, given normal conditions, deaths will occur fairly evenly throughout the year.

Thus: $N_x = P_x + 0.5D_x$.

Placing D_x over both sides of the equation we get:

$$\frac{Dx}{Nx} = \frac{Dx}{Px + 0.5x}$$

$$= \text{qx} = \frac{Dx}{Px+0.5x}$$

Dividing top and bottom by P_x gives,

$$\text{qx} = \frac{Dx/Px}{\frac{Px}{Px} + 0.5(\frac{Dx}{Px})}$$

$$= \frac{Mx}{1+0.5Mx}$$

If the ASDRs ***($_nM_x$s)*** are expressed per 1,000, rather than 1, the equation becomes:

$$qx = \frac{Mx}{1{,}000+0.5Mx}$$

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It is possible to obtain estimates of q_xs from a schedule of ASDRs ($_nM_x$s). "However, it is only an approximation and its accuracy depends on the extent to which reality differs from the assumption that those who died in the year lived, on average, half of a year during that year" [14]. Problems will arise, however, applying this method to the very young because at very young ages, mortality is highly concentrated in the early part of the year, and an assumption of an even mortality for the entire year will produce erroneous results. The fraction of the year lived by the very young is often denoted by a_x. Thus, from the equations above the formula for the probability of dying at very young ages would be:

$$qx = \frac{Mx}{1 + (1 - ax)Mx}$$

For five-year age groups (abridged life tables) the formula would be:

$$nqx = \frac{nMx}{1 + (1 - nax)\ x\ nMx}$$

The a_0, a_1,… values vary from one country to another depending on overall levels of mortality and levels of childhood mortality. "For developing countries, where mortality is high, values of 0.3 for a_0, 0.4 for a_1 and 0.5 for all others are normally used. Where mortality is low, 0.1 is a better figure for a_0. In general, the values chosen are not critical, except for a_0 [14]. For high mortality populations an a_0 of 0.3, indicated that 70 percent (1.0 - 0.3 = 0.7) of infant deaths take place in the first half of the first year of life. An a_0 of 0.1 for low mortality countries suggests that 90 percent of infant deaths happen in the first half of the first year of life due to congenital causes that medical science has not been able to prevent. Fortunately, the life table probability of infant deaths q_0 can be directly calculated without using the formula above as follows:

$$q0 = \frac{D0}{Births\ in\ a\ year}$$

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$$\text{nqx} = \frac{nMx}{1 + (1 - nax)\ x\ nMx}$$

As noted above, the difference between age specific death rates $({}_nM_x)$, and the probability of dying $({}_nq_x)$ is that the former is calculated with the mid-year population as a denominator, whereas in ${}_nq_x$ calculations the dead are "resurrected" (added back to the denominator) to reflect the probability of dying as of the beginning of the year. The ${}_nq_x$ values for ages greater than 5 are calculated by simply entering the ${}_nM_x$s for those ages, and then substituting the a_x value of 0.4 by 0.5. In this way, the ${}_nq_x$ column (the most important column in life table calculations) can be entered for all ages.

Computing the ${}_nq_x$ column is the most important exercise in the construction of abridged or unabridged tables. The quality of data used is also very crucial. Since this depends on the accuracy of the ASDRs, the overall reporting of the numbers of people alive and dead in a given age group becomes very critical. Erroneous data will distort all entries of the life table columns.

Customarily, the first column (Table 7.6) is used to show the age interval chosen (single year, or 5 years, or 10 years). The second and third columns are the midyear population in that age group, and the number of people dead, respectively. The fourth and fifth columns are ASDRs and probabilities of dying $({}_nq_x)$ respectively. The sixth column ${}_np_x$ is simply the complement of values in the fifth column (i.e. ${}_np_x = 1 - {}_nq_x$). The seventh column l_x, is different from the functions entered in columns discussed so far in that it refers to an exact age, and not to age intervals. It is defined as the number still remaining alive at an exact age x out of the original cohort denoted by l_0 [9]. The size of an original cohort (l_0) is determined arbitrarily, the most commonly used number being 100,000. Others numbers such as 1000 could also be used. The observed mortality rates in a population are applied to this hypothetical cohort, known as the *radix*, with individual members being given a measured "mortality dose" until the last surviving member dies. The "dose" often depends on the overall mortality levels in the population which, in turn, determines the mortality at a given age. Catastrophes such as war, or a fatal childhood disease, which selectively affect given age groups could lead to a significant disconnect between overall mortality in the population and the age specific rates for the affected age groups. In sum, the construction of a life table combines the use of real observed numbers and rates, as well as a hypothetical cohort a subjected to the force of mortality represented by those numbers.

The first step in calculating l_x is to chose a suitable radix and then obtain the numbers of individual members of a cohort using the formula:

$$l_x = l_{x-n} \times {}_nP_{x-n}$$

For example, in Table 7.6 $\mathbf{l_{10} = l_5 \times {}_5P_5}$ = 82956 x 0.9824 = 81496. Preston [10] reminds us that "some functions (l_x, T_x, e_x) refer to a single (exact) age, while other functions $({}_nd_x, {}_np_x, {}_nq_x, {}_nm_x, {}_na_x)$ refer to age intervals that begin with exact age **x** and extend for exactly **n** years".

Table 7.7 Life Table Values for Addis Ababa, Ethiopia (Females, 1984 Census)

Age	${}_nM_x$	${}_nq_x$	${}_nP$	*l*	${}_nd_x$	${}_nL_x$	T_x	e_x
0	0.1191a	0.1103	0.8897	100000	11030	92610	5071698	50.71
1 - 4	0.0177b	0.0676	0.9324	88970	6014	339954	4979088	55.96
5 - 9	0.0036	0.0176	0.9824	82956	1460	411128	4639134	55.92
10 – 14	0.0026	0.0129	0.9871	81496	1051	404848	4228006	51.88
15 – 19	0.0045	0.0222	0.9778	80444	1786	398062	3823156	47.53
20 – 24	0.0062	0.0304	0.9696	78658	2391	387462	3425094	43.54
25 – 29	0.0064	0.0316	0.9684	76267	2410	375327	3037632	39.83
30 – 34	0.0068	0.0334	0.9666	73857	2467	363180	2662305	36.05
35 – 39	0.0077	0.038	0.962	71390	2713	350303	2299125	32.21
40 – 44	0.0093	0.0454	0.9546	68678	3118	335810	1948822	28.38
45 – 49	0.0119	0.0577	0.9423	65560	3783	318680	1613012	24.6
50 – 54	0.0161	0.0774	0.9226	61777	4782	297389	1294332	20.95
55 – 59	0.2209	0.1049	0.8951	56995	5979	270645	996944	17.49
60 – 64	0.0329	0.1523	0.8477	51016	7770	236382	726299	14.24
65 – 69	0.048	0.215	0.785	43247	9298	193657	489916	11.33
70 – 74	0.0751	0.3161	0.6839	33949	10731	142979	296259	8.73
75 – 79	0.1046	0.4139	0.5861	23217	9610	91850	153281	6.6
80 – 84	0.1921	0.6326	0.3674	13608	8608	44806	61430	4.51
85 – 89	0.275	0.764	0.0.236	4999	3820	13888	16624	3.33
90 – 94	0.4228	0.8898	0.1102	1180	1050	2483	2737	2.32

Source: [16]

[a] ${}_1a_0$ = 0.330 [b] ${}_4a_1$ = 1.352

In table 7.6 $_n\mathbf{d}_x$ relates of the number of persons in the original cohort dying between ages x and $\boldsymbol{x+n}$. Thus, $_n\mathbf{d}_x = \mathbf{l}_x - \mathbf{l}_{x+n}$. In words the number of deaths between a given age x and $\boldsymbol{x+n}$ equals the difference between the number of persons in the original cohort surviving to age x and the number surviving to age $\boldsymbol{x+n}$**.** The $_n d_x$ column can also be calculated using the formula: $_n d_x = lx \text{ x } _n q_x$. This means that the number of life table deaths between ages $\boldsymbol{x}$ and $\boldsymbol{x+n}$ equals the number of persons in the original cohort of 100,000 surviving to age x, multiplied by the probability of dying between those ages. For example, in Table 7.6 $_5d_{50} = l_{50} - l_{55}$ = 61777 – 56995 = 4782. The same answer is obtained when the second formula is used: $_5n_{50}$ = l50 x $_5q_{50}$ = 61777 x 0.0774 = 4782. The next column, $_nL_x$ is defined as the number of person-years lived between ages x and $\boldsymbol{x+n}$. It is calculated by adding the product of the mean number of person-years lived by those dying in the interval $(_na_x)$ and the number of members of the cohort dying in the interval $(_nd_x)$ to the number of person-years lived in the interval by the members of the cohort who survive the interval $(n.l_{x+n})$**.** In other words $_nL_x = (n \text{ x } l_{x+n}) (_na_x + {}_nd_x)$**.** Using the example in Table, we can calculate $_5L_{10}$ (the person years-lived between ages 10 to 15) for Addis Ababa (females, 1984) as follows:

$$
\begin{aligned}
{}_5L_{10} &= (\text{n x } l_{15}) + ({}_5a_{10} \text{ x } {}_5d_{10}) \\
&= (5\text{x } 80444) + (2.5 \text{ x } 1051) \\
&= 402220 + 2628 \\
&= 404848
\end{aligned}
$$

Perhaps the easiest column to calculate is the T_x column. All it takes is summing the $_nL_x$ values from the bottom of the table upwards. It is defined as the person-years lived by members of the life-table cohort above a given age x. For example, T_{75} in Table 7.6 is the sum of $_5L_{100}$, $_5L_{95}$, $_5L_{90}$, $_5L_{85}$, ***and*** $_5L_{80}$. Thus, T_{75} = 16 + 238 + 2483 + 13888 + 44806 + 91850 = 153281. The column most commonly referred to in demography and population studies is the last one (e_x)**.** In fact, the values in all other columns are calculated to obtain this last column, which shows the expectation of life at a given age $\boldsymbol{x}$. “It refers to the average number of additional years that a survivor at age $\boldsymbol{x}$ will live beyond that age” [10]. It is calculated using the formula $e_x = T_x/l_x$**.** For example the e_{35} for Addis Ababa equals 2299125 divided by 71390, which is equal to 32.2. In other words a 35 year old female in Addis Ababa, Ethiopia can expect to live 32.3 years longer.

Table 7.8 Life Expectancy at Birth (e_0) for African Countries (Year 2008)

Country	e_0	Country	e_0	Country	e_0
Reunion	76	Eritrea	57	Sierra Leone	48
Seychelles	76	Gabon	57	Uganda	48
Tunisia	74	Niger	57	Nigeria	47
Libya	73	Mali	56	Chad	47
Mauritius	72	Benin	56	W. Sahara	47
Algeria	72	Djibouti	54	Namibia	47
Egypt	72	Guinea	54	Rwanda	47
Cape Verde	71	Kenya	53	Liberia	46
Morocco	70	Congo	53	Malawi	46
Sao Tome & P.	64	Congo Dem. Rep	53	Guinea Bissau	45
Comoros	64	Cote d'Ivoire	52	Central Af.R.	43
Senegal	62	Cameroon	52	Angola	43
Mauritania	60	Tanzania	51	Botswana	43
Ghana	59	Burkina Faso	51	Mozambique	43
Equatrl. Guinea	59	South Africa	50	Zimbabwe	40
Madagascar	58	D. Rep. Congo	49	Zambia	38
Sudan	58	Burundi	49	Lesotho	36
Togo	58	Ethiopia	49	Swaziland	33
Gambia	58	Somalia	48		

Source: [12]

THE STABLE POPULATION AND STATIONARY POPULATION

The ${}_nL_x$ column in Table 7.7 can be thought of as ***a stationary population*** with a constant size and age structure. There are two reasons for this: "First, its size is T_0. Secondly, there are l_0 babies being born each year, and, since the population size is unchanging, exactly the same number of persons are dying " [14]. Any population can be thought of a stationary population by making the following three assumptions:

a) Constant age specific death rates over time ,

b) Constant birth rates in which the same number of births are added to the population per unit of time regardless of the unit of time used.

c) Zero Net migration at all ages (in effect, the population is assumed to be closed). Thus:

A stationary population will result from the indefinite continuation of a constant number of births (constant per day, month, and year), a constant life table, and zero migration at all ages. Such a population will have a constant age structure and certain simplified relationships among demographic parameters. For example, the birth rate of a stationary population is the reciprocal of life expectancy at birth. Similar other short-cut methods of demographic accounting can be employed to a stationary population [10].

The assumptions above allow researchers to make comparisons between what is observed in a real population and an imaginary stationary (life table) population. Moreover, since stationary populations do not grow or shrink (hence, the word stationary) observed growth or decline in a given population represents the extent of departures from a hypothetical stationary population. A small departure represents a population approaching a stationary status, while greater departures indicate a situation far removed from conditions of constant fertility, mortality, and zero migrations. Some populations around the world are beginning to approximate a stationary situation due to insignificant changes in fertility or mortality. Only net non-zero migrations are keeping them from becoming truly stationary. None of the countries of Africa can be placed in this category, however. Widening gaps between birth rates and death rates during the past decades has resulted in substantial population increase in almost all countries. Stationary populations do not grow, they remain stable. In other words, ***all stationary populations are also stable populations***. However, all stable populations are not stationary populations.

A population could be stable but growing or shrinking. "Unlike the life table population, which is stationary, as well as stable …[a stable population] may increase or decrease in absolute numbers" [9]. For example, a population could remain stable with constant mortality and migration, but increasing birth rates, provided the latter are growing at a constant annualized growth rate.

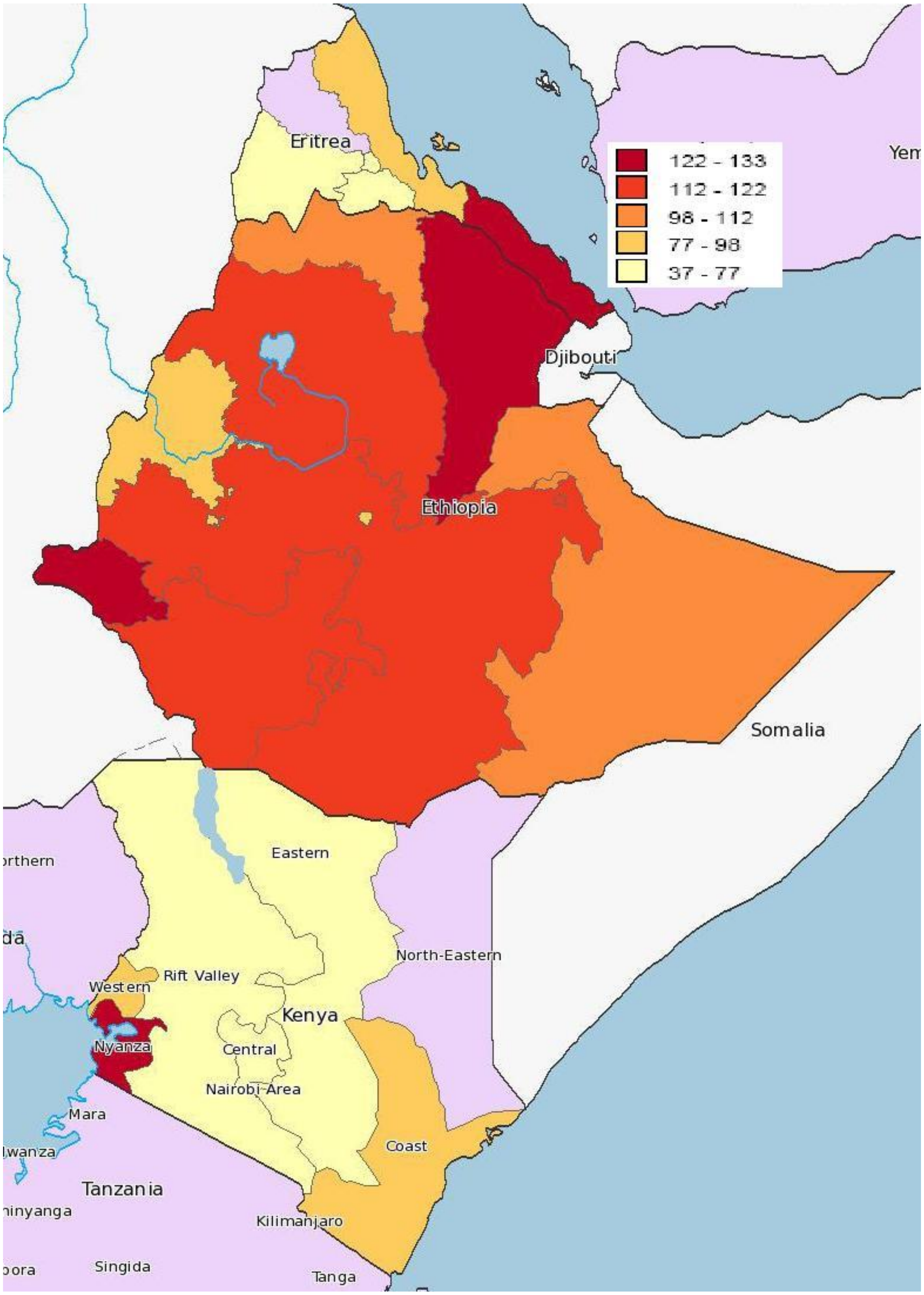
The stable population model is used by demographers to demonstrate the long-term implications of maintaining short-term demographic patterns and also to identify the effects of changes in one parameter on the values of others. It is the device that demographers use most to study how the different components of population structure and processes are linked to one another. It has also been used to estimate the trajectories of demographic elements in populations that can be assumed to be stable [10].

Appendix 1. Infant Mortality Rates IMR (Ethiopia, Eritrea and Kenya) by Administrative Divisions.

See map below map:

Country	Adm. Division	Year	IMR
Eritrea	Anseba	2002	36.56
Eritrea	Debub	2002	57.48
Eritrea	Debubawi Keih Bahri	2002	122.34
Eritrea	Gash-Barka	2002	66
Eritrea	Maekel	2002	38.89
Eritrea	Semenawi Keih Bahri	2002	77.5
Ethiopia	Addis	2000	80.99
Ethiopia	Affar	2000	129.2
Ethiopia	Amhara	2000	112.35
Ethiopia	Ben-Gumz	2000	97.59
Ethiopia	Dire Dawa	2000	105.6
Ethiopia	Gambela	2000	122.62
Ethiopia	Harari	2000	118.35
Ethiopia	Oromiya	2000	116.17
Ethiopia	SNNP	2000	113.37
Ethiopia	Somali	2000	99.38
Ethiopia	Tigray	2000	103.61
Kenya	Central	2003	43.88
Kenya	Coast	2003	77.96
Kenya	Eastern	2003	62.36
Kenya	Nairobi Area	2003	66.98
Kenya	Nyanza	2003	133.48
Kenya	Rift Valley	2003	61.17
Kenya	Western	2003	79.72

Infant Mortality Rates IMR (Ethiopia, Eritrea and Kenya) by Administrative Divisions.



Source: Map: Drawn with help, web-based mapping (http://macroint.mapsherpa.com/statmapper/)
Table: http://macroint.mapsherpa.com/statmapper/table.phtml?sid=4bbf8fd9c256c

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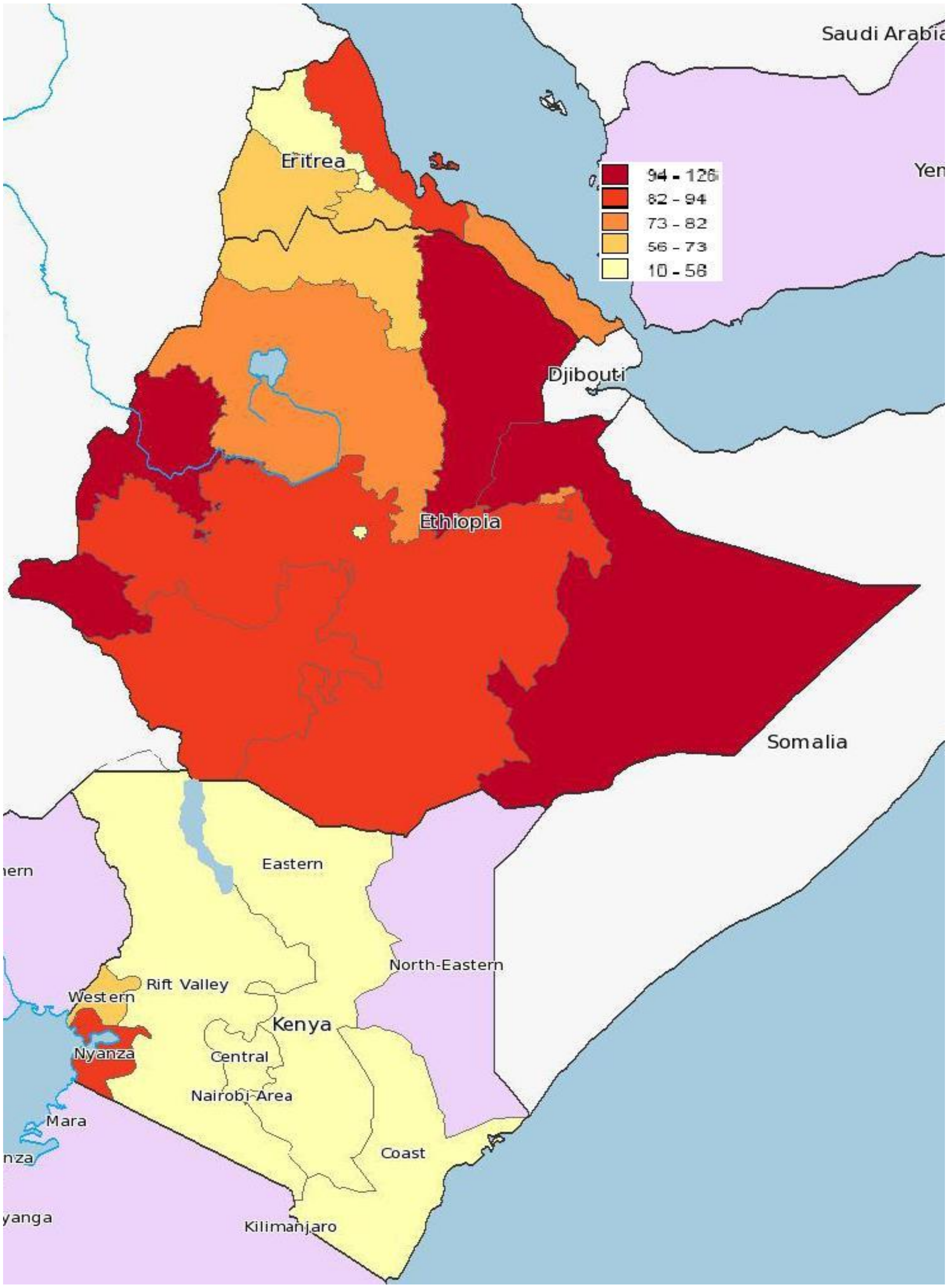
Appendix 2. Child Mortality, $_4q_1$, rate (No. of deaths between ages 1-4 per 1000 births)
See map below

Country	Adm. Region	Year	Child mort. Rate
Eritrea	Anseba	2002	37.35
Eritrea	Debub	2002	56.32
Eritrea	Debubawi Keih Bahri	2002	73.5
Eritrea	Gash-Barka	2002	61.44
Eritrea	Maekel	2002	22
Eritrea	Semenawi Keih Bahri	2002	82.45
Ethiopia	Addis	2000	35.41
Ethiopia	Affar	2000	114.89
Ethiopia	Amhara	2000	80.01
Ethiopia	Ben-Gumz	2000	110.97
Ethiopia	Dire Dawa	2000	78.43
Ethiopia	Gambela	2000	125.96
Ethiopia	Harari	2000	82.39
Ethiopia	Oromiya	2000	87.86
Ethiopia	SNNP	2000	88.16
Ethiopia	Somali	2000	94.15
Ethiopia	Tigray	2000	72.97
Kenya	Central	2003	10.47
Kenya	Coast	2003	41.31
Kenya	Eastern	2003	38.51
Kenya	Nairobi Area	2003	29.69
Kenya	Nyanza	2003	83.62
Kenya	Rift Valley	2003	17.38
Kenya	Western	2003	69.96

Child Mortality, $_4q_1$, rate (Kenya, Ethiopia, Eritrea) by Administrative Divisions



Source: Map: Drawn with help, web-based mapping (http://macroint.mapsherpa.com/statmapper/)
Table: http://macroint.mapsherpa.com/statmapper/table.phtml?sid=4bbf8fd9c256c

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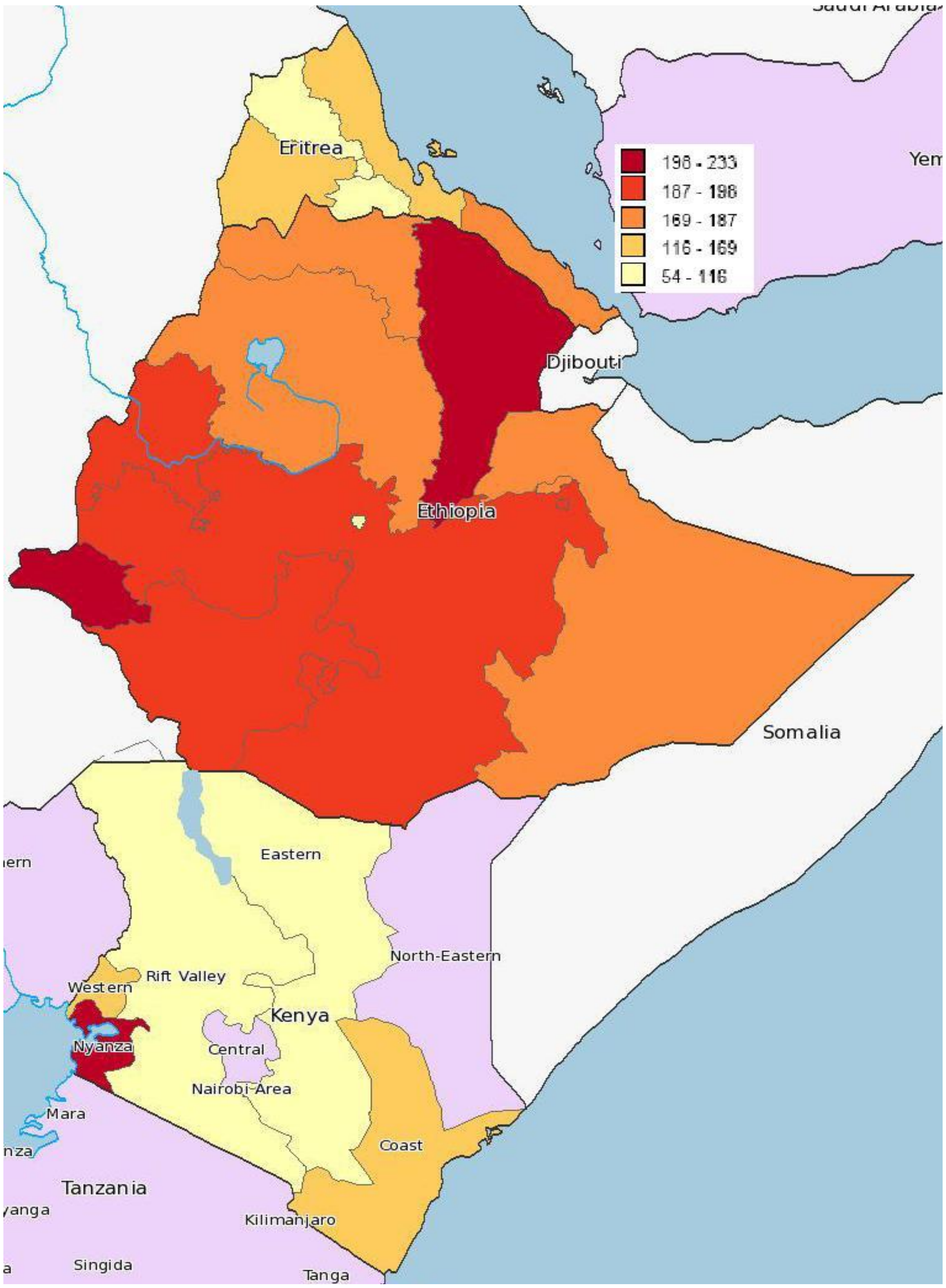
Appendix 3. Under-five mortality rate, 5q0 (no of deaths of children under five per 1000 births
See map below

Country	Adm. Region	Year	Under-five mortality rate
Eritrea	Anseba	2002	72.55
Eritrea	Debub	2002	110.56
Eritrea	Debubawi Keih Bahri	2002	186.85
Eritrea	Gash-Barka	2002	123.39
Eritrea	Maekel	2002	60.03
Eritrea	Semenawi Keih Bahri	2002	153.56
Ethiopia	Addis	2000	113.53
Ethiopia	Affar	2000	229.25
Ethiopia	Amhara	2000	183.36
Ethiopia	Ben-Gumz	2000	197.72
Ethiopia	Dire Dawa	2000	175.74
Ethiopia	Gambela	2000	233.13
Ethiopia	Harari	2000	190.99
Ethiopia	Oromiya	2000	193.83
Ethiopia	SNNP	2000	191.54
Ethiopia	Somali	2000	184.18
Ethiopia	Tigray	2000	169.02
Kenya	Central	2003	53.89
Kenya	Coast	2003	116.05
Kenya	Eastern	2003	98.47
Kenya	Nairobi Area	2003	94.68
Kenya	Nyanza	2003	205.95
Kenya	Rift Valley	2003	77.48
Kenya	Western	2003	144.1

Under-five mortality rate, 5q0 (Kenya, Ethiopia, Eritrea) by Administrative Divisions



Source: Map: Drawn with help, web-based mapping (http://macroint.mapsherpa.com/statmapper/)
Table: http://macroint.mapsherpa.com/statmapper/table.phtml?sid=4bbf8fd9c256c

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Appendix 4. Percentage of unvaccinated children 12-23 months old.
See map below

Country	Adm. division	Year	% children with no vaccination
Eritrea	Anseba	2002	2.11
Eritrea	Debub	2002	6.3
Eritrea	Debubawi Keih Bahri	2002	5.96
Eritrea	Gash-Barka	2002	8.5
Eritrea	Maekel	2002	1.65
Eritrea	Semenawi Keih Bahri	2002	7.44
Ethiopia	Addis	2000	2.18
Ethiopia	Affar	2000	15.58
Ethiopia	Amhara	2000	11.21
Ethiopia	Ben-Gumz	2000	20.72
Ethiopia	Dire Dawa	2000	2.54
Ethiopia	Gambela	2000	27.24
Ethiopia	Harari	2000	2.51
Ethiopia	Oromiya	2000	14.88
Ethiopia	SNNP	2000	30.53
Ethiopia	Somali	2000	30.53
Ethiopia	Tigray	2000	4.36
Kenya	Central	2003	2.09
Kenya	Coast	2003	4.57
Kenya	Eastern	2003	9.75
Kenya	Nairobi Area	2003	0.74
Kenya	Nyanza	2003	18.25
Kenya	Rift Valley	2003	6.8
Kenya	Western	2003	3.94

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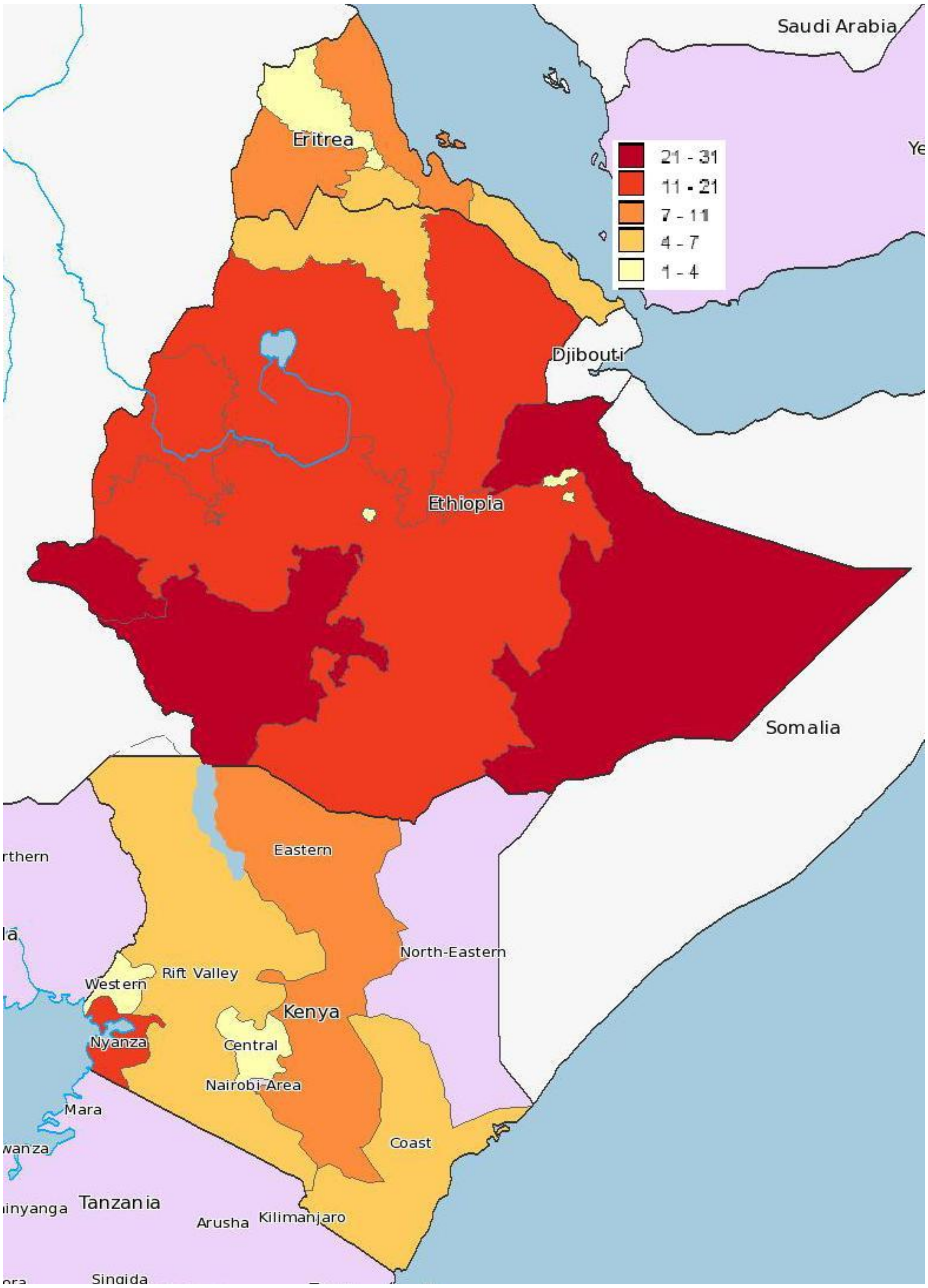
Percentage of unvaccinated children 12-23 months (Kenya, Ethiopia, and Eritrea) by Administrative Divisions



Source: Map: Drawn with help, web-based mapping (http://macroint.mapsherpa.com/statmapper/)
Table: http://macroint.mapsherpa.com/statmapper/table.phtml?sid=4bbf8fd9c256c

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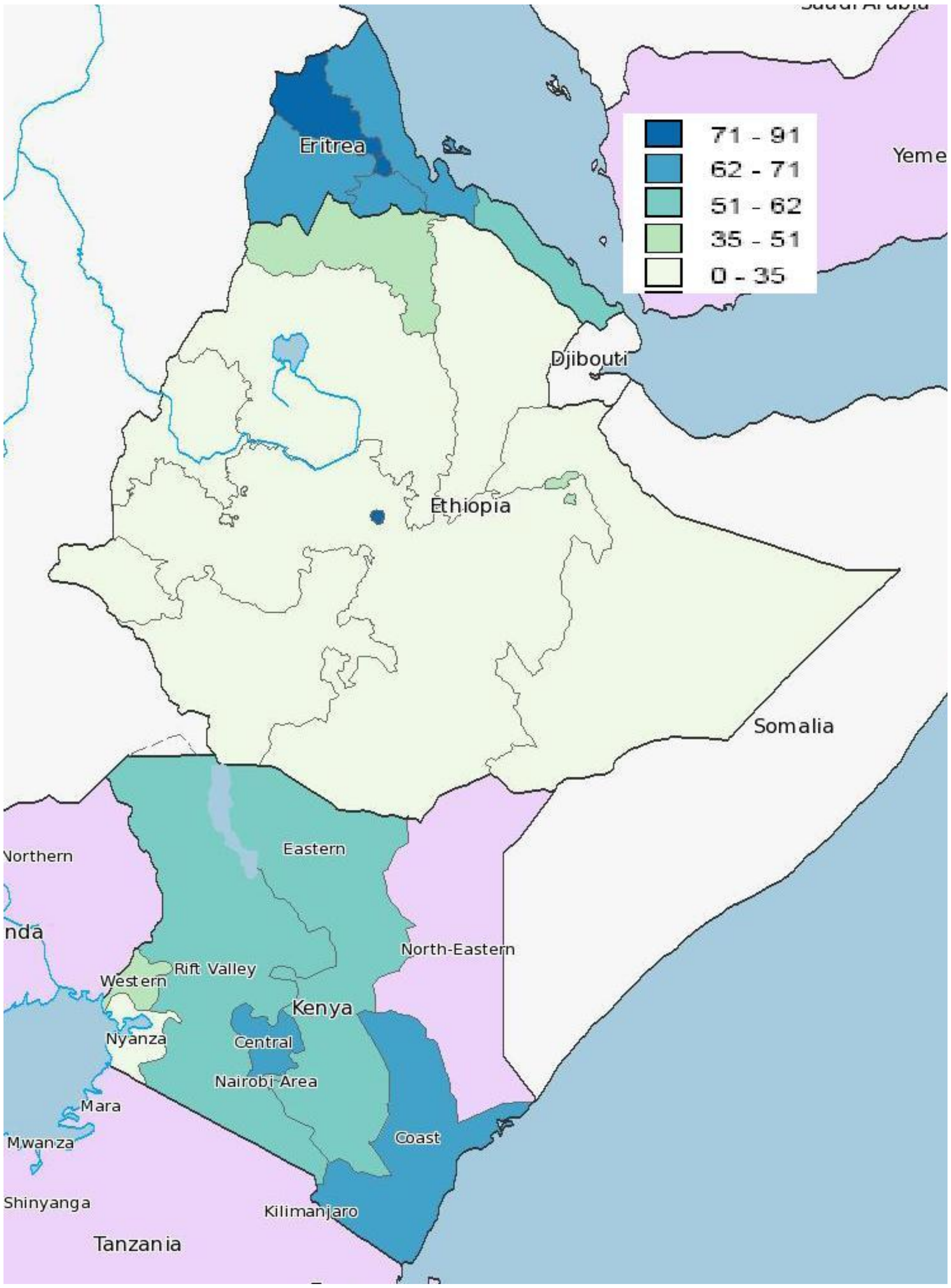
Appendix 5 Percentage of children 12-23 months, fully vaccinated

Country	Adm. Division	Year	% children (12-23 mo.) fully vaccinated
Eritrea	Anseba	2002	91.49
Eritrea	Debub	2002	69.65
Eritrea	Debubawi Keih Bahri	2002	60.08
Eritrea	Gash-Barka	2002	64.2
Eritrea	Maekel	2002	89.22
Eritrea	Semenawi Keih Bahri	2002	69.89
Ethiopia	Addis	2000	73.76
Ethiopia	Affar	2000	0
Ethiopia	Amhara	2000	14.38
Ethiopia	Ben-Gumz	2000	12.16
Ethiopia	Dire Dawa	2000	35.33
Ethiopia	Gambela	2000	10.76
Ethiopia	Harari	2000	35.89
Ethiopia	Oromiya	2000	9.77
Ethiopia	SNNP	2000	10.49
Ethiopia	Somali	2000	22.18
Ethiopia	Tigray	2000	43.52
Kenya	Central	2003	70.76
Kenya	Coast	2003	62.14
Kenya	Eastern	2003	52.54
Kenya	Nairobi Area	2003	54.95
Kenya	Nyanza	2003	32.68
Kenya	Rift Valley	2003	51.48
Kenya	Western	2003	45.42

Percentage of children 12-23 months, fully vaccinated (Kenya, Ethiopia, and Eritrea) by Administrative Divisions



Source: Map: Drawn with help, web-based mapping (http://macroint.mapsherpa.com/statmapper/)
Table: http://macroint.mapsherpa.com/statmapper/table.phtml?sid=4bbf8fd9c256c

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Appendix 6. Percentage of births with no antenatal care (received no care during pregnancy).

Eritrea	Anseba	2002	27.31
Eritrea	Debub	2002	35.52
Eritrea	Debubawi Keih Bahri	2002	29.88
Eritrea	Gash-Barka	2002	32.16
Eritrea	Maekel	2002	8.98
Eritrea	Semenawi Keih Bahri	2002	25.22
Ethiopia	Addis	2000	16.46
Ethiopia	Affar	2000	72.76
Ethiopia	Amhara	2000	82.6
Ethiopia	Ben-Gumz	2000	73.47
Ethiopia	Dire Dawa	2000	44.89
Ethiopia	Gambela	2000	52.43
Ethiopia	Harari	2000	55.2
Ethiopia	Oromiya	2000	72.05
Ethiopia	SNNP	2000	70.33
Ethiopia	Somali	2000	82.79
Ethiopia	Tigray	2000	63.57
Kenya	Central	2003	6.89
Kenya	Coast	2003	12.18
Kenya	Eastern	2003	16.56
Kenya	Nairobi Area	2003	3.84
Kenya	Nyanza	2003	9.4
Kenya	Rift Valley	2003	9.61
Kenya	Western	2003	6.2

Percentage of births with no antenatal care (received no care during pregnancy). Kenya, Ethiopia, and Eritrea (by Administrative Divisions)

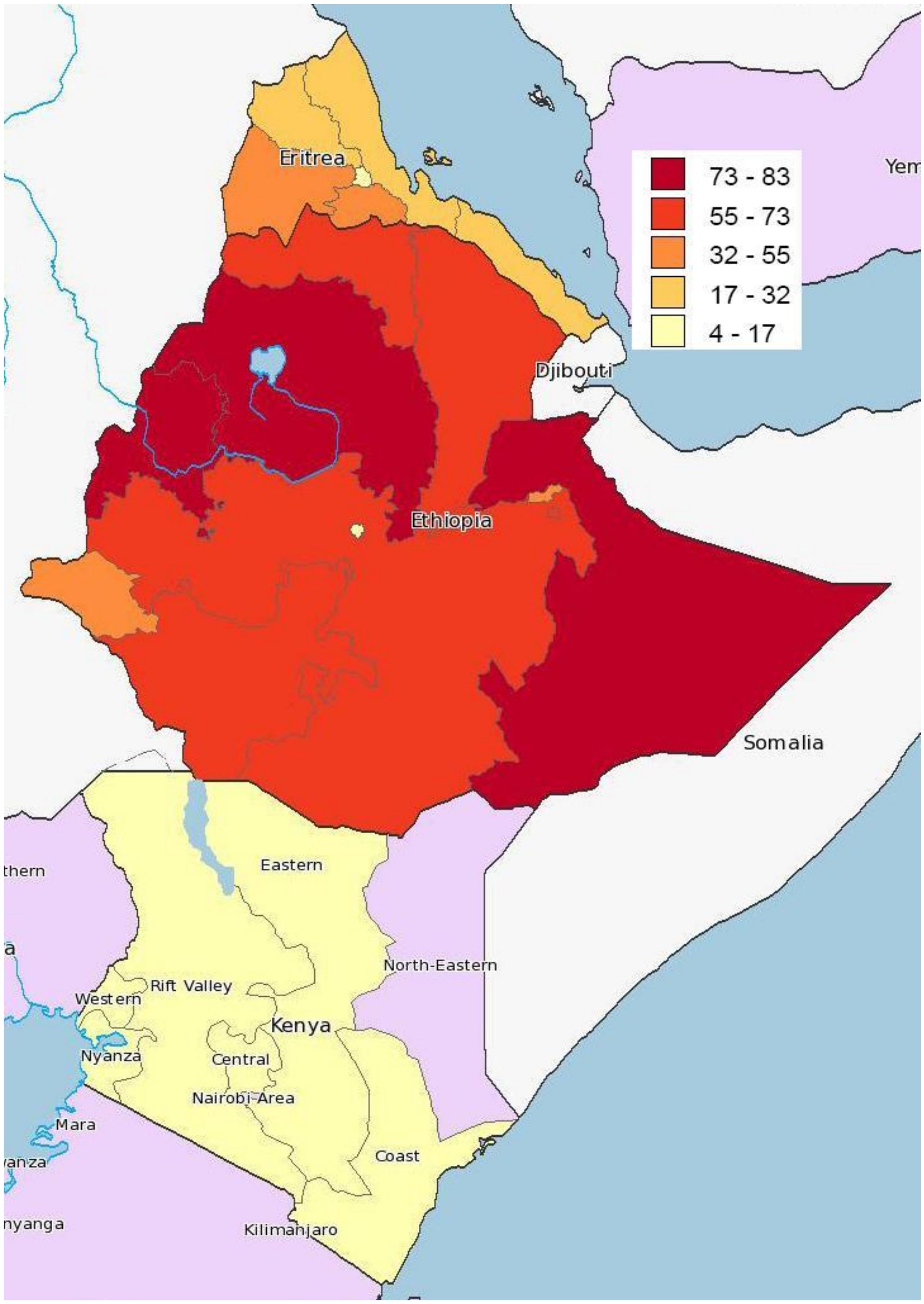

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Table: http://macroint.mapsherpa.com/statmapper/table.phtml?sid=4bbf8fd9c256c

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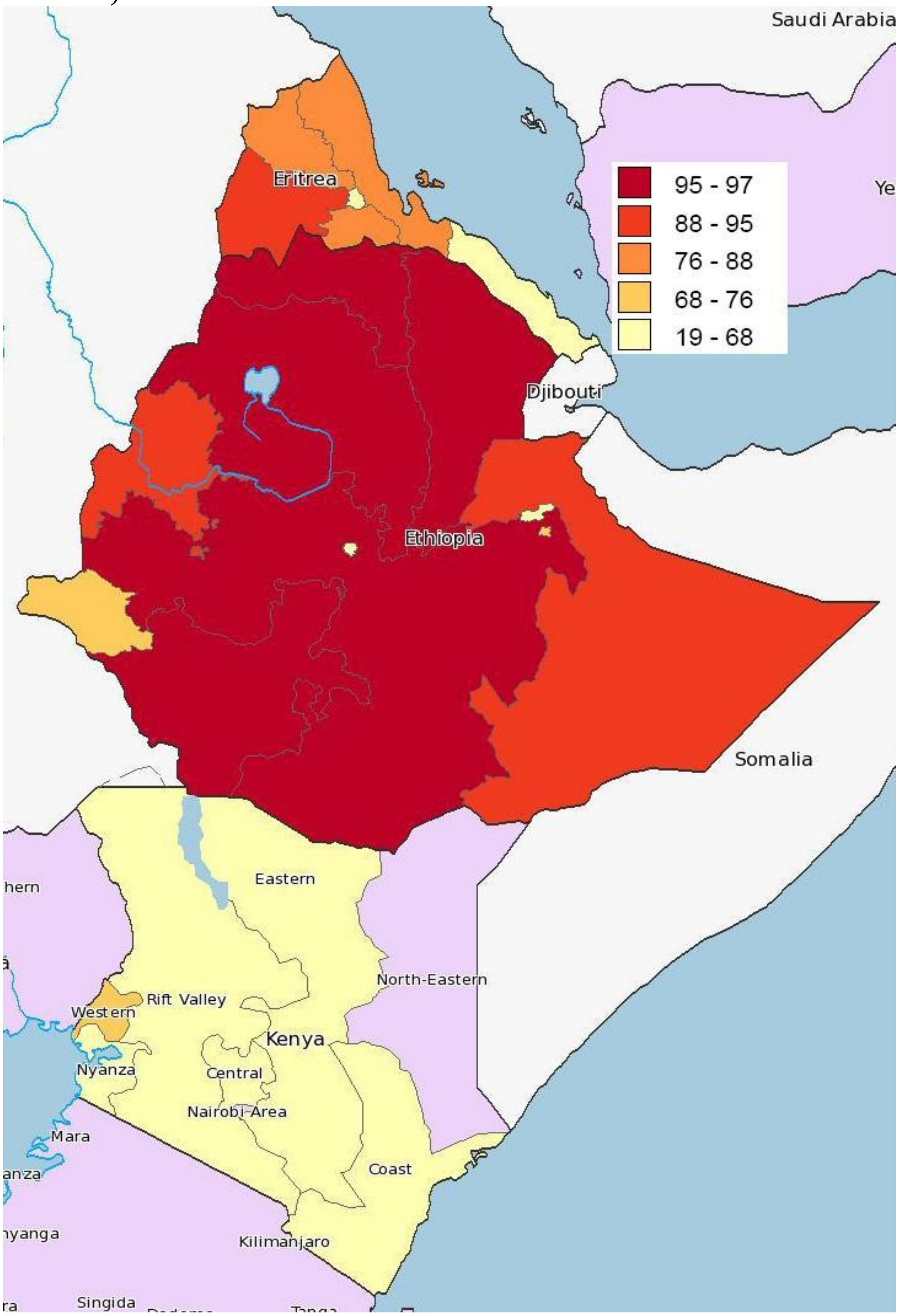
Appendix 7. Percentage of Births Delivered at Home
See map below

Eritrea	Anseba	2002	83.14
Eritrea	Debub	2002	78.07
Eritrea	Debubawi Keih Bahri	2002	54.26
Eritrea	Gash-Barka	2002	88.28
Eritrea	Maekel	2002	28.72
Eritrea	Semenawi Keih Bahri	2002	80.45
Ethiopia	Addis	2000	30.35
Ethiopia	Affar	2000	96
Ethiopia	Amhara	2000	96.97
Ethiopia	Ben-Gumz	2000	89.87
Ethiopia	Dire Dawa	2000	67.76
Ethiopia	Gambela	2000	73.21
Ethiopia	Harari	2000	75.85
Ethiopia	Oromiya	2000	96.25
Ethiopia	SNNP	2000	95.39
Ethiopia	Somali	2000	93.19
Ethiopia	Tigray	2000	95.42
Kenya	Central	2003	33.51
Kenya	Coast	2003	67.96
Kenya	Eastern	2003	64.92
Kenya	Nairobi Area	2003	18.84
Kenya	Nyanza	2003	64.54
Kenya	Rift Valley	2003	62.56
Kenya	Western	2003	73.2

Percentage of Births Delivered at Home. Kenya, Ethiopia, Eritrea(by Administrative Divisions)



Source: Map: Drawn with help, web-based mapping (http://macroint.mapsherpa.com/statmapper/)
Table: http://macroint.mapsherpa.com/statmapper/table.phtml?sid=4bbf8fd9c256c

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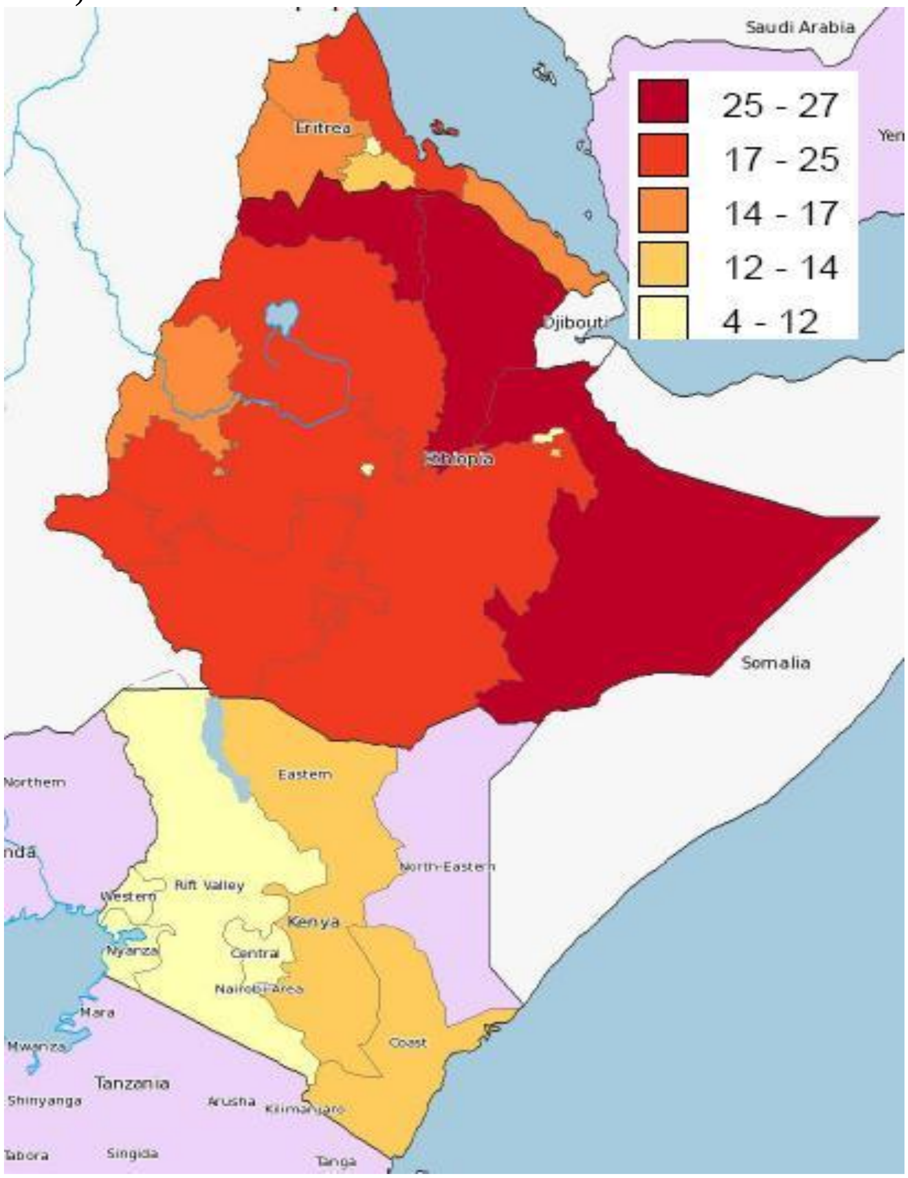
Appendix 8. Children stunted (height-for-age below -2 sd)
See map below

Eritrea	Anseba	2002	14.4
Eritrea	Debub	2002	13.69
Eritrea	Debubawi Keih Bahri	2002	14.34
Eritrea	Gash-Barka	2002	16.99
Eritrea	Maekel	2002	7.97
Eritrea	Semenawi Keih Bahri	2002	17.15
Ethiopia	Addis	2000	7.78
Ethiopia	Affar	2000	27.03
Ethiopia	Amhara	2000	24.59
Ethiopia	Ben-Gumz	2000	15.18
Ethiopia	Dire Dawa	2000	7.57
Ethiopia	Gambela	2000	17.44
Ethiopia	Harari	2000	12.47
Ethiopia	Oromiya	2000	19.72
Ethiopia	SNNP	2000	23.61
Ethiopia	Somali	2000	25.77
Ethiopia	Tigray	2000	26.09
Kenya	Central	2003	9.31
Kenya	Coast	2003	12.42
Kenya	Eastern	2003	13.69
Kenya	Nairobi Area	2003	3.88
Kenya	Nyanza	2003	5.94
Kenya	Rift Valley	2003	11.78
Kenya	Western	2003	11.91

Children stunted (height-for-age below -2 sd). Kenya, Ethiopia, Eritrea (by Administrative Divisions)

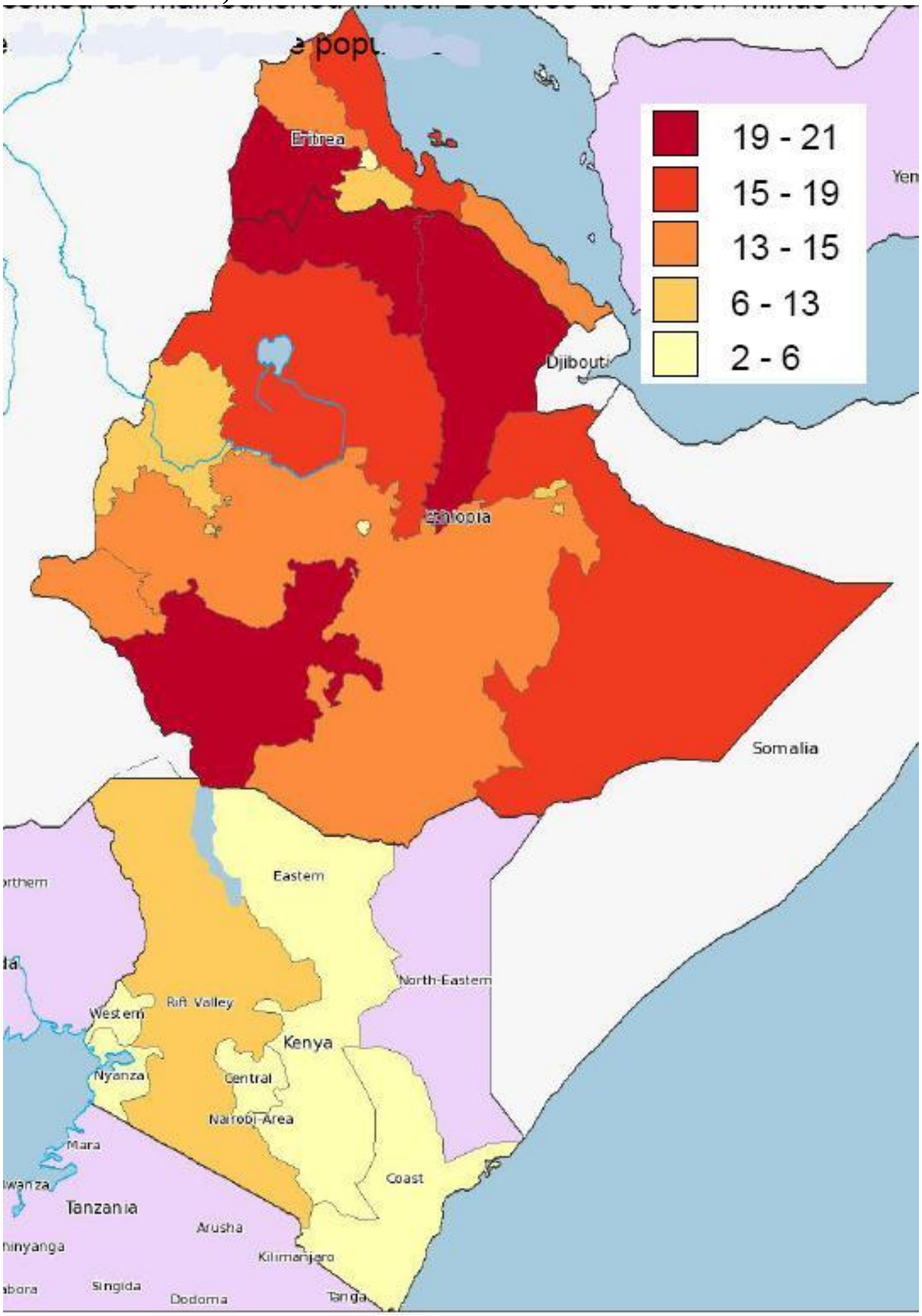


Source: Map: Drawn with help, web-based mapping (http://macroint.mapsherpa.com/statmapper/)
Table: http://macroint.mapsherpa.com/statmapper/table.phtml?sid=4bbf8fd9c256c

Appendix 9. Children under five wasted (weight-for-age below -2 sd)
See map below

Eritrea	Anseba	2002	14.59
Eritrea	Debub	2002	9.52
Eritrea	Debubawi Keih Bahri	2002	14.01
Eritrea	Gash-Barka	2002	20.06
Eritrea	Maekel	2002	2.31
Eritrea	Semenawi Keih Bahri	2002	17.79
Ethiopia	Addis	2000	3.19
Ethiopia	Affar	2000	19.27
Ethiopia	Amhara	2000	17.74
Ethiopia	Ben-Gumz	2000	12.5
Ethiopia	Dire Dawa	2000	8.88
Ethiopia	Gambela	2000	13.83
Ethiopia	Harari	2000	8.01
Ethiopia	Oromiya	2000	14.08
Ethiopia	SNNP	2000	19.59
Ethiopia	Somali	2000	17.56
Ethiopia	Tigray	2000	21.03
Kenya	Central	2003	2.27
Kenya	Coast	2003	5.74
Kenya	Eastern	2003	5.06
Kenya	Nairobi Area	2003	2.28
Kenya	Nyanza	2003	2.79
Kenya	Rift Valley	2003	6.44
Kenya	Western	2003	5.75

Children under five wasted (weight-for-age below -2 sd). Kenya, Eritrea and Ethiopia (by Administrative Divisions)



Source: Map: Drawn with help, web-based mapping (http://macroint.mapsherpa.com/statmapper/)
Table: http://macroint.mapsherpa.com/statmapper/table.phtml?sid=4bbf8fd9c256c

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