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Epidemiological transition of infant mortality in Africa

Alejandro Aguirre, *El Colegio de México*

aguirre@colmex.mx

ABSTRACT

Five groups of causes of death account for over two thirds of infant deaths in practically every population of the world, both contemporay or historical. These groups of causes are: I. Diseases preventable through immunization (DPI). II. Diarrhoeal diseases (DD). III. Acute respiratory infections (ARI). IV. Perinatal conditions (PC). V. Congenital Malformations (CM). When infant mortality declines there is a change in the epidemiologic pattern; namely, some groups of causes turn less important while some others become the leading causes of infant deaths. Before the epidemiologic transition groups I, II and III are the most important. DPIs are the first group of causes to have a significant drop, leaving DD and ARI as the two leading causes of infant mortality. Compared to other regions, Africa is behind in this process. However, it is possible to accelerate the transition following the experience of other countries.

INTRODUCTION

In few words, the demographic transition consists on the passage from a situation in which both mortality and fertility are high (and therefore the growth is moderate) to a situation in which mortality and fertility are low (also with moderate growth). During the transition, the mortality decline precedes the fertility decline. This generates a higher growth rate of the population during a period of time. In the process of demographic transition developed countries are ahead, Latin America and Asia in an intermediate situation and Africa behind.

In developed countries and in some developing countries have already taken place the most important demographic changes that may occur in their history. Nevertheless, it is not possible to consider the demographic transition a closed chapter in those countries. As to fertility and growth, there was the notion of equilibrium at the end of the transition. Many populations have reduced their fertility below replacement level and continue in this direction. The question is how long this trend will go on and whether it will be reversed in the future or not.

As part of the demographic transition, unprecedented changes in mortality have taken place during the last 150 years. In the last decades there has been a reduction of the rhythm of decline in mortality. Nevertheless, the decline follows, even in the populations with the highest life expectancies.

Mortality decline can be analysed within the framework of the epidemiologic transition. The epidemiologic transition consists on the decline in mortality accompanied by a change in the pattern of causes of death. Before the epidemiologic transition infectious diseases are the most important. After the transition chronic and degenerative

diseases such as heart disease, cancer or diabetes become the main causes of death. In Mexico, for instance, in 1922 the five leading causes of general mortality were: 1. Pneumonia and influenza; 2. Diarrhoea and entiritis; 3. Malaria; 4. Whooping cough; and 5. Smallpox. At the time the crude death rate (CDR) was 25 deaths per thousand population, and the life expectancy around 35 years (Mexico, 1994). By 1995 with a CDR of 5 per thousand and a life expectancy at birth of 73 years the epidemiologic pattern comprised within the main five causes of death: 1. Heart diseases; 2. Cancer; 3. Accidents; 4. Diabetes mellitus; and 5. Cerebro-vascular diseases (Mexico, 1996).

The epidemiologic pattern of a given population depends upon several factors. The degree of economic development, social aspects (education is one of the most relevant) and even the climate influence the pattern. For example, in temperate and cold climates respiratory infections may be more important whereas in regions with tropical climates digestive tract infections may have a higher incidence, at least during some periods of the epidemiologic transition. In 1964 in Chile the first cause of death was influenza and pneumonia; in Costa Rica (the same year) was the fifth, while the first cause of general mortality was gastritis and entiritis (PAHO, 1966).

The evolution of the epidemiologic pattern is related to social and economic transformations, to environmental conditions and to public health interventions and their efficay. There are some causes of death that is easier to prevent. Somehow this is related to the technology available and this prevention can occur even in conditions of social and economic stagnation.

The Mexican case summarized above illustrates the well known phenomenon of the epidemiologic transition (first described by Omran (1971)). However it refers to the whole population; namely, to the mortality experienced at all ages. In a way the

epidemiologic transition brings about a modification in the causes of death derived of an early survival. In other words, at least partially, the shift from infectious to chronic and degenerative diseases is due to the fact that the latter are affecting some of those persons whose death was delayed. But, what happens with infant mortality?

EPIDEMIOLOGICAL TRANSITION OF INFANT MORTALITY IN OTHER REGIONS

Infant mortality is the one occurring during the first year of life. One year is a short period of time to develop chronic or degenerative illnesses. Nevertheless, parallel to infant mortality decline dramatic changes take place in the epidemiologic pattern.

For the analysis of the epidemiologic transition of infant mortality, the causes of death can be grouped according to how easy or difficult is to prevent[@@@] them, as follows:

I. Diseases preventable through immunization (DPI).
II. Diarrhoeal diseases (DD).
III. Acute respiratory infections (ARI).
IV. Perinatal conditions (PC).
V. Congenital malformations (CM).

The groups of causes of death are ranked from the easiest to the most difficult to control. In most populations these groups of causes account for over two-thirds of infant deaths, regardless of the stage of the epidemiologic transition.

[@@@] Preventing the deaths due to these causes; not necessarily preventing the morbidity.

Diseases preventable through immunization are those in which it is easier to reduce infant mortality. The application of one or several doses of vaccines in most cases protect children of these illnesses, preventing thereby deaths. The World Health Organization's Extended Programme of Immunization (EPI) comprises a basic scheme of protection against tuberculosis, poliomyelitis, diphtheria, whooping cough, tetanus and measles. Deaths produced by DPI can be averted in most cases even if there is not an improvement of other living conditions of the population.

Incidence of Diarrhoeal diseases can be reduced with access to safe drinking water and sanitary means of excreta disposal. This requires a considerable investment in infrastructure and therefore some degree of economic development. However, even without these measures it is possible to prevent if not the morbidity (diarrhoeal episodes), the mortality caused by DD in a relatively easy way with oral rehydration therapy (ORT). Indeed, since the discovery of ORT in 1968 by the International Centre for Diarrhoeal Disease Research, Bangladesh, deaths due to DD have been significantly reduced in populations of developing countries lacking the sanitary infrastructure which helps the prevention of the diseases.

For acute respiratory infections there is not a magic formula such as vaccines or ORT. Nevertheless, many of the deaths due to ARI can be averted with a series of primary health care interventions both at home or at medical facilities. The key point seems to be the opportune referral to medical units when required.

To reduce mortality due to perinatal conditions it is necessary to implement adequate (preferably medical) attention during the delivery and during the pregnancy. This is costly since it requires medical facilities an skilled human resources, both associated with economic development; therefore in the absence of material progress it

is rather difficult to bring down the mortality caused by PC.

Finally, congenital malformations are ailments not only difficult to prevent but also to diagnose. Therefore in most cases it is little what can be done with the current technology in this field to reduce infant mortality. The exception may exist in countries with highly sophisticated practices like rutinary ultrasound screening of pregnant women. Throug this procedure some congenital malformations can be detected in fetuses and if there are no legal constraints to induced abortion, pregnancies can be interrupted. This is a somehow artificial way to reduce infant mortality.

Six stages can be identified in the epidemiologic transition of infant mortality. In the pretransitional epidemiologic profile deaths due to infectious diseases dominate. In other words, DD, ARI and DPI are the most frequent. In situations of very high mortality diseases preventable through immunization are important. Measles continues to be one of the leading causes of death in some regions of West Africa (Desgrées et. al.). In the past DPI were more important in Latin America as causes of infant deaths. Whooping cough for instance, was within the four leading causes of death in Mexico during the first half of the XX century (Mexico, 1994). In Brazil, at lesat until the early sixties measles was the fifth and tetanus the sixth causes of infant deaths (PAHO,1966). The pattern for the first stage is:

I. DD/ARI/DPI/PC or ARI/DD/DPI/PC

Diarrhoeal diseases or acute respiratoy infections may either get the first position and the other the second one. This may depend on the climate; namely, in tropical climates DD tends to be the first, and ARI in cold regions. Another possiblity is that they alternate positions from time to time. In this case they can continue shifting places until

the third stage of the transition.

With the onset of the epidemiologic transition DPI turn less prevalent. DD and ARI indistinctly remain as the two leading causes of infant mortality. Perinatal conditions become the third and congenital malformations may rise to the fourth place.

II. DD/ARI/PC/CM or ARI/DD/PC/CM

An example of a population in this stage is Mexico in 1970. The main causes of infant mortality were 1. Acute respiratory infections, 2. Diarrhoeal diseases, 3. Perinatal conditions, and 4. Congenital malformations. The infant mortality rate from vital statistics was 68 per thousand (Mexico, 1994); indirect estimation puts it in 85 per thousand livebirths.

As the epidemiologic transition advances DD and ARI become no longer the two main causes: perinatal conditions become the most important cause of infant mortality. Therefore DD and ARI share the second and third positions. Congenital malformations tend to occupy the fourth place.

III. PC/DD/ARI/CM or PC/ARI/DD/CM

Several Latin American countries passed through this stage during the early sixties: Argentina (1962), Brazil (Sao Paulo 1962), Colombia (1963), Mexico (1964), Puerto Rico (1964) and Venezuela (1964) were populations in the first modality (more DD than ARI), whereas in the second were Chile (1963), Peru (1964) and Uruguay (1963) (PAHO, 1966).

The reduction of the infectious diseases continues and consequently the congenital malformations jump to the second position. It is likely that the drop in DD is more significant that the one for ARI due to the high efficacy of the related intervention (ORT). Then there is no more alternation of positions between ARI and DD. The former stays in third position while the latter goes to the fourth.

IV. PC/CM/ARI/DD

By the second half of the 1980's some Latin American countries reached this epidemiologic pattern: Argentina (1986), Costa Rica (1988), Cuba (1988), Chile (1987), Puerto Rico (1987) and Panama(1987) (PAHO, 1990) with a slight variation (PC/CM/DD/ARI), most likely associated with the climate. Infant mortality in Mexico since 1993 is in the fourth stage with the pattern PC/CM/ARI/DD. The pattern in 1990 was PC/DD/ARI/CM. It changed in part as a consequence of the impulse given to the Control of Diarrhoeal Diseases Programme as one of the steps taken to meet the World Summit for Children goals.

Since 1964 Canada and the United States had a similar pattern: PC/CM/ARI/ACC/DD; namely, a pattern in which accidents rise to the fourth place and DD go to the fifth (PAHO, 1966). Later DD and ARI will disappear from the first five causes of infant death.

Indeed, economic development creates healthy settings in which infectious diseases are no longer within the five leading causes of infant mortality. Some other causes like accidents may occupy the third place but with a rather low contribution. The bulk of infant mortality is due to two causes: perinatal conditions and congenital malformations.

V. PC/CM

Most developed countries are currently in this stage of the transition. In the US (1987) and Canada (1988) perinatal conditions and congenital malformations are the first two causes of death accounting for 80% of the infant deaths in the former and 86% in the latter. In both North American countries accidents come as the third cause of infant mortality contributing with just 3% of the deaths of children under one year (PAHO, 1990).

Also in Sweden (1977), Denmark (1977), Norway (1977), Switzerland (1977), Netherlands (1977), Finland (1975), Australia (1977), East Germany (1976), West Germany (1977), Belgium (1976), Scotland (1977), Austria (1977) and Hungary (1977) the binomial PC/CM produced over 80% of infant deaths, and between 70% and 80% in Japan (1977), France (1976), England & Wales (1977), Checoslovakia (1975), Israel (1977), Ireland (1975), North Ireland (1977), Italy (1974), Grece (1976), Singapur (1977) and Hong Kong (1977) (Bourgeois-Pichat, 1980).

Deaths due to infectious diseases are more common during the postneonatal period (with the clear exception of neonatal tetanus). The drop in mortality for these causes changed the balance between neonatal and postneonatal mortality, bringing down the latter. For some time there was the idea that infant mortality reduction necessarily meant an increase in the share of neonatal mortality. However, once infectious diseases become negligible, two main causes of death are overwhelming: PC and CM. Further mortality declines as explained earlier are more likely in perinatal conditions. Therefore while infant mortality continues his way down (probably at one digit [per thousand] levels) there is a reversal in the previously increasing share of neonatal mortality. In terms of our groups of causes that means a proportional reduction

of deaths due to perinatal conditions with the concomitant rise in the proportion of deaths caused by congenital malformations. This process goes to the 'extreme' situation of PC and CM shifting positions and giving way to the sixth stage of the epidemiologic transition of infant mortality:

VI. CM/PC

Between 1970 and 1989 Sweden and Japan experienced neat trends in this direction. In Sweden perinatal conditions drop from 61% to 41% as cause of infant deaths, whereas congenital malformations increased their share from 27% to 33%. In Japan PC declined from 50% to 32%, while CM rose from 15% to 36% (Pinnelli et. al.). This means that Japan is already in this sixth stage of the transition; namely, CM displaced PC.

In summary, the six stages of the epidemiological transition of infant mortality are:

I	DD	ARI	DPI	PC
II	DD	ARI	PC	CM
III	PC	DD	ARI	CM
IV	PC	CM	ARI	DD
V	PC	CM		
VI	CM	PC		

THE TRANSITION IN AFRICA

As in many economic and social aspects, Africa is behind the rest of the world in the demographic transition, in the epidemiological transition in general, and in particular in the one concerning infant mortality. Among other shortages, the availability of information on infant mortality is limited, and it is not always possible to carry out the analysis one would like to do, but only what can be done with the data at one´s disposal. Table 1 shows for most (but not all) African countries, WHO data on the infant mortality rate (IMR) for the year 2005 and the percent distribution of deaths of children **under five** (it was not available for deaths of children under one) for the year 2000.

The epidemiological transition of infant mortality in Africa has some peculiarities that were not present during the transition in other regions of the world. The most outstanding is the presence of HIV/AIDS, that accounts for more than half of the deaths of children under five in four countries in the southern part of the continent: Botswana, Lesotho, Namibia and South Africa. In Swaziland and Zimbabwe is over 40%, and between 10% and 20% in the Central African Republic, Gabon, Kenya, Malawi, Mozambique and Zambia. For the rest of the countries the share of mortality due to this cause is less than 10%. Among the explanations for this is that by the time the HIV/AIDS pandemic started, developed and Latin American countries were already in the fourth or fifth stages of the transition, and above all, the spread of HIV in some parts of Africa has been overwhelming.

Persistence of malaria is another important element in the panorama of mortality, especially in West and Central Africa. Indeed, this disease provokes over 20% of the deaths of children under five in Benin, Burkina Faso, Cameroon, Chad, Congo, Côte d´Ivoire, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea Bissau,

Madagascar, Nigeria, Senegal, Togo, Uganda and Tanzania.

Another characteristic of the current African situation is the availability of the ORT that helps prevent deaths due to diarrhoeal diseases. Indeed, in none of the African countries DD kill more children than Pneumonia. In other regions, for instance Latin America when there were mortality levels like the current in Africa, DD and ARI used to alternate positions, depending a great deal on climate. This indicates that at least partially ORT is getting some results. The other good news is that measles is reducing its effect on mortality: the maximum of deaths that causes is 7.4% (in Equatorial Guinea),

With the remarks made above it is possible to identify several epidemiologic patterns in Africa. First of all, the pattern:

HIV – PC

This pattern is present in the six countries that have over 40% of deaths of children under five caused by HIV/AIDS. In all these countries the second cause of death is PC; these two causes provoke between 69% and 94% of the deaths. Malaria is virtually absent (only 0.2% in Swaziland and Zimbabwe) and measles at very low values. In these countries IMR ranges from 46 per thousand in Namibia to 104 per thousand in Swaziland.

Within the countries were malaria kills over 20% of children under five, there is a group in which there are three leading causes with a similar share. The causes are neonatal causes, malaria and pneumonia and the countries with this profile are: Benin, Burkina Faso, Cameroon, Chad, Guinea, Guinea Bissau, Madagascar, Nigeria, Senegal, Uganda and Tanzania.

Eritrea, with an infant mortality rate of 50 per thousand seems to fit well in the third stage of the transition; i.e. PC/ARI/DD, although malaria is in the fourth place.

Four of the countries that appear on table 1 have an infant mortality rate of less than 50 per thousand and therefore are the most advanced in the process of epidemiological transition; they are Algeria (34), Cape Verde (26), Mauritius (13) and Seychelles (12). Unfortunately table 1 does not provide information on mortality due to congenital malformations separately. They are comprised in the figures of the last column of *other causes*, which for the four countries is 20% or more. A good share of those percentages must actually correspond to CM deaths. Taking that into consideration, Algeria seems to have the pattern:

PC/CM/ARI/DD

that is, fitting in the fourth stage of the original proposal for the epidemiological transition of infant mortality. It should also be pointed out the absence of HIV/AIDS and very low percentages for malaria (0.5%) and measles (0.9%). As it was mentioned before, information on table 1 is fragmentary; Algeria is the only Arab country. However in other Arab countries the situation **might** be similar.

Cape Verde looks very much within the four stage of the ETIM, with an IMR of 26 per thousand. With half of that IMR, Mauritius is already in the fifth stage of the transition; that is, with pattern PC/CM and with infections producing very few child deaths. Seychelles with an IMR of 12 per thousand and no deaths due to HIV/AIDS, DD, measles or malaria is also on the fifth stage of the transition and probably heading to the sixth.

TABLE 1
AFRICA: INFANT MORTALITY RATE AND CAUSES OF DEATH OF CHILDREN UNDER FIVE YEARS

COUNTRY	*Infant Monrtality Rate*	*PERCENTAGE OF DEATHS DUE TO*							
		Neonatal Causes	*HIV/AIDS*	*Diarrhoeal Diseases*	*Measles*	*Malaria*	*Pneumonia*	*Injuries*	*Other Causes*
Algeria	34	48.0	0.0	11.9	0.9	0.5	13.7	5.0	20.0
Angola	154	22.2	2.2	19.1	4.8	8.3	24.8	1.4	17.2
Benin	89	25.0	2.2	17.1	5.3	27.2	21.1	2.1	0.0
Botswana	86	40.3	53.8	1.1	0.1	0.0	1.4	3.3	0.0
Burkina Faso	96	18.3	4.0	18.8	3.4	20.3	23.3	1.5	10.4
Burundi	114	23.3	8.0	18.2	3.0	8.4	22.8	1.8	14.6
Cameroon	87	24.8	7.2	17.3	4.1	22.8	21.5	2.2	0.0
Cape Verde	26	25.9	3.7	12.2	4.4	4.3	13.3	3.5	32.6
Central African Republic	115	27.2	12.4	14.7	6.5	18.5	18.7	2.0	0.0
Chad	124	24.0	4.1	18.1	7.0	22.3	22.8	1.8	0.1
Comoros	53	37.3	3.7	13.6	5.9	19.4	16.3	3.4	0.5
Congo	79	30.9	9.3	11.2	6.6	25.7	13.6	2.6	0.0
Côte d'Ivoire	118	34.9	5.6	14.8	2.5	20.5	19.6	2.2	0.0
Democratic Republic of the Congo	129	25.7	3.7	18.1	4.7	16.9	23.1	1.6	6.3
Equatorial Guinea	123	27.5	7.4	13.6	7.4	24.0	17.3	2.5	0.3
Eritrea	50	27.4	6.2	15.6	2.5	13.6	18.6	3.0	13.0
Ethiopia	109	30.2	3.8	17.3	4.2	6.1	22.3	1.7	14.3
Gabon	59	35.1	10.1	8.8	4.4	28.3	10.7	2.5	0.0
Gambia	97	36.6	1.3	12.2	2.5	29.4	15.5	2.6	0.0
Ghana	68	28.5	5.7	12.2	2.9	33.0	14.6	3.0	0.0
Guinea	98	28.8	2.3	16.5	5.5	24.5	20.9	1.4	0.0
Guinea-Bissau	124	24.1	2.6	18.6	3.4	21.0	23.4	1.4	5.5
Kenya	78	24.2	14.6	16.5	3.2	13.6	19.9	2.7	5.3
Lesotho	102	32.8	56.2	3.9	0.1	0.0	4.7	2.2	0.0
Liberia	157	29.1	3.6	17.3	6.0	18.9	23.0	1.7	0.3
Madagascar	74	25.6	1.3	16.9	5.0	20.1	20.7	2.4	8.0
Malawi	78	21.7	14.0	18.1	0.3	14.1	22.6	1.7	7.6
Mali	120	25.9	1.6	18.3	6.1	16.9	23.9	1.4	5.9
Mauritania	78	39.4	0.3	16.2	1.7	12.2	22.3	1.9	5.9
Mauritius	13	66.0	0.0	1.2	0.0	0.0	3.9	5.2	23.6
Mozambique	100	29.0	12.9	16.5	0.3	18.9	21.2	1.0	0.1
Namibia	46	38.5	53.0	2.5	0.1	0.0	3.0	3.0	0.0
Niger	150	16.7	0.6	19.8	7.3	14.3	25.1	1.4	14.8
Nigeria	101	26.1	5.0	15.7	6.3	24.1	20.1	1.9	0.8
Rwanda	118	21.7	5.0	18.5	1.6	4.6	23.2	1.8	23.7
Sao Tome and Principe	75	32.1	3.7	16.0	4.8	0.6	21.2	3.5	18.1
Senegal	77	22.8	1.0	17.1	8.1	27.6	20.7	2.6	0.2
Seychelles	12	27.2	0.0	0.0	0.0	0.0	10.1	12.3	50.3
Sierra Leone	165	21.9	1.3	19.7	5.3	12.4	25.5	1.2	12.7
South Africa	51	35.1	57.1	0.8	0.0	0.0	0.9	5.0	1.1
Swaziland	104	26.8	47.0	9.6	0.2	0.2	11.8	3.8	0.5
Togo	78	29.0	5.8	13.8	6.6	25.3	17.1	2.5	0.0
Uganda	79	23.6	7.7	17.2	3.0	23.1	21.1	2.2	2.1
United Republic of Tanzania	76	26.9	9.3	16.8	1.3	22.7	21.1	2.0	0.0
Zambia	104	22.9	16.1	17.5	1.2	19.4	21.8	1.0	0.1
Zimbabwe	60	28.1	40.6	12.1	2.9	0.2	14.7	1.2	0.3

REFERENCES

Aguirre, A. ‘Epidemiologic transition of infant mortality’. XXIII General Population Conference. IUSSP. Beijing, 1997.

Bourgeois-Pichat, J. 'Les causes de la mortalité infantile dans les pays dévelopés au cours des toutes dernieres années'. in Boulanger, P. and Tabutin, D. La mortalité des enfants dans le monde et dans l'histoire. Liege,1980.

Desgrées, A., Lou, D. and Pison, G. 'Le role des vaccinations dans la baissede la mortalité des enfants au Senégal' Population. Vol. 50, No. 3. Paris, May 1995.

Mexico. Secretaria de Salud. Compendio Histórico de Estadísticas Vitales 1893-1993. Mexico, 1994.

------ Mortalidad 1995. Mexico, 1996.

Omran, A. “The Epidemiologic Transition. A theory of the Epidemiology of Population Change”. *Milbank Memorial Fund Quarterly*, Vol. XLIX, No. 4. October, 1981.

PAHO. Health Conditions in the Americas, 1961-1964. Washington, 1966.

----- Health Conditions in the Americas, 1990 Edition. Washington, 1990.

Pinnelli, A., Nobile, A, and Lapinch, A. 'La mortalité infantile dans les pays dévelopés et les Republiques de l'ancienne Union soviétique. Tendances et facteurs' *Population*. Vol. 49, No. 2. Paris, March, 1994.

WHO website.