The Competing Risk Model in the Study of Infant Mortality

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1. Introduction

Infant mortality, estimated from the relation between the number of deaths of children aged less than one and live births, apart from being one of the classic indicators of health, is also broadly used as an indicator of the socioeconomic conditions of a country or region. Mainly, its rates are associated to the level of development of the researched areas and to the living conditions of the different cultural, economic and social strata of the population (LAURENTI, 1987; TAUCHER, 1979).

In countries currently found in an advanced stage of socioeconomic development, the decrease in infant mortality was marked by a sharp reduction in the causes associated with preventable exogenous factors. Such causes included sanitary and nutritional conditions, healthcare assistance etc. During the process, most of the infectious and parasitic diseases were eradicated, the same happening to most acute respiratory diseases. However, infant mortality due to endogenous causes, more related to genetic characteristics, child birth, maternal age etc, which are more difficult to prevent, presented a much less significant decrease. In general, most children dying in the first weeks in these regions are victims of endogenous causes, while those dying in the first year of life are victims of exogenous causes.

In these countries, there is a current predominance of children dying in the first days of life, particularly during the first week. These deaths are mostly due to perinatal factors which are generally related to poor conditions during delivery, poor health care assistance and congenital problems.

In this process, it is observed that, as infant mortality decreases, deaths tend to occur during the infant's first days of life. In general, within the first year, a child's death risk rapidly decreases from the first day of life to the completion of one year. Being so, the relative incidence of deaths is greater within the first month; during this period, mortality is greater in the first week, in the first day and hours of life.

In developing countries, where there is still high levels of infant mortality, infectious and parasitic diseases represent the greatest risk of death, which are mainly resulting from exogenous causes.

The State of São Paulo

Several authors (FRENK et al., 1991; LAURENTI,1990; PATARRA, 1988; among others), have pointed out that the epidemiological transition in the State of São Paulo is in a relatively advanced stage. The intense process of urbanization and industrialization of the State, the decline in the fecundity and death rates, and the intense domestic mobility have produced significant aging of the population and

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increased the relative magnitude of death by chronic degenerative diseases, perinatal disorders and others external factors.

In this context, the decrease in child mortality in São Paulo has been possible given to the control of infectious diseases, especially diarrhea and respiratory diseases, particularly pneumonia. During this process, child mortality by perinatal diseases remained high, increasingly extending its relative importance in the overall deaths among children aged less than one year (FERREIRA, 1989; FERREIRA and ORTIZ 1987; ORTIZ, 1999).

Official Civil Registry statistics demonstrate that, in the past twenty years, child mortality in the state of São Paulo has dropped from 51.2 per 1,000 (1980) to 17.5 per 1,000 (1999), which represents a 66% decrease (Table 1). To have a precise idea of the magnitude of such decrease, one may observe that while in this period of time the number of live births decreased 10%, the death of children aged less than one year decreased practically 55%.

In spite of this sharp fall, infant mortality in São Paulo is still much higher compared to the figure registered in developed countries where, in general, it was bellow 8 per 1,000 at the end of the 1990's or even in comparison to certain Latin-American countries, such as Chile (13 per 1,000), Costa Rica (12 per 1,000) and Cuba (9 per 1,000)[1].

A significant part of this reduction is related to the fact that children's healthcare assistance has presented concrete improvement in the last few years, both from the quantitative as from the qualitative perspective. Pediatric activities of basic health services started to contribute more effectively to the treatment of diseases such as diarrhea and in the fight against mortality by infectious diseases in general. Combined with these positive effects, there were vaccination and breastfeeding campaigns which became more regular and reached a broader population coverage. It is also worth mentioning the considerable growth in basic sanitation, especially the expanding of the piped water network during the 1980's (SES - SP 1996).

The evolution of the main causes of death confirms these hypotheses. It was observed that there were dramatic changes in this period of time. Exogenous death causes were the ones presenting most significant reduction. It is worth mentioning that infant mortality due to infectious and parasitic diseases decreased by 90% and infant mortality by disorders in the respiratory system, by 84%. Perinatal death occurrences decreased less than 40%, a much lower percentage when compared to

TABLE 1
Infant Mortality Rates according to main causes
State of São Paulo
1980 and 1999

Major Death Causes	Infant Mortality Rates*		Variation (%)
	1980	1999	1980-1999
Perinatal	18.2	11.1	-39.0
Infectious and Parasitic diseases	12.1	1.1	-90.9
Respiratory Diseases	10.1	1.6	-84.2
Congenital Anomalies	3.0	2.7	-10.0
Others	7.7	3.5	-64.9
Total	51.1	17.5	-65.9

*Per 1,000 live births.
Note: The sign (-) indicates reduction.
Source: SEADE Foundation

[1] UNICEF,1998.

the average decrease of all other causes which practically reached 50% (Table 1). Therefore, in 1999, perinatal disorders already represented 60% of children mortality; deaths by congenital anomalies was slightly over 14%; respiratory disorders represented 9% and infectious and parasitic diseases, 6%.

As expected, the reduction of infant mortality was focused on the post-neonatal component; while the decrease in neonatal mortality was, proportionally, smaller. The analysis of data shows that the decline of 60% in child mortality in São Paulo, between 1980 and 1999, occurred thanks to the decrease of post-neonatal mortality. This is certainly concerned with the fact that post-neonatal mortality is more sensitive to environment changes, while neonatal mortality is more dependent on biological variables and significant improvement of medical assistance. However, this is also a peculiarity of infant mortality in São Paulo, demonstrated by the studies by PUFFER and SERRANO (1973), LAURENTI (1977) and SIQUEIRA (1974), in the sense that even when the post-neonatal component was dominant in infant mortality, neonatal mortality presented relatively high proportions.

In 1999, 75% of the deaths of children aged less than one occurred during the neonatal period; 58% of these deaths took place in the first week of life. Considering only the neonatal period, we can observe that 78% correspond to deaths occurred during the infant's first week of life.

In brief, neonatal mortality levels in the State of São Paulo are still very high if compared to the levels reached in areas with similar infant mortality rates and, especially, in comparison with the levels observed in developed countries. In these countries, before perinatal modern techniques had been developed, the recorded levels of neonatal mortality were already very low, particularly the level of early neonatal mortality. The situation in São Paulo is aggravated by the fact that during postpartum, when a considerable number of newborns are still under the responsibility of the healthcare system, the levels of mortality remain very high (ORTIZ, 1999).

2. Objectives

The main objective of this article is to foster discussions, in the field of demographic studies, about the use of competing risk model in the study of infant mortality, especially the one occurring in the infant's first days of life.

Bearing this goal in mind, we have:

a) the methodology used to:

i) relate deaths belonging to the same generation of live births which originated these children (concatenation);

ii) construct the Neonatal Life Table;

iii) the competin g risk model.

b) the main results of the application of this model in a specific cohort of live births in the State of São Paulo;

c) the main conclusions of the present study.

3. Material and Methods

These data correspond to live births in the State of São Paulo during the first quarter (January- March) of 1993 and to deaths of infants aged less than 28 days experienced in the cohort.

As to the quality of these data, several articles (LAURENTI, 1977, 1987; LAURENTI and SIQUIERA, 1972; ALTMAN, 1982; ALTMAN and FERREIRA, 1982; FERREIRA and ORTIZ, 1982, 1987, 1997; ORTIZ, 1982a, 1982b; WONG, 1982; SANTOS, 1985a; YAZAKI, 1990; MELLO JORGE, 1993; GOMES and SANTOS, 1997) show that, for a long time, São Paulo has had a system of vital statistics records characterized by high coverage and excellent quality, enabling the analysis of its levels, trends and differences.

Concatenation

In order to calculate death probabilities, corresponding to a certain generation of live births, it is necessary to identify the deaths which occurred in this cohort. In Brazil, since the Live Births Certificates and the Death Certificates have different registration numbers bearing no relation between them, routines were created to associate deaths belonging to the same generation with live births who originated this generation. The technique is known as concatenation, linkage or pairing, which assumes the existence of individualized information.

To apply the linkage technique, the starting point are Live Births Certificates corresponding to live births in a given area, which are observed during a limited period of time. Following, Death Certificates referring to deaths theoretically originated from this group of live births are selected. Finally, Death Certificates and their respective Live Births Certificates are paired. In this procedure, live births not paired are considered “survivors” and those paired are considered “effect” (deaths). Thus, a static-retrospective cohort is created because the events have already happened and there is a fixed period of observation to verify the effect. There is no migration and no loss in the observation (ALMEIDA, 1994).

This technique has been largely employed, especially in infant mortality studies, since it enables to recover several information about the characteristics of live births who originated the deaths analyzed[2].

It should be stressed that, in the technique, live births replace deaths in the analytical axis. It also enables to calculate death probabilities according to the presence or absence of certain characteristics which are registered on the Live Births Certificates. At the same time, it allows a greater usage of the information collected by the official systems of live births and of deaths, enabling the use of cohort studies at a very low operational cost.

Death Causes

Information regarding death causes were obtained from Death Certificates and coded according to the International Classification of Diseases, Ninth Revision (ICD-9). The underlying cause was obtained automatically from the ACME system, Automated Classification of Medical Entities.

The classification of death causes assumes great importance in trying to identify the factors which affect infant mortality. Through such classification, it is expected to be drawn a profile of child mortality, showing the level of socioeconomic development and the result of health measures adopted. This should enable us to evaluate the interventions performed and point out those which should be carried out in order to reduce these indexes, both through the health sector as through other sectors of the government scope.

Considering that, today, it is possible to significantly lower the levels of infant mortality through very simple and low cost procedures, the criterion of possible avoidance of certain diseases was adopted as a starting point intending to group death causes in avoidable and unavoidable, according to the current stage of scientific medical knowledge[3].

Diseases considered avoidable were divided according to the several measures that can be taken in order to reduce or eliminate them. All diseases which could cause child death specified in the ICD-9 were included in each group. The groups of causes are as follows:

I. Reducible through:

a. immunoprevention ;

b.appropriate control during pregnancy;

c.appropriate attention during delivery;

[2] See, for example, articles by ALMEIDA (1994); FERNANDES (1997); ORTIZ (1999).

[3] For further details about this new grouping of death causes, see: ORTIZ (1988, 1996); CALLIOLI and ORTIZ (1995).

d. prevention, early diagnosis and medical treatment;

II. Unavoidable;

III. Poorly defined.

The Life Table

In order to study infant mortality, it is of utmost importance to consider the age of the child at the time of death, since the factors involved are of different circumstances. The most suitable tool for this kind of analysis is the Life Table which, through death probabilities, provides the most complete statistical description of age related deaths.

This demographic tool has a very comprehensive use in several areas. For instance, it allows to answer questions such as: for how long, in average, will live births, in a given place and year, survive the first year of life? How many will reach the tenth, eleventh birthday? When the cohort is extinguished, what will the average life span of the individuals in the analyzed group be?

Schematically, if we followed **N** subjects in a cohort of live births until the complete cohort is extinguished, annotating, after every **t** unities of time, how many subjects remained alive and how many died, we would directly obtain the distribution of the length of life, as well as the average life span and other relevant indicators. Proceeding in this manner we would have what is called the Generation Table, which records the actual mortality experience of a particular group of individuals (the cohort) from birth to the death of the last member of the group (BERQUÓ, 1969).

Since human life may last a 100 years or more, it wouldn't be practical to wait all this time to complete data collection. Moreover, the determining conditions of longevity change with time and in the end of a particular cohort will have ceased to exist. Therefore, the construction of these tables considers only a given population during a short period of time, for instance, those individuals aged less than one.

On the other hand, the construction of the so called conventional, current or modern tables is based on the assumption of a population in which the specific age coefficients do not change with time, that is, a stationary population.

In these tables, the way a fictitious generation would vary in time is defined considering that it would be subjected to the mortality rates observed in a given population, during a given period of time. Therefore, the table would show the length of life of a generation which would experience, during each year of its existence, a mortality equal to the one verified in the corresponding year of age of the observed population during the period of observation. In this sense, one must note that the individuals, from which the mortality rates derive, belong to different generations.

In the present article, a Generation Neonatal Life Table is built. This table presents a cohort through time, recording the number of survivors at each particular age. Thus, the calculation of death probabilities (nqx) is done directly, needing not to go through the central rates of mortality (nmx), which are the same both in the stationary population with which they associate and in the actual population from which they originate. The remaining functions are estimated by using conventional relations.

The Competing Risk Model

The statistical method that enables the study of situations in which individuals are susceptible to the risk of dying for various causes is known as analysis of competing risks. One of its valuable tools is the Multiple Decrement Table.

From the competing risks point of view, an individual is susceptible to the risk of dying for various causes, independently of the cause which definitely determined the death. In this sense, there was a certain "competition" among the various risks. It is important, then, to clarify the terms risk and cause. Although both terms may refer to the same condition, the term risk refers to the condition prior to death; after death the same condition is the cause.

On the basis of this study, it is possible to determine what would be the effect, in the population life span, of eliminating and/or reducing the intensity of a certain disease or cause. It also enables the assessment of the mortality rate by a specific cause, in the presence of other causes of death.

In the sixties, the subject gained effective theoretical formulation, especially with CHIANG's concept of competing risks (1968). The issue is to quantify the "effect of the total (or partial) elimination of one or more risks in the structure of mortality in a given population, in the hypotheses that each individual is subject to k (k>=2) risks of death competing for his/her life" (PAES, 1982).

Among several models proposed, specifically Chiang's model considers only the formal effect (CHIANG, 1968; SANTOS, 1985b),

> [...] assuming a constant force of mortality[4] in each age interval for the construction of a life table. The theory of competing risk assumes that various risks of death act simultaneously on each individual of a given population; for each risk there is a corresponding force of mortality. The sum of these forces is the total force of mortality. Besides, there is a constant proportion between the force of mortality of a specific cause and the total force of mortality, in each age interval.

When a cause of death (or group of causes) is eliminated, the new force of mortality is related to the total force of mortality throughout the formula as follows:

$$u_{i.j}(t) = u_i(t)\frac{(D_i - D_{i.j})}{D_i} \qquad (1)$$

where:

ui.j(t) = force of mortality at age i, in which one cause of death (or group of causes) j, in an instant t, has been excluded

ui(t) = total force of mortality at age i, in an instant t

Di = total deaths at age i

Di.j = total deaths at age i, in which deaths resulting from the eliminated cause (or group of eliminated causes) j have been excluded.

In sum, these estimations of death probabilities take into account the interdependency of various risks and their effects when a specific cause (or group of causes) is eliminated.

There are several criticisms against this model. The hypotheses that attributes death to a single cause is deemed to be unsatisfactory, since the death of an individual can be due to the interaction of various risks of death (GURALNICK, 1965). Another example is the hypotheses relating to the total elimination of a certain cause of death (WONG, 1977; KEYFITZ, 1977; TSAI and LEE, 1975 and 1978). In terms of policies and/or measures to be undertaken by the public health sector, it would be more practical to learn the effects of the partial reduction of a cause of death instead of its total elimination. Finally, the assumption that the force of mortality of a disease remain a constant proportion of the total force of mortality, in a short interval, is refuted since it is not valid to the whole interval (KIMBALL, 1971; DAVID, 1970).

Probabilities[5]

The different probabilities associated to the interval (x_i, x_{i+1}), which will be used in the construction of the Multiple Decrement Life Table, are defined as follows:

p_i = probability that an individual alive at age x_i will survive the interval (x_i, x_{i+1})

$q_i = 1 - p_i$ = probability that an individual alive at age x_i will die in the interval (x_i, x_{i+1})

p_{ik} = joint probability that an individual will survive from the exact age x_i to age x_k

[4] Force of mortality is defined as the instant coefficient of mortality.

[5] For detailed information on the probabilities, see GOTLIEB (1967), PAES (1982).

Q_{ij} = probability that an individual alive at age x_i will die in the interval (x_i, x_{i+1}) from cause (or group of causes) R_j in the presence of all other risks acting in the population; it is known as ***crude probability;***

q_{ij} = probability that an individual alive at age x_i will die in the interval (x_i, x_{i+1}) if R_j is the only risk (or group of risks) acting on the population; it is known as ***net probability***;

$q_{i.j}$ = probability that an individual alive at age x_i will die in the interval (x_i, x_{i+1}) if R_j is eliminated as a risk of death; it is also known as ***net probability.***

Estimation of the Crude and Net Probabilities

For age interval (x_i,x_{i+1}), we let:

$n_i = x_{i+1} - x_i$, be the length of interval

p_i = the midyear population

D_i = the number of deaths occurring during the calendar year (current population)

a_i = the average fraction of the interval lived by the Di individuals

E_i = the number of individuals alive at x_i

d_i = the number of deaths (in the table) during the calendar year

l_i = the number of survivors (in the table) at the exact age x_i.

The death rate is given by:

$$M_i = \frac{D_i}{P_i}, \qquad i= 0,1,... \qquad (2)$$

and, the probability of dying in the interval (x_i,x_{i+1}) is estimated from:

$$\hat{q}_i = \frac{D_i}{E_i} \qquad (3)$$

which can be readily derived from the multinomial function of the joint probabilities distribution of the number of deaths and the number of survivals. The estimation is given by:

$$\hat{p}_i = \frac{l_{i+1}}{l_i}, \qquad (4)$$

Therefore, the estimator of the probability that an individual will die in the interval (x_i,x_{i+1}), denoted by q_i, in the life table, is given by:

$$\hat{q}_i = \frac{d_i}{l_i}, \qquad (5)$$

where: $d_i = l_i - l_{i+1}$ (6)

Supposing that the estimation of population is identical to the life table one, by analogy, we infer that:

$$\hat{q}_i = \frac{D_i}{E_i} \qquad (7)$$

is the estimator of the probability of death when the population data is directly used. It is a unique, unbiased and efficient estimator of the probability qi, which satisfies the optimal properties of an estimator.

But,

$$E_i = \frac{P_i + n_i a_i D_i}{n_i} \qquad (8)$$

From the above equation we may rewrite the formula (7) as follows:

$$\hat{q}_i = \frac{n_i M_i}{1 + n_i a_i M_i} \qquad (9)$$

Now, deaths are divided according to the existing causes, with D_{ij} deaths from cause R_j, j=1,2..., r

and,

$$D_i = D_{i1} + D_{i2} + ... + D_{ir} \qquad (10)$$

so that

M_{ij} is the specific mortality rate from cause j, at age i, defined as

$$M_{ij} = \frac{D_{ij}}{P_i} \qquad (11)$$

Thus, the estimator of crude probability of dying from specific cause in the presence of all other risks acting in the population is represented by

$$\hat{Q}_{ij} = \frac{D_{ij}}{E_i} \qquad (13)$$

his estimator may be obtained using the maximum likelihood principle, where we have:

$$\hat{Q}_{ij} = \frac{d_{ij}}{l_i} \qquad (14)$$

and using the same argument as that in q_i estimation, we may say that

$\hat{Q}_{ij}$ is unique, unbiased and efficient estimator of the probability Q_{ij}.

Substituting (8) and (11) in (13), the formula becomes

$$\hat{Q}_{ij} = \frac{n_i M_{ij}}{1 + n_i a_i M_i}, \qquad (15)$$

i= 0,1,..., years
j=1,2,..,r causes

Finally, making the appropriate substitutions we obtain the estimators of net probabilities

$$\frac{D_{ij}}{D_i} \qquad (16)$$

$$\hat{q}_{ij} = 1 - \hat{p}_i$$

which is the probability that an individual alive at age x_i will die in the interval (x_i, x_{i+1}), if R_j is the only risk (or group of risks) acting on the population,

and,

$$\frac{D_i - D_{ij}}{D_i} \qquad (17)$$

$$\hat{q}_{i,j} = 1 - \hat{p}_i$$

i= 0,1,..., years
j= 1,2,..,r causes

the probability that an individual alive at age x_i will die in interval (x_i, x_{i+1}), if R_j is eliminated as a risk of death.

4. Results and Comments

The studied cohort includes 168,131 live births in the State of São Paulo, between January and March of 1993. The corresponding Live Births and Death Certificates were provided by the Civil Register Office to the State Data Analysis System Foundation (SEADE), within the month deliverance routine of such documents.

From the cohort, 51% of live births were male individuals and 9.2% were low birthweight infants (less than 2,500 grams). Concerning delivery characteristics, 4.3% were preterm labor (22 to 36 weeks of gestation); 97.7%, singleton pregnancies; 48.1%, normal deliveries and 49.1%, cesarean sections. In relation to maternal characteristics, the analysis indicated that 17.1% of live births were children of teenager mothers; 39.6% were first pregnancies; 62.1% of the mothers had no educational experience and/or less than 8 years of

TABLE 2
Neonatal Life Table
January – March 1993

Age (days)	n	Nqx	Lx	ndx	NLx	Tx	ex (days)
0	1	0.00700	100,000	700	99,650	2,758,598	27.6
1 - 6	6	0.00752	99,300	747	593,560	2,658,948	26.8
7 - 13	7	0.00189	98,553	186	689,221	2,065,388	21.0
14 - 20	7	0.00073	98,367	72	688,318	1,376,167	14.0
21 - 27	7	0.00063	98,295	62	687,850	687,850	7.0

Source: See text.

school attendance and only 7.3% had university level.

In the live birth cohort, there were 2,955 deaths among children aged less than 28 days, which corresponds to a probability of neonatal mortality of 17.6 per 1,000. From that figure, practically 82% of deaths occurred in the first seven day of life. Out of this percentage, 39.6% of deaths took place during the first 24 hours and 42.3% were children aged between one and six days; the other deaths (18.1%) occurred between 7 and 27 complete days of life.

The Neonatal Life Table

Based on these data, a Neonatal Life Table was built. It corresponds to the generation of live births between January and March of 1993 (Table 2). Considering these probabilities of death, one can note that the risk of death is extraordinarily high in the first day of life. Such risk sharply decreases as the child ages: the probability of dying during the first week of life (which reaches 7.00 per 1,000) is eleven times higher than the one corresponding to the forth week (reaching 0.63 per 1,000).

A comparison between these probabilities and the estimations by ORTIZ (1982), for a cohort of live births of 1976, has shown that neonatal mortality in São Paulo declined 50% during the period. The frequency of infants dying in their third and forth weeks of life were the probabilities reporting the highest reduction (84 and 78%, respectively); the risk of dying in the first day dropped by only 31% (Table 3).

Therefore, children from the cohort of live births in the period between January-March of 1993, survive in the average 27.6 days. This figure represents a survival rate of 98% in the neonatal length of life. Moreover, it is worth pointing out the fact

TABLE 3
Neonatal Life Table
1976 and 1993 (*)

Ages	Probabilities of death (**)		Reduction
(days)	1976	1993	(%)
0	10.06	6.96	-30.8
1 - 6	12.11	7.48	-38.2
7 - 13	5.45	1.88	-65.5
14 - 20	4.50	0.73	-83.8
21 - 27	2.85	0.63	-77.9

(*) It corresponds to the cohort of live births
Between January and March of 1993
(**) per 1,000 live births
Source: ORTIZ 1982

TABLE 4
Probabilities of death per groups of causes according to the child's age at the time of death

Age	Probabilities of Death*				
(days)	Total	Groups of Death Causes Eliminated			
	Qx	Qx.a	qx.b	qx.c	qx.d
0 – 6	1,452.0	1,452.0	1,271.3	1,209.8	873.5
< than 1	700.0	700.0	575.3	557.4	460.0
1 – 6	752.0	752.0	695.6	651.8	411.9
7 – 13	189.0	188.4	175.7	172.1	61.2
14 – 20	73.0	73.0	69.4	70.6	15.8
21 – 27	63.0	63.0	60.0	61.8	10.9
Total	1,768.0	1,767.4	1,568.5	1,506.7	958.8

*Per 100,000 live births.
Source: See text

that the infants who manage to reach their seven days of life will survive the remaining 21 days of the neonatal period.

"Avoidable" Mortality

To better analyze the hypotheses on the impact of eliminating the causes of death over neonatal mortality, the $q_{x.j}$ were calculated, that is, the probabilities of death which would be registered as deaths by avoidable diseases were eliminated through: (a) "immunoprevetion", (b) "appropriate control during pregnancy", (c) "appropriate attention during delivery" and (d) "prevention, early diagnosis and medical treatment". Table 4 presents these probabilities of death, and Table 5, the corresponding relative risks.

The possible elimination of deaths by avoidable diseases through "appropriate control during pregnancy" would represent a reduction of almost 10% in the probability of neonatal mortality, which would drop from 1,768.0 to 1,568.5 per 100,000. Such reduction is inversely proportional to aging. The probability of death in the first day of life would be reduced by almost 20%; while the one corresponding to the fourth week of life would decrease only 5%, dropping from 63.0 to 60.0 per 100,000.

The high percentages attributed to the probable reduction of early neonatal mortality, mainly during the first 24 hours of life, illustrate the magnitude of the problems related to prenatal assistance in São Paulo. Presumably, there were difficulties in the timely identification of cases that could be treated and minimized during gestation. For instance, it is the case of neonatal deaths by asphyxia, included in this group, which are due to poor health attention.

In the hypotheses of eliminating deaths from the group of avoidable diseases through "appropriate attention during delivery", neonatal mortality would decline by 15%, dropping from 1,768.0 to 1,506.7 per 100,000. Such reduction would be of 20% among children aged less than one day and would reach 2% among children in their fourth week of life.

Based on these figures and on the probable high reductions in neonatal mortality by such causes, the quality of health assistance in the State is a questionable issue, specially in what concerns perinatal attention, in terms of availability of technological resources or technical teams and professional ethics (LEITE et al. 1997). In this sense, some studies have signalized the problems that may derive from such circumstances, in which factors linked to the full operation of institutions have been crucial at the moment of delivery, inclusively nullifying the valuable benefits of prenatal care (TANAKA 1995).

The unsatisfactory quality in delivery assistance may be partially attributed to the diminishing in availability of obstetric vacancy which, in the least, causes a delay in the hospitalization of the parturient (GOMES 1995). Concerning this subject,

TABLE 5
Relative risks per groups of death causes eliminated according to the child's age at the time of death

Age (days)	Relative Risks – Groups of Death Causes Eliminated			
	$q_{x.a}$	$Q_{x.b}$	$q_{x.c}$	$Q_{x.d}$
0 - 6	1.00	0.88	0.83	0.60
< than 1	1.00	0.82	0.80	0.66
1 – 6	1.00	0.93	0.87	0.55
7 – 13	1.00	0.93	0.91	0.32
14 – 20	1.00	0.93	0.97	0.22
21 – 27	1.00	0.95	0.98	0.17
Total	1.00	0.89	0.85	0.54

Source: See text

TANAKA (1995) has pointed out that uncertainty about being sent or not to a referral maternity leads pregnant women to wander about from hospital to hospital seeking assistance at the time of delivery. CARVALHO (1993), in a study of the Metropolitan Region of Rio de Janeiro, has observed that from all patients' medical records examined: 50% had no record about gestational history, prenatal care or delivery; 21% had no record about anamneses or physical examination and, 40% had no record about auscultation of the fetal heart during delivery labor. In addition, a high proportion of deaths was considered reducible through adequate control of pregnancy and delivery.

If deaths included in the group of avoidable diseases were totally eliminated through "prevention, early diagnosis and medical treatment measures", the probability of neonatal death would reach 958.8 per 100,000, representing a reduction of over 45%. These data demonstrate that such reduction increases with the child's age at the time of death. Among children aged less than one day, the probability of death would decrease practically 35%; while among children in their fourth week of life, this probability would be reduced by over 80%.

The high relative risk of death by avoidable diseases through "prevention, early diagnosis and medical treatment" indicates that perinatal attention in São Paulo presents dramatic problems. According to LEITE et al. (1997), it also suggests the lack of a regional healthcare system in which the quality of the system's health units would be precisely defined and, in specialized centers, would assure reference for risk pregnancies. Due to the complexity and variety of diseases included in this group, together with the participation of the health sector, it is necessary to engage other sectors of the governmental scope in order to eliminate and/or reduce such diseases.

5. Conclusion

The concatenation of data base systems of deaths and live births avails new perspectives for the analysis of infant mortality, specially in what concern deaths occurring in the child's first days of life.

It promotes a significant improvement in the quality of data, namely the variables with high proportion of ignored factors such as educational experience of the mother and birthweight, in the case of infant mortality. Besides, it allows the estimation of death probabilities based on a cohort, which is essential for the construction of a Neonatal Life Table for a generation of live births in the State of São Paulo, in the period between January and March of 1993.

The mortality pattern derived from these data is a high probability of death in the first days of life, which rapidly falls as the child ages. A comparison between these probabilities of death and the ones estimated for 1976 has shown that, during this period, the most significant mortality rate occurred in the third and fourth weeks of life.

The present study has shown that it is feasible to reduce by 83% the probability of death of infants aged four weeks, in the hypotheses of eliminating diseases from the reducible group through "prevention, early diagnosis and medical treatment"; among children aged less than one day, such reduction in mortality would be of only 35%.

Finally, it is necessary to stress that studies on infant mortality gain new perspectives of analysis as probabilities of death are directly estimated by the infant's age. Similarly, the use of competing risk models enables the deepening of such analyses by causes of death, determining the exact magnitude of the reduction which would be reached if certain diseases were eliminated as a risk of death. These data are of vital importance to make, for example, projections of mortality rates.

6. References

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