The Information System on live births in Brazil, 1997: on the quality of birth weight and gestational age data

Carla J. Machado and Kenneth Hill
The Johns Hopkins University
Bloomberg School of Public Health,
Baltimore, Maryland, USA

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Main Author:	Carla J. Machado
Address of the Main Author:	The Johns Hopkins Bloomberg School of Public Health 615 North Wolfe Street, 4th Floor Baltimore, MD, 21205 U.S.A *email: cmachado@jhsph.edu*

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ABSTRACT

This research seeks to assess the data quality on birth weight and gestational age based on a set of selected indicators. Live births were classified by whether or not they had missing information on gestational age, birth weight and according to their classification as measured by the Lubchenco/Colorado Fetal Growth Standards. The association was also explored by Brazilian Great Regions. The validity of the these data was assessed by verifying, for example, the proportion of male preterm births in relation to female preterm births. In light of data quality, figures were contrasted to what has been suggested by the literature as expected in a pool of live births. Births with missing data on gestational age were more prevalent in the Metropolitan Areas, in the Southeast Region and at lower birth weights. Births with missing data on birth weight were more prevalent in the Northeast Region, in the Non-Metropolitan Areas and at earlier gestational ages. Births outside the growth standards were more likely in the Northeast and in the Southeast and less likely in the South.

Introduction

The Information Systems on Live Births – SINASC – was developed by the Ministry of Health and designed to improve the quality of information on live births in Brazil [1] and to motivate the use.and the analysis of data currently generated by hospitals [2]. It has already been noticed that a means of enhancing the quality of data is to aim for primary data – data that come into the system directly from the source and for a great deal of medical information, especially diagnosis assignment, the source of data should be the care provider [3].

For the first time, since 1990, there were data collected in a mandatory, compulsory basis on very important questions from the standpoint of public health, such as birth weight and gestational age, characteristics related to mother and the labour, and pregnancy. The variables include date of birth, infants'sex, plurality, color, father's name, mother's name, mother's education, attendance and place of delivery, delivery mode, number of prenatal visits, number of children live born, number of stillbirths and number of abortions, Apgar score, birth weight and gestational age.

Another plus is that this system is able to capture more births than the Vital Registration System. It has been effectively used in São Paulo State since 1990, exactly five months after it had been officially launched [4], and in Belo Horizonte since 1992 [1]. In general, the system was implemented at different dates and at different paces in each State of Brazil.

The aim of this paper has is to provide information about the validity and completeness of this official Information System, by means of a study of some variables of this state record birth file, with particular attention to the dependability of birth weight and gestational age data, extremelly useful in perinatal epidemiology. Sex of infant and maternal age were also considered in combination with birth weight and / or gestational age outcomes, in this effort to assess the validity of this routinelly collected information. Also, birth weight and gestational age by selected categories were taken into consideration along with delivery mode (vaginal or cesarean delivery).

A brief literature review about some key determinants of gestational age and birth weight is presented. Second, the usefulness of analysis of liveborn infants based on vital records is discussed. Third, some limitations of the data used will be presented, along with the methodology used. Finaly, we attempt to characterize the validity and reliability of vital records, followed by the discussion and conclusions.

Background: Birth Weight and Gestational Age

Low birth weight (less than 2,500 g) is a major public health problem, contributing substantially both to infant mortality and to childhood handicap. The principal determinant of low birth weight in developed countries, and in a lesser extent in the developing countries, is preterm delivery (less than 37 weeks gestation), a phenomenon of largely unknown etiology [5].

Low birth weight is the central biological mediator of the relationship of social class and economic conditions to infant mortality in industrialized countries[8]. Virtually all of the several indicators of parents' social position (occupation, educational achievement, income, marital status) which are associated with infant mortality exercise their effect in part by altering the birth weight distribution. In developing countries it is likely that the mechanism that translates into low birth weight is poor nutrition. There is evidence about direct and indirect effects of maternal undernutrition in the regulation of fetal growth[6]. The direct supply of nutrients is to provide building blocks for tissue is a component of this regulation. But, there is another component, which exerts and indirect effect in the fetal growth. Adaptation to altered substrate supply, during both undernutrition and refeeding, involves sequential changes in the metabolic and endocrine interactions between the fetus and the placenta[9], which may be dangerous for the fetus. It means that periods of undernutrition followed by refeeding can also be harmful for the fetus and an inference is that the ideal situation would be one in which the pregnant mother were never deprived of food.

Preterm delivery is usually analyzed in association with low birth weight, since most preterm infants (less than 37 weeks' gestation) are usually low birth weight. It is recognized that birth weight is governed by two major considerations: (1) the duration of gestation and (2) the intrauterine growth rate [7]. Consequently low birth weight may be caused by a short gestation (prematurity), intrauterine growth restriction, or a combination of the two. The causal determinants differ for intrauterine growth restriction and prematurity [10].

In biomedical science, splitters view a clinical condition as a heterogeneous collection of homogeneous subgroups, while lumpers view the same condition as an entity in itself. The majority of studies now make a difference between preterm and small-for-gestational-age birth and the option is clear towards the 'splitters' side [8].

Length of gestation, taken as a measure of fetal age, and ultimately of the infant born alive, is the necessary antecedent of fetal growth that produces birth weight. Only in special circumstances could one consider reversing the logical order of the two variables of fetal age and fetal growth – for instance, a small or seriously impaired infant might be delivered prematurely[9]. With the causal structure in mind that fetal age antecedes fetal growth, and weeks' gestation antecedes birth weight at the time of delivery, it becomes evident that fetal age, and age at the time of delivery of a live born is an outcome of study in its own right [12].

A related issue is debated in the literature. Several reports suggest that intrauterine growth restriction is more common in preterm than in term infants, consistent with the hypothesis that intrauterine growth restriction is significantly related to preterm birth [10]. In a recent study, pregnancy induced hypertension was found to be more associated with preterm than with term IUGR[11]. This factor has to be taken into consideration, since the distribution of smaller babies would be more concentrated in the group of preterm births. If this is true one has to be cautious since small for gestational age infants would be a more frequent outcome in preterm infants relatively to term infants and a distinction would need to be done between the two categories.

In summary, many studies in the literature refer to low birth weight only without specifying gestational age [12]. In terms of consequences, birth weight enwraps a large part of the effects of growth restriction. Low birth weight owed to restricted growth on the one hand, and to premature delivery on the other, poses risks for perinatal mortality that may not differ enough to matter [12].

But, the issue is still unsolved. Graphical methods based on a non-parametric version of Poisson regression provided some evidence that neonatal mortality rates should be adjusted for both birth weight and gestational age[12].

Across the sexes, from about the 28th week of gestation onwards, the male fetus is heavier than the female for given gestational age at birth. Yet the sexes are often combined in a single gestational-age-specific birth weight distribution and in such a distribution, it should be a norm that any birth weight threshold for growth must assign more girls than boys to the category of growth restriction[12, 13].

For low birth weight, stillbirths and neonatal mortality, overall results show that women of 35 years and more had higher risks than younger women, and primiparous were also at higher risk than the multiparous [12]. In addition older women tend to bear very large infants[12] since mean birth weight for primiparous births is consistently lower than for multiparous births. These systematic differences in the mean birth weight of women of different parity were argued to be largely mediated by maternal weight[12] (roughly speaking, the older the mother, the higher the parity, the higher her weight). However, several studies have shown independent effects of age and parity on birth weight [14, 15, 16].

Data suggest that there is a reduced birth weight among immature still-growing adolescents as a result of a decreased net availability of nutrients and/or an inability of the placenta to function adequately for active fetal growth, which results in retarded fetal growth[17]. The hypothesis is that among rapidly growing teenagers the nutritional requirements of maternal growth may be greater than those of older women, and that this increased requirement competes with the growth needs of the fetus[18].

However, results are contradictory. A recent study explored three possible hypotheses for reduced birth weights of infants born to US adolescent mothers –

social disadvantage, biologic immaturity, and unhealthy behaviors during pregnancy. The results indicated that the reduced birth weights of infants born to young mothers, particularly women aged 14 to 17, were related to their disadvantaged social environment [19]. In another study, when education, residence, height and weight were controlled, no uniform pattern of risks for youthful childbearing persists [20].

The Usefulness of Vital Records

The birth registration system has already proved to be an excellent source of information to evaluate live birth outcomes. It provides the data necessary to plan and evaluate programs designed to improve maternal and child health[1]. The ability of monitoring the trends in births and its characteristics in a given country, state or region is extremelly important and it is highly desirable that the information collected in birth certificates reflects current needs[1]. Another advantage of utilizing an existing database which decribes the entire population of a geographical area is that it increases the generalizability of the findings.

An example of study which made use of routinelly collected database examined the morbidity and mortality associated with intrauterine growth restriction (IUGR) using the Vermont Oxford Network database – which requires a neonate to have between a birth weight between 501 and 1,500 g to be entered, without respect to gestational age – showed that IUGR within the range of 501 to 1,500g birth weight is associated with increased risks of neonatal death, necrotizing enterocolitis and respiratory distress syndrome (RDS) [21]. This kind of study is critical, and should be carried on in developing countries, since initial evidence has suggested that IUGR was associated with reductions in the incidence of RDS and intraventricular hemorrhage. This supported a view of IUGR as an adaptive reaction to adverse intrauterine conditions, that through the initiation of a fetal stress response, led to improvements in gestational-age specific neonatal morbidity [24].

In Brazil, some studies have been conducted with SINASC and SIM (Information Systems on Mortality) [22, 23, 24]. There was one study [8] which analysed the variables in the birth records as risk factors of small for gestational age infants, and with a view to discovering if restricted intrauterine growth was a risk factor for neonatal mortality, in Santo André county in the São Paulo Metropolitan Area, 1992. The authors found that the small for gestational age live births showed a higher risk of neonatal death, even when allowing for gestational age [8].

Unfortunatelly, a disadvantage of this approach is the uncertain quality and reliability of vital records data [25], especially in the context of a developing country. SINASC, is very much likely to experience the same type of advantages and drawbacks.

Meaningful research in perinatal public health requires a sound knowledge of the quality and completeness of the data used. Characterization of vital records files, the only source of population-wide perinatal data, has obvious importance in this light [28]. A study in Brazil has looked at some inconsistencies within the birth records, for 1995, coutrywide [26]. For instance, there were 469 mothers over 59 years of age and 2,441 with less than 10 years of age [29]. One objective of this paper is to investigate the completeness and accuracy of individual items within the birth files. The primary reason for this is the fact that knowing the reliability of birth records is essential in perinatal mortality research which utilizes birth and death data physically combined to produce consolidated files, required for studies based in birth cohorts, avoiding the problems of inference based on cross-sectional data. In this paper, particular attention was given to the dependability of birthweight and gestational age data.

Description of the data and limitations imposed by the data

The intervals used for birth weight and gestational age were imposed by the data. Data was dowload from the website www.datasus.gov.br, and we were unable, at this point, to have access to have timely access to the original and individualized records. We built this database combining several two-by-two tables. In case of gestational age, it would not make any difference, since all lengths of gestation, even at the individual level, are reported according to a code that refers to a group of weeks' gestation and form five basic category: 20 completed weeks or less, 21 to 27 completed weeks, 28 to 36 completed weeks, 37 to 41 completed weeks. Durations of gestation above 41 completed weeks were, initially, grouped together to produce a truncated curve. It is easy to see that the grouping of intervals under 42 weeks is such that some 90 per cent of all births cluster in the single interval 37 to 41 weeks. For reliabilty and missing records analyses the births were truncated at 37 weeks and more.

Because of our inability to separate the singleton from the multiple births, we were unable to study the hazards of the post - term pregnancy. It has been documented that the median weights of twins were progressively lower than median weights for single-born infants during the late gestation [27]. Fetal growth has been shown to be independent of litter size until about the 30th week of gestation and after that multiple fetuses show an increasing weight deficit. After 33 weeks' gestation, twin weights are clearly less than singleton weights. At term, mean weights for twins are approximately ten per cent lower than single born infant's values [28].

The intervals we used for birth weight were imposed by the grouping available from the downloaded data, since, in reality, data is not collected in such a manner. Initially, all weights above 4,000g were grouped together to produce a truncated curve. However, we are able to have the data grouped in such a manner that the extremelly low birth weight infants(less than 500g), the very low birth weight (500 to 1,499g) and the low birth weight (1,500 to 2,499g) were distinguished. Also, the insufficient weights (2,500 to 2,999g) were distinguished from those infants weighing (3,000 to 3,999g).

The available measure of weeks' gestation, duration of pregnancy, could be unrealiable because the last menstrual period is imprecisely recalled and reported. But in these data, duration of pregnancy was calculated from the record of last menstrual period made before delivery of the child, and this method stands up under validity tests against other criteria [29].

Information on maternal age was grouped in 10 to 19, 20 to 34, and 35 and above. One limitation of this study was our inability to separate the effects of aging from parity, since we do not have information on parity on this available data set. It is known that for low birth weights (less than 2,500g), women of 35 years and above had higher risks than younger women, and women bearing their first child were also at higher risk than those who had borne other children. The risks of age and parity, being additive, were considerable for a first delivery in older woman[12]. But all we can evaluate is the effect of age, not adjusted for parity, or confounded by parity.

On the other hand, no factor inherent in multiparity acts in favor over and above birth weight [12]. It means that multiparity, by itself, does not lead to higher birth weights. So, birth weight should be grouped regardless of parity, as long as we have the true source of the variability. One true source of this variability may be maternal weight. There is evidence that it is fair to suppose that the mortality risk with parity is a function of birth weight (mediated by the mutable variable maternal weight, which tends to increase with parity, and, therefore, with age). But maternal weight is also an unobserved variable[12]. In this situation, birth weights would be also an expression of parity (higher birth weights for higher parities due to higher maternal weight). But, again, parity is an unobservable variable.

However, it has to be borne in mind that parity can be a mediator of socioeconomic status and birth weight in two ways. If higher parity translates into lower socioeconomic status and its effects translates into low birth weight, the effect of parity in low birth weight outcome could be diluted.

Information for infant’s sex was available and used for the consistency checks of the database.

Information on delivery mode (vaginal delivery, cesarean delivery, other than vaginal or cesarean) was also available. Information on forceps delivery, other delivery mode, and unknown were grouped to form a unique category, since the percentages of occurrence of each were very small.

Since Brazil is a very heterogeneous country, analyses were not only conducted countrywide, but also by Region (North, Northeast, Southeast, South and Center-West), which are composed of more homogeneous States in terms of their socioeconomic characteristics. Analyses were also conducted by Metropolitan Area (North: Belem; Northeast: Salvador, Natal, Recife, and Fortaleza; Southeast: Rio de Janeiro, Sao Paulo, Baixada Santista, Vitoria, and Belo Horizonte; South: Curitiba, and Porto Alegre).

Finally, information on delivery attendance(hospital, clinic/health center, home delivery) were also available and we also used this information to assess the improvement of vital records, the change over time of the per cent of non-stated (or ignored, or unknown), by each characteristic, since missing data were not imputed.

Methods

Data for 1994, 1995 and 1996 and 1997 were used in order to verify changes in completeness within the vital records over time. The variables of interest were already presented and described.

Only data on liveborns in 1997 were used for subsequent analysis. Pearson's chi-square was used for the contingency tables.

All variables were treated as categorical. There were four dummy variables for maternal age, according to each group of interest: 10 to 19, 20 to 34, 35 and above and age not specified.

There are five dummy variables for Region, one for each Region.

There are twelve dummy variables for Metropolitan Area, as well as a dummy variable representing if the birth did not occur in a Metropolitan Area.

Also there was a dummy variable for any birth occurring in any Metropolitan Area, regardless of Region, and a dummy variable for births occurring outside Metropolitan Areas, regardless of Region. In this specific analysis, where all births were considered if they belonged to any Metropolitan Region, a dummy variable for the Center West Region was included.

The analyses were conducted using STATA (version 6) software.

RESULTS

Completeness of Data : 1994 to 1997

During the four-year period, all reported births in Brazil were analysed regarding the completeness of the selected items: birth weight, gestational age, place of delivery (hospital, clinic/health center, home delivery), delivey mode, child's sex and mother's age. The information on number of births and the level of completeness for each item, calculated as a percentage of the total number of births in each year, countrywide, are in Table 1 and Table 2.

TABLE 1
Number of Records with Missing Data by Item
BRAZIL, 1994-1997

	YEAR			
DATA ITEM	**1994**	**1995**	**1996**	**1997**
BIRTH WEIGHT	390,458	53,401	49,918	47,394
GESTATIONAL AGE	507,669	763,952	707,078	110,502
PLACE	413,183	699,159	636,141	9,440
DELIVERY MODE	393,053	41,471	36,236	28,039
SEX	28,716	11,066	14,082	5,156
MOTHER'S AGE	133,174	78,917	82,416	67,330
TOTAL NUMBER OF BIRTHS IN THE YEAR	2,571,571	2,824,729	2,929,041	3,022,619

Source: DATASUS/SINASC, Brazil, 2000 – Ministry of Health
Website: www.datasus.gov.br

TABLE 2
Percentage of Records with Missing Data by Item
BRAZIL, 1994-1997

	YEAR			
DATA ITEM	**1994**	**1995**	**1996**	**1997**
BIRTH WEIGHT	15.2	1.9	1.7	1.6
GESTATIONAL AGE	19.7	27.1	24.1	3.7
PLACE	16.1	24.8	21.7	0.3
DELIVERY MODE	15.3	1.5	1.2	0.9
SEX	1.1	0.4	0.5	0.2
MOTHER'S AGE	5.2	2.8	2.8	2.2

Source: DATASUS/SINASC, Brazil, 2000 – Ministry of Health
Website: www.datasus.gov.br

It is clear that the completeness within the birth records has been increasing substantially since 1994. The reporting can be considered essentially complete in 1997, ranging from 0.17 per cent for sex, (5,156 live births) to 3.66 per cent for gestational age (110,502 live births). It is striking the fact that for gestational age and place of attendance the change in the proportion of completed records was enormous comparing 1997 with previous years. It is of interest to understand the reason of these changes. In Table 3 and Table 4 we can observe that in case of place of attendance the smaller proportion of missing records with this information decreased was due, almost exclusivelly, to the fact that more births were registered as hospital deliveries. We may go a step further and suggest that births with missing place of attendance in 1994, 1995, and 1996 were, almost them all, hospital deliveries, a conclusion that follows from Table 4. Another feature is that the improvement from 1996 to 1997 in birth reporting was not restricted to births who took place in hospitals, but was spread over the different places of attendance, as seen in Table 5. At the same time the number of births in the category 'ignored' declined consistently in this time period.

TABLE 3
Number of Births by place of attendance
Brazil, 1994-1997

	Year			
Data Item	**1994**	**1995**	**1996**	**1997**
Hospital	2,066,966	2,042,261	2,218,879	2,917,854
Other health facility	58,931	54,064	46,123	61,608
Home	30,059	27,743	26,701	31,858
Other	2,432	1,502	1,197	1,859
Ignored	413,183	699,159	636,141	9,440
Total	2,571,571	2,824,729	2,929,041	3,022,619

Source: DATASUS/SINASC, Brazil, 2000 – Ministry of Health
Website: www.datasus.gov.br

TABLE 4
Proportion of total births by place of attendance
Brazil, 1994-1997

	YEAR			
Data Item	**1994**	**1995**	**1996**	**1997**
Hospital	*80.4*	*72.3*	*75.7*	*96.5*
Other health facility	*2.3*	*1.9*	*1.6*	*2.0*
Home	*1.2*	*1.0*	*0.9*	*1.1*
Other	*0.1*	*0.1*	*0.1*	*0.1*
Ignored	*16.1*	*24.9*	*21.7*	*0.3*
Total	*100.0*	*100.0*	*100.0*	*100.0*

Source: DATASUS/SINASC, Brazil, 2000 – Ministry of Health
Website: www.datasus.gov.br

TABLE 5
Annual Percent Change in the number of total births
By place of attendance
BRAZIL, 1994 to1997

	Time Period		
Data Item	**1994 to 1995**	**1995 to 1996**	**1996 to 1997**
Hospital	*-1.2*	*8.6*	*31.5*
Other health facility	*-8.3*	*-14.7*	*33.6*
Home	*-7.7*	*-3.8*	*19.3*
Other	*-38.2*	*-20.3*	*55.3*
Ignored	*69.2*	*-9.0*	*-98.5*
Total	*9.8*	*3.7*	*3.2*

Source: DATASUS/SINASC, Brazil, 2000 – Ministry of Health
Website: www.datasus.gov.br

However, we have to look more closely at differences among Regions. Table 6 presents the number of total births in each Region by place of attendance in 1996 and 1997 and Table 7 presents the percent change in this time period. It is clear that there was a decline in the number of ignored category, however, of only 22 per cent in the Northeast Region and and 37 per cent in the North Region, contrasting with more than 80 per cent in the South and Center West and almost 100 per cent in the Southeast Region. In the South Region, the only one with a real decline in the number of total births, the decrease was observed in every single place of attendance. The fact that, in the South, the decline in hospital births was the smallest one (less than the average) suggests that ignored births were actually hospital births and a trend of increasing toward hospital deliveries. In the Center West Region, the highest increase was observed in other health facilities which might be due to the effect of small numbers(from 352 to 481 births in 1997). In 1997, These births represented 0.2 per cent of all births in this Region. In the Southeast Region, the improvements in reporting were very significant in all places of attendance, which clearly reflects an overall betterment in reporting (or coding, or both) of this variable place of attendance.

TABLE 6
Number of Total Births by Place of Attendance - BRAZIL, 1994 to1997

	NORTH		NORTHEAST		SOUTHEAST		SOUTH		CENTER WEST	
	YEAR									
DATA ITEM	1996	1997	1996	1997	1996	1997	1996	1997	1996	1997
Hospital	215486	232291	740419	787372	555431	1,191828	470145	466133	237398	240230
Other h facility	18532	18771	16014	22850	9082	18236	2143	1270	352	481
Home	5733	6572	12746	16477	3154	4600	4024	3220	1044	989
Other	120	121	284	446	444	984	194	191	155	117
Ignored	380	240	1516	1182	631036	7469	2373	420	836	129
Total	240251	257995	770979	828327	1199147	1223117	478879	471234	239785	241946

Source: DATASUS/SINASC, Brazil, 2000 – Ministry of Health
Website: www.datasus.gov.br

TABLE 7
Annual Percent Change in the Number of Total Births
By place of attendance and by Time Period (1996 to 1997)
REGIONS of Brazil

Data Item	North	Northeast	Southeast	South	Center West
Hospital	*7.8*	*6.3*	*114.6*	*-0.9*	*1.2*
Other health facility	*1.3*	*42.7*	*100.8*	*-40.7*	*36.6*
Home	*14.6*	*29.3*	*45.8*	*-20.0*	*-5.3*
Other	*0.8*	*57.0*	*121.6*	*-1.5*	*-24.5*
Ignored	*-36.8*	*-22.0*	*-98.8*	*-82.3*	*-84.6*
Total	*7.4*	*7.4*	*2.0*	*-1.6*	*0.9*

Source: DATASUS/SINASC, Brazil, 2000 – Ministry of Health
Website: www.datasus.gov.br

In case of records with missing information on gestational age, the observed change in the proportion from 1994 - 1996 to 1997 was due, almost exclusivelly, to changes in the proportion of birth records with missing information in the Southeast Region and more specifically in the State of Sao Paulo, as shown in Tables 8 and 9.

TABLE 8
Number of Births with Missing Information on Gestational Age
By Region
Brazil, 1994-1997

	Year			
REGION	**1994**	**1995**	**1996**	**1997**
North	5,427	4,136	3,742	3,237
Northeast	54,694	39,526	43,871	42,426
Southeast	424,745	703,696	646,394	53,773
State of Sao Paulo	407,975	690,509	633,493	42,807
State other than Sao Paulo	16,770	131,87	12,901	10,966
South	12,658	7,682	6,819	5,460
Center – West	10,145	8,912	6,252	5,606
Total	507,669	763,952	707,078	110,502

Source: DATASUS/SINASC, Brazil, 2000 – Ministry of Health
Website: www.datasus.gov.br

TABLE 9
Percentage of Births on the Total Births with Missing Information on Gestational Age
In each Region
Brazil, 1994-1997

REGION	Year			
	1994	**1995**	**1996**	**1997**
North	2.5	1.8	1.6	1.3
Northeast	8.9	5.4	5.7	5.1
Southeast	39.5	61.7	53.9	4.4
State of Sao Paulo	68.8	99.9	90.6	6.1
State other than Sao Paulo	4.4	2.9	2.6	2.1
South	2.7	1.6	1.4	1.2
Center West	5.4	3.7	2.6	2.3
Total	*19.7*	*27.0*	*24.1*	*3.7*

Source: DATASUS/SINASC, Brazil, 2000 – Ministry of Health
Website: www.datasus.gov.br

This is not a surprising finding. Some General Offices of Health (Secretarias Estaduais de Saude) prioritized some variables and not others. This was very problematic in the State of Sao Paulo in 1995 [29]. Even though some birth records were completely filled in, only six variables were systematically typed: *date of birth*, *sex*, *birth weight*, *delivery mode*, *mother's age* and *mother's residency* [29]. A recent report about quality of Perinatal Data Systems in the United States states that to date a major obstacle to a correct data entry has been a reluctance, or inability, to type [30]. This problem was expected to be completely solved in 1997, and that seems to be the case, given results presented in Table 8 and Table 9.

Completeness of Data: 1997

Birth records were shown to be considerably more complete, countrywide, in 1997. The completeness of reporting, however, varied considerably by Regions, as it can be seen by the distribution of records with missing information by Region, for each selected item (Table 10 and Table 11).

TABLE 10
Distribution of Records with Missing Information, for each Item
By Region _ Absolute Numbers
Brazil, 1997

Data Item	North	Northeast	Southeast	Center West	South	BRAZIL
BIRTH WEIGHT	3,037	22,700	18,182	2,204	1,271	47,394
GESTATIONAL AGE	3,237	42,426	53,773	5,460	5,606	110,502
PLACE OF ATTENDANCE	240	1,182	7,469	420	129	9,440
DELIVERY MODE	929	8,677	16,451	1,150	832	28,039
SEX	481	2,601	1,517	112	445	5,156
MATERNAL AGE	7,231	39,085	13,071	4,080	3,853	67,330

Source: DATASUS/SINASC, Brazil, 2000 – Ministry of Health
Website: www.datasus.gov.br

TABLE 11
Proportion of Records with Missing Information in relation to number of births in each region
Brazil, 1997

	REGION				
Data Item	**North**	**Northeast**	**Center West**	**Southeast**	**South**
BIRTH WEIGHT	1.2	2.7	0.9	1.5	0.3
GESTATIONAL AGE	1.3	5.1	2.3	4.4	1.2
PLACE OF ATTENDANCE	0.1	0.1	0.2	0.6	0.03
DELIVERY MODE	0.4	1.1	0.5	1.4	0.2
SEX	0.2	0.3	0.1	0.1	0.1
MATERNAL AGE	2.8	4.7	1.7	1.1	0.8

Source: DATASUS/SINASC, Brazil, 2000 – Ministry of Health
Website: www.datasus.gov.br

There is no apparent reason to explain why it would be the case that the missing birth records, in general, are so low in the North and Center-West Regions, which include the Amazon Rain Forest, making access to health facilities and registrar's offices much harder, and, therefore, the reporting of vital events more difficult as well. It has been shown that, still, in some localities in Brazil, births are not all registered and this is particularly true for the Northeast, North and and Center West Region [29]. This suggests the possibility of selection bias, where the reported births do represent a highly selected population who have access to health facilities, where SINASC was implemented in a timely fashion. If this is the case, the results from analysis of SINASC can not be fully generalized.

DATA QUALITY

Miscoded Births

In Brazil, 1997, there were 90,954 infants whose birth records lacked gestational age information, but did not lack birth weight information. Of those with recorded gestational age, 16,657 had gestational age inferior to 28 completed weeks' gestation. Since we are dealing with the quality of the birth records, it is of interest not only to compare of births which lacked gestational age information to those with complete information, but also to investigate if there was any miscoding of infants who were born under 28 weeks' gestation. As a general rule, high weights for these early infants can be considered outside the range of biological plausibility [28]. At this point it is important to understand to which biological parameters we will be comparing the study population.

Classification of High Risk Infants by Birth Weight and Gestational Age according to the Colorado System

The Colorado classification of newborn infants was devised as a method of defining infants according to birth weight, gestational age, and pattern of intrauterine growth [31]. Data came from 5,635 live born Caucasian infants at 24 to 42 weeks' gestation who were admitted to Colorado General Hospital from July, 1948, to January, 1961 [32]. It has been largely used as a standard curve, since the sample is sufficiently large, particularly in the smaller weight groups, to present weight curves in the form of percentiles [35].

A limitation in estimating intrauterine growth from the weight of infants who have been born at various gestational ages is an undeterminable bias because premature birth itself is probably related to factors other than physiological states of variable duration in either mother or fetus [35]. The weight of fetuses who remain in utero cannot be measured. The question is how the fetuses expelled from the uterus are different from those who remain in utero.

Another potential bias would be the population used to build the growth chart, which could be very different from the live born in Brazil. However, infants of Spanish American parents composed 30 per cent of the Colorado sample. No signifcant differences were present between the mean weights of these American infants and the other Caucasian races at each week of gestation [35].

A recent study made use of the 1994 – 1996 United States Natality Files to calculate distribution percentiles of birth weight for each gestational age. The authors calculated the 10^{th}, 50^{th} and 90^{th} percentiles [33]. The results did not differ much from the Colorado growth chart and they also agree that values below 24 weeks and above 42 weeks should be viewed cautiously, as their accuracy is more suspect, even though the birth weight percentiles they presented range from 20 to 44 weeks [36]. They also report the inherent limitation related to the exclusion of fetal deaths in the investigation, which may well have a different pattern of fetal growth compared to live births. Further, as some preterm deliveries may result from factors that also influence fetal growth, data such as the Colorado data may not accurately estimate the longitudinal growth patterns of normal fetuses that reach each term [36].

It is worth while mentioning that a study conducted in Trent to produce current data on survival of preterm European and Asian live births excluded infants of less than 22 weeks' gestation as there were no survivors in this group [34]. Actually, the variation in birth weight specific mortality by week of gestation was apparent from as early as 24 weeks' gestation, which corroborates the idea of using 24 weeks as the starting point [37].

Based on intrauterine growth for gestational age, the Colorado 10th and 90th percentiles of intrauterine growth encompass 80 per cent of births. Those infants with birth weights over the 90th percentile are large for gestational age, and those with birth weights bellow the 10th percentile are small for gestational age [34]. The differences of about 100 g between the weights of boys and girls was considered quite small when compared to the range of weights at any gestational age. Therefore, curves combining the weights of boys and girls were presented [35] and will be the standard growth curve for this paper.

Nine groups of newborn infants were defined and coded, as in Table 12.

TABLE 12:Classification of Colorado Newborns by Intrauterine Growth Standards

Gestational Age (in weeks)	Birth Weight (in percentile)	Classification
Less than 38	Above the 90th percentile	Preterm Large for Gestational Age
Less than 38	Between 10th and 90th percentile	Preterm Appropriate for Gestational Age
Less than 38	Below 10th percentile	Preterm Small for Gestational Age
Between 38th and 42nd week	Above the 90th percentile	Term Large for Gestational Age
Between 38th and 42nd week	Between 10th and 90th percentile	Term Appropriate for Gestational Age
Between 38th and 42nd week	Below 10th percentile	Term Small for Gestational Age
At or after 42nd week	Above the 90th percentile	Post-Term Large for Gestational Age
At or after 42nd week	Between 10th and 90th percentile	Post-Term Appropriate for Gestational Age
At or after 42nd week	Below 10th percentile	Post-Term Small for Gestational Age

Source: Lubchenco, L. O. The High Risk Infant. W. B. Saunders Company, Philadelphia, 1976 (page 4)

A full explanation and specified values for each gestational age corresponding birth weight percentile can be seen in the original article [34]. In order to make things clearer, examples of values are as follow:

- At 28th week gestation, the 10th smoothed percentile of the Colorado curve is 860 g and the 90th smoothed percentile is 1,550 g.. So, we expect weights for these infants born at 28 th to gather between 860 g and 1,550 g.
- At 36th week gestation, the 10th smoothed percentile of the Colorado curve is 2,753 g and the 90th smoothed percentile is 3,390 g. So, we expect weights for these infants born at 36 th to gather between 2,753 g and 3,390 g.
- At 37th week gestation, the 10th smoothed percentile of the Colorado curve is 2,866 g and the 90th smoothed percentile is 3,520 g. So, we expect weights for these infants born at 37 th to gather between 2,866 g and 3,520 g.
- At 38th week gestation, the 10th smoothed percentile of the Colorado curve is 3,025 g and the 90th smoothed percentile is 3,640 g. So, we expect weights for these infants born at 38 th to gather between 3,025 g and 3,640 g.

However, we were unable to use growth charts directly, since all available values for birth weight and gestational age were grouped. Besides, we were unable to distinguish between singleton and multiple births. Even though we faced all these constraints, an attempt of classification of the live borns from Brazil was made, based on a carefull observation of the Colorado growth curve. The results can be seen in Table 13. More than 90 per cent of all births were considered within the Colorado birth growth standards and less than one per cent of the births were considered miscoded by understimation of gestational age.

TABLE: 13: Classification of Birth Records According to Colorado Birth Growth Standards
Absolute Numbers and Percentages
BRAZIL, 1997

Gestational Age (in weeks)	Birth Weight (in grams)	Most Probable Classification, According to Colorado Birth Growth Standards*	Number Of Records	Percentage Excluding Ignored
Less than 28	Less than 1,500	Within Colorado Appropriate for Gestational Age Growth Standards (Yes)	7,300	0.25
Less than 28	1,500 to 2,499	Error in Calculation of Gestational Age Probably Associated with Post-Conceptional Bleeding (Not at all*)	2,806	0.10
Less than 28	2,500 to 2,999		1,674	0.06
Less than 28	3,000 and above		4,377	0.15
28 to 36	Less than 1,500	Pre-Term Small for Gestational Age (Not Really*)	14,459	0.50
28 to 36	1,500 to 2,499	Within Colorado Appropriate for Gestational Age Growth Standards (Yes)	54,703	1.90
28 to 36	2,500 to 2,999	Within Colorado Appropriate for Gestational Age Growth Standards (Yes)	28,533	0.99
28 to 36	3,000 and above	Pre-Term Large for Gestational Age (Not Really*)	31,944	1.11
37 and above	Less than 1,500	Post-Term Small for Gestational Age (Not Really*)	4,858	0.17
37 and above	1,500 to 2,499	Small for Gestational Age(Not Really*)	137,160	4.76
37 and above	2,500 to 2,999	Within Colorado Appropriate for Gestational Age Growth Standards (Yes)	599,584	20.79
37 and above	3,000 and above	Within Colorado Appropriate for Gestational Age Growth Standards (Yes)	1,996,873	69.23
YES			2,686,993	93.16
NOT AT ALL			8,857	0.31
NOT REALLY			188,421	6.53
Total			*2,884,271*	*100.00*

Note: *This is clearly an approximate classification. The original Colorado classification of Newborn infants made use of discrete and not grouped information and 10th and 90th percentiles of intrauterine growth [34]. In this attempt, "Yes" means that we can consider those birth records reliable."Not at all" means that the births are clearly miscoded, and "Not Really" means that they are, in all probability, miscoded, but there would be still a possibility that they might have not been miscoded.

Source: DATASUS/SINASC, Brazil, 2000
Website: www.datasus.gov.br

Another way of presenting the births coded as 28 weeks' gestation or less in comparison with all the births for whom gestational age was coded is in Figure 1. For the short gestation births (less than 28 weeks), more than 50 per cent of these births had miscoded birth weight (greater than 1,500 g.), and, curiously, more than 20 per cent were coded as having birth weights between 3,000 and 3,999 g. This finding was similar to one of a study on the completeness of data in birth files, for the State of North Carolina,United States [28]

Figure 1 – Frequency Distributions of Report Birthweights in Two Subsets of Birth Records. Brazil, 1997

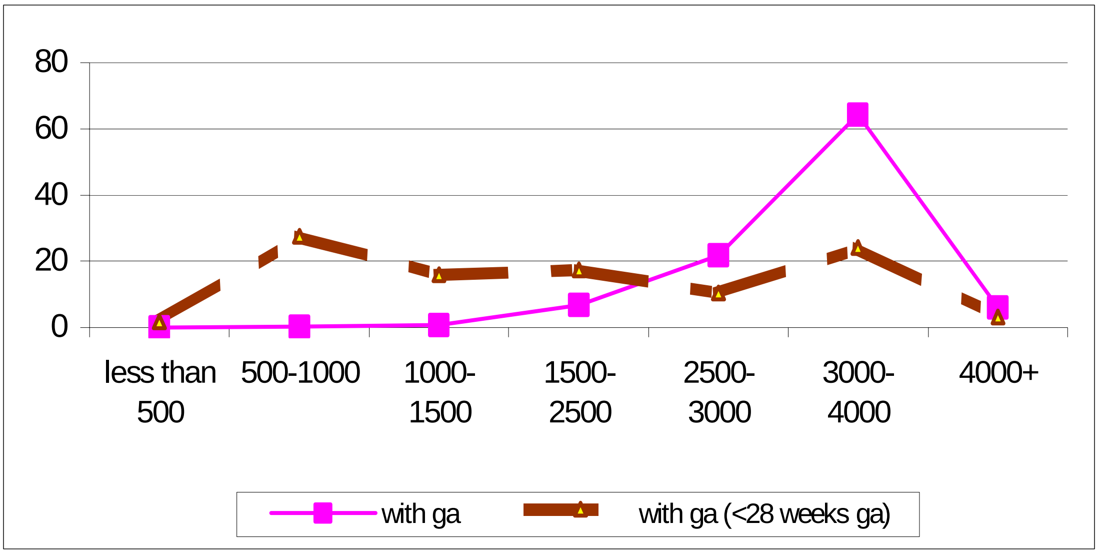
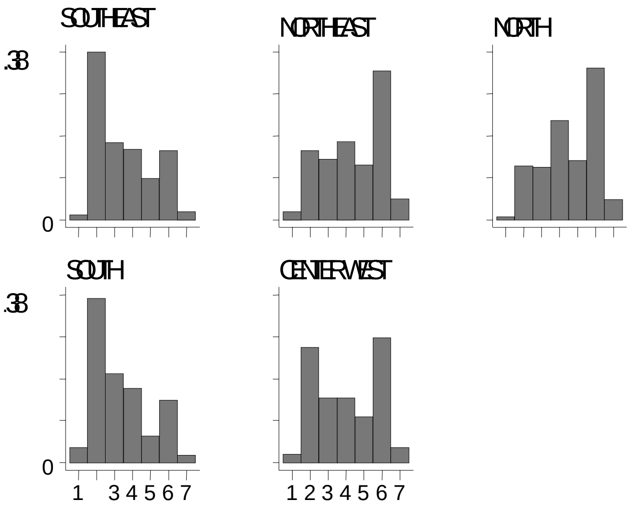


Figure 2 reveals that the distribution of short gestation live births, by the same categories of birth weights as in Figure 2, is quite discrepant among Regions. In the South and Southeast Regions, the distribution of live births is much more ‘reasonable’, since higher proportion of infants are within the limits of viability (equal or less than 1,500 g) and the



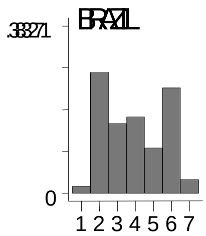


Figure 2
Earlier Births (27 weeks or less), Brazil and Regions, 1997
Center West (N=1242), South (N=2835), North (N=894),
Northeast (N=4742), Southeast (N=5894)

mode of the distribution is at 500g to 999g. In the North and Northeast Regions, the mode is clearly in the range 3,000 to 3,999 g, reflecting the poor quality of these records. In the Center West, the distribution is bimodal, and it becomes difficult to distinguish between births centered around the two modes of the distribution. Previous studies have reported a bimodality of weight distribution in preterm infants at each gestational age which has been attributed to errors in gestational assessment [35].

For all Regions, the proportion of miscoded births is considerable. Even in the South Region, the one with the most acceptable distribution, there is a late peak on the 3,000 to 3,999g. Table 14 shows the distribution of the birth records by selected characteristics.

It is possible that the wide distribution at early gestational ages in the present study is due to errors in the estimation of pregnancy duration as calculated from the last menstrual period. Another less probable possibility is a bias towards the birth weights at the range 3,000 to 3,999g, given an accurate estimation of gestational age. Inacurrate reporting of gestational age has been consistently observed in different studies [28, 36, 37]. Even the parental recall of birth weight was shown in a very recent study to be good across the social classes and up to 16 years after delivery [38]. Also, a true biologic variability is unlikely given the results by Region, since there is no reason for the ‘true biologic variability’ to cluster in some specific Regions (North, Northeast, Center-West) and not in others (Southeast and South).

TABLE 14: Comparison of birth records according to Colorado Birth Growth Standards By selected Characteristics ABSOLUTE NUMBERS BRAZIL, 1997

Characteristics		Within Colorado Birth Growth Standards? Not really	Yes	Not at all (unreliable)	TOTAL
AREA	METROPOLITAN	*76,332*	*891,087*	*1,713*	*969,132*
	NON-METROPOLITAN	133,546	1,682,113	6,495	*1,822,154*
	Total	*209,878*	*2,573,200*	*8,208*	*2,791,286* [b]
REGION	NORTH	20,461	222,952	1,311	244,724
	NORTHEAST	51,745	677,286	2,956	731,987
	SOUTHEAST	90,551	1,034,726	2,436	1,127,713
	SOUTH	32,400	422,704	897	456,001
	CENTERWEST	14,721	215,532	608	230,861
	Total	*209,878*	*2,573,200*	*8,208*	*2,791,286* [b]
DELIVERY MODE	VAGINAL	131,046	1,071,250	5,700	1,638,696
	CESAREAN	78,832	1,501,950	2,508	1,152,590
	Total	*209,878*	*2,573,200*	*8,208*	*2,791,286* [b]
AGE	10 – 19	56,015	595,210	2,338	653,563
	20 –34	133,209	1,773,267	5,207	1,911,683
	35 and above	20,654	204,723	623	226,040
	Ignored	4,784	50,497	341	55,622
	Total	*214,662*	*2,623,697*	*8,549*	*2,846,908* [c]

Notes: *b*: Exclusion of 231,333 records (7.7% of the total records) with ignored birth weight weight, gestational age, mother's age, delivery mode other than vaginal or cesarean.
c: Exclusion of 175,711 records (5.8% of the total records) with ignored birth weight gestational age and delivery mode other than vaginal or cesarean.

Source: DATASUS/SINASC, Brazil, 2000
Website: www.datasus.gov.br

TABLE 15: Comparison of Birth Records according to Colorado Birth Growth Standards By Selected Characteristics PERCENTAGES BRAZIL, 1997

Characteristics		Within Colorado Birth Growth Standards? Not really	Yes	Not at all (unreliable)	Relative risk (not at all)
AREA*	METROPOLITAN**	*7.9*	*91.9*	*0.2*	1.0
	NON-METROPOLITAN	7.3	92.3	*0.4*	2.0
	Total	*7.5*	*92.2*	*0.3*	
REGION*	NORTH	8.4	91.1	0.5	2.7
	NORTHEAST	7.1	92.5	0.4	2.1
	SOUTHEAST	8.0	91.8	0.2	1.1
	SOUTH**	7.1	92.7	0.2	1.0
	CENTERWEST	6.4	93.4	0.3	1.3
	Total	6.9	92.9	0.2	
Delivery Mode*	VAGINAL	10.8	88.7	0.5	3.0
	CESAREAN**	5.0	94.9	0.2	1.0
	Total	*7.5*	*92.2*	*0.3*	
AGE*	10 – 19	8.6	91.1	0.4	1.3
	20 –34**	7.0	92.8	0.3	1.0
	35 and above	9.1	90.6	0.3	1.0
	Ignored	8.6	90.8	0.6	2.3
	Total	*7.5*	*92.2*	*0.3*	

Note: *All comparisons within categories were found significant at p<0.001 (Pearson's chi-square).
** Baseline for relative risks. Differences due to rounding of the last decimal place.
Source: DATASUS/SINASC, Brazil, 2000
Website: www.datasus.gov.br

In 1997, the Northeast Region had the highest proportion of births with uncoded birth weight, gestational age, sex and maternal age. The Southeast Region had the highest percentage of births with uncoded place of attendance and delivery mode. On the other hand, the South Region had the lowest percentage of uncoded births for all variables.

According to selected characteristics (except vaginal delivery), more than 90 per cent of the records are within the Colorado Standards and can be considered reliable records.

The probability of unreliable records in a non-metropolitan area is twice the probability of unreliable records in the metropolitan areas. However, there is a higher probability of births in the metropolitan areas to be “not really” within the growth standards.

The comparison accross Regions reveals that in the North Region, higher proportion of births are classified either as ‘not really’ or ‘unreliable’ . The Southeast Region has the second highest percentage of births not really within the growth standard, and the Northeast Region has the second highest percentage of births classified as unreliable. The Center West Region has the highest percentage of births within the growth standards.

Regarding delivery mode, comparing births delivered by vaginal mode with c-section births, we can see that it is more than twice as likely for a vaginal birth not to be in the growth standards. A clue to understand these differences may rely on socioeconomic status and care provided to the preganant women. A study in the Lazio region, in Italy has shown that the highest cesarean delivery rates were observed in private and semi private maternity units and that the increase in cesarean section rates was associated with the woman’s method of payment and with characteristics of care available in the maternity units, independently of medical factors 39. In a cohort study 40, in California, United States, higher cesarean section rates were found among women with higher socioeconomic status independently of maternal age, parity, birth weight, race, ethnic group, or complications of pregnancy and childbirth 43. So, c-section may be acting as a confounder for the the causal relationship between being born in a facility with a worse care and the the issue of an unreliable records and a ‘not so’ reliable record. In private and semi private facilities we can expect records to be more reliable.

Maternal age reveals that there is higher proportion of normal births among women 20 to 34 years of age in comparison to the other age groups and the ‘ignored’ category. The finding that births of younger mothers are more likely than those of older mothers to have unreliable records seems fairly reasonable, since the irregularities of menstrual cycles for adolescents may play a role in the definition of the last menstrual period (LMP). This would result in higher probability of inconsistencies at this age range.

It is important to understand that we are dealing with the best possible records, given the data set available and the variables available for study. We excluded as many records with missing information as possible. By doing that, we were trying to have some insights about how the the best birth records would be distributed across variables and if it would differ if we would not have excluded the records with at least one piece of missing information. However, there were no meaningfull differences between the analyses with or without the records with missing information, so which table should be used for presentation and analysis was a matter of choice. We choose the exclusion of missing records. This was done to try to expurgate the 'not as good records' and try to have an idea closer to the truth about what might be going on. Of course, this is subject to critique and one can be anticipated: the *Procedure Bias* we might be introducing. The ideal procedure would eliminate the bias caused by the exclusion of records with missing information without introducing other bias due to the method used to generate the tabulations [41].

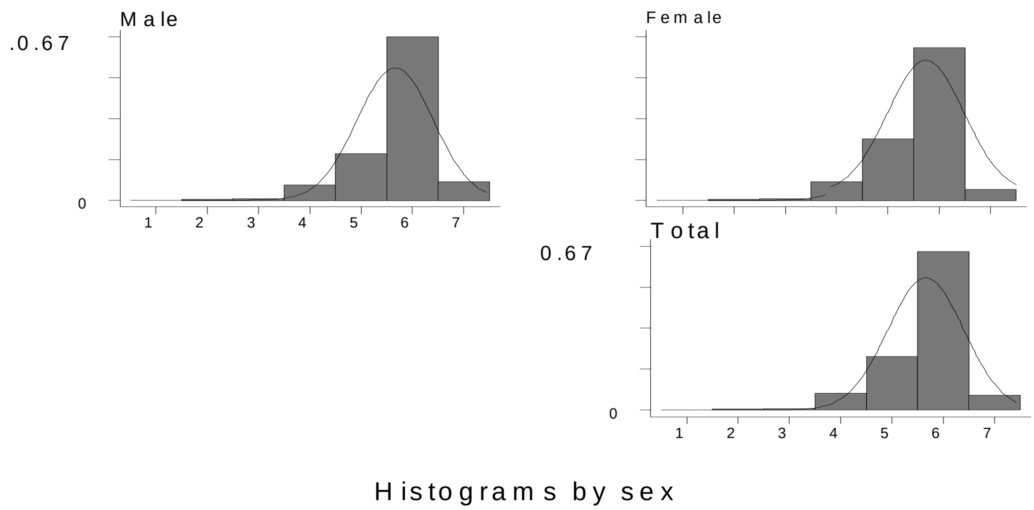
In summary, there is small proportion of miscoded births countrywide (0.3% of all births) and they are more concentrated in the poorest Regions, Northeast and North. Even though they were miscoded, and the records unreliable, we can infer that much of this miscoding is related to a natural inability of the mother to identify the LMP. This inability is understandable in the context of younger mothers whose menstrual cycles are not as regular as in older mothers. There may also be due socioeconomic effects: younger mothers are likely to be of lower socioeconomic status, as we have concluded from the distribution of records regarding age and delivery mode.

In order to continue trying to assess the validity of the birth records, we will analyze the distribution of birth weight and gestational age information by sex of child.

Sex, Birth Weight and Gestational Age

Another indicator of validity of the data can be given by the analysis of birth weight distribution, by sex of infant, as seen in Figure 3.

Figure 3 – Distribution of infants by birth weight, by each sex. Brazil, 1997 (n for males = 1,546,281; n for females = 1,471,632)



It has long been recognized that females are more likely than males to weigh less than 2,500 g despite the fact that males are more often born at gestational ages less than 37 weeks [42]. Lower female birth weight can be observed in Figure 3 and Table 16 and Table 17. Also, in Figure 4, we see that all three curves follow an expected Wilcox – Russel distribution [12], where the birth weight distribution is made up of a main and a residual distribution. The distribution of birth weight can be described as essentially Gaussian, but slightly peaked and with additional births in the lower tail, which has been recognized for many years. In terms of methodology, the mean and the standard deviation of the predominant distribution are estimated by truncating the observed distribution of births at a point above the range in which the residual distribution is assumed to lie. Different authors have selected the truncation point empirically, between

2,500 and 2,700 grams[43]. Once the predominant (Gaussian) distribution has been estimated, the residual distribution can be characterized. In 1983 the innovative work by Wilcox and Russel [48] has shown that the predominant component, a Gaussian distribution is composed largely of term births and the residual component is composed of a collection of small preterm births.

A Gaussian distribution was identified on this grouped data (excluding missing birth weight), where a considerable residual portion of births falls outside the lower tail. Also, among births bellow 2,500 g, 36 per cent were less than 37 weeks' gestation, whereas among those at least 2,500 g, only two percent were less than 37 weeks' gestation (results not shown), which means that these data follow the expect pattern suggested by the literature [12, 48].

TABLE 16: Comparison of male and female birth records by selected aspects within birth weight and gestational age variables Absolute Numbers_BRAZIL, 1997

Characteristics		SEX		
INTERCEPT		**Male**	**Female**	**Total**
Gestational Age	**Ignored**	46,336	44,181	90,517
	Known	1,472,774	1,402,105	2,874,879
	Total	1,519,110	1,446,286	2,965,396 [a]
	Less than 28 weeks	72,618	66,936	139,554
	28 weeks and above	1,400,156	1,335,169	2,735,325
	Total	1,472,774	1,402,105	2,874,879 [b]
Birth Weight	**Ignored**	13,596	12,799	26,395
	Known	1,472,774	1,402,105	2,874,879
	Total	1,486,370	1,414,904	2,901,274 [c]
	Less than 2,500 g	102,261	118,711	220,972
	2,500 g and above	1,370,513	1,283,394	2,653,907
	Total	1,472,774	1,402,105	2,874,879 [b]

Notes: *a*: Exclusion of 57,223 records (1.9% of the total records) with ignored sex and birth weight. *b*: Exclusion of 147,740 records (4.9% of the total records) with ignored sex, birth weight and gestational age. *c*: Exclusion of 121,345 records (4.0% of the total records) with ignored sex and gestational age.

Source: DATASUS/SINASC, Brazil, 2000
Website: www.datasus.gov.br

TABLE 17: Comparison of male and female birth records by selected aspects within birth weight and gestational age variables.
Percentages
BRAZIL, 1997

Characteristics		SEX		
INTERCEPT		**Male**	**Female**	**Total**
Gestational Age	**Ignored**	3.05	3.05	3.05
	Known	96.95	96.95	96.95
	Total	*100.00*	*100.00*	*100.00*[a]
	Less than 28 weeks	4.93	4.77	4.85
	28 weeks and above	95.07	95.23	95.15
	Total	*100.00*	*100.00*	*100.00*[b]
Birth Weight	**Ignored**	0.91	0.90	0.91
	Known	99.09	99.10	99.09
	Total	*100.00*	*100.00*	*100.00*[a]
	Less than 2,500 g	6.94	8.47	7.69
	2,500 g and above	93.06	91.53	92.31
	Total	*100.00*	*100.00*	*100.00*[b]
Sex Ratio at Birth	**Known gestational age and birth weight**		*1.050*	
	Ignored gestational age		*1.049*	
	Ignored birth weight		*1.062*	

Notes: *a*: No significant differences at p=*0.10* (Pearson's chi-square).
b: Significant differences at p < *0.001* (Pearson's chi-square)
Source: DATASUS/SINASC, Brazil, 2000
Website: www.datasus.gov.br

The analyses of the missing records for birth weight and gestational age do not reveal any bias (or systematic error) towards male or female births. These results are also shown in Table 16 and Table 17. The analyses for each Region, (results not shown) reveal the same expected pattern. Also, the birth ratios at birth are fairly reasonable, around 1.05 and 1.06. We can conclude that the report on gestational age by sex is not differential between those infants who had gestational age information and others who did not, which reflect an accurate report of sex in the birth records. The same can be said for birth weight.

Analysis of Birth Weight Missing Records by Metropolitan Area, Region, Delivery Mode, Gestational Age, and Mother's Age

In a recent review about improvement of vital records it was said that the best way to handle missing data is to treat it as a specific category of the variable under consideration [44]. An unacceptable approach to missing data is to assign the average cohort value because infants with missing values on their birth certificate are rarely average in terms of their risk profile [49]. In this section and in the next one we will be trying to better understand the profile of the birth records with missing information on birth weight and see if they are really high risk births, as it has been suggested [40, 49].

By choosing records with a simple missing variable as opposed to multiple missing variables, we can examine the pattern of missingness specific to that variable. Records with missing birth weight only reflect a pattern of missingness specific to birth weight and records missing gestational age only reflect a pattern of missingness specific to gestational age. We have to admit, however, that we are dealing with the available information on these birth records. It may be that these records that we are considering as missing only one of these variables are also missing information on parity, number of abortions, Apgar score and others to which we do not have access. Also, we have to keep mind that the variables sex and delivery attendance were used before to make specific inferences, and were excluded from the analysis regarding distribution of high risk births.

Tables 18 and 19 show the major findings regarding birth weight information.

TABLE 18: Comparison of birth records according to Birth Weight By selected Characteristcs Absolute Numbers BRAZIL, 1997

Characteristics		Missing Birth Weight? NO	YES	TOTAL
AREA	METROPOLITAN	*967,419*	*4,811*	*972,230*
	NON-METROPOLITAN	1,815,659	19,399	1,835,058
	Total	*2,783,078*	*24,210*	*2,807,288[a]*
REGION	NORTH	243,413	2,313	245,726
	NORTHEAST	729,031	13,499	742,530
	SOUTHEAST	1,125,277	6,461	1,131,738
	SOUTH	455,104	984	456,088
	CENTERWEST	230,253	953	231,206
	Total	*2,783,078*	*24,210*	*2,807,288[a]*
DELIVERY MODE	VAGINAL	1,632,996	18,990	1,651,986
	CESAREAN	1,150,082	5,220	1,155,302
	Total	*2,783,078*	*24,210*	*2,807,288[a]*
Gestational Age	Less than 27 weeks	7,081	738	7,819
	27 to 36 weeks	125,339	1,895	127,234
	37 weeks and above	2,650,658	21,577	2,672,235
	Ignored	81,241	4,329	85,570
	Total	*2,864,319*	*28,539*	*2,892,858[b]*
AGE	10 – 19	651,225	5,538	656,763
	20 –34	1,906,476	15,919	1,922,395
	35 and above	225,377	2,753	228,130
	Ignored	55,281	2,248	57,529
	Total	*2,838,359*	*26,458*	*2,864,817[c]*

Notes: *a*: Exclusion of 215,331 records (7.1% of the total records) with ignored gestational age, mother's age , delivery mode other that vaginal or cesarean.
b: Exclusion of 129,761 records (4.3% of the total records) with ignored mother's age, delivery mode other than vaginal or cesarean.
c: Exclusion of 157,802 records (5.2% of the total records) with ignored, birth weight weight, gestational age and delivery mode other than vaginal or cesarean.

Source: DATASUS/SINASC, Brazil, 2000
Website: www.datasus.gov.br

TABLE17 : Comparison of birth records according to Birth Weight By selected Characteristics Percentages BRAZIL, 1997

Characteristics		Missing Birth Weight? (Risk or Incidence of "No" or "Yes" within each category) per 100 infants NO	YES	Crude Relative Risk of Missing BW in each characteristic Relative Risk (YES for missing BW)
AREA*	METROPOLITAN**	*99.5*	*0.5*	*1.0*
	NON-METROPOLITAN	98.9	1.1	*2.2*
	Total	*99.1*	*0.9*	
REGION*	NORTH	99.1	0.9	*4.5*
	NORTHEAST	98.2	1.8	*9.0*
	SOUTHEAST	99.4	0.6	*3.0*
	SOUTH**	99.8	0.2	*1.0*
	CENTERWEST	99.6	0.4	*2.0*
	Total	*99.1*	*0.9*	
DELIVERY MODE*	VAGINAL	98.9	1.1	*2.2*
	CESAREAN**	99.5	0.5	*1.0*
	Total	*99.1*	*0.9*	
Gestational Age*	Less than 27 weeks	90.6	9.4	*11.8*
	27 to 36 weeks	98.5	1.5	*1.9*
	37 weeks and above**	99.2	0.8	*1.0*
	Ignored	94.9	5.1	*6.4*
	Total	99.0	1.0	
AGE*	10 – 19	99.2	0.8	*1.0*
	20 – 34**	99.2	0.8	*1.0*
	35 and above	98.8	1.2	*1.5*
	Ignored	96.1	3.9	*4.9*
	Total	*99.1*	*0.9*	

Note: * All comparisons within categories were found significant at p<0.001 (Pearson's chi-square).
**Baseline for the calculation of the relative risk (or risk ratio)

Source: DATASUS/SINASC, Brazil, 2000
Website: www.datasus.gov.br

Table 16 shows the number of records with and without birth weight only and Table 17 shows the distribution of those records by the same selected characteristics used in the analyses of miscoded births plus gestational age. Selected births with coded birth weight are very concentrated in the Metropolitan Area (62 per cent) but births without information on birth weight are considerably more concentrated in the non-metropolitan area (79 per cent). It means that mothers whose residence were outside the large cities had their births poorer recorded than other mothers.

In this situation where mother's residence can be easily seen as the most probable place of occurence, we can suggest that maybe the maternity unities or health centers in the non-metropolitan areas had a worse reporting of these variable or there was a systematic problem in typing the variable, where it could have been skipped more easily than in metropolitan areas, due to inability of the the staff or not well trained personel.

Births whose gestational age was recorded are more concentrated in the Southeast Region and births who lack information on gestational age are more concentrated in the Northeast Region. No studies were found, at this point, about regional variation concerning missing records, but all studies so far have pointed out the association between a missing value for a given variable and the probability of this record to pertain to a high risk birth [2, 28, 33, 49]. Hence, being born in the Northeast Region would increase the likelihood of being a high risk birth, which would be expected since this Region is the poorest in Brazil. In 1970, it was found that the most developing countries had the highest incidence of infants of low birth weight and within countries, according to socioeconomic status, consistently lowering of birth weights was found in conditions of reduced income and poverty [34]. In a meta analysis conducted among singleton pregnancies occuring at the sea level without chronic illness based on search of English and French language medical literature from 1970 to 1984, socioeconomic status was considered with well established causal impact on intrauterine growth and gestational duration, with indirect effects, ie, whose impact is expressed through one or more direct factors (such as parity or cigarette smoking) [10].

Regarding delivery mode, if cesarean section really relates to higher willingness and ability to pay, as suggested in previous section, we can assume that we are dealing with poorer mothers in the missing records group, since almost 80 per cent of those births were delivered by vaginal mode.

The distribution of births with missing birth weight by gestational age in comparison to the more complete records reveals a clear pattern of higher risk births among the former. The figures show that 9.2 per cent of these births were preterm births, in comparing with 4.7 per cent preterm births among those with complete records. This corroborates other studies about the distribution of births with missing data [2, 28, 33, 49]. As expected the proportion of missing gestational age among the missing group is substantially higher.

Finally, 10.4 per cent of records with missing birth weight are concentrated in ages 35 and above, while for those records with stated birth weights, these percentage is 7.9. This is true for all Regions (results not shown). In Illinois, United States, analyses have consistently demonstrated that the adjusted risk for low birth weight at term is the lowest for teenagers and increases with advancing maternal age [45].

Summarizing, birth records with missing birth weight are more likely to belong to high risk infants. These records are more concentrated in the Northeast Region and at more advanced maternal ages, what, in the absence of a specific variable for parity may be capturing some of the effect of higher parities translated in lower socioeconomic status. We can not assume that records missing birth weight represent the same population as those records with completed information on birth weight.

Analysis of Gestational Age Missing Records by Metropolitan Area, Region, Delivery Mode, Birth Weight, and Mother's Age

Data presented in Tables 19 and 20 relates to complete birth records and records with no information on gestational age.

TABLE 19 : Comparison of birth records according to Gestational Age By selected Characteristcs _ Absolute Numbers _ BRAZIL,1997

		Missing Gestational Age?		
Characteristics		**No**	**Yes**	**TOTAL**
AREA	METROPOLITAN	*967,419*	*32,050*	*999,469*
	NON-METROPOLITAN	1,815,659	49,191	1,864,850
	Total	*2,783,078*	*81,241*	*2,864,319*[a]
REGION	NORTH	243,413	2,387	245,800
	NORTHEAST	729,031	30,126	759,157
	SOUTHEAST	1,125,277	39,520	1,164,797
	SOUTH	455,104	4,313	459,417
	CENTERWEST	230,253	4,895	235,148
	Total	*2,783,078*	*81,241*	*2,864,319*[a]
DELIVERY MODE	VAGINAL	1,632,996	53,370	1,686,366
	CESAREAN	1,150,082	27,871	1,177,953
	Total	*2,783,078*	*81,241*	*2,864,319*[a]
Birth Weight	Less than 1,500 g	25,922	1,573	27,495
	1,500 to 2,499 g	186,520	7,637	194,157
	2,500 g to 2,999	609,253	17,410	626,663
	3,000 and above	1,961,383	54,621	2,016,004
	Ignored	24,210	4,329	28,539
	Total	*2,807,288*	*85,570*	*2,892,858*[b]
AGE	10 – 19	651,225	19,241	670,466
	20 –34	1,906,476	55,031	1,961,507
	35 and above	225,377	6,969	232,346
	Ignored	55,281	4,506	59,787
	Total	*2,838,359*	*85,747*	*2,924,106*[c]

Notes: *a*: Exclusion of 158,300 records (5.2% of the total records) with ignored, birth weight, mother's age, delivery mode other that vaginal or cesarean.
b: Exclusion of 129,761 records (4.3% of the total records) with ignored mother's age, delivery mode other than vaginal or cesarean.
c: Exclusion of 98,513 records (3.3% of the total records) with ignored birth weight weight and delivery mode other than vaginal or cesarean.

Source: DATASUS/SINASC, Brazil, 2000
Website: www.datasus.gov.br

TABLE 20: Comparison of birth records according to Gestational Age By selected Characteristcs Percentages BRAZIL, 1997

Characteristics		Missing Gestational Age? (Risk or Incidence of "No" or "Yes" within each category) per 100 infants		Crude Relative Risk of Missing GA in each characteristic
		No	**Yes**	
AREA*	METROPOLITAN	*96.8*	*3.2*	*1.2*
	NON-METROPOLITAN**	97.4	2.6	*1.0*
	Total	*97.2*	*2.8*	
REGION*	NORTH	99.0	1.0	*1.1*
	NORTHEAST	96.0	4.0	*4.4*
	SOUTHEAST	96.6	3.4	*3.8*
	SOUTH**	99.1	0.9	*1.0*
	CENTERWEST	97.9	2.1	*2.3*
	Total	*97.2*	2.8	
DELIVERY MODE*	VAGINAL	96.8	3.2	*1.3*
	CESAREAN**	97.6	2.4	*1.0*
	Total	*97.2*	*2.8*	
Birth Weight*	Less than 1,500 g	94.3	5.7	*2.1*
	1,500 to 2,499 g	96.1	3.9	*1.4*
	2,500 g to 2,999**	97.2	2.8	*1.0*
	3,000 and above	97.3	2.7	*1.0*
	Ignored	84.8	15.2	*5.6*
	Total	*97.0*	*2.9*	
AGE*	10 – 19	97.1	2.9	*1.0*
	20 –34**	97.2	2.8	*1.0*
	35 and above	97.0	3.0	*1.1*
	Ignored	92.5	7.5	*2.7*
	Total	97.1	*2.9*	

Note: * All comparisons within categories were significant at p<0.001 (Pearson's chi-square).
**Baseline for the calculation of the relative risk (or risk ratio)

Source: DATASUS/SINASC, Brazil, 2000
Website: www.datasus.gov.br

By Table 20 we can observe those records with missing gestational age information are slightly more concentrated in the Metropolitan Areas (42 per cent) comparing to those complete records (37.9 per cent). Records in Southeast Region heavily weight this percentage, especially because of records in Sao Paulo State, as discussed before. Hence, it is not surprising information that almost 50 per cent of all records cluster in the Southeast Region. Also, 37.1 per cent of the records with missing gestational age are in the Northeast Region, and among those with this information the percentage is 26.2.

As already seen in the analyses of unreliable records and records with missing information on birth weight, records with missing gestational age are more common among vaginal deliveries.

Regarding distribution by birth weight, complete records are significantly less concentrated among births that weight less than 2,500 g and also less concentrated on the category of missing information on gestational age.

The percentage of women 35 and above among those births with missing gestational age information is higher relatively to those births with complete information, even though the distirbutions do not seem to differ that much. No surprisingly, infants with non-stated gestational ages are more likely to have missing information on maternal age.

To sum up, the records with missing gestational age are more likely at cluster at lower birth weights, revealing a profile of higher risk births.They are also more concentrated at more advanced and at missing values of maternal age and are more likely to occurr at Southeast and Northeast Regions. Again, we can not assume that records with missing gestational age information represent the same population as those records with completed information on gestational age.

Conclusion

By doing this exercise we hope we would have pointed out some strengths and limitations of the SINASC system. The strengths refer to the fact that there is for the first time some data essential from the perinatal and epidemiological standpoint, and there is now possibility of keep tracking the births in a more comprehensive way.

Limitations concern to the reliability of some records and also to the missingness of important information, on birth weight and gestational age, in other group of records. Reliability was assessed by internal verification, or validation, of those records, on the basis of the literature search of range of possible combinations of birth weight and weeks'gestation. Missing information problems were identified in all Regions, especially in the Northeast, with a clear pattern of high risk births. As a key message, any imputation of data based on complete records should be very carefully done, considering patterns and specificities of missing values for specific variables in each setting.

There is urgency for more systematic research with these database, including other variable, such as parity, plurality, and prenatal care which are now easily available on the web to the researchers at this point, in order to assess and clarify the potential causes of the mistakes and absence of complete information.

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