Original article

Completeness and reliability of the National Mortality Information System for perinatal deaths in Brazil, 2011-2012: a descriptive study*

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Abstract

Objective: to analyze the completeness and reliability of data on perinatal deaths held on Brazil's Mortality Information System (SIM) in 2011-2012. **Methods:** this was a study evaluating the quality of completeness of data on perinatal deaths reported on SIM compared to data from the 'Birth in Brazil' survey for the same period; to evaluate reliability, we used the Kappa coefficient, the intraclass correlation coefficient (ICC) and the Bland-Altman plot method. **Results:** completeness was greater than 80%, and agreement was 0.61 for 10 of the 12 evaluated fields; aggregated gestation length (Kappa coefficient=0.542) and continuous gestation length (ICC=0.448) for early neonatal deaths and fetal deaths, respectively, had regular agreement; graphical evaluation of gestation length showed that the fetal death metric was underestimated and that early neonatal deaths were overestimated by between 25 and 35 weeks of gestation. **Conclusion:** the information analyzed available on SIM for perinatal deaths is complete and reliable for the period analyzed.

Keywords: Date Accuracy; Vital Statistics; Perinatal Mortality; Information Systems; Death Certificates.

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Introduction

In order to measure the magnitude of perinatal mortality, systematic and reliable case recording is essential. In Brazil this is done via the Mortality Information System (SIM), based on the information obtained from death certificates. This information is relevant for assessing causes of death, identifying and understanding the risk factors involved, informing priorities for public health policies and prevention strategies.[1,2] However, it is possible to use the perinatal mortality rate as a direct indicator of vital statistics in only eight of the twenty-seven Federative Units due to underrecording of fetal deaths and low quality of data registered on death certificates.[3]

The absence and the low reliability of information available on SIM hamper the construction of indicators and analysis of factors related to the occurrence of perinatal death, especially with regard to maternal characteristics and socioeconomic variables. National studies[1,4-6] have highlighted the shortcomings in recording information and the need to improve the quality of information available on Brazilian official vital statistics. Comparing this information with hospital medical records is one of the ways of evaluating information quality, which is commonly investigated through reliability and completeness studies.[7]

In the first decade of the 21st century, the degree of adequacy of vital statistics improved throughout the country, especially in the Northern and Northeastern regions.[6] The quality of information available on the Brazilian Live Birth Information System (SINASC) was also found to be better - in relation to SIM -[8] for live births when compared to the information on stillbirths.[9]

Comparing this information with hospital medical records is one of the ways of evaluating information quality, which is commonly investigated through reliability and completeness studies.

The low reliability of data on perinatal deaths available on SIM highlights the need for investigations into information quality. The objective of this study was to analyze the completeness and reliability of data on perinatal deaths held on Brazil's Mortality Information System (SIM) in 2011-2012.

Methods

This was a descriptive study analyzing the quality of completeness of data on perinatal deaths reported on SIM, compared to the data from the "Birth in Brazil" (*Nascer no Brasil*): National Survey on Child Delivery and Childbirth'. It is national hospital-based study of puerperal women and their newborn babies, conducted between February 2011 and October 2012.

The study was carried using a probabilistic sample, selected in three stages. The first stage related to hospitals, stratified by the country's macroregions (North, Northeast, Southeast, South and Midwest), location (capital; interior) and type (public, private and mixed); [10.11] within each stratum, probability of hospital selection was proportional to size (the same sample size of 90 puerperal women corresponded to each hospital within each stratum). In the second stage, an inverse sampling method was used to quantify the time needed to achieve the number of mothers to be interviewed in each hospital (days needed to achieve the number of 90 puerperal women in each establishment). The third stage related to puerperal women and their fetuses (quantity of puerperal women to be selected per day, depending on the number of births, survey shifts and interviewers, per hospital and per day).[10]

In the first stage of the survey, face-to-face interviews were conducted with puerperal women, data was collected from their medical records and from those of their babies, and their antenatal care record booklets were photographed. Telephone interviews were conducted 45 days after delivery, to collect data on maternal and neonatal outcomes, including neonatal death.[11]

Perinatal death was considered to be death occurring before birth, with effect from the 22nd week of pregnancy and/or birth weight ≥500g until the 6th full day of life.[3] Deaths were identified during the interview with puerperal woman, from medical records or during follow-up by telephone. Subsequently, we paired the survey data we collected with SIM data for 2011-2012, in order to identify perinatal deaths occurring in hospitals that participated in our survey and which had not been identified during our field work, either because of refusal or due to loss owing to early hospital discharge. For the purposes of analysis, the variables available on SIM and the variables we collected through our survey were considered to be:

- Sex of dead fetus/baby;
- Maternal age;
- Maternal schooling;
- Number of children born alive
- Number of fetal losses/miscarriages
- Type of pregnancy
- Type of delivery;
- Gestation length;
- Child delivery-related death;
- Birth weight; race/skin color; and
- Underlying cause of death.

With effect from 2011, the gestation length began to be recorded on death certificates as the number of gestational weeks. Prior to that this information was recorded in six bands: less than 22; 22-27; 28-31; 32-36; 37-41; and 42 or more gestational weeks.[2] In this study we found information held on SIM in both formats and as such we opted for continuous and categorical analysis. In our survey, gestation length was obtained by means of an algorithm which calculated gestational age at birth, combining the date of last menstruation and obstetrical ultrasound performed between 7 and 20 weeks of gestation.[12]

Information system completeness refers to the degree of completeness of each field examined, measured by the ratio between complete and incomplete fields.[13] In our study we evaluated data completeness according to the classification proposed by Romero & Cunha:[14] excellent (above 95%); good (90-95%); regular (80-90%); poor (50-80%); and very poor (below 50%). The 'ethnicity/skin color' variable was evaluated only for early neonatal deaths, since this field is not filled out in the case of fetal death.[2] When necessary, we applied statistical tests (Pearson's chi-square test or Fisher's exact test) to evaluate differences between fetal deaths and early neonatal deaths. A 0.05 significance level was used.

Categorical variable reliability was assessed by the degree of agreement as measured by the Kappa coefficient, while ordinal variable reliability was assessed using quadratic weighted Kappa,[15] and respective 95% confidence intervals (95%CI). Agreement was qualified according to the following scale: poor (<0.00); low (0.00-0.20); reasonable (0.21-0.40); regular (0.41-0.60); good (0.61-0.80); almost perfect (0.81-0.99); and perfect (1.00).[16]

For the continuous variables - maternal age, gestation length and birth weight -, we calculated the intraclass correlation coefficient (ICC) and respective 95%CI. For the continuous variables we also used the method proposed by Bland-Altman, namely a scatter chart, on which the absolute differences (the ordinate axis) and the averages of the measurements (the abscissa axis) are plotted, to assess graphically the magnitude of the disagreements between continuous measurements, limits of agreement, systematic errors or patterns, and to identify outliers.[17]

All analyses were performed for perinatal deaths and their fetal and early neonatal components. The statistical analyses were applied using SPSS version 22.0 and MedCalc version 16.6.4.

The research project 'Birth in Brazil: National Survey on Child Delivery and Childbirth' was approved by the Research Ethics Committee of the Oswaldo Cruz Foundation National School of Public Health (No. 92/10). Our study was also approved by the same Committee, Opinion No. 1,356,170 (Certificate of Submission for Ethical Appraisal [CAAE] No. 49356915.5.0000.5240), dated 8 December 2015. The research proposal was explained prior to each interview, and women who agreed to participate, or those responsible for underage puerperal women, signed a Free and Informed Consent Form, which also authorized review of medical records and contact by telephone after the postpartum period.

Results

The final sample was comprised of 23,894 women selected from 266 hospitals. Four hundred and twenty Five perinatal deaths were identified, of which 245 (57.6%) were fetal deaths. We assessed the degree of SIM data information completeness of 383 of the 425 deaths, given that 42 deaths (9.9%) found in our survey were not identified on SIM after pairing: 26 fetal deaths and 16 early neonatal deaths. Two hundred and ten deaths (49.4% of the total) were included in the analysis of reliability since information was recorded on them both by the 'Birth in Brazil'' survey and also on the SIM system.

The levels of completeness for perinatal deaths were greater than 95% (excellent) for sex and basic cause of death, and between 50% and 80% (poor) for maternal schooling and number of fetal losses/miscarriages. No significant differences were found between the completeness of fetal deaths and early neonatal deaths for the variables analyzed (Table 1). There was one case of fetal death classified as a non-fetal death on SIM, and one case of early neonatal death classified as fetal death.

Almost perfect agreement was found for perinatal deaths in relation to type of pregnancy (Kappa=0.942), type of delivery (Kappa=0.979) and sex (Kappa=0.947). When assessing each component of perinatal death (fetal death and early neonatal death), we found that categorical gestation length and the number of children alive had better agreement for fetal death than for early neonatal death. Among fetal deaths the variable with the worst agreement was the number of fetal losses/miscarriages, although agreement was considered reasonable (Kappa=0.348); with regard to early neonatal deaths, this variable was classified as regular (Kappa=0.633) (Table 2).

The intraclass correlation coefficient (ICC) showed less variability for maternal age, number of children born alive and birth weight, classified as almost perfect agreement; gestation length (continuous analysis), in spite of having shown lower agreement than the other variables, was considered good (ICC=0.673) for perinatal deaths. Regular agreement was found for gestation length among fetal deaths (ICC=0.448), and almost perfect agreement among early neonatal deaths (ICC=0.925) (Table 2).

The Bland-Altman scatter graph of birth weight showed that most of perinatal deaths had near-zero differences and a positive mean difference line (17.8 grams), well distributed along the abscissa, with variability of approximately 1,000g (95%CI-478,7;507.3) and outliers in both directions. With regard to the maternal age variable, most of points were around zero and around mean difference. A series of points was noted close to the lower standard deviation limit, indicating underestimation of this variable by 1 year on SIM (Figure 1).

The gestation length variable (Figure 2) showed high amplitude of differences between the measurements (95%CI -15.4;20.6) for fetal deaths. On average, the information contained on SIM showed underestimation of the gestation length in relation to the gestational age calculated by our survey (2.6 weeks). In the case of early neonatal deaths, there was less variability between the confidence interval limits (95%CI -6.2;5.6), and mean differences close to zero (0.3 weeks). The concentration of points below zero difference for pregnancies lasting 25 to 35 weeks on average indicates overestimation of the gestation length in SIM data for this gestational age range.

Table 1 – Completeness of selected variables on the Mortality Information System (SIM) for perinatal deaths, Brazil, February/2011 - October/2012

Variables	Perinatal death	Fetal death	Early neonatal death	p -value[a]
	n (%)	n (%)	n (%)	
Maternal age	377 (88.0)	190 (86.8)	147 (89.6)	0.392
Maternal schooling	292 (76.2)	162 (74.0)	130 (79.3)	0.228
Number of live births	314 (82.0)	175 (79.9)	139 (84.8)	0.222
Number of fetal losses	297 (77.5)	128 (78.0)	169 (77.2)	0.838
Gestation length	334 (87.2)	192 (87.7)	142 (86.6)	0.753
Type of pregnancy	360 (94.0)	208 (95.0)	152 (92.7)	0.350
Type of delivery	356 (93.0)	205 (93.6)	151 (92.1)	0.562
Childbirth-related death	348 (90.9)	200 (91.3)	148 (90.2)	0.717
Sex	374 (97.7)	212 (96.8)	162 (98.8)	0.311[b]
Ethnicity/skin color	137 (83.5)	<20[c]	137 (83.5)	<20[c]
Birth weight	352 (91.9)	202 (92.2)	150 (91.5)	0.783
Underlying cause of death	382 (99.7)	218 (99.5)	164 (100.0)	1.000[b]

a) Pearson´s chi-square test.
b) Fisher's exact test.
c) This variable was not assessed, because it is not obligatory to fill out this field of the SIM notification form.

Table 2 – Agreement and 95% confidence interval (95% CI) between variables available on the Mortality Information System (SIM) and in the 'Birth in Brazil' survey for perinatal deaths, Brazil, February/2011 - October/2012

Variables	Perinatal Death (N=210)	Fetal Death (N=102)	Early neonatal death (N=108)
	(95% CI)	(95% CI)	(95% CI)
Categorical and discrete variables		Kappa Coefficient	
Maternal schooling[a,h]	0.687 (0.596;0.778)	0.649 (0.543;0.814)	0.678 (0.548;0.808)
Number of children born alive[b,h]	0.704 (0.619;0.789)	0.881 (0.765;0.996)	0.542 (0.429;0.996)
Number of fetal losses/miscarriages[c,h]	0.483 (0.342;0.624)	0.348 (0.169;0.527)	0.633 (0.444;0.822)
Type of pregnancy[d]	0.942 (0.867;1.000)	1.000 (1.000;1.000)	0.931 (0.842;1.000)
Type of delivery	0.979 (0.950;1.000)	1.000 (1.000;1.000)	0.960 (0.905;1.000)
Gestation length[f,h]	0.704 (0.619;0.789)	0.881 (0.765;0.996)	0.542 (0.429;0.655)
Sex	0.947 (0.900;0.993)	0.932 (0.857;1.000)	0.959 (0.903;1.000)
Continuous variables		Intraclass correlation coefficient	
Maternal age[i]	0.999 (0.999;0.999)	0,998 (0,997-;0,999)	0,999 (0,999;1,000)
Birth weight	0.972 (0.989;0.989)	0.990 (0.985;0.994)	0.978 (0.967;0.985)
Gestation length[l]	0.673 (0.540;0.768)	0.448 (0.098;0.667)	0.925 (0.881;0.953)

a) number of pairs: 168 (perinatal), 82 (fetal) and 86 (early neonatal).
b) number of pairs: 170 (perinatal), 77 (fetal) and 93 (early neonatal).
c) number of pairs: 156 (perinatal), 72 (fetal) and 84 (early neonatal).
d) number of pairs: 198 (perinatal), 94 (fetal) and 102 (early neonatal).
e) number of pairs: 194 (perinatal), 93 (fetal) and 101 (early neonatal).
f) number of pairs: 181 (perinatal), 85 (fetal) and 96 (early neonatal).
g) number of pairs: 193 (perinatal), 90 (fetal) and 103 (early neonatal).
h) weighted Kappa.
i) number of pairs: 192 (perinatal), 93 (fetal) and 99 (early neonatal).
j) number of pairs: 186 (perinatal), 85 (fetal) and 101 (early neonatal).
l) number of pairs: 132 (perinatal), 59 (fetal) and 73 (early neonatal).

Discussion

We observed high completeness and reliability of the data available on the SIM system for perinatal deaths identified by the 'Births in Brazil' survey, notwithstanding the higher disagreements found for important variables, such as gestation length, maternal schooling and number of children born alive.

This study is derived from Brazilian national hospital data, representative of the majority of births occurring in the country,[10] thus demonstrating the internal validity of this study. Its limitations include perinatal deaths identified during our field work that were not found on the SIM database, as well as those that were identified on the SIM database but were not identified during the field work and for which, therefore, we neither interviewed the puerperal women nor accessed the corresponding medical records. We only had access to these cases via the information contained on SIM and it was therefore not possible to include them in the reliability analysis. This impaired the external validity of the results.

Data collected at the time of occurrence of childbirth by means of direct interviews with puerperal women, access to hospital records and to antenatal care record booklets, allowed variables to be built that were more reliable and suitable for comparison with the SIM data fields. In addition, assessing fetal death and early neonatal death fields separately enabled differences to be identified regarding the reliability of the fields relating to obstetric history and gestation length, indicating the need for greater care in filling out and defining the method used to estimate gestational age. Completeness ranged between regular and excellent for the majority of the variables analyzed. This was an improvement on data registered on SIM in eight Brazilian states in 2002, when percentage completeness was classified as being between poor and regular.[8] When consulting the records of fetal deaths and early neonatal deaths in 2007, in municipalities in the Ribeirão Preto region of São Paulo state,[18] higher percentages of completeness were found than those observed in our study for the

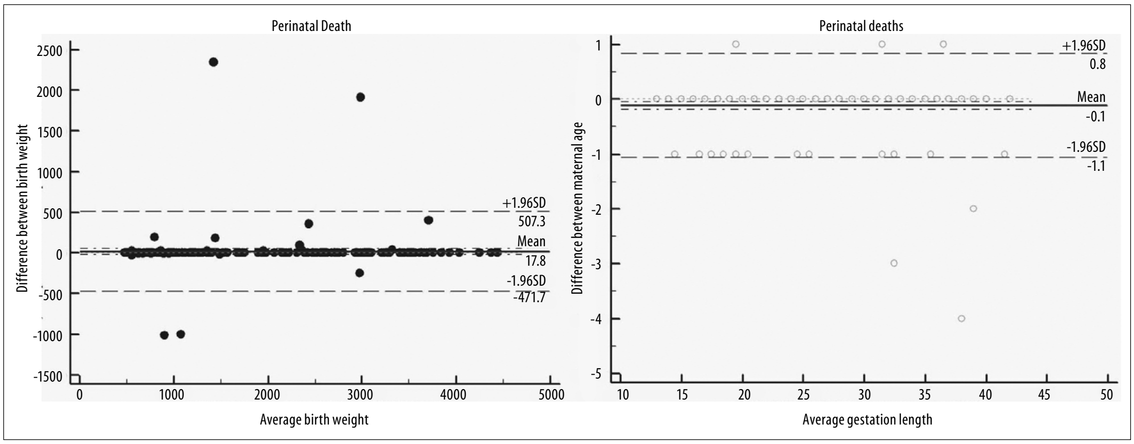

Figure 1 – Limits of agreement, with a confidence interval of 95%, for measurements of birth weight and maternal age for perinatal deaths, Brazil, February/2011 - October/2012

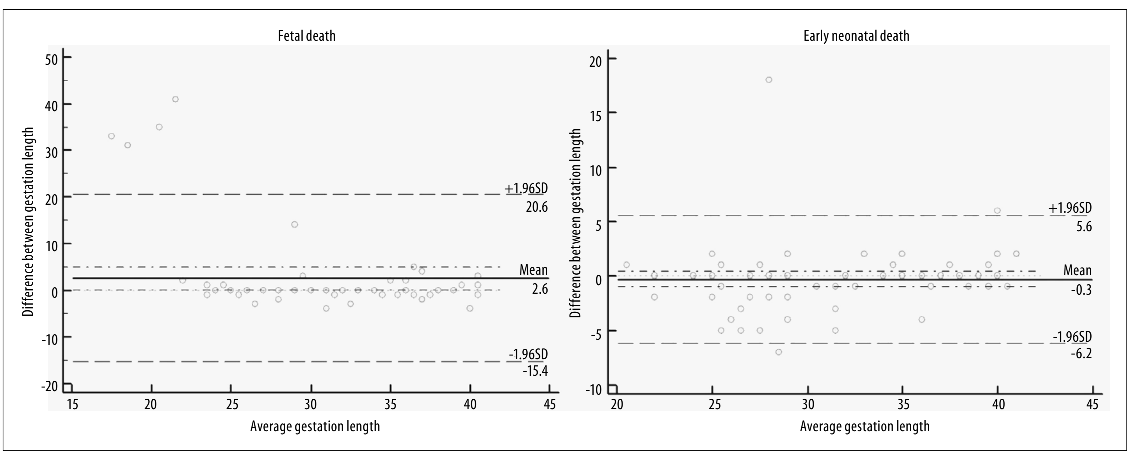

Figure 2 – Limits of agreement, with a 95% confidence interval, for measured gestation length for fetal deaths and early neonatal deaths, Brazil, February/2011 - October/2012

same fields, except for gestation length and sex (89.5 and 99.0% *versus* 86.6 and 98.8%, respectively) among early neonatal deaths. Pedrosa et al.[19] also found a lower percentage of data completeness for early neonatal deaths recorded in the city of Maceió, Alagoas, between 2001 and 2002, for sex, birth weight, maternal age, type of delivery and gestation length. Research performed only on fetal deaths in the state of São Paulo in 2008[1] found higher completeness only for gestation length (92.1%) and sex (98.9%). A recently published evaluative study of stillbirth rate trends in Brazil between 1996 and 2012[4] using SIM data found significant decrease of incompleteness in that period in relation to maternal age, maternal schooling, gestation length, type of pregnancy and birth weight.

Maternal schooling is an important socioeconomic indicator associated with the occurrence of perinatal death.[20.21] However, it was the least complete field, according to that study, with 23.8% of information missing. A similar result (22.4%) was found on the national level for fetal deaths in 2012,[4] This result being higher than that for fetal deaths (18.8%) and early neonatal deaths (16.5%) related to congenital syphilis for the period 2012-2013.[22] In a study conducted in the state of Pernambuco on data relating to fetal deaths occurring between 1999-2001 and 2009-2011,[23] percentage missing information was also greater than 20% in both periods. Another variable that increases the risk of perinatal death[18] is unfavorable reproductive history. The absence of this on the system was high in relation to the number of fetal losses and/

or miscarriages (22.5%). When examining fetal deaths in the city of São Paulo in 2008, Almeida et al.[1] found completeness levels lower than those found by us.

The divergent behavior of agreement regarding gestation length, in both its continuous form and time-band forms, between fetal deaths and early neonatal deaths may be a reflection of how the information was notified on the death certificates. Data on gestation length obtained in time-bands would appear to provide greater agreement with the information coming from the survey, because each category encompasses some weeks of gestation and this only occurred in the case of fetal deaths. Moreover, the information available on SIM was found to be more frequent in the time-band form and information in the continuous form was not always available. The method use to calculate gestational age is another point that may be responsible for the disagreements found, given that an algorithm is used to calculate length of gestation, based above all on obstetric ultrasonography.[12] When filling out death certificates, no indication is provided of any preferred method for estimating gestational age, nor is there any field to indicate the method chosen.[2]

The existence of outliers, with positive differences greater than 30 weeks of pregnancy among fetal deaths, interfered negatively with agreement and underestimated the measures contained on the system, which may indicate errors in filling out death certificates or inputting them onto the information system. We did not find any national or international studies evaluating the magnitude of disagreement between information obtained on vital statistics and any other source of information.

The findings of this study indicate that the reliability of the data available on SIM has improved when compared to the findings of other national studies, such as the aforementioned descriptive study of early neonatal deaths in hospitals in Maceió,[19] which found good agreement for type of delivery (Kappa=0.65) and excellent agreement for sex (Kappa=0.88), while birth weight, maternal age and gestation length had a Kappa of 0.19, 0.34 and 0.55, respectively. Lansky et al.,[24] when comparing the information available on SIM with that obtained from hospital records for perinatal deaths in Belo Horizonte in 1999, found almost perfect agreement for the birth weight (Kappa=0.89) and type of delivery (Kappa=0.91) variables, and regular agreement for gestation length (Kappa=0.46).

Death certificates are often filled out inappropriately. As this is exclusively a medical prerogative, this fact can be attributed to poor teaching of how to fill out vital record documents during medicine degree courses, in addition to little importance being given to death certificates as documents of epidemiological relevance. The filling out of socioeconomic information, for example, tends to be delegated to administrative staff.[13] A qualitative study conducted in the municipality of São Paulo in 2009[25] found that physicians are aware of the legal aspects of death certificates and aware of the importance this data for epidemiological and public health purposes, but give emphasis to the filling out of the cause of death to the detriment of other fields, in addition to reporting being helped by other professionals to fill out identification information and maternal characteristics.

The quality of death certification information input to the system can also interfere with the quality of the data held on it. When comparing death certificates filled out by physicians with their corresponding information on the SIM database of early neonatal hospital deaths, the descriptive study carried out in Alagoas[19] found information omitted by the technicians in charge of inputting declarations onto the system, so that the database did not reflect the real information contained in the medical records of early neonatal deaths. It is important for public health to have a periodic doctor training program on the importance of correct and proper completion of death certificates, as well as training for professionals responsible for inputting the document onto the system.[26] Another point to focus on is the qualification of health professionals involved with the epidemiological surveillance of infant and fetal death, building their capacity to investigate deaths at municipal and hospital level, as well as to update revised information system data, including unreported deaths, by filling out an epidemiological death certificate.[2]

In conclusion, the information provided on the Mortality Information System for perinatal deaths was found to be of good quality and reliable and capable of being used in perinatal mortality planning and monitoring in Brazil. Notwithstanding, there is a need to improve the quality of information relevant to the assessment of perinatal mortality, through strategies that involve training and qualification of professionals involved in filling out death certificates and inputting them onto the system.

Authors' contributions

Rodrigues PL contributed to the conception and design of the study, data collection, analysis and interpretation, discussion of results and manuscript writing. Gama SGN and Mattos IE participated in the conception of the study and critical review of the manuscript. All the authors have approved the final version and declared themselves to be responsible for all aspects of the study, ensuring its accuracy and integrity.

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