Trends in the Prevalence of Live Macrosomic Newborns According to Gestational Age Strata, in Brazil, 2001–2010, and 2012–2014

Tendências na prevalência de recém-nascidos vivos macrossômicos, estratificadas por idade gestacional, Brasil, 2001–2010 e 2012–2014

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Abstract

Purpose To describe the trends in the prevalence of macrosomia (birth weight ≥ 4,000 g) according to gestational age in Brazil in the periods of 2001–2010 and 2012–2014.

Methods Ecological study with data from the Brazilian Live Birth Information System (SINASC, in the Portuguese acronym) regarding singleton live newborns born from 22 gestational weeks. The trends in Brazil as a whole and in each of its five regions were analyzed according to preterm (22–36 gestational weeks) and term (37–42 gestational weeks) strata. Annual Percent Changes (APCs) based on the Prais-Winsten method and their respective 95% confidence intervals (CIs) were used to verify statistically significant changes in 2001–2010.

Results In Brazil, the prevalence of macrosomic births was of 5.3% (2001–2010) and 5.1% (2012–2014). The rates were systematically higher in the North and Northeast Regions both in the preterm and in term strata. In the preterm stratum, the North Region presented the highest variation in the prevalence of macrosomia (+137.5%) when comparing 2001 (0.8%) to 2010 (1.9%). In the term stratum, downward trends were observed in Brazil as a whole and in every region. The trends for 2012–2014 were more heterogeneous, with the prevalence systematically higher than that observed for 2001–2010. The APC in the preterm stratum (2001–2010) showed a statistically significant trend change in the North (APC: 15.4%; 95%CI: 0.6–32.3) and South (APC: 13.5%; 95%CI: 4.8–22.9) regions. In the term stratum, the change occurred only in the North region (APC:-1.5%; 95%CI: -2.5–-0.5).

Keywords
- macrosomia
- prevalence
- trends
- epidemiology
- maternal health
- child health

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Conclusion The prevalence of macrosomic births in Brazil was higher than 5.0%. Macrosomia has potentially negative health implications for both children and adults, and deserves close attention in the public health agenda in Brazil, as well as further support for investigation and intervention.

Resumo

Objetivo Descrever tendências nas prevalências de macrossomia (peso ao nascer ≥ 4.000 g) segundo idade gestacional no Brasil em 2001–2010 e em 2012–2014.

Métodos Estudo ecológico com dados do Sistema de Informação sobre Nascidos Vivos (SINASC), incluindo bebês nascidos vivos a partir de 22 semanas, de gestações únicas. As tendências no Brasil como um todo e nas suas cinco regiões foram analisadas nos estratos pré-termo (22–36 semanas de gestação) e termo (37–42 semanas de gestação). Mudanças percentuais anuais (APCs) baseadas nos modelos de regressão propostos por Prais-Winsten e intervalos de confiança (ICs) de 95% foram calculados para verificar diferenças estatisticamente significantes no período 2001–2010.

Resultados No Brasil, a prevalência de macrossomia foi de 5,3% (2001–2010) e 5,1% (2012–2014). As frequências foram sistematicamente maiores nas regiões Norte e Nordeste, tanto no pré-termo quanto no termo. No pré-termo, a região Norte apresentou a variação mais importante na prevalência de macrossomia (+137,5%) quando comparados o ano de 2001 (0,8%) e o de 2010 (1,9%). No termo, tendências declinantes foram observadas no Brasil e em todas as suas regiões. As tendências em 2012–2014 foram mais heterogêneas, com frequências maiores do que aquelas observadas em 2001–2010. As APCs no estrato pré-termo (2001–2010) mostraram que as mudanças foram estatisticamente significantes no Norte (APC: 15,4%; IC95%: 0,6–32,3) e no Sul (APC: 13,5%; IC95%: 4,8–22,9). No termo, a mudança ocorreu apenas no Norte (APC: -1,5%; IC95%: -2,5–-0,5).

Conclusão A prevalência de macrossomia no Brasil foi maior do que 5,0%. A macrossomia tem implicações potencialmente negativas para a saúde da criança e do adulto, e merece mais atenção das políticas de saúde pública no Brasil, bem como mais apoio para investigação e intervenção.

Palavras-chave
- macrossomia fetal
- prevalência
- tendências
- epidemiologia
- saúde materna
- saúde da criança

Introduction

The term *fetal macrosomia* implies fetal growth beyond a specific weight, regardless of the fetal gestational age.[1] However, there is little consensus on the cut-off weight that properly allows to classify newbornss as macrosomic.[2] Definitions based on percentiles are dependent on gestational age[3] and regional features.[4] These parameters increase the complexity to estimate the fetus' measures, and this limits their use in the obstetric practice. Simpler classifications based only on the cut-off weight are commonly used, and macrosomic newborns are considered those who were born with a birth weight ≥ 4,000 g[5] or ≥ 4,500 g.[3,6]

Even though low birth weight is an issue of major interest in the specialized scientific literature focusing on unfavorable perinatal outcomes, the effects of macrosomia are also adverse, with potentially serious consequences for the mothers and newborns.[3] Maternal problems include high frequency of cesarean sections, perineum lacerations, postpartum hemorrhage, prolonged hospitalization, and puerperal infections. The newborns are at risk of shoulder dystocia, fracture, intrauterine hypoxemia, intensive care unit admission and death.[7,8]

Besides the potential for immediate injuries to both the mothers and the newborns, macrosomia is suspected to be related to long-term harmful health effects, such as increased risk of developing obesity during childhood[9] and adulthood,[10] as well as cancer,[11] diabetes,[12] and other chronic diseases.

The conditions associated to macrosomia include pregestational and gestational diabetes mellitus, maternal obesity, and gestational weight gain,[2] which may be reasonably controlled via adequate prenatal care. Considering prenatal care as universally offered in Brazil, and the scarce scientific literature investigating macrosomia at the population level, this study aimed to describe trends in the prevalence of live newborns weighing ≥ 4,000 g according to gestational age strata, in Brazil and in its five regions, in the periods of 2001–2010 and 2012–2014.

Methods

This is an ecological study based on nationwide information provided by the Department of Informatics of the Brazilian Unified Healthcare System (DATASUS, in the Portuguese acronym), the main national vital statistics subsystems coordinator in Brazil. The Brazilian Live Births Information System (SINASC, in the Portuguese acronym) is the subsystem that stores epidemiologic information on live births in Brazil, and it is the source of the variables (namely year of birth, number of live newborns, gestational age, and birth weight) used in the present study. All live newborns from singleton pregnancies from 22 gestational weeks from 2001 to 2010 and from 2012 to 2014 were included in the study. The data for 2011 were not used because the gestational age field in the birth certificate form was modified in that year, and its inclusion could cause the erroneous classification of some babies in regard to gestational age. The definition of macrosomia was based on the cut-off birth weight $\geq$ 4,000 g.

Prevalence of macrosomic births in Brazil as a whole and in its five regions (North, Northeast, Midwest, Southeast and South) was calculated for each year, for all live newborns from 22 gestational weeks, for preterm newborns (from 22 to 36 gestational weeks), and for term newborns (from 37 to 42 gestational weeks). Considering the improvement in coverage and data quality provided by the SINASC in more recent years, a correction factor created by Szwarcwald et al[13] was used to reduce the effect of underreported births only during the 2001–2010 period, so as to more accurately represent the real number of live births in Brazil.

As differences between the SINASC data and the primary data studied by Silveira et al[14] were more marked involving newborns weighing up to 3,000 g, with lower or no significant difference above this weight group, no factor was used to correct the birth weight $\geq$ 4,000 g in relation to gestational age.

Secular Trends Analysis

First, a trend assessment (increasing, decreasing, or stationary) was visually obtained through the inspection of specific graphs for Brazil as a whole. The dependent variable (prevalence of live newborns weighing $\geq$ 4,000 g) was placed on the y-axis and correlated with the independent variable (year of birth), which was placed on the x-axis. The analyses were repeated for each of the five Brazilian regions.

Trend Variation in the 2001–2010 Period

Anticipating that some random effects related to prevalence variations over time would make it more difficult to interpret potential trends, a second step was taken with the plotting and reevaluation of smoothed prevalence rates using a third-order moving average. This step was only adopted for the 2001–2010 period, as this statistical technique is not recommended for analysis of historical data with less than 7 time points.[15]

Next, to address the residue autocorrelation effects determined by time frame proximity, a step-by-step procedure proposed by Antunes and Cardoso[15] was followed beginning with the ten-base logarithmic transformation of the prevalence rates. Finally, parameter estimations were made by generalized linear regression designated as autoregressive modeling, using the Prais-Winsten method, and with statistical significance evaluated via the Durbin Watson test. The annual percent changes (APCs) and their respective 95% confidence intervals (95%CIs) were estimated as described by Antunes and Cardoso.[15] The statistical procedures were performed using The Microsoft Excel Software (Microsoft Corporation, Redmond, WA, US).

Ethical Procedures

This study followed the recommendations for scientific research involving human subjects, and as it was conducted using de-identified secondary datasets publicly available on the DATASUS website; therefore, it was exempt from formal ethical procedures.

Results

In Brazil, the number of live births after 22 gestational weeks reached over 30 million during 2001–2010, and over 8 million during 2012–2014. The number of newborns with birth weight $\geq$ 4,000 g reached 1,606,330 (2001–2010) and 422,069 (2012–2014), determining an overall prevalence of 5.3% (2001–2010) and 5.1% (2012–2014). This indicator decreased slightly (−8.9%) when comparing the frequency obtained in 2001 (5.6%) and in 2010 (5.1%). There was no change in the 2012–2014 period (►**Fig. 1**).

Prevalence indicators showed distinct trends according to gestational age strata and time periods. Comparing the preterm strata rates observed in the 2001–2010 period, the prevalence of macrosomia increased both in Brazil as a whole and in four of its five regions, with the Southeast Region registering a variation of zero. The highest increase occurred in the North Region (> 130.0%). In the 2012–2014 period, macrosomia preterm rates registered a slight negative change. The highest reduction occurred in the South Region (−20.0%).

In the term strata, from 2001 to 2010, the prevalence rates for macrosomia decreased in Brazil as a whole and in all regions. In the 2012–2014 period, the frequency was somewhat heterogeneous. The prevalence of newborns born from 37 gestational weeks and weighting $\geq$ 4,000 g decreased in Brazil as a whole and in the South Region, but it increased in the North and Southeast Regions. There were no variations in the Northeast and Midwest Regions (►**Table 1**).

Pictorial representations of the time series allowed the visualization of prevalence trends (solid lines) in Brazil and in every region separately for the 2001–2010 period. Smoothed data (dotted lines) showed that preterm macrosomia prevalence rates changed harmonically during 2004–2005 (►**Fig. 2**).

The results indicate statistically significant elevation trends in preterm macrosomic births in the North and South Regions. According to the APCs, the North Region had the most important annual variation (APC: 15.4%; 95%CI: 0.6–32.3) followed by the South Region (APC: 13.5%; 95%CI: 4.8–22.9). In term macrosomic births, the APCs suggest statistically significant declining trends only in the North Region (APC: −1.5%; 95%CI: −2.5–−0.5). In Brazil as a whole and in the other four regions, the trends were stationary (►**Table 2**).

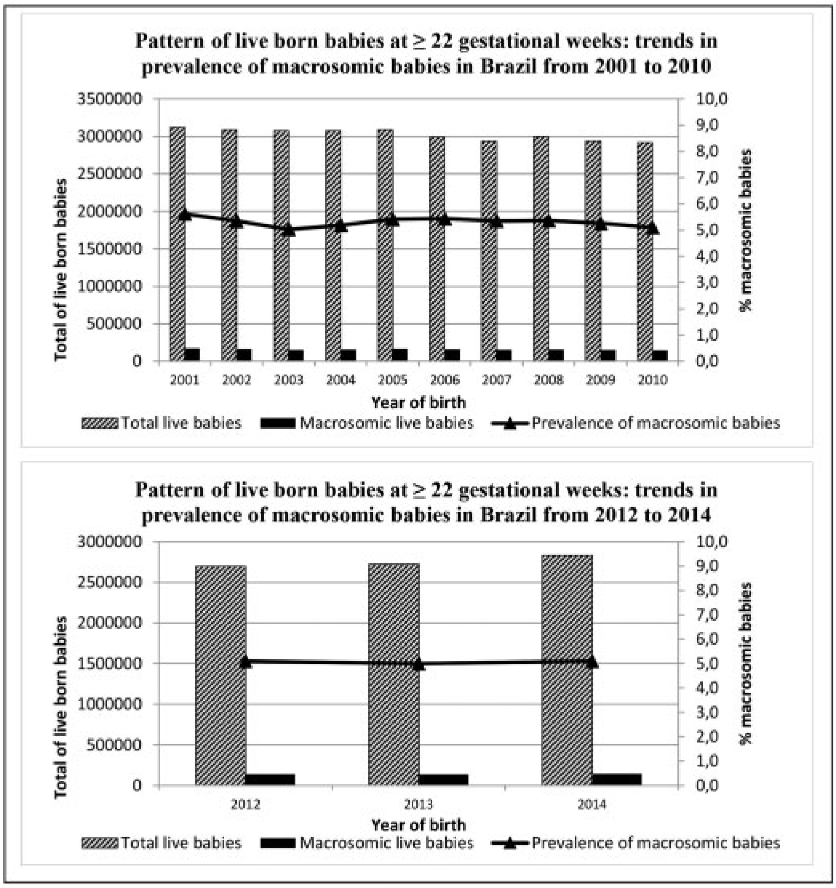

Fig. 1 Birth of live newborns after 22 gestational weeks registered in the Brazillian Live Births Information System (SINASC, in the Portuguese acronym), and trends in the prevalence of macrosomic live newborns in Brazil, from 2001 to 2010, and from 2012 to 2014. The principal y-axis shows the total number of births. The secondary y-axis shows prevalence of macrosomic babies. The x-axis shows the year of birth.

Table 1 Prevalence of live macrosomic newborns (≥ 4,000 g) according to GW strata in Brazil and its regions, from 2001 to 2010 and from 2012 to 2014

Year	Brazil		North		Northeast		Midwest		Southeast		South	
	22 to 36 GW (%)	37 to 42 GW (%)	22 to 36 GW (%)	37 to 42 GW (%)	22 to 36 GW (%)	37 to 42 GW (%)	22 to 36 GW (%)	37 to 42 GW (%)	22 to 36 GW (%)	37 to 42 GW (%)	22 to 36 GW (%)	37 to 42 GW (%)
2001	0.6	5.9	0.8	7.3	0.7	7.5	0.5	5.8	0.6	4.5	0.3	5.6
2002	0.4	5.6	0.7	6.9	0.3	7.1	0.5	5.5	0.5	4.4	0.2	5.3
2003	0.3	5.3	0.6	6.4	0.4	6.5	0.2	5.2	0.4	4.2	0.2	5.0
2004	0.3	5.5	0.6	6.5	0.2	6.7	0.3	5.3	0.4	4.4	0.2	5.3
2005	0.3	5.7	0.6	6.4	0.2	7.0	0.2	5.6	0.3	4.6	0.3	5.5
2006	1.0	5.7	2.5	6.5	1.5	7.1	0.8	5.6	0.7	4.6	0.5	5.3
2007	0.9	5.6	2.5	6.4	1.3	7.1	0.7	5.4	0.6	4.4	0.6	5.1
2008	0.9	5.7	1.9	6.4	1.4	6.9	0.9	5.4	0.6	4.6	0.6	5.5
2009	0.9	5.5	1.8	6.3	1.4	6.8	1.0	5.3	0.5	4.5	0.5	5.3
2010	0.9	5.4	1.9	6.1	1.2	6.7	0.8	5.1	0.6	4.4	0.6	5.1
Change* 2001 to 2010	50.0	−8.5	137.5	−16.4	71.4	−10.7	60.0	−12.1	0.0	−2.2	100.0	−8.9
2012	2.0	5.6	2.8	6.4	2.7	6.9	1.8	5.0	1.4	4.6	1.5	5.3
2013	1.8	5.4	2.4	6.2	2.5	6.6	1.7	5.0	1.3	4.6	1.3	5.3
2014	1.8	5.5	2.5	6.5	2.6	6.9	1.5	5.0	1.2	4.7	1.2	5.2
Change* 2012 to 2014	−10.0	−1.8	−10.7	1.6	−3.7	0.0	−16.7	0.0	−14.3	2.8	−20.0	−1.9

Abbreviation: GW, gestational weeks.
Note: *Change (%) after comparing the prevalence of macrosomia in 2001with the prevalence of macrosomia in 2010, and in 2012 with the prevalence in 2014.

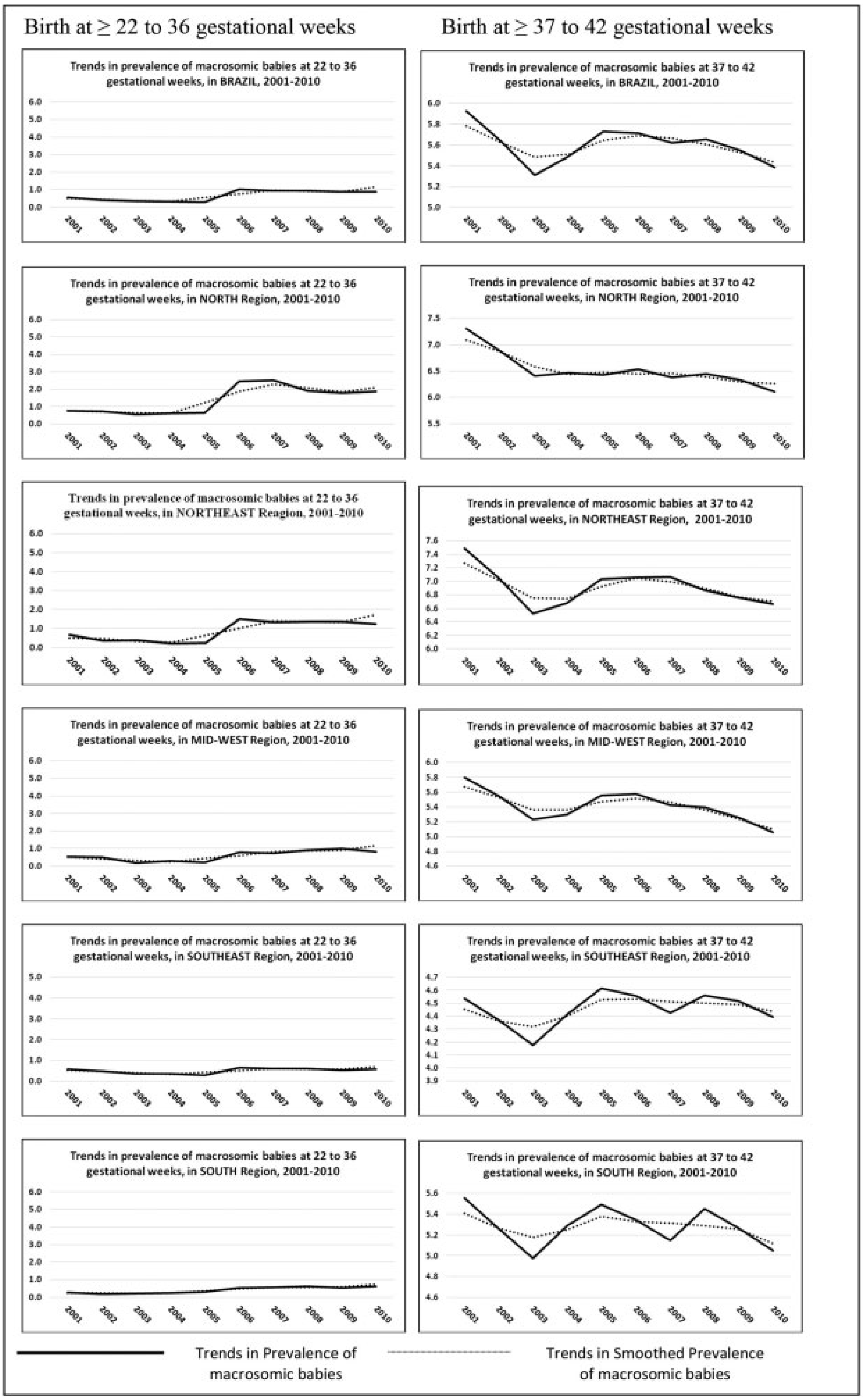

Fig. 2 Trends in prevalence rates and in smoothed prevalence rates of macrosomic live newborns born between 22 to 36 and 37 to 42 gestational weeks, in Brazil and its regions, from 2001 to 2010. The y-axis shows the prevalence, and the x-axis shows the year of birth.

Table 2 Trends and APCs in the prevalence of live born macrosomic newborns (≥ 4,000 g), Brazil and regions, 2001–2010

	22 to 36 gestational weeks		37 to 42 gestational weeks	
Region	APCs (%) and 95%CI	Trend Interpretation	APCs (%) and 95%CI	Trend Interpretation
Brazil	10.3 (−2.1; 24.3)	stationary	−0.5 (−1.5; 0.5)	stationary
North	15.4 (0.6; 32.3)	increasing	−1.5 (−2.5; −0.5)	declining
Northeast	16.8 (−2.8; 40.6)	stationary	−0.8 (−2.0; 0.5)	stationary
Midwest	12.2 (−3.2; 30.0)	stationary	−1.1 (−2.1; 0.0)	stationary
Southeast	3.1 (−4.5; 11.4)	stationary	0.2 (−0.7; 1.0)	stationary
South	13.5 (4.8; 22.9)	increasing	−0.3 (−1.2; 0.6)	stationary

Abbreviations: 95%CI, 95% confidence interval; APCs, annual percent changes.

Discussion

This study focused on large newborns (≥ 4,000 g) born from 2001 to 2014 in Brazil, excluding the year 2011. The overall prevalence of macrosomic live births in the country as a whole was of 5.3% (2001–2010) and 5.1% (2012–2014). This frequency declined over the first period (2001–2010), and remained relatively stationary in the more recent period (2012–2014). The prevalence of macrosomia in the North and Northeast Regions was systematically higher than in Brazil as a whole and in the other regions, both by gestational age strata and by time period.

Over time, the macrosomia among preterm newborns showed an upward trend in Brazil and in its regions, except in Southeast Region, where this problem kept a stationary trend. On the other hand, downward trends were found in the term strata (2001–2010). The macrosomia problem was more heterogeneous in the 2012–2014 time period.

In Brazil, the general indicator of macrosomia was near the lowest estimates found amongst high-income countries (5.0% to 20.0%), but it was higher than the findings concerning term large newborns reported in a Brazilian research coordinated by the World Health Organization (WHO's Global Survey on Maternal and Perinatal Health) conducted by Koyanagi et al[4] with 14,804 newborns (4.1%), and in another study conducted by Ye et al[3] with 13,373 newborns (4.4%). The survey results were restricted only to live births occurring in 3 maternity hospitals between 2004 and 2005. Even though the maternity hospitals were randomly selected in the WHO study, the outcomes presented in our study may be closer to true population parameters, since they reflect SINASC data of almost all live births registered in Brazil.

Reductions in macrosomia rates in Brazil resemble a trend described in South Korea.[16] Considering all live births in that country, macrosomia dropped by almost half, going from 6.7% to 3.5%, in the 1993–2010 period. The lowest rates were correlated with improvements in pregnancy management, particularly for gestational diabetes, considered to be one of the leading causes of fetal macrosomia.

Fetal growth is more prominent in the last month of pregnancy.[17] However, it was in the preterm strata before the physiological weight gain acceleration expected in the last 4 gestational weeks that the macrosomia frequency became more noticeable, comparing 2012–2014 to 2001–2010 in the present study. In the 2001–2010 period, the estimates were within the limits of prevalence of preterm newborns weighing between 4,000 g and 5,000 g obtained with a correctional equation provided by Silveira et al.[14] For the 2012–2014 period, the estimates were higher than those found in the first period, and this probably reflects the improvement in the quality of the data from SINASC.

In Denmark, a secular trend study involving all live newborns born from 20 gestational weeks from 1973 to 2003 showed that the increase in mean birth weight was of 5.0 g per year both for boys and girls. Stratifying by gestational age, the birth weight increased 3.5 g or 4.0 g per year among term newborns. However, stronger variations were seen among preterm newborns, a group in which the mean birthweight rose 8.3 g or 9.0 g per year.[18]

The increase in the frequency of births of heavier preterm newborns is a complex phenomenon for which there are no easy or obvious explanations. Although three major health conditions (diabetes, maternal obesity and maternal weight gain during the gestational period) may account for disproportionate increases in fetal weight,[19,20] they may also be controlled via adequate prenatal care. Considering the wide prenatal care coverage provided in Brazil as well as the high proportion of women attending six or more prenatal visits, a question opportunely presented is: Why has the frequency of overweight involving preterm newborns increased in Brazil?

Labor induction and cesarean section indicated specifically to deliver a fetus suspected to be overweight for gestational age or macrosomic could partially explain the preterm births of those newborns who experienced higher weight gain and faster intrauterine growth.[21] In a way, this could reflect in the decline in weight in the last gestational weeks, as recorded in the United States. In that country, Zhang et al[22] reported that term and post-term macrosomia rates dropped from 2.2% to 1.6% respectively, from 1992 to 2003, while the rates of labor induction and cesarean section increased from 14.3% to 27.0% and from 21.3% to 25.0% in the same period respectively.

Statistically significant findings in the term strata (2001–2010) were observed only in the North Region, maybe as an effect of the pattern of births of macrosomic newborns before 37 gestational weeks. In Beijing, China, the proportion of live newborns weighing $\geq$ 4,000 g increased from 6.6% in 1996 to 9.5% in 2000, and declined to 7.0% in 2010.[23] This trend was accompanied by gestational age shortening, and by more premature newborns in 2010 (6.6%) than in 1996 (4.1%). According to Shan et al,[23] the magnitude of the prevalence of macrosomia could be reflecting an excessive maternal gestational weight gain, a situation maximized by both socioeconomic progress and increased consumption of highly caloric foods, which has been typical during these nutritional transition years.

The smoothing statistical method eliminates some effects related to random fluctuations and facilitates the visualization of cyclical or seasonal components in time series studies.[15] Inflections coincided in the years 2004 and 2005. As descriptive analyses are inappropriate to draw causal inferences, it would be important to conduct further research to verify whether public policies to combat hunger and to improve income distribution, along with its resulting socioeconomic improvement, could partially explain the variations in macrosomia rates found in Brazil.

It is noteworthy that there is evidence showing that the initiative entitled Family Grant Program (Programa Bolsa Família – PBF, in the Portuguese acronym) is associated to an increase in the number of prenatal visits, and to a reduction in low birth weight, particularly in the less-affluent regions, such as the Northeast region of Brazil.[24] Conditional money transfers via PBF were accelerated in the 2004–2005 biennium, and they expanded rapidly throughout Brazil. The contingent of benefited families grew from 10 million to 12 million between 2008 and 2009, reaching almost 13 million in 2011. The target was the poorest people living in the North and Northeast Regions of the country, but PBF coverage currently reaches all Brazilian municipalities.[25] The question was raised above because social investment in the country has aimed to achieve the best results in terms of the improvement in quality of life of the poorest people in Brazil. Studies showed that the increase in fetal macrosomia followed a socioeconomic improvement in some regions of China,[26] outlining a context that might resemble the changes that are happening in Brazil.

Fetal weight influences maternal and perinatal outcomes. The North and Northeast Regions experienced higher macrosomia prevalence, suggesting that regional inequalities may be determining the worst results in those regions compared with Brazil as a whole and to the more affluent Southeast, Midwest and South Regions. In accordance with data from the report Saúde Brasil 2013,[27] only 57.0% and 67.0% of mothers from the North and Northeast Regions had 6 or more prenatal visits, in 2012 respectively. The frequency of mothers who had up to 3 appointments was unacceptably high both in the North (21.0%) and in the Northeast (14.1%) Regions. Considering that fetal weight gain is influenced in a way by optimal prenatal care, this highlights the importance of improving the frequency of mothers attending six or more prenatal visits in the North and Northeast Regions.

Public policies focusing on the poorest people have relatively more positive impact on the income of people living in the poorest regions.[28] For example, the per capita amount received in 2006 by families in the 10 poorest states in the country via the PBF was almost double the amount received by those in the 10 richest states.[29]

Dependence on the PBF benefit is greater in the North and Northeast compared with the Southeast Region. Such circumstance seems to be related to a high consumption in the former of unhealthy foods such as sugar, fat, coffee, beans and soft drinks.[30] Moreover, an insufficient prenatal coverage reduces the possibility of controlling the conditions related to macrosomia, mainly among minorities living in socioeconomically disadvantaged areas. In view of these problems, the magnitude of the prevalence found in the present study suggests the difficulty of tackling macrosomia conditions in some Brazilian regions.

Some limitations should be mentioned. This study was developed with data from a secondary vital statistics source in which databases were fed with information collected by healthcare workers on a day-to-day basis. However, SINASC is an official live birth records system that covers all of the national territory, and it is the main source of birth data in Brazil. Even though in this study the parameter was prevalence, inconsistent values present in large databases must be dealt with appropriately. However, no studies were found regarding inconsistencies in large-newborn birth weight values in the SINASC database, or that recommended any data correction for the rates found therein.

Another limitation was that macrosomia was based on the cut-off birth weight at $\geq$ 4,000 g, and this prevented comparisons with studies that used other definitions. Furthermore, changes in the gestational age calculation inserted in the birth certificate form in 2011 hindered the development of the secular analysis for the entire period (2001–2014). The prevalence was instead estimated for separate time periods (2001–2010 and 2012–2014). The performance of statistical procedures was possible only for the first period (2001–2010), since only 3 time points were available in the final period (2012–2014).

Finally, the prevalence of macrosomia was calculated in relation to all live births from 22 gestational weeks, including newborns weighting $\geq$ 500 g. Even so, the prevalence was higher than the estimates found in previous studies that only included live births of newborns weighing $\geq$ 1,000 g.[3,4]

In conclusion, the prevalence of live newborns weighing $\geq$ 4,000 g was higher than 5%, and the trends in Brazil were heterogeneous. The upward trend in preterm macrosomic births was a finding that may partially explain the downward trend found among heavy newborns born from 37 gestational weeks in 2001–2010. In the 2012–2014 period, the preterm rates were systematically higher than in the 2001–2010 period, although they were almost stationary among term newborns. Considering the causes and effects of macrosomia in maternal and perinatal morbimortality, as well as their potential implications on the child's and adult's health, fetal macrosomia requires more attention in the Brazilian public healthcare agenda, and more support for investigation and intervention.

Conflicts of Interest
There are no conflicts of interest to declare.

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