Secular Trends in Birthweight

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Abstract

From the mid- to late 20th century, average birthweight increased in many countries, including the United States. However, more recent data now suggest that mean birthweight has begun to decline. The most recent US data indicate that in 2008, compared with 1990, about half as many babies were macrosomic at birth (≥5,000 g), whereas there was a 17% increase in low birthweight (<2,500 g). Part of the observed decline in birthweight likely relates to decreases in gestation length and corresponding increases in rates of preterm and early term birth over the past several decades. However, available data suggest that fetal growth has also declined independent of gestational age at birth. Since 2000, rates of small for gestational age have increased, whereas rates of large for gestational age have decreased. Declines in birthweight and macrosomia are most likely largely explained by decreases in gestation length, itself caused by obstetric interventions, especially induction of labor and to a lesser extent elective cesarean delivery. However, it appears that fetal growth is also declining, at least in some settings, independent of gestation length. Reasons for this decline are as of yet unexplained and merit further investigation.

Introduction

According to the popular press and public perception, babies are becoming bigger and bigger at birth. For example, the July 2011 birth of a 16 pound, 1 ounce baby in Texas sparked extensive news coverage and editorials regarding the 'steady upward trend in birthweight' and 'alarming' increase in rates of macrosomia [1, 2]. In addition to its ability to sell newspapers, birthweight matters because it is a marker of maternal health and health care as well as an important predictor of both short and longer-term child health outcomes [3].
Lower weight at birth is associated with higher risks for neonatal morbidity and mortality among both term and preterm infants [4], and high birthweight predicts cesarean delivery, shoulder dystocia, and newborn hypoglycemia. In later life, individuals born at lower birthweights have higher risks of type 2 diabetes, hypertension, cardiovascular disease, and mental illness, whereas those born at higher birthweights are more likely to develop obesity and breast cancer [5–8].

From the mid- to late 20th century, average birthweight increased in many countries, including the United States [9–11], Canada [11–15], the UK [16–18], Scandinavia [19–21], China [22, 23], and Japan [24]. These increases have been attributed to greater fetal growth resulting from improved prenatal care, lower rates of smoking and teen pregnancy, and secular increases in maternal prepregnancy weight, gestational weight gain, and gestational diabetes mellitus [13, 25]. Many of these factors have continued to follow the same trajectories since the 1990s. However, more recent surveillance data now suggest that mean birthweight has in fact begun to decline in the US [26] and other developed countries. Part of the observed decline in birthweight likely relates to recent decreases in mean gestation length and corresponding increases in rates of preterm birth over the past several decades [26–30]. As gestation length and fetal growth (birthweight for gestational age) have different determinants and sequelae [31], it is important to disentangle their relative contributions to trends in weight at birth.

In this paper, I will summarize evidence regarding trends in birthweight, with a focus on the past 20 years. I also include data on trends in both high birthweight (macrosomia) and low birthweight. I also review contributors to birthweight, including gestation length and fetal growth, their contributors, and their trends over time. I primarily focus on data from the United States, but also include published studies from other developed countries.

**Trends in Mean Birthweight, Low Birthweight, and High Birthweight**

Prior to 1990, abundant evidence suggested that birthweight was on the rise. For example, using birth certificates from infants born in Illinois in 1950–1990, Chike-Obi et al. [10] observed a trend towards higher birthweights including increases in the mean, mode, and upper end of the birthweight distributions. This rightward shift was especially evident among children (born 1989–1991) whose parents (born 1956–1976) were also included in the dataset (fig. 1), indicating that demographic trends such as immigration did not explain the increase [10].

However, these curves have now switched places (fig. 2). In 2005, compared with 1990, the range of birthweights was lower among all infants born in the US [28, 32]. The most recent data indicate that in 2008, compared with 1990, about half as many babies were macrosomic at birth (≥5,000 g; table 1), whereas there was a 17% increase in low birthweight (<2,500 g).
Similar trends have been seen outside of the United States. Canada has experienced similar increases in low birthweight [33], although some areas have experienced increases in birthweight [34]. In France, birthweight increased until about 1995, and subsequently decreased thereafter. By 2003, mean birthweight among term births in France had decreased back to a level last seen in 1972 [35].
In Queensland, Australia, both birthweight and term macrosomia increased from 1988 to 2001, and subsequently dropped to 2005 [36]. In Denmark, birthweight increased steadily from 1970 to about 2000, and subsequently declined [37]. Unfortunately, the authors present macrosomia rates grouped in 5-year intervals, so it is impossible to determine whether similar declines were evident after 2000. Interestingly, although these studies both suggest a U-turn in birthweight and macrosomia trends by the late 1990s, the study authors apparently did not see, or discounted, the reversals. Both Lahmann et al. [36] and Schack-Nielsen et al. [37] concluded that both mean birthweight and the prevalence of high birthweight increased steadily during the entire period studied.

In China, Liu et al. [23] had previously reported increases in mean birthweight and rates of macrosomia (from 2.6% to 13.2%) between 1970 and 1999. More recently, however, Han et al. [38] reported decreases in mean birthweight from 1987 to 2006, among both boys (3,227–3,051 g) and girls (3,268–3,027 g) in Henan province. Both low birthweight and very low birthweight increased during the same period, whereas macrosomia decreased. Similarly, in Southern China, Lu et al. [39] found that the rate of macrosomia rose from 6.0% in 1994 to 8.5% in 2000, and subsequently decreased to 7.8% in 2005. Similar turnarounds were observed in mean birthweight trends. The Republic of Korea has also reported increases in rates of low birthweight among singleton births since 1995 [40]. Japan, however, has reported a decrease in birthweight and increase in rates of low birthweight dating back to the 1970s [41].

What could be accounting for these recent, unexpected, and apparently worldwide decreases in birthweight? To understand these trends, it is important

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<tbody>
<tr>
<td>Percent of total births</td>
<td>Percent change</td>
<td></td>
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<tr>
<td>Less than 1,000 g</td>
<td>0.63</td>
<td>0.72</td>
<td>0.70</td>
<td>14</td>
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<tr>
<td>1,000–1,499 g</td>
<td>0.65</td>
<td>0.76</td>
<td>0.75</td>
<td>17</td>
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<tr>
<td>1,500–1,999 g</td>
<td>1.33</td>
<td>1.63</td>
<td>1.58</td>
<td>23</td>
</tr>
<tr>
<td>2,000–2,499 g</td>
<td>4.37</td>
<td>5.15</td>
<td>5.14</td>
<td>18</td>
</tr>
<tr>
<td>2,500–2,999 g</td>
<td>16.03</td>
<td>18.44</td>
<td>18.57</td>
<td>15</td>
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<tr>
<td>3,000–3,499 g</td>
<td>36.71</td>
<td>38.87</td>
<td>39.20</td>
<td>6</td>
</tr>
<tr>
<td>3,500–3,999 g</td>
<td>29.40</td>
<td>26.61</td>
<td>26.41</td>
<td>–9</td>
</tr>
<tr>
<td>4,000–4,499 g</td>
<td>9.10</td>
<td>6.75</td>
<td>6.60</td>
<td>–26</td>
</tr>
<tr>
<td>4,500–4,999 g</td>
<td>1.59</td>
<td>0.96</td>
<td>0.92</td>
<td>–40</td>
</tr>
<tr>
<td>5,000 g or more</td>
<td>0.19</td>
<td>0.11</td>
<td>0.10</td>
<td>–42</td>
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Adapted from Martin et al. [3].
to consider separately the two components of birthweight: gestation length and fetal growth.

**Gestation Length and Its Determinants**

Length of gestation is the most important predictor of size at birth [42]. In the United States, the rate of preterm birth (i.e. births before 37 completed weeks of gestation) has increased over the past 2 decades. From 1990 through 2006, preterm births increased steadily from 10.6 to 12.8%, a 20% increase (table 2) [3]. During the same period, the early preterm rate (birth at <34 weeks) increased modestly by 9%, whereas the late preterm rate (34–36 weeks) climbed by 20% (table 2). However, after 2006 both early and late preterm births decreased, back down to 12.3% in 2008 [3].

Mothers under age 15 and aged 45 and over are most likely to have a preterm delivery [3]. Preterm rates for these youngest and oldest mothers are about twice those of mothers aged 25–34 years. The preterm rates for older women are strongly influenced by their greater likelihood of having a multiple birth, itself a strong predictor of gestation length. However, trends in singleton preterm births have paralleled those for preterm births overall, with an increase from 1990 (9.7%) to 2006 (11.1%), and subsequent decline to 2008 (10.6%) [3]. Furthermore, although births to older mothers have been increasing, rates of teen pregnancy have declined substantially over time [3]. Other drivers of preterm birth in developed countries include cigarette smoking and low maternal pre-pregnancy weight [42], both of which are also increasingly less common.

Term births (37–41 weeks) have traditionally been viewed as a homogenous group. There is, however, growing evidence of increased neonatal morbidity.

**Table 2.** Percent distribution of US births by gestational age, in 1990, 2006, and 2008

<table>
<thead>
<tr>
<th>Percent of total births</th>
<th>Percent change</th>
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<tr>
<td>Total under 28 weeks</td>
<td>0.71</td>
</tr>
<tr>
<td>Total under 34 weeks</td>
<td>3.32</td>
</tr>
<tr>
<td>34–36 weeks</td>
<td>7.30</td>
</tr>
<tr>
<td>Total under 37 weeks</td>
<td>10.62</td>
</tr>
<tr>
<td>37–38 weeks</td>
<td>19.66</td>
</tr>
<tr>
<td>39 weeks</td>
<td>21.72</td>
</tr>
<tr>
<td>40–41 weeks</td>
<td>36.68</td>
</tr>
<tr>
<td>42 and more weeks</td>
<td>11.33</td>
</tr>
</tbody>
</table>

Adapted from Martin et al. [3].
among early term (37–38 weeks) infants compared with those born full term (39–41 weeks) [43, 44]. In response, organizations such as the March of Dimes are recommending that researchers differentiate between ‘early term’ and ‘full term’ births [45]. Trends in early term births have paralleled those of preterm births, with increases from 1990 to 2006, followed by a recent slight decrease (table 2). Conversely, late-term births, those after 41 completed weeks, have dropped dramatically, with an almost 100% drop over the past 2 decades.

Predictors of late preterm and early term birth are likely to differ from predictors of early preterm birth. Much of the increase in births at 35–38 weeks may well be iatrogenic, as ‘indicated’ and elective cesarean deliveries as well as induction of labor account for an increasing proportion of births in the US [3, 29, 43]. As many as 28–36% of scheduled deliveries occurring before 39 weeks are elective, i.e. scheduled in the absence of medical or obstetrical indications [46]. Similar trends in both gestation length and obstetric interventions have been seen many other countries as well [38, 47–49].

Whether trends in obstetric practice entirely explain those in gestation length remains uncertain, however. Cesarean deliveries have not varied in parallel with gestation length. The proportion of cesarean deliveries decreased throughout the early 1990s, and has steadily increased from 1996 to 2008 [3]. Although the rate of increase has slowed during the past few years, no decrease is yet apparent that could explain the recent flip in gestation length trends. Induced labor steadily increased throughout the 1990s and into the early 21st century. In an ecologic analysis of US birth certificate data, Zhang et al. [29] concluded that increasing use of labor induction was a likely cause of declines in gestation length from 1992 to 2003. Unfortunately, national surveillance reports do not include the most recent trends in labor induction to help understand the most recent increases in gestation length. Some data do suggest that early term deliveries may be starting to wane. After a regional health care system in Utah implemented guidelines in 2001 to discourage early term elective deliveries, the prevalence of near-term elective deliveries decreased from a baseline 28% of all elective deliveries to less than 10% within 6 months, and after 6 years continued to be less than 3% [50]. In 2007, the American College of Obstetrics and Gynecology published an opinion recommending against elective cesarean delivery prior to 39 weeks [51], which may result in similar practice changes nationwide.

However, even among spontaneous vaginal births, the distribution of gestational ages has shifted to the left [28, 30]. In an analysis of US term singleton births, Donahue et al. [28] found that declines in gestation length from 1990 to 2005 were strikingly similar regardless of route of delivery or whether labor was induced (fig. 3). Similar trends were also apparent among a homogenous ‘low risk’ subgroup, defined as women who were 25–29 years old, non-Hispanic white race/ethnicity, greater than 12 years of education, married, received prenatal care in 1st trimester, non-smoker, no medical complications during current or previous pregnancy, delivered vaginally, labor not induced, had an ultrasound, and
gained 26–35 pounds during the current pregnancy (fig. 3). These findings suggest that demographic shifts in the population and trends in obstetric care are not likely to be entirely explaining the declining gestational age among US births.

More relevant to the current topic, however, is whether trends in gestation length, whatever the cause, can explain the observed trends in birthweight. To address this question, it is necessary to examine trends in fetal growth independent of gestational age at birth.

**Fetal Growth and Its Determinants**

Fetal growth is typically defined as birthweight for gestational age, and typically reported as a percentile or z score within a given week of gestation compared with a sex-specific population reference [31]. Small for gestational age (SGA) is usually considered to be birthweight for sex and gestational age below the 10th percentile, and large for gestational age (LGA) as birthweight for sex and gestational age above the 90th percentile, although other definitions exist [52].

In addition to sex, other determinants of fetal growth include maternal racial/ethnic origin, height, pre-pregnancy weight, gestational weight gain, parity and weights of prior births, general morbidity and episodic illness, alcohol
and tobacco use, and paternal weight and height [31, 42]. Because many of these factors, including race/ethnicity, birth order, and siblings' birthweights, are not modifiable, some have recommended the use of ‘customized’ birthweight percentiles [53]. However, others have argued that since maternal characteristics account for only a small percent of the total factors influencing birthweight, and since customized percentiles are unable to distinguish between pathological and physiological influences of maternal characteristics on birthweight, the best estimate of an infant’s optimal birthweight remains close to the population average [54]. Furthermore, while these factors may be important for assigning a fetal growth percentile to an individual infant, they are less relevant to population trends, especially if the characteristics of mothers do not dramatically change over time, or are accounted for in analysis. Most analyses reporting trends in fetal growth have not used references customized to maternal characteristics. However, it is essential to account for infant sex and plurality, given their strong contributions to fetal growth.

Compared to the more numerous papers with information on birthweight trends, fewer papers provide information regarding trends in fetal growth among singletons. However, available data do suggest that fetal growth has declined independent of gestational age at birth. Donahue et al. [28] found that, as birthweight decreased, rates of SGA increased among term singleton births from 1990 to 2005, especially after 2000, whereas LGA decreased during this same period. Birthweight decreased within each week of gestation, further evidence that decreases in gestation length did not fully explain the observed birthweight trends. Table 3 shows similar trends of SGA and LGA, by sex, among all singleton US births. Although SGA and LGA rates differed by race/ethnicity, trends over time were similar in all groups [25]. In contrast, however, and using the same dataset, Zhang et al. [29] reported decreases in SGA and increases in LGA over a similar time period. A likely explanation for this discrepancy may be the use of gestational age determination by last menstrual period vs. clinical estimate.

Maternal weight and gestational weight gain are two important contributors to offspring size at birth that have both shown dramatic increases over the past two decades, in the US and worldwide [25, 55–58]. Both factors contribute to risk for gestational diabetes mellitus, which itself promotes fetal growth [3]. Smoking, which predicts poor intrauterine growth, has been on the decline. The ongoing trends in these factors should, if anything, be spurring increases in fetal growth, rather than the recently observed decreases. In the paper by Donahue et al. [28], the maternal characteristics routinely recorded on the birth certificate did not appear to be responsible for observed decreases in fetal growth. This observation was concordant with the fact that the directions of trends in all maternal characteristics have continued since the early 1990s without any reversals. Since these trends explained past increases in birthweight and fetal growth, they could not explain recent decreases. Although maternal pre-pregnancy body mass index (BMI) was not available in this dataset, accounting for increasing pre-pregnancy
BMI trends should adjust fetal growth estimates even further downward. Similarly, accounting for route of delivery or induction also did not explain the trends.

In France, trends in SGA and LGA were also consistent with the trend in mean birthweight: there was a marked decrease in SGA between 1972 and 1995, whereas between 1995 and 2003, an increase in SGA and a decrease in LGA were observed [35]. The decrease in fetal growth after 1998 could not be explained by adjustment for induction of labor, maternal weight or weight gain, or any other available measure [35]. However, the method of gestational age determination in the French dataset evolved over time, and this methodological difference may account for part of the observed fetal growth trends.

**Discussion**

What might account for these recent, unexpected, downwards trends in infant size at birth? Increases in multiple gestation are not the cause, since trends are the same among singletons only. Trends in maternal characteristics such as prepregnancy weight, gestational weight gain, and smoking should, if anything, promote even greater fetal growth over time. Some authors have speculated that routine testing for and improved treatment of gestational diabetes mellitus might provide an explanation [25, 59]. However, fetal growth has apparently declined also among infants born to non-diabetic mothers.

Gestation length is clearly an important factor. While obstetric practice, especially induction of labor, likely accounts for observed decreases in gestation length and at least part of the decline in birthweight and macrosomia, it is not likely to explain the decrease in fetal growth entirely. If babies with higher fetal growth percentiles were over time more likely to be delivered earlier in

### Table 3. Estimates of SGA and LGA for gestational age births by sex and year, United States

<table>
<thead>
<tr>
<th></th>
<th>Percent of total births</th>
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<tbody>
<tr>
<td>SGA</td>
<td></td>
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</tr>
<tr>
<td>Boys</td>
<td>10.5</td>
<td>10.5</td>
</tr>
<tr>
<td>Girls</td>
<td>10.7</td>
<td>10.5</td>
</tr>
<tr>
<td>LGA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>11.1</td>
<td>10.7</td>
</tr>
<tr>
<td>Girls</td>
<td>10.5</td>
<td>10.3</td>
</tr>
</tbody>
</table>

Adapted from Institute of Medicine [25].
gestation, then birthweight would have dropped, but rates of LGA would not have changed. Conversely, change over time in how gestational age was assessed would result in apparent trends in fetal growth, but would not influence birthweight. One explanation that fits the evidence would be that only babies with an upward trajectory of fetal growth are increasingly more likely to be delivered earlier. Thus, a baby that would have become LGA if allowed to stay in utero longer would be delivered earlier, resulting in both lower rates of LGA and lower birthweights over time. This rationale seems implausible, however, and does not explain increasing SGA trends.

Surveillance data are an important foundation for describing secular trends in birthweight. However, many datasets report birthweight among singletons and multiples, term and preterm infants combined. Furthermore, many report rates of macrosomia and low birthweight without information on SGA and LGA. To fully understand underlying contributors to trends in fetal growth as well as gestation duration, it is crucial that data be readily available to allow determination of fetal growth, by gestation length and plurality as well as maternal characteristics.

Conclusion

Babies are not increasingly being born at higher birthweights. In fact, despite the headlines and counter to trends in maternal obesity, gestational weight gain, diabetes, and smoking, babies are being born at smaller and smaller birthweights, and a decreasing proportion of babies are born macrosomic. These declines are most likely largely explained by decreases in gestation length, itself caused by obstetric interventions, especially induction of labor and to a lesser extent elective cesarean delivery. However, it appears that fetal growth is also declining, at least in some settings, independent of gestation length. Reasons for this decline are as of yet unexplained and merit further investigation. Perhaps the 1879 Guinness record for heaviest baby (23.12 pounds) will remain unbroken for some time to come.

References