CHAPTER 1

The Epidemiology of Obesity in Pregnancy

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With the rapid increase in the prevalence of obesity in many countries, obesity during pregnancy has become a common high-risk obstetric condition in many populations. The immediate and long-term consequences are considerable. Obesity during pregnancy is associated with several adverse reproductive outcomes, including hypertensive disorders, gestational diabetes mellitus, cesarean delivery, macrosomia, shoulder dystocia, and fetal death [1–7]. Long term, the consequences may be even greater: maternal obesity also is associated with an increased risk for type 2 diabetes mellitus for the mother and child, as well as an increased risk for obesity for the child later in life [8–15].

This chapter will: discuss the definition of overweight and obesity, as well as specific issues concerning the measurement of maternal obesity; present available estimates on the prevalence of maternal obesity in various countries; describe the impact of excessive gestational weight gain on the prevalence of maternal obesity; and summarize studies that have estimated the healthcare costs associated with obesity during pregnancy.

Defining the prevalence of obesity

Estimates of obesity prevalence in populations depend on the definition of obesity. Ideally, obesity should be defined by the amount of excess fat that increases health-related risk factors and associated morbidities; however, in practice, a single, ideal definition of obesity for use in population-based estimates is not possible, for three main reasons. First,

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*The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

Pregnancy in the Obese Woman, 1st edition. Edited by Deborah L. Conway.

an ideal definition requires an exact measurement of excess fat, which involves expensive and complicated methods; second, health risks associated with obesity increase on a continuum, not at a particular defined cut-off point; and third, the impact of excess fat on health varies among individuals and populations.

Historically, the precise measurement of body fat was done using hydrostatic weighing, which involves immersion underwater; currently, the most precise methods for measuring body fat involve the use of computed tomography or imaging techniques such as magnetic resonance imaging [16]. Although these methods most accurately measure body adiposity, the expense, the relative scarcity of the necessary equipment, and the need for an individual clinical visit make these methods impractical for measuring the population prevalence of obesity.

Body mass index (BMI; weight (kg)/height squared (m^2)) is highly, although not perfectly, correlated with fat mass [17,18]. For this reason, as well as the ability to use recorded or self-reported data, BMI is perhaps the most widely used measure to estimate adiposity. One primary limitation of this measurement is that it does not distinguish fat mass from lean mass. For example, BMI would underestimate body fat in older persons, because of their differential loss of lean mass and decreased height [19] and overestimate body fat in persons with a muscular build, such as athletes [20]. Nonetheless, for most clinical and epidemiological studies, BMI is considered an efficient and useful measure for estimating increased health risks related to excess body fat [21,22].

Another issue affecting prevalence estimates of obesity is defining BMI cut-off points. In the USA, one of the earliest suggested criteria for categorizing maternal BMI was included in the 1990 Institute of Medicine (IOM) report *Nutrition during Pregnancy* [23]. The IOM guidelines provided guidance on appropriate pregnancy weight gain levels based on pre-pregnancy BMI primarily to address low-birthweight deliveries related to insufficient nutrition and weight gain during pregnancy. Acknowledging that BMI is a better indicator of maternal nutritional status than is weight alone, the IOM subcommittee suggested the weight-for-height categories shown in Box 1.1. These cut-off points generally correspond to 90%, 120%, and 135% of the 1959 Metropolitan Life Insurance Company weight-for-height standards, standards that were in common use in the USA at that time.

In 1997, the World Health Organization (WHO) proposed a BMI classification based on the risk for co-morbidities (Box 1.1) [24]. These categories of underweight, normal weight, overweight, and obese classes I, II, and III are age-independent and the same for both genders.

Although these standards were developed for adults of European descent, they have been frequently used in many countries and have facilitated international comparisons.

Box 1.1 Body mass index (BMI) categories: World Health Organization (WHO) and Institute of Medicine (IOM; 1990) classifications

BMI category (kg/m^2)	WHO	IOM
Underweight	<18.5	<19.8
Normal weight	18.5–24.9	19.8–26.0
Pre-obese/overweight	25.0–29.9	>26.0–29.0
Obese	≥30.0[a]	>29.0

[a] The WHO/National Heart, Lung, and Blood Institute obese category is sometimes further divided into obese I (30.0–34.9 kg/m^2), obese II (35.0–39.9 kg/m^2), and obese III (≥40.0 kg/m^2), corresponding to moderate, severe, and very severe risk for co-morbidities.

In 1998, the US National Heart, Lung, and Blood Institute (NHLBI) published *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults* [25]. The BMI criteria published in this report were essentially the same as those recommended by the WHO, except for a difference in labeling BMI 25.0–29.9 kg/m^2 as "overweight" rather than "pre-obese." As stated by the NHLBI expert panel, this BMI classification was based on available scientific evidence from observational and epidemiological studies of BMI and risk for morbidity and mortality. These guidelines specifically excluded pregnant women with the following statement: "Pregnant women who, on the basis of their prepregnant weight, would be classified as obese may encounter certain obstetrical risks. However, the inappropriateness of weight reduction during pregnancy is well recognized; hence, this guideline specifically excludes pregnant women." Nonetheless, these NBHLI/WHO BMI classifications have been used extensively for prevalence estimates and in etiological studies of pregnant women.

The WHO and the IOM criteria will yield different BMI prevalence estimates in the same population; overall, the WHO criteria will result in higher prevalence estimates of overweight and lower prevalences of obese and underweight than estimates based on the IOM criteria [26]. While the differences in BMI criteria would not affect the ability to monitor trends in obesity of a country or subpopulation, criteria differences can affect international comparisons and etiological studies estimating obesity prevalence and the association with adverse health outcomes.

In 2009, the IOM revised the 1990 guidelines for weight gain during pregnancy, in large part to address the high rates of overweight and obesity in the US population [26]. These new guidelines adopted the WHO BMI cut-off points, recognizing the wider general acceptance of these criteria, which has enabled comparisons between populations, both within countries and internationally. However, these categories were developed using a standard based on adults of European descent, and there is substantial evidence that body fat distribution and the effect of excess body fat on health differ among race and ethnic populations.

BMI does not necessarily describe the same degree of fatness in different populations, partly because of differences in body proportions. For example, Asians have a more centralized distribution of body fat for a given level of BMI compared to people of European descent, and some studies have shown that obesity-related morbidity and mortality among Asians occur at a lower BMI than in other race and ethnic groups [27–29]. This is particularly relevant for gestational diabetes mellitus: Asians have some of the highest rates among all race and ethnic groups, but have a low prevalence of obesity [30]. Thus, visceral fat measurements may be more predictive of risk than BMI. African-Americans tend to have a lower percentage of body fat than people of European descent at the same BMI [31], and there is some suggestion that certain obesity-related conditions (macrosomia, pre-eclampsia) occur at higher BMI levels among black individuals than other race and ethnic groups [32].

Finally, health risks associated with body mass are on a continuum and do not necessarily correspond to rigid cut-off points. For example, an overweight individual with a BMI of 29 does not acquire additional health consequences associated with obesity simply by crossing the BMI threshold of 30 or above. Although health risks generally increase with increasing BMI, these cut-off points may not be as useful as a diagnostic tool [21].

Measuring the prevalence of maternal obesity

In addition to the issues affecting the measurement of obesity prevalence in the general population, there are concerns about the measurement of the prevalence of obesity in pregnant women. First, national reports generally have used the prevalence of obesity among women of reproductive age as an estimate of the prevalence of obesity among pregnant women [33]. While these data are readily available, pregnant women are a distinct subgroup of all women in that age group and estimates based on all women of reproductive age may not accurately reflect estimates among pregnant women.

Second, many prevalence estimates of maternal obesity are clinic rather than population-based. This also can result in inaccurate prevalence estimates, especially if the clinic serves a specific population, selectively excludes healthier women, or does not serve large numbers of women in a particular area.

Finally, information on maternal body mass or weight must reflect status preceding any significant pregnancy weight gain. Because of this, most estimates of maternal obesity based on BMI rely on retrospective self-reported data. These values generally result in underestimates of the prevalence of obesity, as individuals tend to underreport their weight and overreport their height [34], although studies that have examined this error among women who recently delivered have found that, on average, the magnitude of underreporting for overweight women was less than 10 lb [35,36].

Worldwide prevalence of obesity during pregnancy

Obesity has reached epidemic proportions globally [37]. Although the prevalence is highest in developed countries, obesity has become an important health issue in many developing countries, often co-existing with undernutrition [38]. Concomitant with the increased rates of obesity in the general population, obesity during pregnancy has also escalated, and it is now a common obstetric high-risk condition. Although data on the prevalence of obesity among pregnant women are limited in most countries, available information demonstrates the extent and range of the problem in many areas in the world. Figure 1.1 displays studies reporting the prevalence of overweight and obesity during pregnancy in various countries; included studies were limited to those that were population-based, used weight or BMI measurements pre-pregnancy or early in pregnancy before substantial weight gain, and included data collected during the year 2000 or after.

In the USA, the reported prevalence of maternal obesity in different cities and states ranged from 10% to 26% [39–42] (Figure 1.1); in part, these disparities reflect differences in populations and years of data collection. In the largest, most recent survey based on data from 26 states and New York City during 2004–05, approximately one in five US women who delivered were obese; in some state, race/ethnicity, and socioeconomic status subgroups, the prevalence was as high as 35% [43]. Race was the strongest predictor of higher obesity prevalence, with black women having an obesity prevalence about 70% higher than white and Hispanic women (black, 29.1%; white, 17.4%; Hispanic, 17.4%). Moreover, these obesity rates are notably higher than in previous years; a previous study of nine US states showed that the prevalence of obesity at the start of pregnancy increased from 13% in 1993–94 to 22.0% in 2002–03, a 70% increase over a 10-year period [44]. The other North American

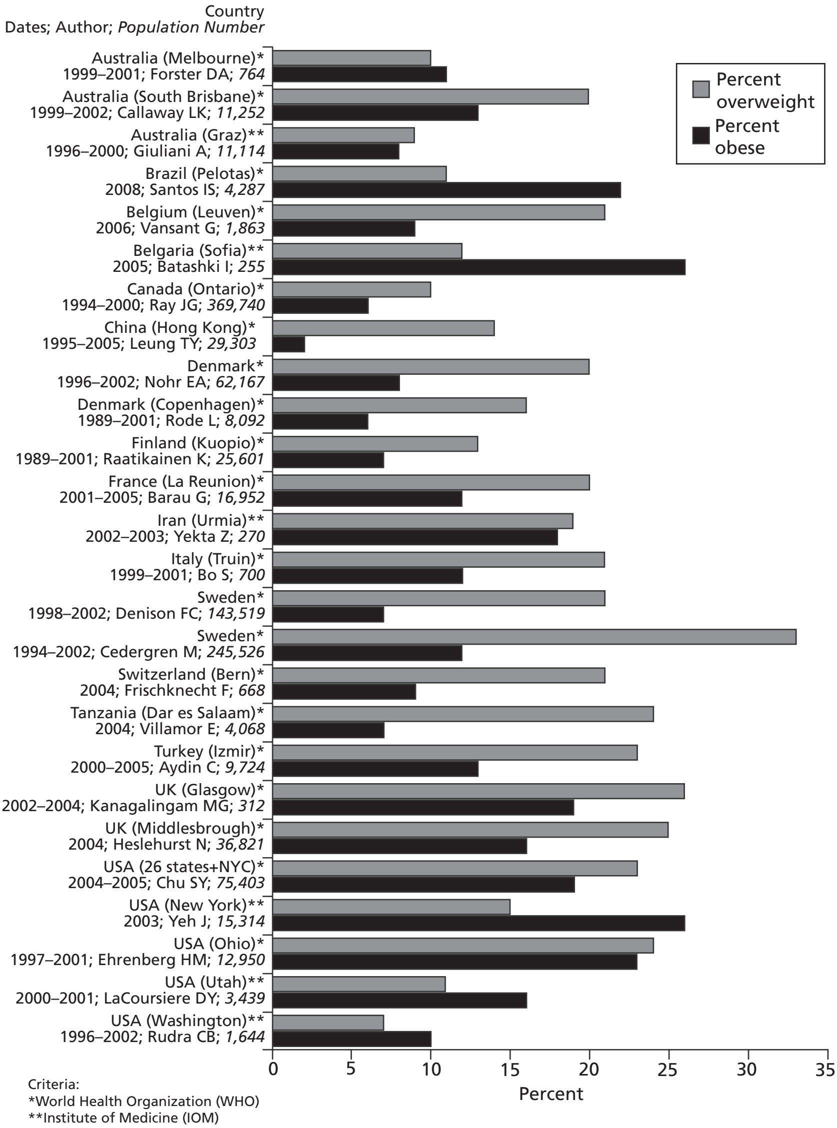

Figure 1.1 Prevalence of overweight and obesity among pregnant women in population-based studies. (Adapted from Guelinckx et al. [6], with permission.)

country with available data, Canada, reported lower prevalence rates of maternal obesity than for the USA (6%) [45], although a direct comparison is difficult given that years of the studies and body weight measures were not equivalent.

The prevalence of obesity among pregnant women in Europe varied considerably by country, with the highest prevalence rates reported in the UK [46,47]. Both UK studies reported a 50% increase in obesity between

1990 and 2002–04, and found that socioeconomic disadvantage or deprivation was a strong independent predictor of maternal obesity. Race and ethnicity differences were not examined closely as over 90% of the UK study populations were Caucasian. About one in eight pregnant women were obese in studies from France, Italy, and one of the two reports from Sweden [48–51]. Several European countries reported maternal obesity rates below 10% [52–57], although even in the country with the lowest reported prevalence, Denmark, about one in 15 women who are pregnant were obese [55].

Prevalence data on maternal obesity from countries outside the Western hemisphere and Europe are more limited. In one of the more developed countries in the Oceania continent, Australia, prevalence rates of maternal obesity were similar in two east coast areas (Melbourne, 11%; South Brisbane, 13%) [58,59]. Available reports suggest that high levels of maternal obesity are found even in some generally less affluent countries (Bulgaria, 26%; Turkey, 13%; Brazil, 22%; Iran 18%) [60–63]. The prevalence of maternal obesity was lower in the single African study from Tanzania (7%) [64]; however, the prevalence of overweight among these African pregnant women was as high as in Western countries (24%). China was the exception, with low obesity prevalence (2%) even in a well-developed city, Hong Kong [65]. Direct comparisons among countries cannot be made as the reported obesity prevalence is affected by the criteria used (i.e. WHO versus IOM), the size and representativeness of the population surveyed, and the years of the study.

Certain maternal characteristics, such as older maternal age and higher parity, are consistently associated with higher rates of obesity, regardless of culture and geographic location. In the USA, obesity prevalence differs significantly by race and ethnicity, but most studies outside the USA are not able to examine rates by racial and ethnic groups. However, when examined in developed countries (US, UK, Denmark, Sweden), reported maternal obesity was higher in population subgroups with lower socioeconomic status; in contrast, in Tanzania, maternal obesity was associated with higher education and more income earned outside the home. This highlights the importance of considering how differences in economic situation and cultural context can affect the patterns of and the risk factors for obesity in various countries or populations.

Impact of gestational weight gain on trends in maternal obesity

In many countries, the current trend of increasing maternal obesity is in part related to excessive levels of weight gain during pregnancy [66,67].

Historically, gestational weight gain guidelines were developed to reduce the well-known adverse impact of inadequate pregnancy weight gain on reproductive outcome [66], with smaller gains recommended for heavier women. However, major changes have occurred in the body weights of pregnant women, prompting discussion to produce new guidelines that consider the short- and long-term adverse impacts of excessive gestational weight gain. Short-term consequences include preterm delivery, neonatal hypoglycemia, and macrosomic infants [67–71]; long term, excessive gestational weight gain increases the risk for weight retention after pregnancy and excessive body weight later in life [70,72–75].

Excessive weight gains during pregnancy have been documented in several developed countries. In a US study of 52,988 underweight, normal, overweight, and obese women who delivered a singleton, full-term infant in 2004–05, approximately 40% of normal-weight and 60% of overweight women gained excessive weight during pregnancy, with the highest rates of excessive gestational weight gains among the youngest and those who were nulliparous [76]. Similar excessive levels of gestational weight gain have been reported among pregnant women in other developed countries, including Belgium [54], Denmark [70], Australia [77], Sweden [51,73,74], Germany [78], and Switzerland [57]. These trends in excessive gestational weight gains predict a further escalation of the problem of obesity among women of reproductive age in many parts of the world.

Economic costs of maternal obesity

Obesity is not only a health issue, but also has economic consequences. Total costs involve both the direct costs related to medical expenditures from obesity-related diseases, including type 2 diabetes, cardiovascular disease, several types of cancer, and musculoskeletal disorders, as well as indirect costs related to absenteeism, reduced productivity, and disability [79]. Many countries have reported on the substantial and increasing economic burden of obesity, including the USA [80,81], Canada [82], Europe [83], Eastern Europe [84], the UK [85], China [86,87], and Japan [88]. A recent projection based on data from the US National Health and Nutrition Examination Survey estimated that, by the year 2030, costs related to overweight and obesity will account for 16–18% of total US healthcare costs [81].

However, precise estimates of the economic costs directly related to maternal obesity are very limited. It is clear that the costs are substantial, because maternal obesity not only increases the risk for adverse pregnancy and infant outcomes, but also may be associated with a higher risk for developing type 2 diabetes mellitus later in life for both mother and child

[8–10]. Moreover, maternal obesity, either independently or through gestational diabetes mellitus, may increase the risk for obesity in offspring [11–15]. The medical care costs related to chronic diabetes and obesity in the mother and her offspring far exceed the immediate costs associated with adverse short-term pregnancy outcomes. So although pregnancy is a time-limited condition in a woman's life, differences in risk during this time can affect the lifelong health of the mother and her offspring.

And although it is recognized that the use of healthcare is increased for pregnant women who are obese, published estimates of the magnitude of that increase are quite limited. Numerous studies have documented the increased risks of adverse outcomes associated with obesity during pregnancy, but few studies have provided quantitative estimates of the associated increase in healthcare utilization. Two papers from Montpellier, France, estimated the complications and costs of obesity during pregnancy based on the same clinic population during two time periods (1980–93 and 1993–94, respectively [88,90]. The authors found that average costs were significantly higher among overweight and obese pregnant women than among normal-weight women; however, these cost estimates were based only on hospitalizations. In a qualitative study from the UK, 33 maternity and healthcare professionals were interviewed on their views of the impact of maternal obesity on maternity services and healthcare resources [91]. There was general consensus that maternal obesity has a major impact on the level of care required for both the mother and the infant, but this study could not provide quantitative estimates of the impact.

Quantitative increases in healthcare services related to maternal obesity were documented in a US study of 13,442 pregnancies among women aged 18 years and older who were participants in a large group practice Health Maintenance Organization [92]. Maternal obesity was associated with significantly greater use of inpatient and outpatient healthcare services, including costly measures such as length of stay during the hospitalization for delivery and use of physician services; mid-level providers were used less during prenatal visits. Almost all of the increase in utilization was related to the increased rates of cesarean delivery and the presence of gestational diabetes, diabetes mellitus, or hypertensive disorders among obese pregnant women. These findings are consistent with a recent systematic review of the literature on the impact of maternal obesity and obstetric care, in which maternal obesity was associated with increased rates of cesarean and instrumental deliveries, hemorrhage, infection, longer hospital stays, and increased use of neonatal intensive care [93]. Because maternal obesity is no longer rare in many countries, even a small increase in healthcare costs associated with obesity can have a substantial economic impact. Understanding the total impact of obesity during pregnancy on the lifetime health of the mother and her children as well as the economic consequences may impel the level of individual and societal changes necessary to control the growing epidemic of obesity.

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