Is the Health Burden Associated With Obesity Changing?

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Prioritization of obesity prevention and management policy is based on one’s understanding of the health risks associated with increasing body weight. However, there is evidence that the magnitude of these health risks may be changing over time. Here, the authors analyze the theoretical drivers of these changes and then examine whether there is empirical evidence to support the theory. They conclude that, although the mortality risks associated with increasing body weight may be decreasing over time, the overall health burden appears likely to increase.

chronic disease; mortality; obesity; risk; trends

Abbreviation: CVD, cardiovascular disease.

The health risks associated with increasing body weight are generally well understood. There are multiple cohort studies demonstrating that overweight and obesity are associated with an increased risk of a range of conditions, including diabetes, cardiovascular disease (CVD), some cancers, musculoskeletal disease, infertility, sleep apnea, disability, dementia, and mortality (1–3). An accurate understanding of the magnitude of these health risks is the basis of society’s prioritization of obesity prevention and management strategies. There has been recent suggestion that the risk of mortality associated with increasing body weight has decreased over time (4), as well as questioning of the extent to which current body weight trends pose a real threat to population health (5, 6).

There are a number of pathways through which changes in the relative risk relation between excess body weight and health risk factors, disease, and mortality may occur. There may be intrinsic differences in the extent to which excess body weight is associated with risk factor or disease incidence and mortality rates. This may in turn reflect different “types” of obesity or changes in factors such as ethnicity, activity, and dietary patterns associated with excess body weight. On the other hand, improvements in the treatment of risk factors and diseases will lead to increases in risk factor or disease prevalence but decreases in mortality rates.

Here, we analyze the evidence that the magnitude of the health risk associated with increasing body weight is changing over time. We analyze the theoretical drivers of these changes and then examine whether there is empirical evidence to support the theory. We searched in PubMed (National Library of Medicine, Bethesda, Maryland) for articles using the keywords (“obesity” [MeSH Terms] or “obesity” [All Fields]) and (“trends” [Subheading] or “trends” [All Fields]) and (“risk” [MeSH Terms] or “risk” [All Fields] or “mortality” [Subheading] or “mortality” [All Fields] or “mortality” [MeSH Terms]). References identifiable within the abstract as having examined changes in the relation between excess body weight and a risk factor or health outcome were retrieved. Articles published post-2004 were retrieved to represent recent trends. Additional references were retrieved from article reference lists and citation sources.

Factors potentially leading to a decrease in the health risks associated with increasing body weight

There has been a rapid improvement over the past few decades in the prevention and treatment of CVD and its risk factors. Rates of antihypertensive and statin therapy have increased, and population cholesterol and blood
pressure levels have accordingly decreased (7–10). Similar improvements have been observed with the management of diabetes, with the relative risk of mortality in those with diabetes also falling over time (11). Consequently, rates of CVD mortality have also declined (8, 12). Between 1980 and 2002, the age-standardized coronary heart disease mortality rate in adults aged ≥35 years decreased by 52% in men and 49% in women in the United States, with similar decreases observed in most other developed countries (8, 13–16).

As diabetes and CVD constitute a significant proportion of the pathway between obesity and mortality (17–19), a reduction in diabetes-related mortality and CVD mortality would be expected to substantially reduce the excess mortality risk associated with increasing body weight.

**Evidence of a decrease in the health risks associated with increasing body weight over time**

There are few studies enabling an empirical evaluation of the question of changes in health risks associated with obesity over time. Repeat studies, with comparable measures and comparable population inclusions, are needed. The National Health and Nutrition Examination Surveys in the United States are one such data source, and it is primarily from studies using these surveys that we have identified the following empirical evidence.

Analysis of the US National Health and Nutrition Examination Surveys from 1971–1975, 1976–1980, and 1988–1994 suggested that the relative risk of mortality may be decreasing over time (4). It was demonstrated that, although the relative risk of mortality for those with mild or severe obesity compared with normal weight was 1.5 and 2.8, respectively, in the mortality follow-up of the 1971–1975 survey, this was reduced to only 1.4 and 1.6 in the mortality follow-up of the 1988–1994 survey. However, in this study, the relative risks from the 1976–1980 survey were not intermediate, as might have been expected, but were around 0.8 and 1, respectively. A follow-up analysis of cause-specific mortality from the same National Health and Nutrition Examination Surveys also indicated a decrease in the relative risk of CVD mortality associated with obesity over time (19). A subsequent analysis by Calle et al. (20) compared obesity-associated mortality risks in the Cancer Prevention Study cohort across 3 time periods (1982–1991, 1992–1997, and 1998–2002), using body mass index measured in the 1982 study for all analyses. They found no evidence of a decrease in relative risks over time. However, it is likely that individuals’ body mass index increased between 1982 and 1992 to 1998, making comparison between the categories at the different time points and, consequently, inference about obesity-related risks over time difficult. A recent analysis of this question compared obesity-related mortality risks among 3 longstanding US data sources on health and mortality: 1) the Framingham Heart Study (comparing the periods 1948–1970 and 1985–2003), 2) the National Health and Nutrition Examination Surveys (comparing the periods 1971–1987 and 1988–2006), and 3) the National Health Interview Survey (comparing the periods 1987–1996 and 1997–2006) (21). A consistent decline over time in class I (body mass index: 30–34.9 kg/m²) obesity-related mortality relative risks was observed. For class II/III (body mass index: ≥35 kg/m²) obesity, a decline over time in the relative risk of mortality was observed when comparing the 2 National Health Interview Surveys but not the Framingham survey or the National Health and Nutrition Examination Surveys. All the decline in the relative risk of mortality observed for class I obesity appeared to be attributable to declines in the relative risk of CVD mortality but not cancer mortality or non-CVD/noncancer mortality (21).

Many time-series analyses of population risk factor surveys have reported on both decreasing levels of blood pressure and cholesterol and increasing levels of overweight and obesity. From this, one might assume that the association between excess body weight and blood pressure and blood cholesterol has weakened over time. However, few studies have addressed this question. A study of a series of the US National Health and Nutrition Examination Surveys reported on changes in the association between overweight and obesity and cardiovascular risk factors between 1960–1962 and 1999–2000. In this analysis, they demonstrated a greater decrease in the prevalence of high blood pressure and high blood cholesterol in those with obesity compared with those with normal weight, over time (22). Between 1960 and 2000, the prevalence of high blood pressure (as measured) decreased by around 14, 16, and 18 percentage points in those with normal weight, overweight, and obesity, respectively. For those with obesity, this represented a change in prevalence from 42% to 24%, compared with a decrease from 25% to 11% for those with normal weight. Similarly, the prevalence of high cholesterol (as measured) decreased by around 12, 21, and 21 percentage points in those with normal weight, overweight, and obesity, respectively. For those with obesity, this represented a change in prevalence from 39% to 18%, compared with a decrease from 27% to 15% for those with normal weight. As a consequence, the excess risk of high blood pressure and high blood cholesterol associated with obesity decreased between 1960 and 2000. Analysis of trends between later time points demonstrated a decrease in the excess risk for high blood cholesterol, but not high blood pressure, between 1990 and 2000. A comparison of serial cohorts of Swedish men aged 50 years between 1963 and 2003 also suggested a weakening of the relation between obesity and cardiovascular risk factors over time (23). The study found that in 2003 compared with 1963 obese men had a 2.7-fold increase in the odds of being normotensive, compared with a 1.7-fold increase for the normal weight group. Similarly, obese men had an 8.3-fold increase in the odds of having a serum cholesterol measurement less than 5 mmol/L, compared with a 6.1-fold increase for the normal weight group.

From these analyses, it is not possible to identify whether the excess risk of incident hypertension and hypercholesterolemia has decreased over time. Simply through a combination of primary and therapeutic changes over time, the differences in the levels of cholesterol and blood pressure between those with increasing body weight have decreased. A decrease in the excess risk of high blood
pressure and high blood cholesterol over time is likely to be associated with a decrease over time in the risk of CVD events and CVD mortality associated with obesity.

In contrast, a time-series study of the association between blood pressure and obesity in a Taiwanese population between 1996 and 2006 found no change or an increase in the association between obesity and blood pressure, depending on the age and sex group examined (24).

**Factors potentially leading to an increase in the health risks associated with increasing body weight**

There are a number of factors that would suggest that the obesity we observe today should be associated with greater health risks than in the past. The simplest of these is that the population distribution of weight (and consequently body mass index) is not increasing uniformly but is also increasing in its skew to the right. Consequently, although between 1980 and 2000 the prevalence of class I obesity in Australian adults increased by around 60%, the prevalence of class III obesity (body mass index $\geq 40$ kg/m$^2$) increased over 4-fold in Australian adults (25). Similar trends have been observed for other countries, including the United States and New Zealand (26, 27).

This indicates that, all other things being equal, we would expect the health risks associated with the classification of obesity to have increased over time, as that category is now defined by a higher mean and range of body mass indexes.

There are also a range of factors that suggest that the nature of the excess body weight itself may be different today.

One such factor is that the population increases in waist circumference appear to be greater than would be expected from the observed increases in body mass index. It has been shown that, in the United States, there has been a significant increase in waist circumference over the past 20 years independent of changes in body mass index (28, 29). In adults aged 25 or more years, this led to an increase in the average waist circumference between 1988–1994 and 2005–2006 of around 5 cm, which is 0.86 cm greater than would have been expected from the changes in body mass index. Although this has not yet been examined in other countries, the same observation is likely to hold. It has been reported that abdominal obesity, defined better by waist circumference than body mass index, is generally associated with a higher risk of metabolic diseases. such as diabetes and cardiovascular disease (30, 31); however, a recent meta-analysis study has found that body mass index, waist circumference, and waist/hip ratio each estimates a similar risk of type-2 diabetes (32). Consequently, the implications of a differential increase in waist circumference are not yet clear.

A second such factor is that the duration of obesity is increasing in our population. Although prior to 1980 generally less than 10% of children and young adults were obese, the prevalence of obesity in these population groups has more than doubled in many countries around the world (33). The consequences of this are that many of today’s middle aged obese population have been obese for in excess of 10 years. We have shown that, for every additional year lived with obesity, there are a 4% increased risk of diabetes and a 6% increase in the risk of all-cause mortality (34, 35). Those who have been obese for 15–24 years have more than double the risk of diabetes compared with those who have been obese for less than 5 years (34).

In addition, the degree of weight gain during childhood and adulthood has been identified as a risk factor for increased glucose and HbA1c levels in adulthood, partially independent of attained body mass index (36). As a consequence, we would predict that the earlier onset and increasing duration of obesity over time would confer an increased excess risk of a variety of diseases, including diabetes and cardiovascular disease, for a given level of body mass index.

**Evidence of an increase in the health risks associated with increasing body weight over time**

A further time-series analysis of the National Health and Nutrition Examination Surveys compared the distribution of type II diabetes cases across body mass index categories between the 1976–1980 Survey and the 1999–2004 Survey (37). It was observed that the increase in national diabetes prevalence over the studied 25-year period was disproportionately attributable to those with obesity. Of the additional diabetes cases (both known and newly diagnosed) reported in the 1999–2004 Survey, about half the additional cases were in those with a body mass index of 35 or greater; in contrast to the fact that this group made up only between 4% and 13% of the body mass index distribution during this time period (22, 37). The authors postulate that this may be due to the large increases at the upper end of the body mass index spectrum and the decreases in mortality in those with obesity, but no further data on this are presented (37).

Once again using a comparison of the repeat National Health and Nutrition Examination Surveys (1988–1994 and 1999–2004) in the United States, Alley and Chang (38) reported an analysis of the changes in the prevalence of disability associated with different body weight categories. Between surveys, the odds ratio of disability associated with obesity compared with normal weight increased from 1.3 to 2.1 for limitations in activities of daily living and from 1.8 to 2.7 for the less severe category of functional limitations. However, the reason for these similar trends differed. For limitations in activities of daily living, this reflected a decrease in the prevalence of limitations for those with normal weight over time, compared with no change in the prevalence of limitations for those with obesity. In contrast, for functional limitations, this reflected an increase in the prevalence of disability for those with obesity compared with those who had no change in the disability prevalence for those with normal weight.

A further analysis of the National Health and Nutrition Examination Surveys used a birth cohort analysis based on successive waves of the Surveys between 1971 and 2002 to evaluate changes in the relation between obesity and arthritis (39). They described an increase in the relative risk of arthritis associated with obesity over time, such that, compared with those with normal weight, those with obesity were 20%
more likely to report arthritis in 1970 but 60% more likely to report arthritis in 2002. The authors hypothesize that these increases were driven by changes in the body mass index distribution within the obese population over time (mean body mass index in 1971: 33.8 kg/m²; and in 1999–2002, 35.5 kg/m²), but this was not specifically analyzed.

A recent comparison of health-care expenditure in the United States between 1997 and 2006, using a series of nationally representative surveys of Medicare beneficiaries, indicated a greater increase in health-care expenditure over time in those with obesity compared with those with normal weight (40). Obese participants in the later time period were also more likely to have chronic conditions such as diabetes and hypertension, and this appeared to explain the more rapid increase in health-care expenditure in obese participants.

**Conclusion**

The available evidence, emanating from analyses of cross-sectional surveys and predominantly the National Health and Nutrition Examination Surveys of population risk factors, suggests that, although the obesity-associated risks of mortality, in particular CVD mortality and key CVD risk factors of high blood pressure and high blood cholesterol, may have decreased over time, the relative morbidity risks of diabetes and disability may be increasing. Although the survey series in each of the reports are not identical, 3 reports compare earlier time periods with the 1999–2000 National Health and Nutrition Examination Survey. In addition, the mortality follow-up from this Survey, although initiating from 1988–1994, extends to 2000, suggesting that the conclusions across the different analyses can be compared, and implications about recent changes in obesity-related health risks can be derived. The data from the most recent time-point comparisons suggest that improvements in high blood pressure may have ceased since the 1990s.

The theory and observation taken together suggest that obesity today is associated with a lesser relative risk of CVD mortality than in previous decades. It may also suggest that obesity today is associated with a greater relative risk of disabling conditions, possibly due to both improved survival from diabetes and CVD and an increased associated metabolic risk. As was the case previously with improvements in management of acute coronary heart disease leading to an increased prevalence of chronic heart failure and associated conditions, it is likely that improved management of both CVD and diabetes will lead to an increased prevalence of the chronic sequelae of CVD and diabetes, such as chronic heart failure, stroke, chronic renal failure, and various microvascular conditions. These likely opposing trends on obesity-related risks of mortality and morbidity underscore the importance of estimating the burden of obesity by using constructs such as years lived with and without disability and quality-adjusted life-years (41, 42). Such constructs demonstrate the overall impact on the burden of disease of a risk factor or intervention’s effect on morbidity and mortality.

Observed changes in cross-sectional associations between excess body weight and health outcomes may also be due to changes in the sociodemographic composition of body weight groups. For instance, a higher prevalence of females in the higher body weight groups over time would be associated with a decreasing risk of CVD alongside an increasing risk of disability. It is difficult to estimate from current reports the extent to which this has occurred since the 1970s. The analysis of US Medicare beneficiaries between 1997 and 2006 suggested that the proportion of those with obesity who are male and who are highly educated has actually increased (40). Such changes would drive the opposite observations to those described here. Further changes that may mediate apparent changes in excess body weight health outcome relations are those of related risk factors such as physical activity, inactivity, and diet, all of which also exert an effect on health outcomes independent of excess body weight. One final cluster of factors potentially linked to excess body weight but also contributing independently to health risks is the in utero environment. It is well described that factors such as maternal body mass index, weight gain, and gestational diabetes are associated with both future childhood and adulthood weight and cardiovascular risk factors in the child (43). The extent to which the latter association is independent of the future child’s or adult’s weight is less clear.

This analysis of the available evidence is substantially limited by the fact that the comparable, repeat cross-sectional surveys most reported upon are those from the National Health and Nutrition Examination Surveys. Although the surveys are of high quality, this limits any conclusions on changing excess body weight health outcome associations over time to the US population. It is likely that other high-income countries are going through similar transitions; however, the United States differs from many such countries through its substantial ethnic mix, relatively large social inequalities, and nonuniversal health-care coverage. These trends are not likely to be transferable to low- and middle-income countries, which are at different stages in both the obesity and epidemiology transitions. To advance our understanding of this issue, it will be critical to develop similar time-series analyses in other populations. Many countries now have serial population surveys with measures of body mass index, cardiovascular risk factors, and common diseases. Analyses of trends in the relation between excess body weight and each of these risk factors and health outcomes over time would enable us to conclude more clearly on which risk factor relations are weakening and strengthening over time and whether the observed trends are common to most of the developed world.

Here, we suggest that, although the cardiovascular sequelae of excess body weight are being better managed today, the overall health risks associated with excess body weight may be increasing. We hypothesize that the distribution of body fat and the duration of obesity are worsening over time, such that, for a given level of weight or body mass index, there is a higher level of health risk compared with those with normal weight. It will be important to continue to estimate a range of excess body weight-related health risks from contemporary cohorts to ensure that our estimates of the potential health burden associated with current body weight trends, as well as the potential benefits associated
with intervention, are realistic. When trying to determine the current health risks associated with excess body weight, we recommend estimating the health risks both independent of and including all these potentially clustering risk factors, to indicate both the likely causative effect of excess body weight itself and the likely overall health risks associated with a given level of excess body weight today. Although the excess risks of some cardiovascular risk factors and consequently mortality may be decreasing, the high and often increasing prevalence of obesity means that the obesity-related population attributable fraction for such factors is likely to remain high unless the prevalence of obesity or the relative risks reduce substantially.

The combination of better prevention and treatment of CVD and its risk factors with the potentially increased metabolic risk of obesity today makes estimating overall trends in the obesity-CVD relation difficult. In addition, it is likely that more recent trends differ from earlier trends. We recommend, first, synthesizing a series of contemporary excess body weight-related health risks across diabetes, CVD, and with a particular focus on other, disabling outcomes, such as the sequelae of coronary heart disease and diabetes, osteoarthritis, mental health, and disability itself. In order to better predict the likely future health risks associated with excess body weight, we further recommend more analyses of the trends in excess body weight-related health risks over time. To do this, more comparable observational studies over time are needed, with a range of health outcomes and potential confounders, and in a variety of populations. In the meantime, we recommend that health economic and other policy analyses take into account the likely changes in risk over time discussed in this article to ensure appropriate prioritization of obesity prevention and management strategies.

In conclusion, in spite of advances in cardiovascular prevention and treatment, it is likely that the overall health burden associated with excess body weight will increase over time, particularly through an increasing prevalence of more disabling conditions.

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