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OBESITY

High obesity incidence in northern Sweden: How will Sweden look by 2009?

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Abstract. The study objective was to evaluate the incidence of overweight and obesity in two rural areas of Sweden and the U.S. Previously collected data were used from 1990 to 1999 Multinational Monitoring of Trends and Determinants in Cardiovascular Disease (MONICA) studies in northern Sweden. Health censuses of adults in Otsego County, New York were collected in 1989 and 1999. Adults aged 25–64 year in 1989 with reports from both surveys were included. The 10-year change in body mass index (BMI), overweight (BMI 25–29.9 kg/m^2) and obesity (BMI $\geq$ 30) were obtained from panel studies. Incidences of overweight and obesity were calculated and compared between countries. The 10-year incidence of obesity was 120/1000 in Sweden and 173/1000 in the U.S. ($p < 0.001$ for difference between countries). In 1999, prevalence of obesity rose to 18.4% (Sweden) and 32.3% (U.S.). Cumulative distribution curves show that the BMI distribution in Sweden during 1999 is nearly identical to the U.S. during 1989. The obese proportions of these rural populations increased from 1989 to 1999. Sweden's obesity epidemic has a progression similar to that of the U.S., implying that by 2009, the prevalence of obesity in rural northern Sweden may mimic that present in rural New York during 1999. Attention should be paid to the increased obesity rates in rural areas.

Key words: Body mass index, Obesity, Sweden/epidemiology, United States/epidemiology

Abbreviations: BMI = body mass index; MONICA = Multinational Monitoring of Trends and Determinants in Cardiovascular Disease; U.S. = United States; WHO = World Health Organization

Introduction

The prevalence of obesity in industrialized countries is reaching epidemic proportions. Obesity has many well-known health consequences including increased mortality and morbidity, increased risks of cardiovascular disease, diabetes mellitus, hypertension, stroke, cancer, osteoarthritis, and increased rates of physical inactivity, disability, and social isolation [1-3]. In the U.S., two of three adults are currently classified as obese, the rates of obesity are increasing rapidly, and for nearly two decades there has been a national call to assess and intervene on obesity [4, 5]. Obesity is also increasing in Nordic countries [6, 7]. In Sweden, while there is increasing recognition of the increase in body weight and adiposity among the population, no national call for action on obesity has occurred [8].

While there are numerous studies that identify trends in obesity within different geographic locations and ethnic groups, there are few studies that have evaluated or compared rural populations in industrialized countries [9]. This study was undertaken to provide information on the worldwide problem of obesity within rural populations of industrialized countries. Most previous studies comparing different countries have only had access to cross-sectional data. While such information is important, it fails to provide the same information as incidence data do.

The aims of this study were to evaluate and compare the incidence and prevalence of overweight and

obesity between 1989 and 1999 in rural areas of northern Sweden and the eastern United States.

Methods

Data were obtained from previously conducted cohort studies. The studies complied with the Declaration of Helsinki. World Health Organization (WHO) Multinational Monitoring of Trends and Determinants in Cardiovascular Disease (MONICA) data from northern Sweden were used. The Northern Sweden MONICA study was approved by the Research Ethics Committee of Umeå University. Computer data handling procedures for MONICA data were approved by the Swedish National Computer Data Inspection Board. Health Census '89 and Health Census '99 were approved by the Institutional Review Board of Bassett Healthcare in Cooperstown, NY, USA. Approval for use of data for this analysis was granted by the Health Census '99 Data Monitoring Committee.

MONICA was started in the early 1980s, with the aim of measuring trends in cardiovascular disease mortality, coronary heart disease and cerebrovascular morbidity, and assessing the relationship of these trends to known risk factors in different countries [10]. In most countries, MONICA consists of serial cross-sectional samples of the selected population. The northern Swedish MONICA study has a panel cohort that was initially seen in 1990 and underwent a repeat survey in 1999. The sampled adults were from the counties of Norrbotten and Västerbotten. The total population of Norrbotten and Västerbotten counties is 510,000. The inhabitants reside in an area of 59,450 km^2 and have a population density of approximately 4/km^2 [11]. A random sample of men and women aged 25–64 years, stratified by age and sex, were invited to a health survey. The participation rates for these surveys were $\geq 80\%$ [12]. For the comparative purposes of this study, the 9 year interval between surveys will be considered the decade of 1989–1999. Self-reported demographic data included age, sex, marital status and years of education. Objective measurements of height and weight were performed in a standardized fashion [13].

In rural northern New York State, two health censuses were conducted of the entire adult population ($\geq$ 18 years of age) of Otsego County in 1989 and 1999. These were funded by the New York State Department of Health and conducted by the Bassett Healthcare Research Institute. Otsego County has a total population of 61,676, covers an area of 1003 km^2, and has a population density of 18/km^2 [14]. One adult from each household completed the census form. Only the self-reporting adults were included in this analysis since we could not adjust for proxy report of body mass index. Adults aged 25–64 years in 1989 with reports from both surveys were included in these analyses. Response rates for the 1989 and 1999 surveys were 86 and 78.6%, respectively [15]. All data from the censuses were self-reported.

The Swedish data were used as measured. Previously validated adjustment factors were required to attain corrected BMIs for the U.S. population [16]. BMI corrections were made by multiplying the self-reported BMI with an adjustment factor (ranging from 1.029 to 1.068) specific to sex and four BMI categories ($<$18.5, 18.5–24.9, 25–29.9, $\geq$30).

A combined dataset was formed that contained variables common to both studies. New variables were created as needed. For example, the information on marital status from Sweden and the U.S. was similar, but not identical. A dichotomous variable for marital status was created that classified participants as married (for Sweden included co-habitation) or not married (never married, widowed, divorced, or separated). Separate descriptive analyses were performed by country. As appropriate, combined analyses for the countries and by subgroup were conducted to evaluate cross-country incidence and prevalence rates.

Descriptive statistics included frequencies of BMI category by country, sex, and 10-year age groups. Independent *t*-tests were performed to compare cross-country differences in BMI at baseline, change in BMI over 10 years, and change in BMI over 10 years for subgroups. Absolute change in BMI over 10 years was calculated as BMI in 1999 minus BMI in 1989. Individual changes over time were evaluated using change in relative BMI units and change in standard BMI units. Relative BMI units were calculated as

$$\frac{(\text{BMI in 1999} - \text{BMI in 1989})}{\text{BMI in 1989}}$$

Using subgroups defined by sex and age group, *z*-scores were calculated. The *z*-scores were compared between countries using an independent *t*-test.

The percentages of the population who were overweight and/or obese at baseline vs. 10-year follow-up were compared within and between countries using χ^2-tests. Age distributions and the 10-year incidences of overweight and obesity for each country were compared with McNemar's tests. Cumulative distribution curves by year and country were formed for the frequency of body mass index.

Power calculations prior to data analyses showed that this comparison has adequate power (80%) to find the following differences in the proportion of obese adults: 3.5% between countries, 5.0% between males and females by country, and 9.0% between age groups by sex and by country (nQuery Advisor®, Statistical Solutions, Saugus, MA).

Results

There were 1145 Swedes and 8211 Americans in the study samples. The age range of included participants was 25–64 years. The mean age (±SD) in years was 45.5 ± 11.0 in Sweden and 44.1 ± 10.6 in the U.S. ($p \leq 0.001$). Of the Swedish sample, 547 (48%) and 3837 (47%) of the U.S. sample were men. The average years of education was 10.5 ± 3.2 in Sweden and 13.6 ± 4.1 in the U.S. ($p \leq 0.001$). Of the Swedish and U.S., participants 83 and 84% were married. Overall the Swedish population was slightly older than the U.S. population, but there were no differences in the distributions of men and women within the 10-year age groups. The sex and age distributions of the survey sample are shown in Table 1. The U.S. population had a higher mean BMI in every subgroup at each survey.

Changes in obesity from 1989 to 1999 are shown in Table 2. Relative changes in BMI were greater in the U.S. The 10-year incidences of overweight and obesity were higher in the U.S. Substantial weight

Table 1. Distribution of adults and body mass indices in the study populations by country, sex and 10-year age groups

	10-year age group; number (%)				
	25–34	35–44	45–54	55–64	Total
Sweden (*n* = *1145*)					
Men	108 (19.7%)	140 (25.6%)	157 (28.7%)	142 (26.0%)	547 (100%)
1989 BMI*	24.8 ± 3.6	25.3 ± 3.2	26.6 ± 2.9	26.1 ± 2.9	25.8 ± 3.2
1999 BMI	26.5 ± 4.0	26.6 ± 3.5	27.6 ± 3.1	26.6 ± 3.2	26.9 ± 3.4
Women	126 (21.1%)	153 (25.6%)	160 (26.8%)	159 (26.6%)	598 (100%)
1989 BMI	23.2 ± 4.2	23.9 ± 3.5	25.5 ± 4.0	26.4 ± 4.2	24.8 ± 4.2
1999 BMI	25.0 ± 4.2	26.1 ± 3.8	26.9 ± 4.5	27.2 ± 4.7	26.4 ± 4.5
U.S. (*n* = *8122*)					
Men	908 (23.7%)	1204 (31.4%)	966 (25.2%)	759 (19.8%)	3837 (100%)
1989 BMI	26.9 ± 4.2	27.4 ± 4.2	28.1 ± 4.2	27.6 ± 4.2	27.5 ± 4.2
1999 BMI	27.3 ± 6.3	28.4 ± 6.5	28.6 ± 6.1	28.2 ± 5.5	28.2 ± 6.2
Women	1024 (23.9%)	1309 (30.5%)	1027 (24.0%)	925 (21.6%)	4285 (100%)
1989 BMI	24.9 ± 5.4	26.2 ± 5.6	26.9 ± 5.5	27.2 ± 5.3	26.3 ± 5.5
1999 BMI	27.3 ± 6.3	28.4 ± 6.5	28.6 ± 6.1	28.2 ± 5.5	28.2 ± 6.2

*Mean ± SD.

Table 2. Changes in obesity from 1989 to 1999 in rural Swedish and U.S study populations[a]

	Sweden (n = 1145)	U.S. (n = 8122)
Weight 1989 (kg)	72.9 ± 13.3	77.5 ± 16.2[b]
Weight 1999 (kg)	76.7 ± 14.0	83.6 ± 16.4[b]
10-year change in weight (kg)	3.8 ± 6.0	6.1 ± 8.9[b]
BMI[c] in 1989 (kg/m^2)	25.3 ± 3.8	26.9 ± 5.0[b]
BMI in 1999 (kg/m^2)	26.6 ± 4.1	28.5 ± 5.6[b]
Relative change in BMI (%)	0.06 ± 0.08	0.07 ± 0.12[b]
z-Score for change in BMI	-0.059 ± 0.739	0.008 ± 1.031[d]
Normal, BMI < 25 kg/m^2 (%)		
1989	51.1%	40.8%[b]
1999	37.4%	28.7%[b]
Overweight, BMI 25–29.9 kg/m^2 (%)		
1989	39.3%	37.9%[b]
1999	44.1%[e]	39.0%[b]
10-year incidence of overweight	337/1000[f]	336/1000
Obese, BMI ≥ 30 kg/m^2 (%)		
1989	9.6%	21.3%[b]
1999	18.4%	32.3%[b]
10-year incidence of obesity	120/1000[f]	173/1000[b]

[a]Data presented as mean ± SD unless otherwise noted.
[b]$p \leq 0.001$ between countries.
[c]BMI = body mass index.
[d]$p = 0.006$ compared to Sweden.
[e]$p = 0.002$ compared to Sweden in 1989.
[f]Adjusted for 9 years of Swedish data to determine 10-year incidence rate.

loss was uncommon in either population. The incidence of reaching a normal BMI (< 25), if overweight in 1989, was 60.5/1000 in Sweden and 78.5/1000 in the U.S. No Swedes moved from the obese to the normal BMI category. Changes in BMI category, both loss and gain, are shown in Table 3. The incidence for achieving a normal BMI if obese in 1989 was 15/1000 in the U.S. In each BMI category, there was greater weight gain within the U.S. population. This can be primarily attributed to the fact that the U.S. adults had higher body mass indices at baseline. Both countries had shifts into higher BMI categories by 1999, but women in both countries were more likely to have and maintain a normal BMI than men. Men are more rapidly becoming overweight and obese (data not shown).

Comparison of *z*-scores for BMI illustrates that BMI is increasing slightly more rapidly in the U.S. than in Sweden. The changes are further illustrated by graphing the cumulative frequency of BMI by country (Figure 1a and b). The 50th and 75th percentiles for BMI are marked with vertical lines for comparative purposes. When the curves are superimposed, the distribution of body mass indices in Sweden in 1999 is similar to that of the U.S. in 1989.

Discussion

This study provides evidence of the progression of the obesity epidemic [17, 18] in rural areas of the U.S. and Sweden. Our data are unusual in their ability to allow comparison of information from two geographically distinct, but rural areas of the developed world. Both regions have economies that have traditionally been based on farming, sustain long winters, were experiencing economic recession, and have lower socioeconomic indicators than other areas of their respective countries [19–21]. Previously published data show that obesity has a higher prevalence in rural (compared to urban) areas [19, 22], but few other studies have compared rural areas to each other. In addition, the ability to evaluate the same individuals after a 10-year interval makes this study particularly strong because we are able to calculate incidence rates. Most of the large population studies, including the international MONICA sites and the U.S. National Health and Nutrition Examination Survey (NHANES), use cross-sectional surveys and are only able to evaluate the change in prevalence of obesity. While some would argue that prevalence is the most valuable indicator for estimating the magnitude of the obesity epidemic, incidence rates can help focus intervention efforts by determining who becomes obese.

Because the Swedish population was older, and changes in BMI may exhibit cohort effects, it was important to use *z*-scores when comparing BMI trends between the countries. Younger cohorts have previously been reported to develop obesity at higher rates [23], and we found that to be the case in the Swedish and U.S. populations. The data from the U.S. were self-reported, and while this was adjusted for by a factor validated in the same U.S. population, it is possible that the BMI values used still underestimate the actual BMIs. If this is the case, our data are a conservative estimate of obesity incidence in the U.S.

We found the proportions of the population that are overweight and obese increased by approximately 10% over the decade studied. A minority of the population maintained a normal body mass index, and very few individuals achieved a normal body mass index through weight reduction.

The 18.4% prevalence of obesity that we found in the two counties in northern Sweden is higher than the 13.7% reported for this region from Swedish national sources [24, 25], and the reported 9% national prevalence rate for these age groups reported from Survey of Living Conditions (Undersökningar av Levandsförhållanden, ULF) [26]. The current study also affirms the higher prevalence of obesity in a rural area of New York State compared to the U.S. national rates. In Otsego County during 1999, the prevalence of obesity was 32.3% compared to the

Table 3. Number of adults changing body mass index (BMI) by 1989 BMI category and country

BMI in 1989	BMI in 1999				
Sweden	< 25	25–29	30–34	≥35	Row total
< 25	399 (68.6%)	177 (30.4%)	6 (1.0%)	0 (0%)	582 (100%)
25–29	27 (6.1%)	314 (70.4%)	101 (22.6%)	4 (0.9%)	446 (100%)
30–34	0 (0%)	11 (12.1%)	58 (63.7%)	22 (24.2%)	91 (100%)
≥35	0 (0%)	0 (0%)	4 (22.2%)	14 (77.8%)	18 (100%)
U.S.					
< 25	2061 (62.2%)	1113 (33.6%)	124 (3.7%)	13 (0.4%)	3311 (100%)
25–29	242 (7.9%)	1871 (60.7%)	836 (27.1%)	132 (4.3%)	3081 (100%)
30–34	21 (1.7%)	168 (13.8%)	639 (52.3%)	393 (32.2%)	1221 (100%)
≥35	6 (1.2%)	20 (3.9%)	84 (16.5%)	399 (78.4%)	509 (100%)

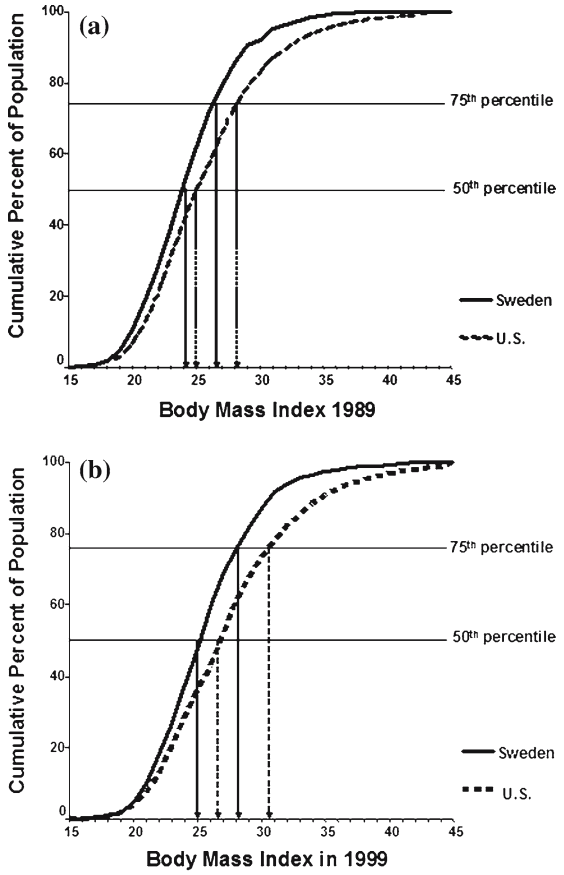

Figure 1. (a) Cumulative distributions of body mass index for the Swedish and U.S. populations in 1989. (b) Cumulative distributions of body mass index for the Swedish and U.S. populations in 1999.

national U.S. rate of 21.5% in 2001 [27]. In addition, we found that the 1.1% per year incidence of obesity is higher than the U.S. national average of 1.0% per year [28, 29]. This demonstrates obesity is increasing more quickly in these rural areas than the national averages.

The BMI cumulative distribution curves allow the reader to see the proportion of the population with BMI above or below a particular percentile. The similarity in the curves for the U.S. in 1989 and Sweden in 1999 suggests that Sweden's obesity epidemic is rapidly increasing with rates like those in the U.S. Unless changes are made soon, one would expect that by 2009, the rates of obesity in northern Sweden may mimic those present in the rural U.S in 1999. Because the development of numerous chronic disease are linked to obesity, (e.g. diabetes, hypertension), one can also predict increases in the incidences of obesity-related health risks and conditions in both countries. This is of importance because while there is mounting awareness in the U.S. of both the obesity epidemic and the health risks of obesity, Sweden lags behind in her efforts to address this area. While the Swedish government has targeted good eating habits and increased physical activity in their eleven target areas for all work in the field of public health, it has fallen short of directly addressing the problem of obesity [30].

The use of cohort panels for this study provides important insight into obesity trends. We are evaluating a critical period of obesity development, and the ability to track individuals is unusual and gives a robust assessment of obesity trends.

This study did not attempt to assess the impact of socioeconomic or health factors on obesity development. Others have shown the link between lower socioeconomic status and higher rates of overweight and obesity [24, 31, 32]. Both study populations have had some public health interventions to lower cardiovascular risk [20, 33]. The intervention programs did not have components that directly addressed body weight and did not effect the entire study populations of either country. They included interventions to encourage healthy eating and increases in physical activity. We were unable to assess whether these public health efforts have affected the rates of obesity development reported here.

In the U.S., national guidelines have been developed to encourage weight loss and weight maintenance and the public and medical professions are being educated about the health risks of obesity [1]. To date, there have been no evaluations of the effectiveness of these interventions in rural areas. In Sweden, although there is growing awareness of the increase in overweight and obesity, addressing this problem is not a national health priority [30].

This study calls for heightened attention to the progressing obesity epidemic in Sweden. Because weight maintenance may be easier to achieve than weight reduction, early and aggressive efforts should be made to curb the obesity epidemic in Sweden. State and national efforts to reduce obesity are already underway in the U.S., and their success remains to be determined. However, since the incidence of obesity is higher in rural New York State than the U.S. as a whole, this study clearly shows that specific attention should be paid to funding, designing, and implementing public health interventions that are appropriate to rural populations.

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