Past trends of obesity attributable mortality in Europe; an application of Age-Period-Cohort Analysis.

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Abstract

Background: Obesity has dramatically increased over time and constitutes a major health burden which can be estimated by obesity-attributable mortality. Although there is evidence of age, period and cohort increments on obesity mortality association, previous studies in Europe did not account for the multiple dimensions of the obesity epidemic, namely age, period and cohort.

Objective: To better capture the complexity of the obesity epidemic and its impact on mortality by assessing age, period and birth cohort effects and patterns in Europe, in the past.

Data and Methods: We obtained the following data (by age and sex): Obesity prevalence by available sources, Relative Risks (RR) of dying from obesity from a recent meta-analysis and all-cause mortality by Human Mortality Database. We applied the standard Clayton & Schifflers age-period-cohort analysis.

Results: Based on our preliminary results for the Netherlands, obesity-attributable mortality doubled in between 1981 and 2010; in Dutch men, the fraction of mortality due to obesity rose from 0.7 % to 1.3 % while in Dutch women from 1.0 to 2.0 %. The effect of birth cohort to obesity-attributable mortality was larger among Dutch women as compared to men. In specific, for women born after 1941-1945, obesity-attributable mortality is increasing with every next generation.

Conclusions: Next to age and period a substantial effect of birth cohort on obesity-attributable mortality was shown for the Netherlands, especially in women. Future studies on obesity–attributable mortality should not ignore the multiple dimensions of obesity.

Introduction

Obesity has dramatically increased the last decades so that is now considered a global epidemic (1). Worldwide obesity prevalence more than doubled between 1980-2014 while in EU there has been a threefold increase in the last 20 years (2). Based on recent estimates, its prevalence ranges from 35% in the United States (3) to 10-30% in European countries (2). In detail, among EU countries obesity prevalence varies threefold from a low of around 8% in Romania to over 25% in Hungary and the United Kingdom while on average across EU member states, 17% of the adult population is obese.

Obesity constitutes a major health burden (4), as there is evidence of strong links between obesity and life-threatening diseases such as diabetes, heart disease, stroke, and multiple types of cancer (5-7). Previous studies attempted to estimate the health burden of obesity, especially in US (8-10), by assessing obesity-attributable mortality, but did not account for the multiple dimensions of the obesity epidemic: age, period and birth cohort (11).

In specific, although obesity is influenced by the biological aging process (i.e., age effects) and broad societal changes that have transpired in recent decades (i.e., period effects), it is also influenced by birth cohort membership (i.e., cohort effects)— the so-called “third dimension” of the obesity epidemic (12). Birth cohort membership is important because it represents the onset of exposure to obesogenic environments; newer birth cohorts tend to have earlier onset and, thus, higher rates of obesity than their predecessors (13).

When it comes to obesity-attributable mortality, evidence of cohort increments in overweight or obese excess mortality is consistent with a growing body of evidence showing that excess fat in adolescence or early adulthood and weight gain over the life course have long-term implications for metabolic, cardiovascular, and mortality risks (14, 15).

Although recent work suggests that birth cohort dynamics are key to understanding the future of US health and longevity (12), existing PAF estimates for obesity as a cause of US mortality omit them from consideration. As we expect that the observed extended exposure to obesity among younger birth cohorts is likely to also occur in Europe and to affect mortality, the aim of the present study is to better capture the complexity of the obesity epidemic and its impact on mortality by assessing age, period and birth cohort effects and patterns in a European context.

Data and Methods

Obesity prevalence data were obtained by National Statistical Offices sources like Health Surveys in various European countries. Subjects with a BMI ≥30kg/m^2 were defined as obese (16).

All- cause mortality data by sex and year were obtained from Human Mortality Database. The combination of ages and periods resulted in the calculation of birth cohorts.

Source of age and sex specific Relative Risks was the Meta-analysis from Wang Z, including worldwide data (17).

The population fractions attributable to obesity (PAF) was calculated using the following formula:

PAF= (P(O) x (RR-1))/((P(O) x (RR-1))+1) (18)

where P(O) is obesity prevalence and RR is the relative risk of mortality associated with obesity.

Finally, the resulting PAF was then multiplied by all-cause mortality to obtain the number of deaths attributable to obesity (Obesity-attributable mortality).

We will also explore a different methodology to estimate obesity-attributable mortality.

Statistical analysis

All analyses were done separately for men and women. To compare obesity– attributable mortality trends across sexes, the obesity– attributable mortality rates were directly age-standardized.

Age-period-cohort (APC) modelling

Obesity attributable mortality rates were modelled as a function of age, period and birth cohort and fitted Poisson regression models, with the natural logarithm of population at risk as the offset term (see Box 1). There is a linear dependency between age, period, and birth cohort (a = p – c), resulting in overidentification if all three variables are included in the analysis. To deal with this we applied the standard Clayton and Schifflers approach (19, 20): we decomposed obesity-attributable mortality rates as the effect of age, the effect of the shared linearity of period and birth cohort (referred to as drift), and nonlinear period effects and nonlinear birth cohort effects.

We choose two reference categories for cohort, so we could add the effect of drift to the period dimension and not the cohort dimension.

Box 1. APC modeling

Model parameters	Statistical notation
Age (A)	$\ln[o_{ap}] = \mu + \alpha_a$
Age + drift (AD)	$\ln[o_{ap}] = \mu + \alpha_a + \delta$
Age + period (AP)	$\ln[o_{ap}] = \mu + \alpha_a + \beta_p$
Age + period + cohort (APC)	$\ln[o_{ap}] = \mu + \alpha_a + \beta_p + \gamma_c$

Where o is the obesity attributable mortality rate. μ is the intercept, α, β and γ represent the age, period and birth cohort effects, and δ represents the drift.

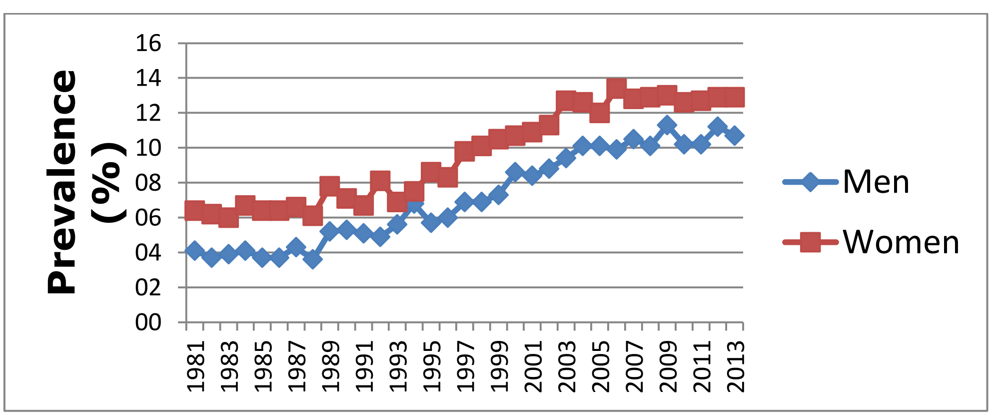
To evaluate the contribution of drift, the non-linear period effect and the non-linear birth cohort effects we compared the goodness of fit of age (A), age-drift (AD), AP, and APC for the different models by assessing the reduction in scaled deviance. In specific, we compared the subsequent models I) AD with A, II) AP with AD and APC with AP. Additionally, we tested the fit of the AP and the APC models to the data using a log-likelihood ratio test.

Preliminary Results

At the moment we focus our analysis in the Netherlands, in the period 1981 to 2010 but further analyses will be conducted in other European countries.

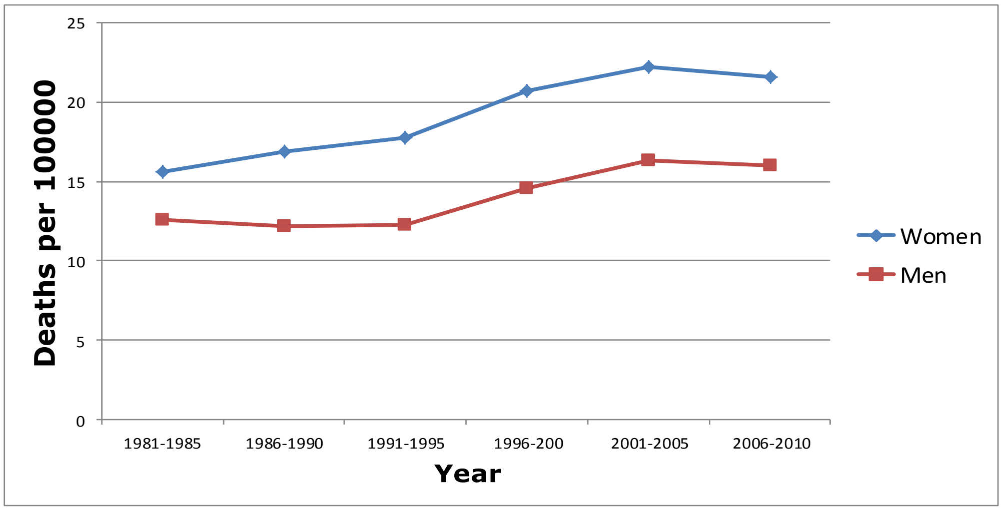
In the Netherlands, obesity prevalence showed an increasing trend in the studied period both for men and women, with women having higher prevalence during the whole period while there was a sharp increase in the 1990 for both sexes (**Figure 1**).

Figure 1: Obesity prevalence in the Netherlands (1981-2013), 20-89 years



Age-standardized obesity-attributable mortality rates shared the same pattern in Dutch men and women, although the levels were lower in men than women. There was an increasing trend in both sexes; in men deaths due to obesity per 100.000 increased from 12.6 to 15 and in women from 15.6 to 21.6 during the period 1981 to 2010(**Figure 2**).

Figure 2: Age-standardised obesity-attributable mortality rates in the Netherlands,1981-2010



All components of the APC model were significant at the P<0.005 (one-tailed) level (**Table 1**). Birth cohort statistically significantly contributed to the fit of the obesity-attributable mortality model in Dutch women. In Dutch men, the contribution of period was larger than the contribution of birth cohort (14.4% vs 9.5% respectively). The APC model provided a good fit to the data only in Dutch women.

Table 1: Contribution to the deviance reduction between models A and APC of obesity attributable mortality, by sex in the Netherlands.

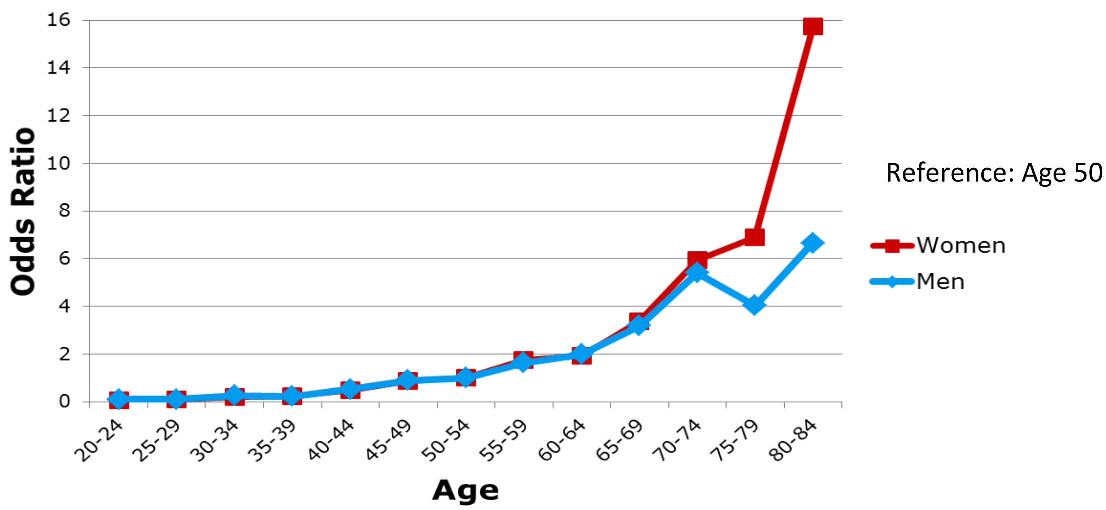
	Percentage reduction	
	Women	**Men**
Drift	35.5% [a]	76.0% [a]
Period	11.6% [a]	14.4% [a]
Cohort	52.8% [a, b]	9.5%

[a] Statistical significant (model reduction test)

[b] Statistical significant (model fit to data test)

Obesity-attributable mortality increased with age for Dutch men and women until around ages 70-74 (**Figure 3**). Thereafter a decline was observed for the ages 75-79 followed by an increase for men, whilst in women a sharp increase was observed after the ages 75-79.

Figure 3: Age pattern of obesity attributable mortality in the Netherlands



Period patterns were similar for Dutch men and women. Moreover we observed that the obesity epidemic started to increase substantially in the 1990's in the Netherlands (**Figure 4**).

The non-linear birth cohort patterns were different for Dutch men and women (**Figure 5**). For women born after 1941-1945, obesity-attributable mortality is increasing with every next generation.

Figure 4: Period pattern of obesity attributable mortality in the Netherlands

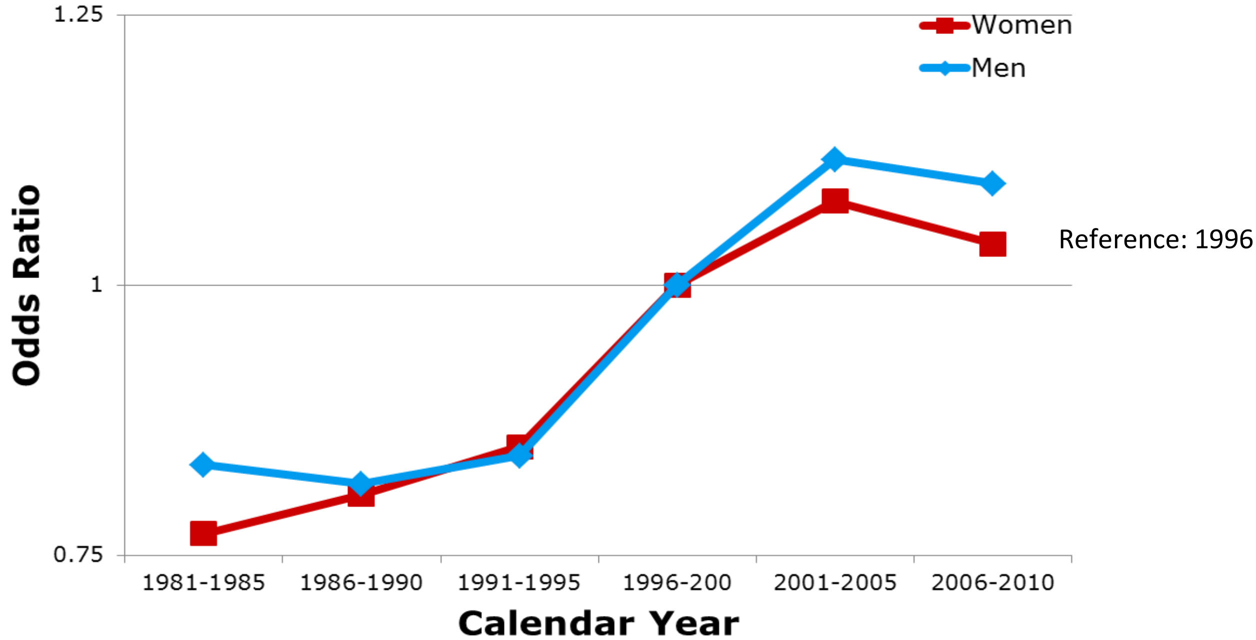
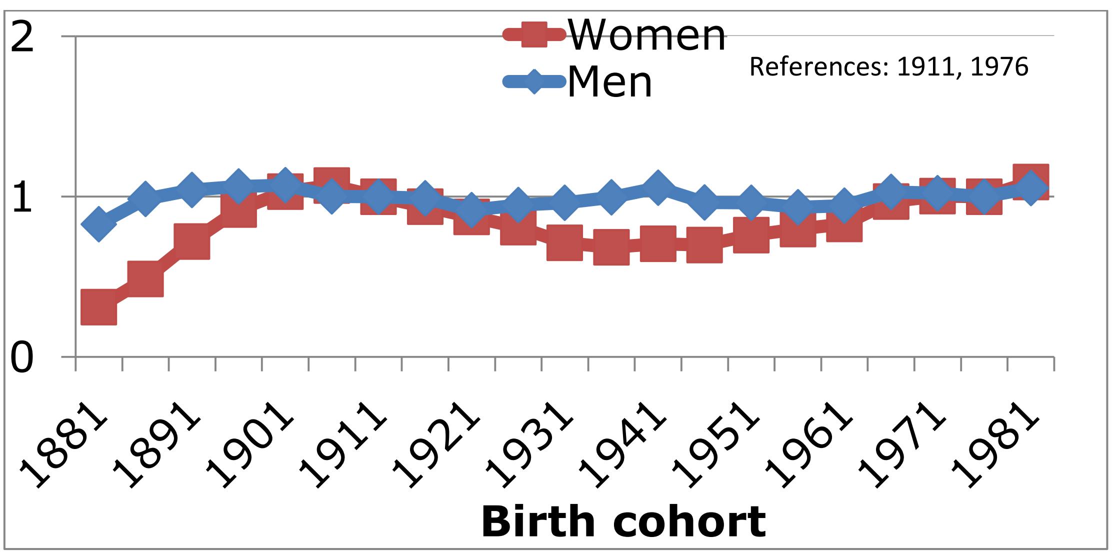


Figure 5: Cohort pattern of obesity attributable mortality in the Netherlands



Discussion

In the Netherlands, next to age and period a substantial effect of birth cohort on obesity-attributable mortality was shown, especially in women. The larger contribution of cohort for Dutch women than men has also been observed in other studies in US (11, 15) and may be linked to the fact that BMI is a better reflection of fat mass accumulation in women than men (21).

Bases on these results, it is crucial that future studies on obesity–attributable mortality do not ignore the cohort effect.

References

1. Finucane MM, Stevens GA, Cowan MJ, Danaei G, Lin JK, Paciorek CJ, et al. National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9.1 million participants. Lancet. 2011 Feb 12;377(9765):557-67.

2. Branca F, Nikogosian H, Lobstein T., editor. The challenge of Obesity in the WHO European Region and the Strategies for Response: Summary. Copenhagen: ; 2007.

3. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of childhood and adult obesity in the United States, 2011-2012. JAMA. 2014 Feb 26;311(8):806-14.

4. Wang YC, McPherson K, Marsh T, Gortmaker SL, Brown M. Health and economic burden of the projected obesity trends in the USA and the UK. Lancet. 2011 Aug 27;378(9793):815-25.

5. Calle EE, Kaaks R. Overweight, obesity and cancer: epidemiological evidence and proposed mechanisms. Nat Rev Cancer. 2004 Aug;4(8):579-91.

6. Berrington de Gonzalez A, Sweetland S, Spencer E. A meta-analysis of obesity and the risk of pancreatic cancer. Br J Cancer. 2003 Aug 4;89(3):519-23.

7. Field AE, Coakley EH, Must A, Spadano JL, Laird N, Dietz WH, et al. Impact of overweight on the risk of developing common chronic diseases during a 10-year period. Arch Intern Med. 2001 Jul 9;161(13):1581-6.

8. Allison DB, Fontaine KR, Manson JE, Stevens J, VanItallie TB. Annual deaths attributable to obesity in the United States. JAMA. 1999 Oct 27;282(16):1530-8.

9. Flegal KM, Graubard BI, Williamson DF, Gail MH. Excess deaths associated with underweight, overweight, and obesity. JAMA. 2005 Apr 20;293(15):1861-7.

10. Mehta NK, Chang VW. Mortality attributable to obesity among middle-aged adults in the United States. Demography. 2009 Nov;46(4):851-72.

11. Reither EN, Hauser RM, Yang Y. Do birth cohorts matter? Age-period-cohort analyses of the obesity epidemic in the United States. Soc Sci Med. 2009 Nov;69(10):1439-48.

12. Reither EN, Olshansky SJ, Yang Y. New forecasting methodology indicates more disease and earlier mortality ahead for today's younger Americans. Health Aff (Millwood). 2011 Aug;30(8):1562-8.

13. Masters RK, Reither EN, Powers DA, Yang YC, Burger AE, Link BG. The impact of obesity on US mortality levels: the importance of age and cohort factors in population estimates. Am J Public Health. 2013 Oct;103(10):1895-901.

14. Hobcraft J, Menken J, Preston S. Age, period, and cohort effects in demography: a review. Popul Index. 1982 Spring;48(1):4-43.

15. Yu Y. Reexamining the declining effect of age on mortality differentials associated with excess body mass: evidence of cohort distortions in the United States. Am J Public Health. 2012 May;102(5):915-22.

16. WHO. Obesity: preventing and managing the global epidemic
Report of a WHO Consultation (WHO Technical Report Series 894). 2000.

17. Wang Z. Age-dependent decline of association between obesity and mortality: A systematic review and meta-analysis. Obes Res Clin Pract. 2015;Jan-Feb;9(1):1-11.

18. Rockhill B, Newman B, Weinberg C. Use and misuse of population attributable fractions. Am J Public Health. 1998 Jan;88(1):15-9.

19. Clayton D, Schifflers E. Models for temporal variation in cancer rates. I: Age-period and age-cohort models. Stat Med. 1987 Jun;6(4):449-67.

20. Clayton D, Schifflers E. Models for temporal variation in cancer rates. II: Age-period-cohort models. Stat Med. 1987 Jun;6(4):469-81.

21. Diouf I, Charles MA, Ducimetiere P, Basdevant A, Eschwege E, Heude B. Evolution of obesity prevalence in France: an age-period-cohort analysis. Epidemiology. 2010 May;21(3):360-5.