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Risk of Obesity in the United States, 1976-2018: Cohort Effects and Increasing Educational Inequalities

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Abstract

While interest in health inequalities is increasing, few studies have investigated the long-term evolution of inequalities with a cohort perspective. Using obesity as health outcome, we apply a new development in age-period-cohort analysis to (a) identify if cohorts are similarly affected by obesity risk, and (b) assess the evolution of educational inequalities in obesity for White and African American men and women.

Data came from NHIS 1976-2018. APC-Trend analysis was used to estimate slopes of obesity rates across cohorts. APC-Gap analysis allowed estimation of gaps between BA-holders and nonholders.

We detect steep non-linear increases among all considered population groups in risk of obesity from the 1960s cohort onwards. In White men, and even more pronounced in White women, educational gaps in obesity are increasing steeply.

Women born in 1960+ show higher obesity rates and will likely soon be in higher need of obesity-associated social and healthcare provisions than earlier-born cohorts.

Background

Obesity carries a high disease burden (GBD 2015 Obesity Collaborators, 2017) and substantially contributes to the slow improvements in life expectancy in the United States (Preston et al., 2018). Obesity burden of more recently born cohorts is higher (Keyes et al. 2010). Physiological dysregulation has increased over a century of birth cohorts, particularly because of rising obesity rates (Zheng & Echave, 2021). It is important to investigate obesity as a risk factor for adverse health, functional limitations and chronic conditions, particularly in later mid-adulthood and older age, as it comes with burden related to work ability (Tunceli et al., 2006) and limitations in activities of daily living (Backholer et al., 2012). Obesity has been related to food insecurity in the U.S. (Adams et al., 2003). However, few analyses have systematically explored cohort inequalities in obesity burden.

Since Case and Deaton's (2015) hallmark study, mid-aged low-educated White men have been identified as at risk for multiple indicators of morbidity and mortality, including obesity. This vulnerability has since been further validated (Case & Deaton, 2020), and we have recently shown it to be a cohort effect (Chauvel, Leist, & Smith, 2016). Obesity as such is one indicator among a range of health problems related to morbidity and mortality which is needed to be better understood. While the increasing prevalence of obesity has been investigated in numerous studies, obesity has rarely been investigated from a cohort perspective, which can reveal social change across time (Smith, 2008). Few recent studies have employed age-period-cohort analyses to the study of obesity (Taylor et al., 2015; Vidra et al., 2018; Wilson & Abbott, 2018). Furthermore, competing approaches to solving the identification problem of age-period-cohort models have led to conflicting findings about the magnitudes of age, period, and cohort effects in the obesity epidemic in the United States (Bell & Jones, 2014; Reither et al., 2009).

The first aim of this paper is to investigate cohort inequalities in the burden of obesity in more detail, by first identifying trends in risk of obesity across cohorts, then stratifying risk of obesity across cohorts by sex/gender, and race/ethnicity. This is important to understand different burden of morbidity by generation and in sub-groups of the population.

The second aim of the paper is to estimate educational gaps in obesity risk across cohorts, in order to better understand social change. Obesity-associated healthcare and social care needs of already disadvantaged or discriminated groups may further increase health inequities. For this, we will present a new method of age-period-cohort **gap** analysis:

The approach taken in this study is designed to overcome limitations of earlier models by specifying the age-period-cohort model with state-of-the-art approaches to solve the identification problem (Bar-Haim, Chauvel, & Hartung, 2019; Chauvel, Leist & Smith, 2021). In doing this, this study's approach permits identification of cohort effects, beyond the period effects that are well established within obesity research (e.g. Rokholm et al.'s (2012) observation of the obesity epidemic "leveling off").

Method

Data came from the NHIS (1976-2018), with information on body mass index (BMI) for 1,317.604 individuals. Data from 2019 did not contain information on relevant variables, e.g., education. Data were aggregated into 5-year periods (1976-2018) and five-year age groups (20-60).

A total of 230,177 individuals (17.47% of the sample) reported a weight-height-ratio (BMI) of 30 or more than 30, and were categorized as obese, and 322,461 (24.47%) respondents were holders of a tertiary education degree (BA or higher). We investigated separately trends and inequalities in obesity risk for 489,518 White women, 461,578 White men, 99,058 African American women, and 68,444 African American men. In the following, we will refer to non-Hispanic Whites as Whites.

Strategy of Data Analysis

New Age-Period-Cohort analysis

The general purpose of age-period-cohort models is to use a Lexis table (age x period) in order to decompose a dependent variable y into effects of age (α_a), period p (π_p) and cohort membership c (γ_c). Equation I specifies the linear composition of those effects:

Equation I

$$y^{apc} = \mu + \alpha_a + \pi_p + \gamma_c (APC)$$

Since cohort is a linear combination of age and period (c = p - a), the basic model cannot be solved. This identification problem is well known (Mason & Wolfinger, 2001), and different attempts have been made to solve this problem (O'Brien, 2011; Smith, 2008). Chauvel and Schroder (2015) have suggested ignoring the actual linear trends of age, period, and cohort, and introduced further constraints to detect deviations from those trends: this Age-Period-Cohort Detrended model has been applied to detect lucky (or protected) and unlucky (or disadvantaged) cohorts on outcomes such as political participation, income, and suicide mortality (e.g., Chauvel, Leist, & Ponomarenko, 2016). The Age-Period-Cohort Detrended model posits the sum of age, sum of period, and sum of cohort trends to be zero, and the linear trends of age, period, and cohort to be zero (Equation II).

Equation II

$$\begin{cases} y^{apc} = \alpha_a + \pi_p + \gamma_c + \alpha_0 rescale(a) + \gamma_0 rescale(c) + \beta_0 + \varepsilon_i \\ \begin{cases} \sum \alpha_a = \sum \pi_p = \sum \gamma_c = 0 \\ Slope_a(\alpha_a) = Slope_p(\pi_p) = Slope_c(\gamma_c) = 0 \\ \min(c) < c < \max(c) \end{cases} \end{cases}$$

Analysis of obesity trends across cohorts. The Age-Period-Cohort Detrended model presented in Equation II has been further developed to overcome its inability to identify linear trends. This new Age-Period-Cohort Trended Lag (APCTLAG) model results from wisely adapting the different constraints to the model: the age linear trend is now constrained to the average within-cohort age effect. Further, the sum of age and period vectors are set to zero, and the period linear trend is set to zero. In doing so, the APCTLAG is now able to identify (linear) social change via the cohort vector (Equation III).

Equation III

$$\begin{cases} y^{apc} = \alpha_a + \pi_p + \gamma_c + +\varepsilon_i \\ \begin{cases} \sum \alpha_a = \sum \pi_p = 0 \\ Slope(\pi_p) = 0 \\ Slope(\alpha_a) = \dfrac{\sum (y_{\mathrm{a+1,p+1,c}} - y_{\mathrm{a,p,c}})}{(\mathrm{p}-1)(\mathrm{a}-1)} \\ \min(c) < c < \max(c) \end{cases} \end{cases}$$

The APCTLAG has been applied to age-period-cohort income analysis (Bar-Haim, Chauvel, & Hartung, 2019; Bar-Haim et al., 2018). The code is available in Stata (ssc install apcgo).

Analysis of the development of inequalities (gaps) in obesity across cohorts. In order to arrive at a quantification of the gaps in obesity between different social groups (based on education, gender, race/ethnicity), we apply another recently developed method: APCGO (Chauvel, Hartung, & Bar-Haim, 2017). The Age-Period-Cohort Gap/Oaxaca (APCGO) model also uses data structured in the Lexis table (age x period) in order to identify the trends across cohorts for two social groups (e.g. higher- and lower-educated individuals), and quantifies the gap between the two groups by the APCTLAG coefficient. Plotting the coefficient across cohorts depicts the inequalities across cohorts, their evolution over time and the non-linear accelerations or decelerations in the cohort trend. To our knowledge, the APCGO is the only method currently available that is able to systematically quantify inequalities between social groups across cohorts.

Results

Trends: Obesity risk in the total population and for White and African American men and women across cohorts

Trend age-period-cohort analysis shows an almost flat trend across cohorts born before 1950, with substantial acceleration of obesity rates particularly for individuals born in the late 1950s and after, continuing until the most recent cohorts under investigation (born in 1985, Figure 1). This nonlinearity can also be observed in the separate analyses of White and African American men and women (Figure 2).

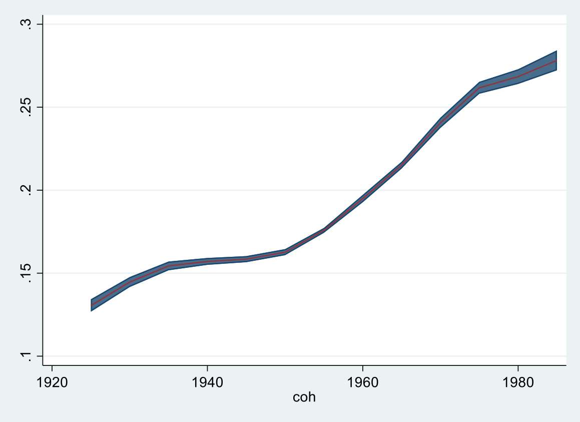

Figure 1. Obesity risk by birth cohort, total population.

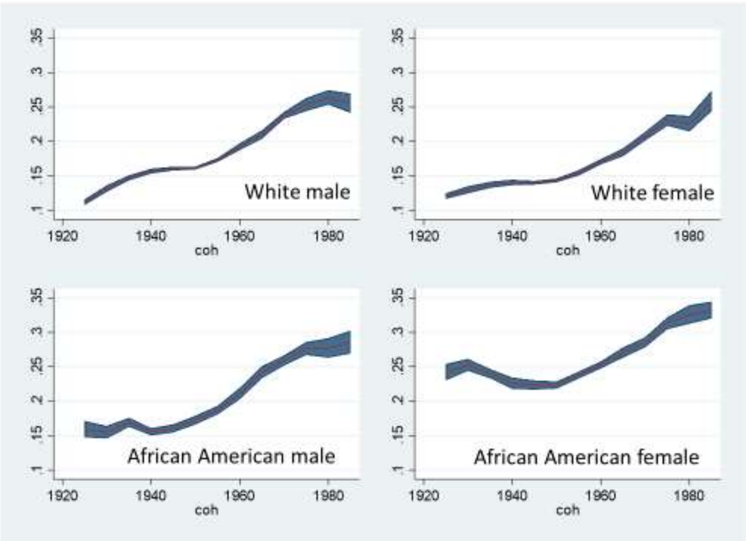

Figure 2. Obesity risk across birth cohorts, for White and African American men and women.

APCTLAG cohort coefficients show different accelerations of obesity risk by group: White men showed steeper increase in risk of obesity across cohorts, which is flattening in the cohorts born around 1975 and after, whereas white women show increases across all observed cohorts. With a more predominant social change (cohort trend change) for the cohorts born after 1950, and smaller increases overall (see the y axis for the obesity rate in logit), African-American women and men had similar social change in risk of obesity, however due to the smaller samples with wider confidence intervals (Figure 3).

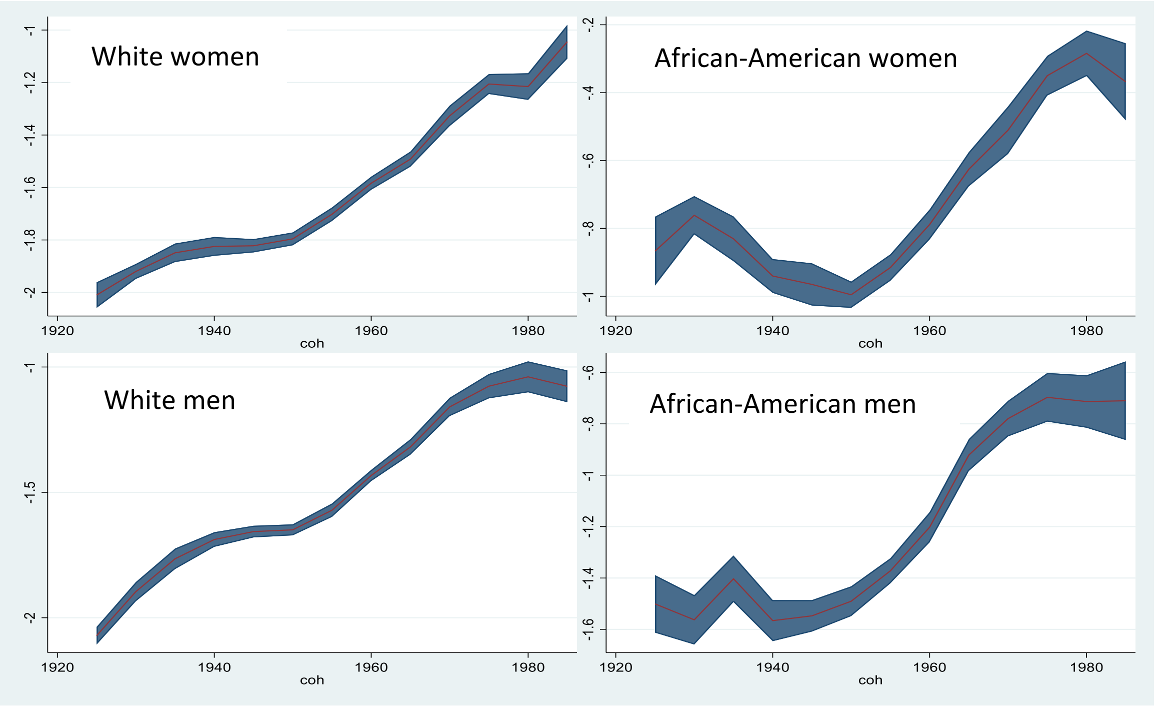

Figure 3. APCTLAG cohort coefficients of logit obesity rate.

Inequalities: Gap between BA-holders and nonholders in the total population

Educational gaps in obesity between BA-holders and nonholders are increasing in the overall sample (Figure 4), particularly from the 1960s cohort onwards.

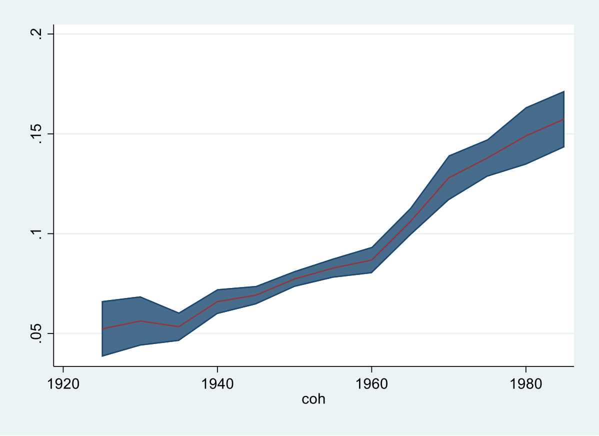

Figure 4. Obesity risk difference between BA holders and nonholders, total population.

Inequalities: Gap in obesity risk between BA-holders and nonholders for White and African American men and women

Investigating the evolution of the educational gaps in obesity, the steepest increases in the educational gap in obesity risk across cohorts can be found in White women, and in White men similar increases in educational gaps in obesity risk can be found, albeit with a smaller gap overall (Figure 5). The educational gaps in obesity risk for African-American women that were very high in the cohorts born before 1940 are declining across cohorts, and remain approximately constant in African-American men across the cohorts under observation (Figure 5).

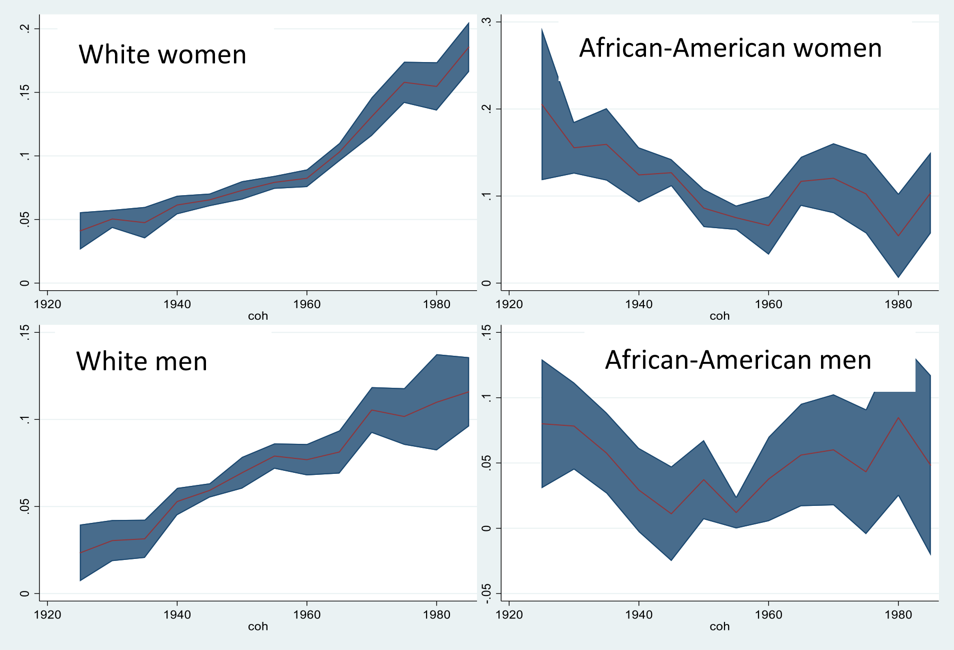

Figure 5. Obesity risk difference between BA holders and nonholders across birth cohorts, for White and African American women and men.

Finally, we investigate the educational gaps in obesity risk further in the group with steepest changes, White women, by illustrating the educational gaps in BMI across age and period with a Lexis heatmap. Here, a reversal of trends is noticeable: While the educational gap in BMI in White women is relatively low in the periods 1970 to the early 2000s, from 2005 we observe a strong increase in the educational gap in BMI for age groups 30 and 35, which extends across all age groups from 25- to 45-year-olds in the period around 2015 (Figure 6).

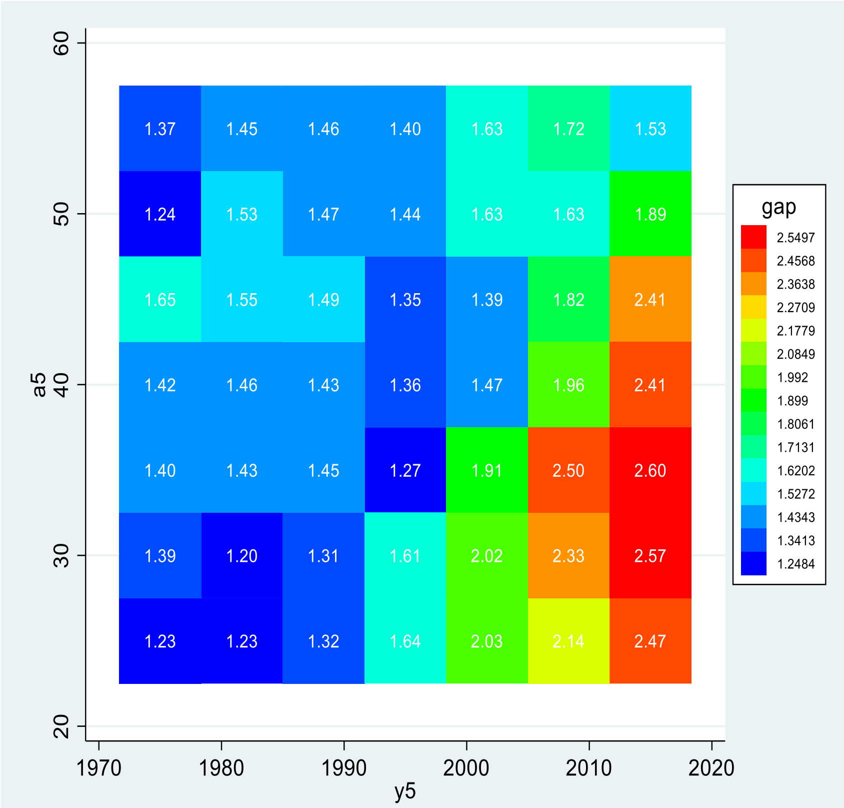

Figure 6. Differences in BMI between Bachelor holders and non-holders for white women by period and age group.

Discussion

We find increasing risk of obesity across all cohorts, particularly since the cohorts born in 1955.

Educational gaps in obesity increase across cohorts overall. Stratifying by group (White and African-American, women and men), we observe strongest increases in White women, and notice an expansion of the educational gap particularly in the period around 2010 for younger age groups, which extends to middle ages in the period around 2015.

Men and women of the cohorts born in the late 1950s and later will enter old age in the next decade with sharply increased obesity rates, with associated challenges for social and healthcare systems. Increasing gaps in obesity risk between higher- and lower-educated individuals point to increasing disease burden among socioeconomically less advantaged parts of the population.

Disease burden across the life course will likely be even more pronounced for the young cohorts born in the 1980s and after, as they already had weight gains in their childhood, adolescence, and young adulthood. Long-term exposure to obesity and its common underlying symptoms associated with the metabolic syndrome, will likely have cumulative health effects over the life course.

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