Paper in progress, DO NOT CITE

Obesity, disability and aging in Costa Rica*

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Short abstract

Study of aging and obesity and its effect on mortality and disability in a middle-income country using longitudinal data from the "Costa Rica: Longevity and Healthy Aging Study". Obesity prevalence is higher among women and it clearly declines with age after about the 70th birthday. The decline comes from generation effects (younger cohorts are less obese) but there is also a genuine effect of weight loss with aging as longitudinal data show. There is a complex relationship between obesity and risk of dying, which increases with body mass and, especially with abdominal girth, but only in individuals younger than 75 approximately. After this age the relationship reverses and body mass is a protective factor against death, which somehow neutralizes the catastrophic effect on life expectancy that some predict from increasing obesity trends. The impact of obesity on disability is clearer than on mortality, although it disappears at very old ages.

∗ Paper to be presented at the 2009 meeting of the International Union for Scientific Studies of Population IUSSP.

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Long abstract

Introduction

The increase in obesity prevalence in the world has raised the interest of both researchers and the public in general, given that excess body fat is associated with several chronic and degenerative diseases (Popkin, 2006). In wealthy industrialized countries, such as the U.S.A., demographers have forecasted a decrease in life expectancy as a product of the upward trend in obesity (Olshansky et al., 2005). According to the nutrition transition theory (Popkin, 2004, 2006), developing countries will experience an increase in the prevalence of obesity and overweight, as well as in the prevalence of diseases associated with obesity. These trends result from a nutritional change characterized by a diet full of saturated fat and carbohydrates and an increasingly sedentary life that makes the body to require less energy in daily activities. This nutritional change diffuses through globalization of cultural behaviors typical of wealthy nations in countries that still have high malnutrition prevalence during early ages.

Recent obesity trends among Latin Americans have made researchers to forecast an increase in prevalence of functional limitations and non-communicable diseases, such as diabetes mellitus, infarction, and atherosclerosis (Kain, Vio & Albala, 2003; Popkin, 2004). These somber projections are frequently linked to the health status of Latin American elderly, given that this population is the most affected by chronic diseases (Drumond-Andrade, 2006; Barceló et al., 2007; Monteverde et al., 2007; Palloni et al., 2006).

Nevertheless, according to the scientific literature, the deleterious effects of body fat on elderly health are not as fully established as they seem. In industrialized countries, obesity prevalence is inversely associated with age (Cornoni-Huntley et al., 1991; Ferraro, Thorpe & Wilkinson, 2003; Reynolds, Saito & Crimmins, 2005), given that the effect of obesity on death rates also diminishes as age increases (Bender et al., 1999; Fontaine et al., 2003; Lindsted & Singh, 1997; Thorpe & Ferraro, 2004), even if disability and life expectancy with disability is higher among obese elders (Reynolds, Saito & Crimmins, 2005).

Some authors claim that the negative effects of obesity on old-age health are leveled off due to several plausible reasons: differential survival of non-obese elderly compared to obese elderly; being BMI an inappropriate measure of obesity among old-age populations, the difficulty of gathering data about voluntary and involuntary weight loss, or being physical activity rather than obesity *per se* the actual causal mechanism that explains morbidity and mortality (Adams *et al.*, 2006; Meyer et al., 2002; Elia, 2001; Zamboni et al., 2005).

Research questions

Costa Rica has the second highest life expectancy at birth in the Americas (Canada has the highest), higher even that the USA white population (PRB, 2007). It also has lower cardiovascular mortality levels than industrialized nations with similar life expectancies (Rosero-Bixby, 1991, 2008). To what extent does this Costa Rican mortality advantage come from lower prevalence of obesity? Are the effects of obesity on Costa Ricans' health milder than in other countries? To what extent the well-documented advantage in cardiovascular mortality with respect to industrialized countries is due to different obesity distributions? Is it plausible that in Costa Rica –and in the rest of Latin America as well– life expectancy will fall in the near future as a consequence of the increasing trend in obesity prevalence? Will the combination of increasing trends in life expectancy and obesity produce a steep increment in the number of disabled elderly?

Main objective

To determine the relation of aging on obesity and on its effect on mortality and disability among the elderly in a Latin American country.

Data and methods

We analyze data from the CRELES project. CRELES is the acronym in Spanish for "Costa Rica: Longevity and Healthy Aging Study". This is a longitudinal study based on a probabilistic nationally representative sample of 2,827 adults born in 1945 or earlier (ages≥60 during first interview) and living in Costa Rica in 2000. The selection probability increases with age in order to have oversamples of older persons. The analysis is based on information from the two waves (2004-2006 and 2006-2008).

The study comprises a structured interview with a 90-minute questionnaire, anthropometric indicators (weight, height, waist circumference, among others) measured in a standardized procedure, diet, and collection of blood and urine samples. Data and biological specimens were collected at respondents' homes after they signed an informed consent form, approved by the University of Costa Rica Ethical Board.

Obesity is measured using two criteria: Body Mass Index (BMI) and Waist Circumference (WC). BMI is expressed as weight in Kilograms (Kg) divided by height in square meters (m^2). WC, which refers to abdominal obesity, is measured in centimeters (cm). The cutoff points used to classify a respondent as obese are recommended by NHLBI Obesity Education Initiative (2000). Persons are classified as obese if BMI >= 30, and abdominal obesity is defined as WC greater or equal to 88 and 102 cm for women and men, respectively.

Disability is defined as having functional limitations, according to 5 areas: (1) Physical disability, measured using 3 groups of activities: functional, basic, and instrumental (Katz & Akpom, 1976; Rosow & Breslau, 1966). We constructed a scale and use it to identify respondents with 7 or more activities that they could not perform without help. Functional disability implies limitations in any of the following activities: walking outside the house, climbing stairs, pushing objects, and raising arms. Basic disability refers to having limitations in any of the following activities: walking across a room, taking a bath, eating, going into bed, using the toilet, and cutting toenails. Instrumental disability is defined as having limitations in cooking, managing money, going shopping, and taking medication

Statistical analyses are performed using Stata (Statacorp, 2005). For mortality analyses, information was organized in "survival time" format (Stata "st" command), setting the origin at respondent's date of birth, entry into risk at CRELES first interview date, and exit at either date of death or the final date of the follow-up period. We estimated semi-parametric (Cox) and parametric (Gompertz) survival multiple regression equations (Hosmer & Lemeshow, 1999). In the multivariate analysis of prevalence of disability, we use logistic regression (Hosmer & Lemeshow, 1989).

Preliminary results.

The prevalence of obesity among Costa Rican elderly is 45% according to WC criteria and 26% according to BMI criteria (Table 1). Some research suggests that people with overweight (BMI between 25 and 30 Kg/m^2) should be classified as having high mortality and morbidity risk, especially with regards to metabolic diseases. More than two thirds of Costa Rican elderly are overweight or obese (Table 2). Compared to other Latin American populations, obesity prevalence ($BMI \geq 30$ kg/m^2) is in mid-range. It is lower than in Montevideo (Uruguay), Santiago (Chile), and Mexico City, but higher than in Sao Paulo (Brazil) and, especially, than in Havana (Cuba) and Bridgetown (Barbados). In order to further contextualize the Latin American figures, Table 1 presents information about two extreme populations in terms of obesity. On one side, prevalence in the U.S.A. is considerably higher than in the rest of the countries, especially among men (although Mexican and Uruguayan women have a high probability of being obese, too). On the other hand, Taiwan has substantially lower obesity prevalence than any Latin American population represented in the table (although the prevalence among Cuban males is remarkably similar to Taiwanese elderly men).

Prevalence is much higher among women than among men: 33% vs 19% based on BMI; 66% vs 22% based on WC. Recall that the cutoff point for abdominal obesity is higher among men (90 cm) than among women (80 cm), according to the International Diabetes Federation, and these differential cutoff points might be explaining the large differences in prevalence by sex. Besides the large difference by sex, obesity is also strongly associated with age. People age 80 and over have half the prevalence that people age 60 to 79 have. In addition, more educated people are more likely to be obese according to BMI than their less educated counterparts, but not according to WC.

The relevance of the notion of the obesity epidemics masks the importance of another serious health issue: malnutrition or low body weight. Only 3% of Costa Rican elderly are considered as underweight, according to BMI criteria, but this figure grows to 8% among the oldest old (Table 2).

Obesity and aging

What is the relationship between aging and obesity among Costa Ricans? We mention earlier that obesity prevalence is smaller among the oldest old than among younger seniors. Figure 1 shows general and abdominal obesity curves by single years of age, smoothed using local regression techniques (Stata "lowess" command). Obesity prevalence diminishes with age, especially from age 75 on, and the decrease is steeper among women than among men. Even though this figure provides plenty of information about obesity prevalence by age, the curves do not necessarily represent the effect of aging on obesity, given that the information is drawn from cross-sectional data and each age group represents a different cohort. This decreasing pattern might be explained by either the effect of aging on obesity, or by different cohort composition among obese and non-obese elderly. In other words, these curves confound age and cohort effects. A third effect that might have an influence on this pattern is selective survival of leaner persons: obesity prevalence might be smaller at older ages because heavier people have died earlier, under the assumption that obesity is positively associated with death risk. We aim to disentangle these three effects utilizing longitudinal data from CRELES.

It is not possible to measure pure cohort effects with CRELES data. In order to do this, we would need several measurements for different cohorts at a same age, and this would imply an extended period of observation, even decades. Nevertheless, external data based on past nutrition surveys (Ministerio de Salud, 1996) suggest that in Costa Rica, the prevalence of obesity and overweight has been increasing among younger cohorts (data available only for women). According to the 1982 nutrition survey, 56% of women born between 1922 and 1936 (age 45 to 59 in 1982) were overweight (BMI>= 25 Kg/m^2). According to the 1996 survey, among female cohorts born between 1936 and 1951 (age 45 to 59 in 1996), prevalence of obesity and overweight grew to 75%. This is equivalent to a generational increment of 19 percentage points in just 14 years. CRELES data confirm the result from 1996: 77% of women born in 1936-1945 have overweight or obesity, even though these women are 10 years older than the women interviewed in 1996. Hence, there is a cohort effect in the curves in Figure 1, at least among women.

Being a longitudinal study, CRELES data is well-suited to isolate the effect of aging by measuring anthropometric changes within the same persons. No significant reductions in BMI or WC during the two years between waves 1 and 2 would mean that the downward trend in the curves by age is not a consequence of the aging process. On the contrary, reductions within the same persons would imply that a person loses weight while growing older.

Based on data from wave 1 and wave 2, Figure 2 shows that there is more weight loss than weight gain at every age. The exception is the group of men 90 years old or older (nonagenarians), who experienced abdominal fat gain during the inter-wave period. However, this finding might be due to selective survival: those who lost abdominal fat might have died during the approximately 2 year period between waves. Loss of body mass and abdominal fat is greater among women, especially among the youngest groups.

Obesity and mortality

As mentioned earlier, the third possible component of the variation of obesity prevalence by age is selective survival of non-obese elderly. This can be explored by studying the relationship between body weight and mortality. If the notion that obesity raises the risk of dying is verified, smaller obesity prevalence at oldest ages might be explained by a smaller probability of reaching to such ages among obese people. Besides, the measurement of the effect of obesity on mortality would let adapting these obesity models to other Latin American populations, in order to forecast or simulate any fall in life expectancy due to a generational increase in obesity.

CRELES respondents' vital status was followed by linking the dataset to the Civil Registry. At the end of the last follow-up (March 2008), 368 individuals have died. Such a small number of deaths limit the statistical power of finding significant associations for small relative risks. This means that relative risks between 0.7 and 1.5 estimated with regression models might not be statistically significant.

Before analyzing mortality data, it is necessary to study its coherence with vital statistics. One-year death rates by 5-year age groups, derived from CRELES, are graphed in Figure 3. The shape of the curve is congruent with death rates for the whole Costa Rican population, according to the official Costa Rican life table 2000-2005. CRELES logged death rates increase almost linearly with age. Given this shape, a Gompertz model is appropriate for analyzing the hazards curve. Using a parametric model, such as Gompertz, is useful for easing analysis and estimating smoothed curves.

Table 3 contains transition probabilities to the states of obesity, non-obesity, and death. Contrary to what was expected, probability of dying is higher among non-obese persons than among obese elderly. Further analysis –that includes controlling by age– is needed in order to understand whether the higher probability is due to some confounding effect. We estimate preliminary Cox proportional hazards regression models (Hosmer & Lemeshow, 1999) to explore the age effect. In these models, mortality risk among obese persons is not significantly different than among non-obese persons using BMI as classification criteria, but it is significantly lower for obese elderly (relative risk of 0.71, 95%CI 0.52-0.97) using WC as the criterion. Given that this finding might be affected by including undernourished elderly (who typically have a higher risk of dying) among the normal weight group, new models were estimated subdividing respondents in three groups: underweight, eutrophic (normal weight), and overweight. In the new proportional hazards model, death hazards are significantly larger among underweight people compared to eutrophic people (the base group): The hazard ratio is equal to 2.5 (95% CI 1.74-3.6). Nonetheless, mortality risk among obese or overweight people is still not significantly different to the mortality risk of people with normal weight.

A typical problem in these preliminary analyses is that the standard cutoff points for BMI or WC might not be appropriate for the elderly (Adams et al., 2006; Monteverde, Noronha and Palloni, 2007). Besides, there is smaller statistical power when introducing categorical variables derived from originally continuous variables into regression-like models. Coefficients for BMI and WC are significantly different to zero in the regression equations when these variables are introduced into the model as continuous, as well as quadratic terms. This means that the relationship between BMI –or WC– and mortality is very likely to be curvilinear, with higher death rates at extreme values in obesity variables. These models also show that the effect of BMI or WC is conditioned by age. When interaction variables are included in the model, quadratic terms are no longer significant, thus implying that the curvilinear shape might be a consequence of interactions between age and obesity variables. Figure 4 contains predicted death hazards by BMI or WC, in 4 different age groups (no sex difference is shown given that there is not enough statistical power to find significant differences between males and females).

Among the youngest groups (65 years old in Figure 4), mortality increases with BMI or WC. Obesity and overweight are risk factors for dying among these groups. Besides, the gradient is steeper across WC vales than across BMI values. Having a 12 cm larger waist (the standard deviation for WC is approximately 12) increases the death rate in 70%, compared to a 21% increase due to a one standard deviation change in BMI. All these estimates correspond to people age 65 (Figure 5). Among people age 75, the effect of a one-standard deviation difference with abdominal fat (WC) falls to 20%, and the same effect for BMI not only disappears but is slightly in the opposite direction.

For the oldest old, the mayor problem seems to be underweight. Moreover, the data suggests that overweight and body fat are protecting factors that reduce the risk of dying. Among nonagenarians in Figure 4, a one standard deviation (5 kg/m^2) difference in BMI halves the death hazard, and a 12 cm difference in WC reduces the death hazard in 36%. This protecting effect of overweight is, therefore, stronger when body mass is considered instead of abdominal fat.

Gender does not significantly modify the described effects, which, by the way, are controlled by smoking, cancer diagnose, involuntary weight loss and under nutrition.

Given that the direction of obesity effects on mortality depend on age, the final balance between negative and positive effects will depend on the relative importance of mortality in different ages, which, in turn, depends on the age structure of the population and the age-slope of the mortality curve. A way of summarizing these effects is with the attributable fraction on deaths. Table 4 shows this fraction, computed as the weighted average of age-specific attributable fractions with the 2006 Costa Rican deaths as weights. BMI-based obesity in balance has a null effect on mortality. Abdominal obesity, instead, could be the cause of 6% deaths of elder Costa Ricans (8% among women).

Obesity, aging, and disability

Whereas the relationship between obesity and aging might be explained by both age and cohort effects, there is a clear relationship between aging and disability. Disability prevalence increases with age. Additionally, the prevalence is higher among people classified as obese, using any of both criteria: BMI≥ 30 Kg/m2 or WC≥88 cm (women) or 102 cm (men), as it might be clear from Figure 5. Nonetheless, it is interesting to note that disability prevalence among obese and non-obese elderly converges at very old ages. Around age 85 or 90, disability prevalence is greater than 90% for both obese and non-obese persons.

Becoming disabled as part of the aging process is also clear from the analysis of CRELES longitudinal data. During the two-year inter-wave period, 41% of elderly with no functional limitations became disabled. This process is more frequent among non-obese persons than among obese persons, and the probability of transition into disability is greater when using abdominal fat as the obesity criterion, rather than BMI. On the other hand, only 18% of people classified as disabled in the first wave transit out of the disabled status. This transition is more common among leaner people (Table 5).

The interaction between obesity and disability has also an impact on mortality differentials. Table 4 shows the well-known fact that disabled elderly are more likely to die, and confirms what was discussed above: obese elderly have lower mortality probabilities than leaner elderly. Mortality advantage of disabled vs. non-disabled elderly is smaller among respondents with BMI of 30 Kg/m2 or more, than among those with lower BMI. However, the relative death risk of disabled compared to non-disabled Costa Rican elderly is smaller among people with wider WC, than among those with less abdominal fat. These relationships suggest that obesity may not make elderly be at higher risk of death, but it does make them be at higher risk of becoming disabled. Hence, obesity seems to have an important effect on increasing the years living with functional limitations among old-age Costa Ricans.

Discussion

The negative perception about obesity and overweight is rather recent, from both a health and an aesthetical perspective. The women portrayed in Rubens's beautiful masterpieces are examples of the health and beauty ideals of the past.

CRELES data about Costa Rican elderly confirm, to a certain extent, the modern paradigm that obesity and overweight are deleterious to health. In terms of mortality, this paradigm is confirmed only during the early years of being a senior citizen, somewhat up until age 75. The deleterious effect of excess fat is stronger when measured by abdominal fat (WC) than when measured using BMI. On the other hand, at oldest ages, data reveal the inverse association: excess weight becomes a protecting factor against death. The data show as well a clear tendency of losing weight as a consequence of aging, therefore it is rarer to find obese persons at older ages; malnourishment and low weight are more prevalent, instead.

If the relationship between obesity and mortality changes its direction with age, prevalence of disability –operationalized as having functional limitations– is clearly higher among older people, especially among those with greater body mass or wider waists. Therefore, it seems that the effect of obesity on old-age health has a greater impact on life expectancy with disability, rather than

Public health polices to overturn obesity should be aware of these relationships, and consider making an exception at very old ages. Models that forecast potential diminutions in life expectancy due to increases in obesity prevalence should develop more complex models to take the two following relationships: weight loss increases with age, and the association between body weight and death risks shifts its direction. However, an "obesity epidemic" among the elderly might require more thorough policies regarding the need of caretakers and health services for disabled elderly.

An important extension of the present study is to explore whether there is a causal link between obesity and death rates. Is excess weight per se the factor that increases (or reduces, depending on what age range we observe) the risk of dying, or is weight just the manifestation of other causal mechanisms? If the second statement is true, individual or population level interventions to modify excess weight in the population might not have the alleged impact on a population's life expectancy.

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Table 1. Percentage of obesity (BMI≥30 Kg/m²) among the elderly in Costa Rica, the six SABE Latin American cities, Taiwan and the U.S.A.

Country/City	Obesity Total	Men	Women
Taiwa	8.6	5.1	13.0
Havna	14.5	6.3	19.3
Sao Paulo	20.6	9.5	28.3
Bridgetown	23.9	11.5	32.3
Costa Rica	*26.1*	*19.1*	*32.5*
México City	30.4	20.2	37.1
Santiago	30.6	22.9	34.5
U.S.A.	31.4	28.9	33.4
Montevideo	34.4	18.7	43.3

Source:E Own compuations bases on datasets from the projects CRELES, NAHNES, SEBAS and from Drumond-Andrade 2006.

Table 2. Body mass index (BMI) and waist circumference (WC) among Costa Rican elderly, by sociodemographic characteristics.

Nutritional status	Total	Sex		Age (years)		Place of residence		Education	
		Men	Women	60-79	80 & over	San José	Other	Less than 6 years	6 years or more
BMI									
Underweight (<18.5)	3.3	2.9	3.6	2.4	8.0	2.7	3.9	4.1	2.4
Eutrophic (18.5 a 25)	28.5	32.4	24.9	25.5	45.2	26.5	30.6	30.5	26.3
Overweight (25 a 30)	42.1	45.6	39.0	43.7	33.1	43.9	40.2	42.0	42.3
Obesity (>=30)	**26.1**	**19.1**	**32.5**	**28.3**	**13.7**	**26.9**	**25.3**	**23.4**	**29.1**
N	2,698	235	1463	1698	1000	1346	1352	1888	810
Abdominal obesidad *	**45.1**	**22.0**	**66.3**	**46.5**	**36.9**	**46.5**	**43.6**	**45.2**	**45.1**
N	2,632	211	1421	1690	942	1314	1318	1838	794

Weighted results.
* For women, WC≥ 88, and for men, WC≥ 102 cm.

Table 3. Change in obesity status and death. CRELES waves 1 y 2

Final state	Initial state (ronda 1)			
	BMI >= 30		WC >= 88/102	
	Non-obese	Obese	Non-obese	Obese
Non-obese	0.85	0.22	0.71	0.09
Obese	0.04	0.72	0.16	0.84
Dead	0.12	0.06	0.13	0.07
Total	1.00	1.00	1.00	1.00
N	1,942	523	1,310	970

Table 4. Obesity-attributable mortality fraction.
Costa Rican elderly 2006

Indicator	Total	Males	Females
BMI >= 30	-0.6%	0.3%	-1.6%
Abdominal	6.5%	5.0%	8.2%

Table 5. Change in disability status and death, by obesity status in wave1. CRELES waves 1 y 2

	Initial state (wave 1)					
	Total [1/]		Non-obese		Obese	
Final state	Non-disabled	Disabled	Non-disabled	Disabled	Non-disabled	Disabled
Using BMI						
N	**633**	**1,876**	**534**	**1,445**	**99**	**431**
Total	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
Non-disabled	0.57	0.18	0.58	0.21	0.52	0.12
Disabled	0.41	0.75	0.40	0.72	0.44	0.82
Dead	0.02	0.07	0.02	0.07	0.04	0.06
Using WC						
N	**633**	**1,809**	**434**	**970**	**199**	**839**
Total	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
Non-disabled	0.57	0.19	0.59	0.25	0.53	0.13
Disabled	0.41	0.75	0.38	0.67	0.46	0.82
Dead	0.02	0.07	0.03	0.08	0.01	0.05
Note	1/ Relative frequencies for total population excludes respondents with missing values in BMI and WC, respectively					

Figure 1. General (BMI>=30) and abdominal (WC>=82/100) obesity prevalence, by age and sex. CRELES waves 1 (2004-206) and 2 (2006-8)

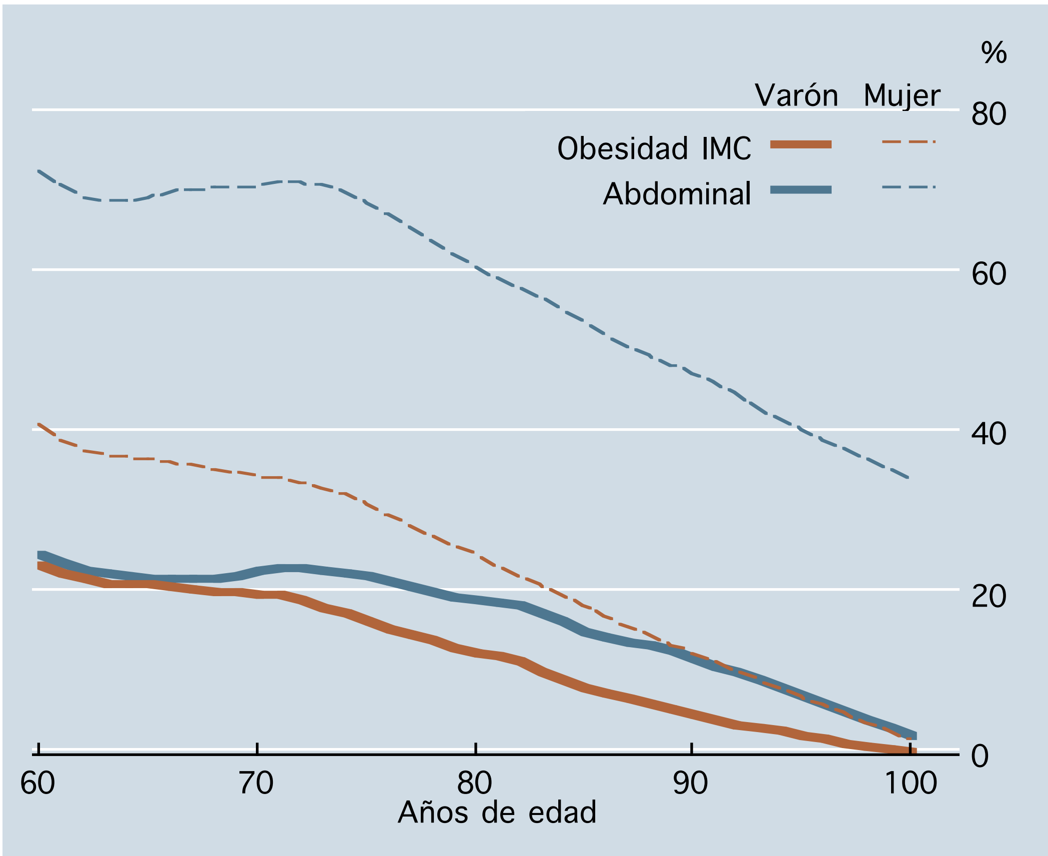


Figure 2. Annual variation by age and sex in BMI and WC. CRELES waves 1 (2004-2006) and 2 (2006-2008) (in %)

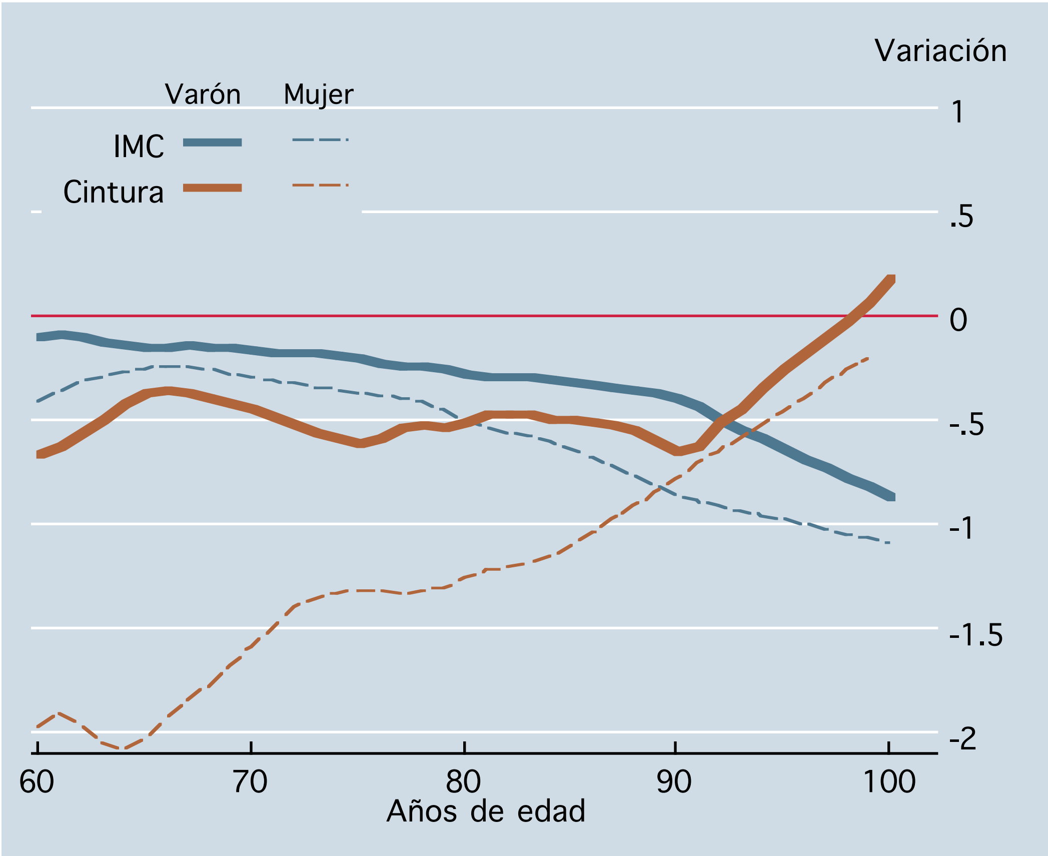


Figure 3. Death rates by age, CRELES 2005-2008

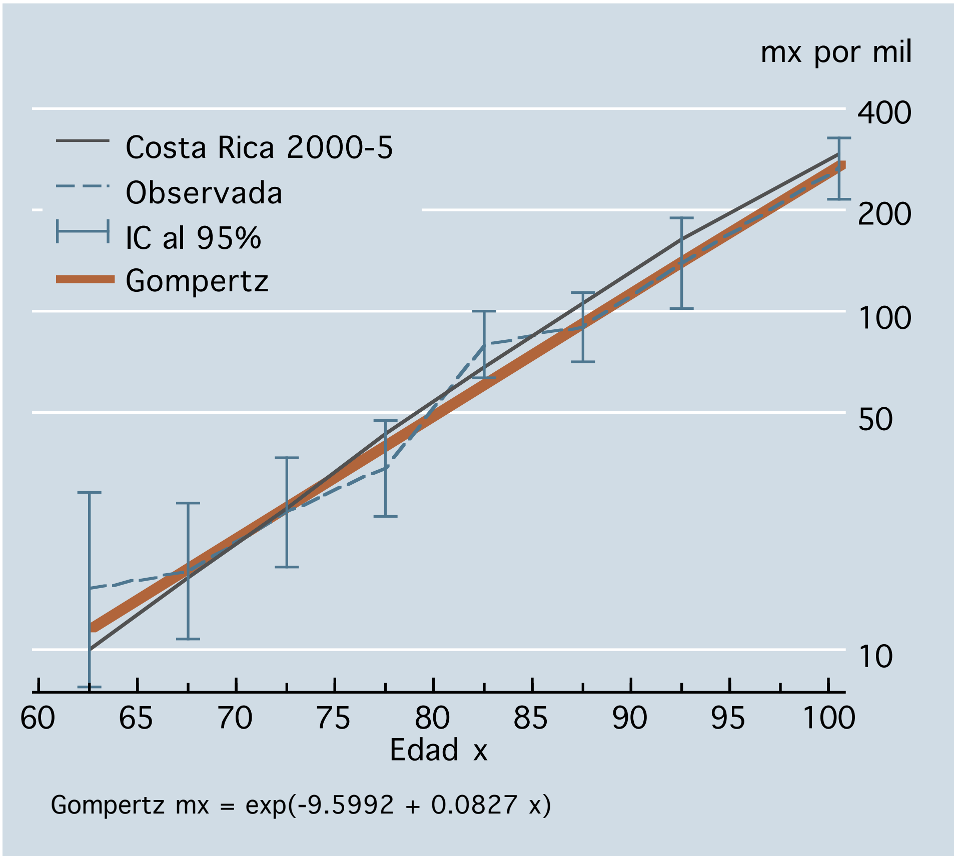


Figure 4. Adjusted death rates by BMI and WC, for not undernourished, no smoking, with cancer diagnose and with no resent involuntary weight loss women, and selected ages. Costa Rica 2005-2007

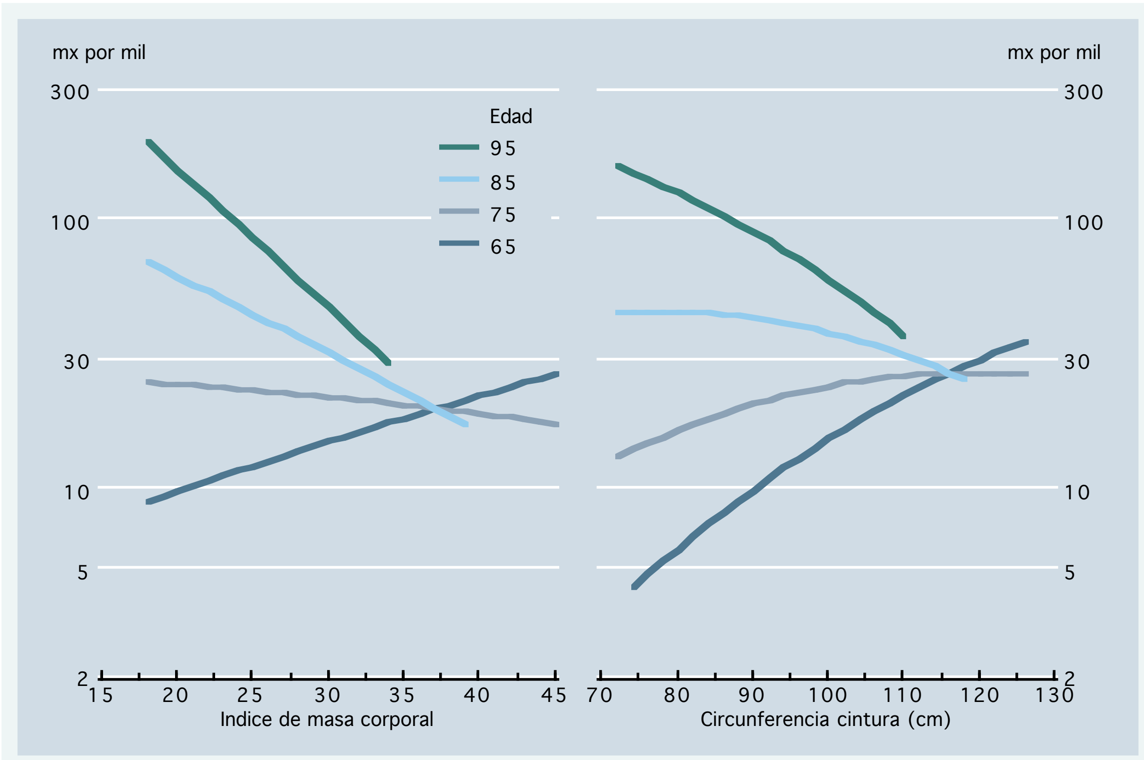
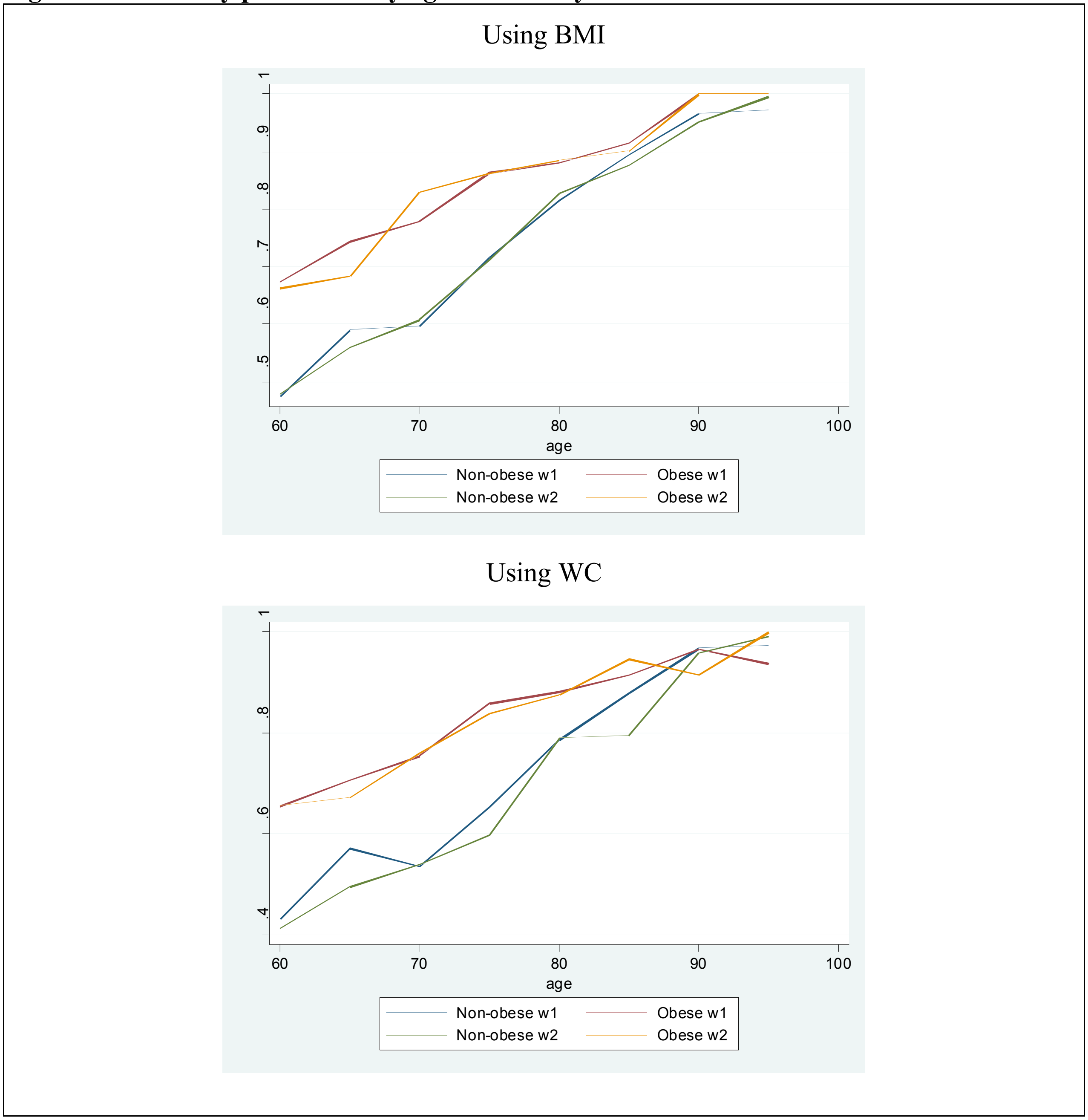


Figure 5. Disability prevalence by age and obesity status.



Note: Excludes persons who died between waves

Figure 6. Relative risks of death for BMI by age, controlling for sex and disability status

Figure 7. Relative risks of death for WC by age, controlling for sex and disability status.