The Relationship between Socio-Economic Status through the Life Course and Adult Obesity among Older Singaporeans: Application of the 'Accumulation of Risk', 'Social Mobility' and 'Sensitive Periods' Frameworks

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ABSTRACT

The effect of life course socio-economic status on (current) obesity is investigated among older Singaporeans by applying the accumulation of risk (AR), social mobility (SM) and sensitive periods (SP) frameworks. Obesity (Body Mass Index $\geq$ 27.5 kgm^{-2}; based on the cut-off defined for Asian populations) was assessed for 4193 older Singaporeans. Dichotomous indicators of childhood SES (family financial status while growing up), adult SES (education) and older adult SES (housing type) were used to operationalize the AR (cumulative socio-economic disadvantage score), SM (eight trajectories using SES at the three life time-points) and SP (independent effect of each life time-point SES) frameworks. Both high childhood SES and low adult SES were associated with significantly higher odds of obesity (SP framework). There was no association with cumulative socio-economic disadvantage (AR framework). Those moving up the SES ladder from childhood to adulthood had the lowest prevalence of obesity, while those moving down had the highest prevalence of obesity (SM framework). The effect of life course SES with obesity in adulthood is context specific, and the three frameworks complement each other and can be simultaneously utilized to gain a better understanding of this association.

INTRODUCTION

Obesity is an important adverse health condition among older adults, being associated with health conditions such as diabetes, hypertension, arthritis, cardiovascular diseases, dementia, frailty, locomotor disability, poorer self rated health, and with increased health care utilization.(Al Snih et al. 2007; Beydoun, Beydoun and Wang 2008; Goya Wannamethee et al. 2004; Hubbard et al. 2009; Luchsinger et al. 2003; Peytremann-Bridevaux and Santos-Eggimann 2008; Woo et al. 2002) Studies also suggest that obesity may increase the risk of all-cause mortality among the elderly.(Berraho et al. ; Heiat, Vaccarino and Krumholz 2001; Thinggaard et al. ; Weiss et al. 2008; Zhou 2002) While obesity has a multi-factorial etiology,(Grundy 1998) an important and well-documented distal determinant among adults, including older adults, is socio-economic status (SES).(Gonzalez, Nazmi and Victora 2009; McLaren 2007; Monteiro et al. 2004; Pollitt, Rose and Kaufman 2005; Senese et al. 2009)

SES has been defined as "the social and economic factors that influence what positions individuals or groups hold within the structure of a society".(Galobardes et al. 2006a) Various indicators have been used, to measure SES in adulthood, the most common being individual or household-level education, occupation, income and wealth, either alone or in combination.(Braveman et al. 2005; Galobardes et al. 2006a, 2006b; McLaren 2007; Monteiro et al. 2004; Shavers 2007) Further, there is increasing recognition that SES through the life course is not stable, but rather dynamic.(Braveman et al. 2005; Galobardes et al. 2006a, 2006b) Childhood SES may not necessarily predict SES in adulthood, and may influence health outcomes in adulthood independent of or in combination with SES in adulthood, the presence and strength of such an influence varying by health outcome.(Braveman et al. 2005) This has resulted in interest in assessing the role that SES at a particular stage of the life course

(childhood or adulthood) or the stability or change in SES status over the life course (childhood through adulthood) plays in the etiology of health conditions in adulthood. Three different but somewhat overlapping frameworks or conceptual models have been suggested for studying the mechanism through which life course SES may affect health outcomes in adulthood.(Berkman 2009; Cohen et al. 2010; Kuh et al. 2003; Loucks et al. ; Pollitt et al. 2005; Shavers 2007) The 'sensitive periods' (SP) framework posits that certain time periods ('sensitive' or 'critical' time periods) in the life course are independently important for health outcomes in adulthood. The 'accumulation of risk' (AR) framework posits that the accumulated socio-economic disadvantage (or advantage) through the life-course, rather than SES at any particular stage or time-point in the life-course is associated with health outcomes in adulthood. The 'social mobility' (SM) framework posits that stability or mobility across SES levels through the life-course is associated with health outcomes in adulthood.

Most studies assessing the association of SES with obesity in adulthood, however, do not take a comprehensive life course perspective of SES, operationalizing SES only through adulthood SES indicators, often measured at a single point in time.(McLaren 2007; Monteiro et al. 2004) Recognizing the limitation of this operationalization, some recent studies do utilize one or more of the three life course SES frameworks, either implicitly or explicitly, for assessing the association of life course SES with obesity in adulthood.(Gonzalez et al. 2009; Heraclides and Brunner 2010; Kavikondala et al. 2009; Pollitt et al. 2005; Senese et al. 2009) However, most utilize just one of the three frameworks; most commonly the SP framework, the results suggest either an inverse or no association of childhood SES with obesity in adulthood.(Gonzalez et al. 2009; Pollitt et al. 2005; Senese et al. 2009) Simultaneously applying more than one framework or model linking life course SES to cardiovascular disease (CVD) risk factors (which include

obesity) and outcomes has been suggested to understand how well the different conceptual frameworks fit the same observed data.(Pollitt et al. 2005) Only one recent study has applied both the AR and SM frameworks in context of overweight and obesity in adulthood, concluding that both frameworks can operate simultaneously over the life course.(Heraclides and Brunner 2010) However, no study has ascertained if all the three frameworks are helpful in explaining obesity in adulthood. There is evidence to suggest that at least when considering myocardial infarction as the outcome, all the three frameworks may be operating, are in fact conflated and difficult to disentangle.(Hallqvist et al. 2004) Additionally, most studies taking a life course perspective of SES, for assessing the SES-obesity association, pertain to Caucasian populations from the US and Europe, and to middle aged (at the time of assessment of body weight) individuals.(Gonzalez et al. 2009; Heraclides and Brunner 2010; Pollitt et al. 2005; Senese et al. 2009) Very few pertain to Asian populations,(Kavikondala et al. 2009) who have experienced development at a pace, and in periods, different from that experienced by most Western populations, or to older adults (Regidor et al. 2004). In fact, a recent review of the association between childhood SES and adulthood obesity has suggested assessment of the association in racial/ethnic groups other than Caucasians as an important area of future research.(Senese et al. 2009)

Taking advantage of a recent, representative survey of community-dwelling older adults ($\geq$ 60 years) in Singapore, a multi-ethnic Asian country, which has witnessed rapid economic transition from a developing to developed country over a short period of time, we aim to describe the association of life course SES and current status of obesity among older Singaporeans, using the AR, SM and SP frameworks. Obesity, defined as a BMI $\geq$ 27.5 kg/m^2 using the Asian body mass classification,(Health Promotion Board 2005; Singapore. Ministry of Health. and Singapore

Association for the Study of Obesity. 2004; WHO expert consultation 2004) is an important health condition among older Singaporeans (aged ≥ 60 years), with an estimated prevalence of 18.6%. (Ostbye, Malhotra and Chan In press.)

METHODS

Setting

Singapore is a multi-ethnic (Chinese [74.1%], Malays [13.4%], Indians [9.2%] and others]3.3%]) country, its population enumerated to be 5.08 million as of end-June 2010.(Singapore Department of Statistics 2010a) The urban landscape of the city state consists primarily of high-rise high-density public housing (Housing Development Board [HDB] housing), where more than 80% of Singaporeans reside.(Yuen 2009)

Social Isolation, Health and Lifestyles Survey (SIHLS) 2009

The SIHLS 2009, a representative cross-sectional survey of community dwelling older Singaporean citizens and permanent residents was conducted by the Ministry of Community Development, Youth and Sports, Singapore. The sample and sampling procedure of the SIHLS have been described elsewhere.(Chan et al.) Briefly, a random sample of 8400 older Singaporeans, stratified by gender, ethnicity and 5 year age groups, was drawn from the national database of dwellings. Those aged ≥75 years, and Malays and Indians were oversampled by a factor of two. A total of 5000 older Singaporeans were interviewed, at their residence, after providing informed consent. Proxy interviews were conducted for 9.2% of the survey participants unable to respond due to health reasons.

Outcome: Obesity (older adult - current status)

Details on the procedure for measuring height and weight of the survey participants have been described elsewhere.(Ostbye et al. In press.) Briefly, height (barefoot; in cm, one decimal

point) and weight (in kg, one decimal point; electronic scale: Tanita HD-355) were measured for 4460 and 4532 participants, respectively, by trained interviewers. Obesity was defined as a BMI (weight [kg] / height [m]$^{-2}$) $\geq$ 27.5 kgm^{-2} as per the Asian body mass classification.(Health Promotion Board 2005; Singapore. Ministry of Health. and Singapore Association for the Study of Obesity. 2004; WHO expert consultation 2004)

Childhood SES: Family financial status while growing up

The respondent's childhood SES was classified as low (poor) or high (pretty well off or average) based on the response to "Now think about your family when you were growing up, from birth to age 16. Would you say your family during that time was pretty well off financially, about average, or poor?" Though the most commonly used indicator of childhood SES is parental occupation,(Senese et al. 2009) the survey did not collect information on the same; financial status of the family while growing up has been used as an indicator of childhood SES in previous studies.(Luo and Waite 2005; Moody-Ayers et al. 2007)

Adult SES: Education

Education is considered to reflect the transition from childhood or parental SES to one's own SES, and also be strongly associated with subsequent adult SES indicators such as income and occupation.(Galobardes et al. 2006a) Ascertained through self-report, educational status was categorized as low (none or up to primary) and high (secondary or higher [vocational/ technical/ junior college/ polytechnic/ university education]).

Older adult SES: Type of housing

Type of housing was considered as the indicator of current SES for older Singaporeans. Housing type is a suitable indicator of current SES for older Singaporeans, as more than two-thirds of older Singaporeans reside with their children, and any indicator of their current SES

should be reflective of the household SES. Housing size, in term of number of rooms, of the public HDB housing is reported to be correlated with household income in Singapore, larger units reflective of higher household income.(Housing and Development Board 2010) Though total monthly household income was also assessed in the SIHLS, it was not used as an indicator as it was missing for more than 20.0% of those with data available on the outcome of interest (obesity). No participant has missing data for type of housing. Based on type of housing, older adult SES was classified as low (1-3 room public [HDB] housing) or high ($\geq$ 4 room public [HDB] housing or private housing or other housing [bungalow/ terrace house/ semi-detached house/ shop-house]).

SES over the life course

SP framework: This framework was operationalized by considering the independent effect of each life time-point SES indicator (i.e. after adjusting for the other two SES indicators).

AR framework: This framework was operationalized by calculating a cumulative socio-economic disadvantage score (range: 0-3) by adding up the three SES indicators. (score of '1' given to a value of 'low' and score of '0' was given to a value of 'high' for each of the three indicators). A higher score was indicative of greater cumulative socio-economic disadvantage.

SM framework: This framework was operationalized by defining eight mutually exclusive and exhaustive social mobility trajectories, based on the SES (high or low) at the three life time-points: 'low/low/low' (LLL; stable low), 'low/high/low' (LHL), 'low/low/high' (LLH), 'low/high/high' (LHH), 'high/low/low' (HLL), 'high/high/low' (HHL), 'high/low/high' (HLH), and 'high/high/high' (HHH; stable high).

Statistical analysis

A total of 807 (16.1%) respondents, including 576 individuals without height or weight measurements (thus, with missing BMI data) and an additional 231 individuals with a missing value for childhood or adult SES, were excluded from the analysis. The weighted prevalence of demographic characteristics (age, gender and ethnicity), of the three life course SES frameworks (low and high status for the three life time-point SES indicators; the four cumulative socio-economic disadvantage score categories; and the eight social mobility trajectories), and of obesity by the three life course SES frameworks was calculated. The correlation between the three life-time point SES indicators was assessed using Spearman's rank correlation coefficient. The association of the three SES life course frameworks with (current) obesity was assessed using unadjusted and adjusted (for current age and gender) logistic regression models. The reference group in the SP framework analysis were those with a 'high' status on the individual life time-point SES indicator, in the AR framework analysis were those with the minimum cumulative socio-economic disadvantage (score = 0), and in the SM framework analysis were those with a stable high (HHH) trajectory. All analyses, conducted using SAS for Windows, version 9.2, included survey sampling weights to adjust for oversampling and non-response. The analyses, involving de-identified data from the SIHLS, were exempted from full review by the Institutional Review Boards of the National University of Singapore and Duke University Health System.

RESULTS

Most respondents were aged 60-69 years (60.6%), female (53.4%), and of Chinese ethnicity (82.7%). (Table 1) The weighted prevalence of obesity in the analysis sample was 18.9%.

The weighted prevalence of the three life time-point SES indicators, cumulative socio-economic disadvantage categories and social mobility trajectories, and of obesity by (life course) SES is presented in Table 2. The maximum proportion of study participants had a low childhood SES (57.1%), a low adult SES (65.5%), and a high older adult SES (65.7%). Participants with either the lowest (= 0; the same as those experiencing a stable high [HHH] trajectory) or the highest (= 3; the same as those experiencing a stable low [LLL] trajectory) cumulative socio-economic disadvantage score were less than 20%. Participants did experience social mobility in SES during their life course, both in upward (LLH, LHH) and downward (HLL, HHL) directions, more experiencing the former (35.1%) than the latter (12.3%). There were also participants who experienced more than one change in SES in their life-course, their adult SES being different from their childhood SES and older adult SES (LHL [2.9%], HLH [13.5%]) Prevalence estimates of obesity were higher among those of high (versus low) childhood SES, of low (versus high) adult SES and of low (versus high) older adult SES. The prevalence was more or less similar across levels of cumulative socio-economic disadvantage. While those in the HLL trajectory had the highest prevalence of obesity (26.6%), closely followed by those in the HLH trajectory (24.7%), the lowest prevalence was observed for those in the LHH trajectory (11.8%).

There was a significant but low correlation between the three life time-point SES indicators (0.27: childhood and adult SES, 0.10: childhood and current SES, 0.21: adult and current SES).

The unadjusted and adjusted (for current age and gender) association between the life course SES frameworks with obesity among older Singaporeans is presented in Table 3. In adjusted analysis, according to the SP framework analyses, both childhood and adult SES were significantly associated with obesity. However, their effects were in opposite directions: a low

childhood SES decreased the odds for obesity while a low adult SES increased the odds. There was no association of cumulative socio-economic disadvantage over the life course with obesity. Relative to those with high SES through the life course (HHH), the odds of obesity were significantly lower for those with low childhood SES and high adult and older adult SES (LHH), while the odds were significantly higher for those with high childhood SES and low adult and current SES (HLL) and those with high childhood SES, low adult SES and high current SES (HLH).

DISCUSSION

SP framework

The most surprising finding of the current analyses was the direction of association between childhood SES and obesity, with lower odds of obesity among those with low childhood SES, even after controlling for adult and current SES. Previous studies report either no association, or if present, an inverse association, with a higher odds or risk of obesity among individuals with a lower SES in childhood.(Gonzalez et al. 2009; Pollitt et al. 2005; Senese et al. 2009)

To understand the possible reasons for the discrepancy between our and the findings of previous studies, it is important to contextualize our finding, in terms of the setting (country) and time period when the participants experienced their 'childhood'. Most (85.0%) Singaporeans aged 60 years and above in 2010 were born either in what is today Singapore (68.2%) or Malaysia (16.8%).(Singapore Department of Statistics 2010b) Thus, the majority of the age cohort represented by the SIHLS participants in our analysis sample, aged 60 to 97 years in 2009, born between 1912 and 1949, would have spent their childhood years (0-16 years; all or a considerable part) in what is today Singapore or Malaysia, mostly the former. Both these

countries were developing economies during the period (1912 to 1965) the SIHLS participants were in their 'childhood' years, and under foreign/ colonial (British [as part of British Malaya until 1962] and Japanese (1942-45)) rule or administration for most part of this period. Further, in their lifetimes, these elderly experienced periods of economic (and food) insecurity, in the early 1930's due to the economic depression in the West,(Huff 2001; Seng 2006) in the early 1940s due to the Japanese occupation (1942 to 1945; rationing of rice, the staple food, was implemented by the Japanese),(Kratoska 1988, 1998; Nicholls 1948) and in the post-war years due to limitations in food production and availability in the region.(Kratoska 1988) Though all social classes would have been affected to some extent by the economic and food insecurity, members of poorer families, including children, would have been disproportionately exposed to a nutritionally inadequate diet or to limited caloric intake. Previous studies have suggested adult lower limb length (calculated as standing height minus sitting height) to be a marker of energy intake in early childhood (at 4 years).(Wadsworth et al. 2002) Using data collected in the SIHLS, we observed the average lower limb length for those with a low childhood SES (76.71 cm [95% CI: 76.47-76.97]) to be significantly lower ($p = 0.002$; unpaired t-test) than those with a high childhood SES (77.37 cm [95% CI: 77.04-77.70]), lending support to our hypothesis. The continuing influence of such nutritional or caloric inadequacy may account for the lower odds of current obesity associated with low childhood SES among older Singaporeans, even after adjusting for adult and current SES. Childhood fatness (indicated by higher BMI z-scores, greater skin fold thickness or rapid gain in BMI after 2 years of age) has been shown to be predictive of adiposity in adulthood.(Freedman et al. 2005; Yliharsila et al. 2008)

There can be alternative explanations for the discordance between our and previous findings, namely the choice of childhood SES indicator. While most previous studies use

parental occupation,(Senese et al. 2009) we used financial hardship faced by the family (though self reported), which may be more sensitive in capturing nutritional or caloric inadequacy experienced during the growing up years. Though we adjusted for adult SES (education) and current SES (housing type), we cannot rule out residual confounding by other measures of adult SES and current SES, which if accounted for could result in a null association. However, it is unlikely that accounting for residual confounding will lead to a reversal of the observed association. Another possible explanation is the presence of a 'healthy' survivor bias. While most previous studies that observe an inverse association between childhood SES and adult obesity, define obesity based on body weight measured at an age of less than 60 years,(Gonzalez et al. 2009; Senese et al. 2009) all participants in our study were aged ≥ 60 years. It is possible that an inverse association did exist when the age cohort the SIHLS participants represent were middle-aged, with a greater proportion of obese individuals among those with 'low' childhood SES. However, as mortality from obesity-related health conditions is expected mostly during or after middle age, the proportion of those dying of obesity-related health conditions, and thus, of 'healthy' (non-obese) survivors, is likely to be disproportionately higher among those with a low (versus high) childhood SES, resulting in a lower odds of obesity in old age among those with low childhood SES.

The direction of the association of adult SES, operationalized using educational status, with obesity mirrors what has been reported from other developed societies,(McLaren 2007) with a higher odds of obesity among those with low educational status. It is likely, as suggested previously,(McLaren 2007) reflective of the association of a lower educational (and subsequently income) status, in an era when Singapore was developing rapidly with expanding availability of

food, with lower levels of knowledge and of adoption of healthy lifestyles and greater consumption of cheaper but calorie dense foods.

Though the unadjusted and adjusted point estimates of current SES were indicative of higher odds of obesity among those of lower SES they were not statistically significant. The use of an alternative indicator, more discerning to nutritional status or obesity, may have provided significant results.

Previous reports suggest that the availability of food in Singapore and Malaysia was most limited during and for a few years after the Japanese occupation.(Kratoska 1988; Seng 2006) It is thus possible that the detrimental influence of a low childhood SES, through inadequate caloric intake during childhood, on adult body mass status may be stronger for individuals experiencing their childhood during and in a few years subsequent to 1942 than before the Japanese occupation. On the other hand, the association of a lower educational status with unhealthy lifestyle and food choices, leading to obesity may be more prominent among those who spent a substantial portion of their young adult and middle-aged life (16 to 60 years) in Singapore when the country was rapidly developing or developed, than when it was an under-developed nation. To explore these aspects, we tested the SP framework, stratifying age into 3 groups, 60-69 years in 2009 (young-old; born 1940 to 1949; childhood 1940 to 1965; young adult and middle-aged 1956 to 2009), 70-79 years in 2009 (old-old; born 1930 to 1939; childhood 1930 to 1955; young adult and middle-aged 1946 to 1999) and $\geq$ 80 years in 2009 (oldest-old; born 1912 to 1929; childhood 1912 to 1945; young adult and middle-aged 1928 to 1989). The results (adjusted for gender; not shown) were in line with expectations, with a low childhood SES associated with significantly lower odds of obesity among the young-old and old-old but not among the oldest-

old, and a low educational status SES associated with significantly higher odds of obesity only among the young-old.

AR framework

An increase in the risk or odds of a higher BMI or of overweight or obesity or of adverse cardiovascular outcomes with an accumulation of socio-economic disadvantage over the life-course has been reported.(Heraclides and Brunner 2010; Pollitt et al. 2005) In these studies, hailing from western populations, the associations of low childhood SES and of low adulthood SES are in the same direction i.e. both increase the odds of an adverse outcome, resulting in higher odds for an adverse outcome among individuals experiencing socio-economic disadvantage at one or more time points in their lifetime, relative to those experiencing no socio-economic disadvantage throughout. However, in our study, the associations of low childhood SES and of low adulthood SES with obesity were in opposite directions, as indicated in the SP framework analysis, resulting in a null association of cumulative socio-economic disadvantage with adult obesity. We would have reached the same conclusion if none of the life-time point SES indicators were associated with adult obesity. Thus, one should explore the (behind the scene) independent associations of life-time point SES indicators with the outcome to understand the results of the AR framework as it cannot distinguish between no effect and opposite effects of SES at different life-time points. The discordant findings between our study from Singapore and previous studies from western populations also suggest that the effect of cumulative SES disadvantage may be context specific.

SM framework

Previous studies have reported social mobility to play a role in the development of CVD risk factors, including obesity in adult life.(Heraclides and Brunner 2010; Pollitt et al. 2005) We

too observed the presence of social mobility and of differences in prevalence of obesity between mobility trajectories. As discussed previously, we need to look at the independent influence of life-time point SES indicators to understand the relative importance of a downward or upward or stable SES trajectory in context of obesity in our population. Given the non-significant association of older adult SES with obesity, it is not surprising that key drivers behind the SM framework, in our analysis, were childhood SES and adult SES. Those moving up from a low childhood SES to a high adult SES (both protective against obesity) had the lowest prevalence of obesity (LHH: 11.0%; LHL: 14.5%), while those moving down from a high childhood SES to a low adult SES (both favoring obesity) had the highest prevalence of obesity (HLL: 26.8%; HLH: 25.0%). That said, older adult SES did seem to have some influence: among those moving up from a low childhood SES to a high adult SES, those of high older adult SES had a lower prevalence of obesity; among those moving down from a high childhood SES to a low adult SES, those of low older adult SES had a higher prevalence of obesity.

Those who remained in the stable low or in the stable high positions had a similar prevalence and odds of obesity, suggesting that among those without any social mobility, the health advantage (in context of risk for obesity) gained (or lost) by being in a low (or high) childhood SES was countered by the health advantage lost (or gained) by being in a low (or high) adult and older adult SES.

It has been postulated that those upwardly mobile are better off than those they leave behind and worse off than those they join, and that those downwardly mobile are worse off than those they leave behind and better off than those they join.(Heraclides and Brunner 2010) The results of the present study provided only partial support for these hypotheses: while the odds of obesity of the upward mobile (LHH and LHL) were lower than those they left behind (LLL;

results not shown), in line with the hypothesis, their odds of obesity were also lower relative to those they joined (HHH), suggesting that they were, in fact, better off than those they joined; and, while the odds of obesity of the downward mobile (HLL and HLH) were higher than those they left (HHH), congruent with the hypothesis, they were also worse off than those they joined (odds of obesity were higher than those in the LLL trajectory; results not shown). These findings also suggest that, among those experiencing social mobility, the health advantage or disadvantage offered by childhood SES in context of obesity persists even in face of the advantage or disadvantage offered by SES in later life, a phenomenon referred to as 'social protection'.(Heraclides and Brunner 2010)

Limitations

In addition to the limitations mentioned above, a key limitation, also observed in many previous studies,(Heraclides and Brunner 2010; Mckenzie and Carter 2009; Pollitt et al. 2005) was the retrospective recall of childhood SES. However, it has been suggested that this results in greater error in childhood, relative to adult, SES measures and an underestimation of the true effect of childhood SES,(Mckenzie and Carter 2009; Pollitt et al. 2005) while we observed a strong association of childhood SES with obesity. Though there may be a considerable variation in SES at each of three life-time points, we dichotomized each life-time point SES to aid in the formation of a manageable number of groups, with sufficient numbers in each, in the SM framework. It may be contended that while education is a good measure of adult SES for males, especially in the setting and among the age cohort we analyze, it may not be so for females. We did consider using alternative indicators, however, each of them had their own limitations when applied for females: longest occupation (the maximum proportion [31.7%] of females were homemakers, making distinction by occupation difficult), or husband's education or longest

occupation (this information was collected in the SIHLS only for currently married females; majority [58.3%] of the females in the analysis sample, given their age, were widowed [or separated or divorced or never married], thus, had missing data for these variables). Further, education, given its association with knowledge and adoption of healthy lifestyles (and with subsequent adult SES indicators), may be more suitable as an SES indicator when considering obesity as the outcome.

Strengths

The current study, based on a large, representative sample, is possibly the first to simultaneously apply the three life-course SES frameworks in context of obesity in adulthood. It is also among the few studies assessing the association of life course SES with obesity in adulthood from Asia, and among older adults. More studies, though mostly from Western countries, ascertaining this association among older adults can be expected in the future as the birth cohorts being studied in these countries age.(Heraclides and Brunner 2010) BMI was defined using measured height and weight, instead of self-reported, often used in large scale surveys. A higher BMI cut-off (≥ 30 kg/m^2) is used to define obesity in the World Health Organization (WHO) International classification.(World Health Organization 2006) To test if our findings could be replicated, we performed a sensitivity analysis defining obesity as per the WHO classification, and found the life-course SES frameworks/obesity associations (results not shown) to be similar to those observed in the primary analysis.

CONCLUSION

The three frameworks complement each other by providing different insights into the life course SES-adult obesity relationship. The association of life course SES with obesity in

adulthood is context specific, and all the three frameworks can be simultaneously utilized to gain a broader understanding of this association.

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Conflict of interest

None declared.

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Table 1: Demographic characteristics of older Singaporeans included in the analysis sample

Demographic characteristic	Weighted % (n)* N = 4193
Age (in years)	
60-69	60.6 (1875)
70-79	29.9 (1608)
≥80	9.5 (710)
Gender	
Male	46.6 (1956)
Female	53.4 (2237)
Ethnic group	
Chinese	82.7 (2973)
Malay	9.5 (717)
Indian	6.4 (453)
Others	1.4 (50)

* weighted by survey sample weights

Table 2: Weighted prevalence of the three life time-point socio-economic status (SES) indicators, four cumulative SES score categories, eight social mobility trajectories, and of obesity by life course SES indicators among older Singaporeans

SES indicator	Weighted % (n) N = 4193	Prevalence of Obesity Weighted row %
Childhood SES		
Low	57.1 (2372)	16.5
High	42.9 (1821)	22.1
Adult SES		
Low	65.5 (2962)	20.3
High	34.5 (1231)	16.2
Older adult SES		
Low	34.3 (1514)	19.7
High	65.7 (2679)	18.5
Cumulative socio-economic disadvantage		
3 (maximum disadvantage)	19.1 (878)	18.2
2	35.9 (1549)	19.3
1	27.9 (1116)	18.5
0 (minimum disadvantage)	17.1 (650)	19.3
Social mobility trajectory *		
LLL (stable low)	19.1 (878)	18.2
LHL	2.9 (101)	14.8

LLH	24.5 (1059)	17.4
LHH	10.6 (334)	11.8
HLL	8.5 (389)	26.6
HHL	3.8 (146)	15.2
HLH	13.5 (636)	24.7
HHH (stable high)	17.1 (650)	19.3

* L: Low; H: High; first, second and third alphabets represent childhood, adult and older adult

SES, respectively

Table 3: Association of life-course SES frameworks with (current) obesity among older Singaporeans: Unadjusted and adjusted odds ratio (OR) estimates with 95 % confidence intervals (CI) (N = 4193)

Life-course SES framework	Unadjusted OR (95% CI) for Obesity	Adjusted OR* (95% CI) for Obesity
Sensitive period [#]		
Low (versus high) childhood SES	**0.70 (0.60, 0.81)**	**0.64 (0.54, 0.75)**
Low (versus high) adult SES	**1.32 (1.12, 1.56)**	**1.44 (1.20, 1.74)**
Low (versus high) older adult SES	1.08 (0.92, 1.27)	1.05 (0.89, 1.23)
Accumulation of risk		
(Cumulative socio-economic		
disadvantage)		
3 versus 0	0.93 (0.72, 1.20)	0.89 (0.69, 1.16)
2 versus 0	1.00 (0.80, 1.25)	0.97 (0.77, 1.21)
1 versus 0	0.95 (0.75, 1.20)	0.93 (0.74, 1.18)
Social mobility trajectory [##]		
LLL versus HHH	0.93 (0.72, 1.20)	0.91 (0.71, 1.18)
LHL versus HHH	0.72 (0.43, 1.22)	0.71 (0.42, 1.20)
LLH versus HHH	0.88 (0.69, 1.12)	0.87 (0.68, 1.11)
LHH versus HHH	**0.56 (0.40, 0.78)**	**0.57 (0.40, 0.80)**
HLL versus HHH	**1.51 (1.13, 2.03)**	**1.49 (1.10, 2.00)**
HHL versus HHH	0.75 (0.47, 1.19)	0.77 (0.48, 1.23)
HLH versus HHH	**1.37 (1.06, 1.78)**	**1.32 (1.01, 1.72)**

* Adjusted for current age and gender

Unadjusted ORs for a particular life time-point SES indicator are not adjusted for the other two life time-point SES indicators or for current age and gender; Adjusted ORs for a particular life time-point SES indicator are adjusted for the other two life time-point SES indicators as well as for current age and gender

L: Low; H: High; first, second and third alphabets indicative of childhood, adult and older adult SES, respectively