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Social inequality in obesity in an Eastern Mediterranean population: evidence from a national health survey in Cyprus

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Key words: Social inequalities, Socio-economic, Education, Social Class, Obesity
Parole chiave: Disuguaglianza sociale, Determinanti socioeconomici, Livello di istruzione, Classe sociale, Obesità

Abstract

Background. *We aimed to explore socioeconomic factors associated with obesity among adults and to investigate social inequality in obesity prevalence in Cyprus.*
Study design. *Cross-sectional study*
Methods. *We conducted a survey among 3,021 Greek-Cypriots aged 25-64 years, collecting self-reported demographics, health behaviors, socioeconomic characteristics and anthropometric measurements. We performed univariable and multivariable (adjusting for demographics and health behaviors) sex-specific Poisson's regression with robust variance, reporting adjusted prevalence ratios (PRs) and 95% confidence intervals.*
Results. *The prevalence of obesity was 22% among males and 17% among females.*
According to univariable analyses, higher obesity prevalence was associated with increased age, decreased physical activity and decreased alcohol consumption in both genders. In addition, obesity was associated with refugee status and former smoking in males and with a higher healthy diet score in females. There was a clear linear decrease in obesity prevalence each step up the socioeconomic hierarchy in both genders. In the fully adjusted model, a clear inverse gradient in obesity prevalence by educational attainment was observed in females (p=0.002), while, in males, lower obesity prevalence remained significantly associated with the highest level of family-net income and educational attainment (aPR:0.48; 95% CI:0.27-0.84 and aPR:0.46; 95% CI:0.25-0.84, respectively). Occupational social class was not associated with obesity.
Conclusions. *This study highlights striking social inequalities in obesity in an Eastern Mediterranean population, which only recently moved from rural living to high levels of development. We recommend that public health interventions should address education - and income-related barriers, as a means of tackling health inequalities.*

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Background

The prevalence of obesity has been increasing worldwide, rising from 6% in 1980 to 13% in 2016 (1). Large socioeconomic inequalities in obesity exist globally, while in Europe, low socioeconomic groups are almost two times more likely to become obese, with inequalities more pronounced in females than in males (2, 3).

Interestingly, this inverse gradient is observed in high-income countries, while in lower-income countries obesity tends to be more prevalent in individuals with higher socioeconomic status (4).

This interesting phenomenon is not fully understood, thus investigation of social inequalities in rapidly developed societies can elucidate the origins of inequalities and how these take place in recently developed countries.

The social stratification observed in high-income countries is a recent phenomenon in the Republic of Cyprus, which rapidly developed in the last 40 years, transforming from a largely rural island into one of the most affluent nations in the world, with dramatic changes in lifestyle habits, which could potentially be socially patterned. Currently, there is limited evidence on obesity prevalence in the country (5, 6), and no information on social determinants. Thus, a more systematic and comprehensive investigation on social inequalities of obesity in Cyprus is needed, which could act as a model for the formation of health inequalities in rapidly developing societies.

Dietary habits, physical activity (PA), smoking and alcohol consumption are known health behaviors associated with obesity (7), and these are also strongly socially patterned, with detrimental behaviors being more prevalent in lower Socio-Economic Status (SES) groups (8). Therefore, lifestyle could mediate the relationship between SES and obesity.

The aims of the present study are: (a) to assess the prevalence of obesity in adult Greek-Cypriot males and females, (b) to identify the major sociodemographic and behavioral determinants of obesity, and (c) to investigate the presence of socioeconomic inequalities in obesity and the mediating role of lifestyle behaviors.

Methods

Study design and sampling

Aiming to study the general health status, health behaviors and social circumstances in the adult population, commissioned by the Ministry of Health, we undertook a cross-sectional household survey in the Republic of Cyprus in 2009-2010, among a random sample of 3,021 Greek-Cypriots aged 25-64 years, comprising 46.1% males and 53.9% females. The sampling methodology and the recruitment of participants have been previously described (9).

Briefly, we conducted a multistage sampling recruiting individuals based on predefined age-group and gender strata, proportional to those recorded in the population census; thus, our sample is representative of the country's young and middle-aged adult population. Based on available published data (5), our sample size is adequate for estimating the population obesity prevalence, giving a 95% confidence interval (CI) with a statistical error margin of 1.6.

During the household visit, trained interviewers informed participants about the study aims before obtaining written informed consent, excluding participants unable to give consent or to complete the study questionnaire, hence in-person interviews were conducted. The response rate was 100% with full cooperation of the individuals in all households approached. Ethical approval was obtained from the Cyprus National Bioethics Committee (28/4/2014, ΕΕΒΚ/ΕΠ/2014/01.56).

Data collection and assessment of study variables

We used the Countrywide Integrated Noncommunicable Disease Intervention program questionnaire, including questions on sociodemographic factors and lifestyle habits (10), which was adapted to the cultural local context, and pilot tested for validity, as previously described (9), and the International Physical Activity Questionnaire – Short Form (11), to estimate participants' PA level.

We calculated body mass index (BMI) from self-reported weight and height, and classified individuals as underweight (<18.5 kg/m^2), normal weight (≥18.5 to 24.9 kg/m^2), overweight (≥25 to 29.9 kg/m^2) and obese (≥30 kg/m^2). For the purpose of this study, we created a binary outcome variable to compare obese and non-obese individuals.

All demographic and socioeconomic characteristics were self-reported by the participants. We defined as 'refugee' any person internally displaced, after the 1974 Turkish invasion of the island. Marital status was classified as single, married/engaged/cohabiting, divorced, or widowed.

We used three indicators for SES. Family-net income was categorised as ≤€1,000, €1,001-2,000, €2,001-3,000, €3,001-4,000, and >€4,000 per month. Educational attainment was classified as no education or up to gymnasium (middle school), lyceum (high school), undergraduate university degree, and postgraduate university degree. Based on participants' reported profession, we assigned them to one of the following occupational social class (OSC) categories: higher managerial/professional, lower managerial/professional and intermediate occupations, skilled non-manual, skilled/semi-skilled manual and unskilled, according to the UK National Statistics Socioeconomic Classification (NS-SEC) and the UK Registrar General's Social Class (RGSC) classification (12). The two systems were combined to better reflect the working conditions of the Cypriot population.

We estimated PA score in metabolic equivalent of tasks and categorized participants into three groups: low, moderate and vigorous activity (11).

Assessment of smoking in the current survey has been extensively reported elsewhere (9). Briefly, we grouped participants into one of the following categories: never, former, or current smoker. We categorized alcohol consumption based on type, amount, and frequency over the last week as: never, low-risk consumption (≤ 14 drinks per week for males and ≤ seven drinks per week for females) or high-risk consumption (> 14 drinks per week for males and > 7 drinks per week for females), as per the national recommendations. Drink portions and standard units were defined according to the national guidelines (13).

From answers to questions on dietary habits and frequency of food consumption over the last week, we built a healthy diet index score based on nine food groups, of which three were considered beneficial for health: 1) fresh vegetables, 2) frozen/canned vegetables, and 3) fresh fruits; and six detrimental: 1) french fries, 2) red meat, 3) processed meat, 4) cakes, 5) sweets (e.g. candies, creams) and 6) soft drinks, following the national dietary recommendations (13).

Frequency of food consumption was grouped as never, 1-2 times a week, 3-5 times a week, and >5 times a week. For each food group we converted the frequency into a score ranging between 1-4. For beneficial food groups the higher the frequency of consumption, the higher the score (i.e., score=4 if consumed >5 times a week, while score=1 if never consumed), whereas for detrimental food groups the score was reversed, thus the lower the frequency of consumption the higher the score (i.e., score=1 if consumed >5 times a week, while score=4 if never consumed). Hence, the total healthy diet index score could range between 9 and 36, where 9 represents the lowest score

(unheathy diet) and 36 the highest (healthy diet). Based on the score sum distribution, we used tertiles to define low, medium and high healthy diet index.

Statistical analysis

We performed descriptive analysis and present all study variables in absolute and relative frequencies. We used the chi-squared test to compare frequencies by gender.

We performed Poisson's univariable regression analysis with robust variance and calculated crude prevalence ratios (PRs) of obesity and 95% CIs, for each SES indicator (model 0) as well as for demographic characteristics and health behaviors, stratified by gender. Ordinal independent variables were analyzed both as categorical and continuous data.

Furthermore, we evaluated the association between each SES indicator (main exposure) and each health behavior to confirm the latter as potential confounders. Finally, for each SES indicator, we performed multivariable regression analyses, stratified by gender, with two models: model 1 (adjusted for demographic characteristics: i.e., age groups, district, area, marital status, and refugee status) and model 2 (as model 1, with further adjustment for health behaviors: i.e., PA, alcohol consumption, smoking status and healthy diet index), and calculated adjusted PRs (aPRs) of obesity. In the regression models, we combined low- and high-risk alcohol consumption into one category for females, due to paucity of participants in the high-risk consumption category.

A p-value <0.05 was considered statistically significant. All analyses were performed using STATA® version 16 (StataCorp., USA).

Results

Characteristics of study participants and prevalence of obesity

Demographic characteristics were similar to those observed in the source population. In terms of health behaviors, study participants were generally physically inactive and not high-risk drinkers, while half of them were current/ex-smokers. Regarding socioeconomic factors, the majority belonged to middle SES classes (based on occupation and income), while about 2/3 did not attain higher education. Statistically significant gender differences were observed for most demographics and health behaviors as well as for body weight status and SES indicators. The overall prevalence of obesity was 21.5% among males and 16.9% among females (Table 1).

Furthermore, when respondents with available BMI-related information (94.7%) were compared with those without (5.3%), a significantly higher proportion of the latter were single or widowed, lived in rural areas, and belonged to the lowest categories of PA, healthy diet index, educational attainment and family-net income. No differences in gender and age group distribution were observed (data not shown).

Demographic and behavioural factors in relation to obesity

The analysis included 2,860 participants (94.7% of original sample) with data on BMI. In both genders there was a significant positive trend of obesity prevalence with increasing age (Table 2). Obesity was significantly associated with being widowed (both genders) and being a refugee (males only). The prevalence of obesity was lower in those reporting higher PA (PR high vs low: 0.56; 95% CI: 0.43-0.73). Participants reporting low- and high-risk alcohol consumption had a lower prevalence of obesity (PR: 0.71; 95% CI: 0.61-0.83 and PR: 0.63; 95% CI: 0.42-0.94, respectively) compared to abstainers. In males, former

Table 1 - Characteristics of the study population, by gender. Household survey in Greek Cypriot adults[1]

Characteristics		Total		Males		Females		p
		N	%	n	%	n	%	
Overall		3,021	100	1,393	46.1	1,628	53.9	-
Weight Status by Body Mass Index (n= 2,860)	Underweight	59	2.1	3	0.2	56	3.6	**<0.001**
	Normal weight	1,238	43.3	409	31.1	829	53.7	
	Overweight	1,020	35.7	622	47.2	398	25.8	
	Obese	543	19.0	283	21.5	260	16.9	
Age groups (years) (n= 3,021)	25-34	751	24.9	360	25.8	391	24.0	0.272
	35-44	739	24.5	333	23.9	406	24.9	
	45-54	775	25.7	339	24.3	436	26.8	
	55-64	756	25.0	361	25.9	395	24.3	
District (n= 3,019)	Nicosia	1,225	40.6	549	39.4	676	41.6	0.262
	Limassol	864	28.6	394	28.3	470	28.9	
	Larnaka	507	16.8	248	17.8	259	15.9	
	Paphos	283	9.4	127	9.1	156	9.6	
	Famagusta	140	4.6	74	5.3	66	4.1	
Area (n= 3,016)	Urban	2,054	68.1	937	67.4	1,117	68.7	0.450
	Rural	962	31.9	453	32.6	509	31.3	
Refugee status (n= 2,989)	Yes	1,022	34.2	459	33.3	563	35.0	0.320
	No	1,967	65.8	921	66.7	1,046	65.0	
Marital status (n= 3,020)	Single	398	13.2	225	16.2	173	10.6	**<0.001**
	Married-engaged	2,392	79.2	1,113	80.0	1,279	78.6	
	Divorced	170	5.6	42	3.0	128	7.9	
	Widowed	60	2.0	12	0.9	48	3.0	
Physical activity (n= 3,021)	Low	1,751	58.0	782	56.1	970	59.6	**0.015**
	Moderate	790	26.2	361	25.9	428	26.3	
	High	480	15.9	250	18.0	230	14.1	
Alcohol consumption (n= 3,006)	No	1,379	45.9	341	24.7	1,038	63.8	**<0.001**
	Low-risk	1,465	48.7	902	65.5	563	34.6	
	High-risk	162	5.4	135	9.8	27	1.7	
Smoking status (n= 3,021)	Never	1,614	53.4	413	29.7	1,201	73.8	**<0.001**
	Former	354	11.7	273	19.6	81	5.0	
	Current	1,053	34.9	707	50.8	346	21.3	
Healthy diet index (n= 2,887)	Low	1,201	41.7	647	49.0	554	35.4	**<0.001**
	Medium	934	32.4	397	30.1	537	34.4	
	High	748	25.9	276	20.9	472	30.2	
Occupational social class (n= 2,193)	Unskilled	287	13.1	117	9.8	170	17.0	**<0.001**
	Skilled semi-manual	667	30.4	522	43.9	145	14.5	
	Skilled non-manual	971	44.3	385	32.4	586	58.4	
	Intermediate	140	6.4	87	7.3	53	5.3	
	Lower managerial	63	2.9	36	3.0	27	2.7	
	Higher managerial	65	3.0	43	3.6	22	2.2	
Family-net income (euro) (n= 2,885)	≤1,000	450	15.6	151	11.3	299	19.3	**<0.001**
	1,001-2,000	1,249	43.3	595	44.4	654	42.3	
	2,001-3,000	701	24.3	330	24.7	371	24.0	
	3,001-4,000	262	9.1	138	10.3	124	8.0	
	>4,000	223	7.7	125	9.3	98	6.3	
Educational attainment (n= 3,009)	Up to gymnasium	931	30.9	431	31.1	500	30.9	**<0.001**
	Lyceum	1,088	36.2	529	38.1	559	34.5	
	Undergraduate	796	26.5	322	23.2	474	29.2	
	Postgraduate	194	6.5	106	7.6	88	5.4	

[1]p-values in bold font are significant

Table 2 - Univariate analyses of factors associated with obesity, by gender. Household survey in Greek Cypriot adults[1]

		Total			Males			Females		
		PR[2]	95%CI[3]	*p*	PR[2]	95%CI[3]	*p*	PR[2]	95%CI[3]	*p*
Age groups (years)	25-34	1.00			1.00			1.00		
	35-44	**1.33**	**1.03 - 1.73**	**<0.001**	1.29	0.93 - 1.79	**0.002**	1.44	0.94 - 2.20	**<0.001**
	45-54	**1.83**	**1.44 - 2.32**		**1.43**	**1.04 - 1.95**		**2.52**	**1.73 - 3.68**	
	55-64	**2.04**	**1.61 - 2.58**		**1.58**	**1.17 - 2.13**		**2.81**	**1.93 - 4.10**	
District	Nicosia	1.00			1.00			1.00		
	Limassol	0.99	0.83 - 1.19		0.86	0.67 - 1.11		1.14	0.88 - 1.47	
	Larnaka	0.98	0.78 - 1.23	0.187	0.94	0.69 - 1.28	0.734	1.01	0.72 - 1.41	0.085
	Paphos	**0.71**	**0.52 - 0.98**		0.77	0.51 - 1.16		0.65	0.40 - 1.05	
	Famagusta	1.00	0.69 - 1.44		1.18	0.77 - 1.80		0.68	0.33 - 1.39	
Area	Urban	1.00		0.062	1.00		0.431	1.00		0.066
	Rural	1.16	0.99 - 1.37		1.09	0.88 - 1.36		1.24	0.99 - 1.57	
Refugee status	Yes	1.00		0.343	1.00		**0.020**	1.00		0.418
	No	0.93	0.79 - 1.09		**0.78**	**0.63 - 0.96**		1.10	0.87 - 1.40	
Marital status	Single	1.00			1.00			1.00		
	Married-engaged	**1.46**	**1.12 - 1.92**	**0.002**	**1.55**	**1.10 - 2.20**	**0.011**	1.41	0.92 - 2.17	**0.009**
	Divorced	1.44	0.95 - 2.16		1.23	0.58 - 2.59		1.64	0.95 - 2.83	
	Widowed	**2.15**	**1.31 - 3.54**		**2.48**	**1.06 - 5.81**		**2.24**	**1.17 - 4.30**	
Physical activity	Low	1.00			1.00			1.00		
	Moderate	**0.82**	**0.68 - 0.98**	**<0.001**	**0.72**	**0.56 - 0.93**	**<0.001**	0.93	0.72 - 1.19	**0.006**
	High	**0.56**	**0.43 - 0.73**		**0.56**	**0.40 - 0.78**		**0.54**	**0.36 - 0.83**	
Alcohol consumption[4]	No	1.00			1.00			1.00		
	Low-risk	**0.71**	**0.61 - 0.83**	**<0.001**	**0.68**	**0.55 - 0.85**	**<0.001**	**0.50**	**0.38 - 0.68**	**<0.001**
	High-risk	**0.63**	**0.42 - 0.94**		**0.54**	**0.34 - 0.84**				
Smoking status	Never	1.00			1.00			1.00		
	Former	**1.42**	**1.15 - 1.75**	0.728	**1.52**	**1.14 - 2.01**	0.809	0.88	0.51 - 1.49	0.095
	Current	1.01	0.85 - 1.20		1.08	0.84 - 1.40		0.78	0.58 - 1.05	
Healthy diet index	Low	1.00			1.00			1.00		
	Medium	1.10	0.91 - 1.33	**0.045**	1.12	0.88 - 1.44	0.083	1.17	0.87 - 1.57	**0.047**
	High	1.22	1.00 - 1.47		1.26	0.97 - 1.65		1.34	1.00 - 1.78	

Occupational social class	Unskilled	1.00			1.00			1.00		
	Skilled semi manual	1.19	0.89 - 1.58		1.21	0.81 - 1.79		0.81	0.48 - 1.38	
	Skilled non-manual	**0.72**	**0.54 - 0.97**	**0.011**	0.83	0.54 - 1.27	0.176	**0.65**	**0.43 - 0.98**	**0.025**
	Intermediate	0.76	0.47 - 1.23		0.95	0.54 - 1.69		0.33	0.10 - 1.04	
	Lower managerial	0.86	0.46 - 1.60		0.97	0.45 - 2.06		0.65	0.21 - 1.97	
	Higher managerial	0.85	0.46 - 1.57		0.94	0.46 - 1.94		0.53	0.14 - 2.08	
Family-net income (euro)	≤1,000	1.00			1.00			1.00		
	1,001-2,000	0.86	0.69 - 1.06		0.92	0.66 - 1.29		0.78	0.59 - 1.03	
	2,001-3,000	0.80	0.63 - 1.02	**<0.001**	0.96	0.67 - 1.38	**0.012**	**0.63**	**0.45 - 0.89**	**0.001**
	3,001-4,000	**0.68**	**0.48 - 0.95**		0.70	0.44 - 1.13		0.62	0.37 - 1.02	
	>4,000	**0.50**	**0.33 - 0.75**		**0.54**	**0.31 - 0.93**		**0.42**	**0.22 - 0.82**	
Educational attainment	Up to gymnasium	1.00			1.00			1.00		
	Lyceum	**0.71**	**0.60 - 0.84**	**<0.001**	0.89	0.71 - 1.12	**<0.001**	**0.54**	**0.42 - 0.70**	**<0.001**
	Undergraduate	**0.55**	**0.45 - 0.68**		**0.72**	**0.53 - 0.96**		**0.44**	**0.33 - 0.59**	
	Postgraduate	**0.34**	**0.22 - 0.54**		**0.42**	**0.23 - 0.75**		**0.26**	**0.12 - 0.57**	

[1]Prevalence ratios, 95%CIs and p-values in bold font are significant
[2]PR: Prevalence ratio
[3]CI: Confidence interval
[4]Low- and high-risk consumption categories in women were combine

smokers had a higher prevalence of obesity compared to never smokers (PR: 1.52; 95%CI: 1.14-2.01). A weak positive trend in obesity with increasing healthy diet index was observed among females (p-trend=0.047).

Associations between socioeconomic indicators and obesity

In unadjusted analyses (Table 2; model 0 in Figure 1) there was a decreasing trend of obesity prevalence with increasing family-net income and educational attainment (i.e., inverse gradient) in both males (p-trend: 0.012 income; <0.001 educational attainment) and females (p-trend: 0.001 and <0.001, respectively). Particularly, those reporting the highest family-net income had much lower prevalence of obesity (PR: 0.54; 95%CI: 0.31-0.93 in males, PR: 0.42; 95%CI: 0.22-0.82 in females), compared to those reporting the lowest income. Similarly, males holding a postgraduate university degree had much lower prevalence of obesity (PR: 0.42; 95%CI: 0.23-0.75) than those with the lowest educational attainment, while in females this was even more pronounced (PR: 0.26; 95% CI: 0.12-0.57) (Table 2; model 0 in Figure 1). Although there was no clear trend in obesity by OSC in both genders, the prevalence significantly decreased with increasing social class in females (Table 2).

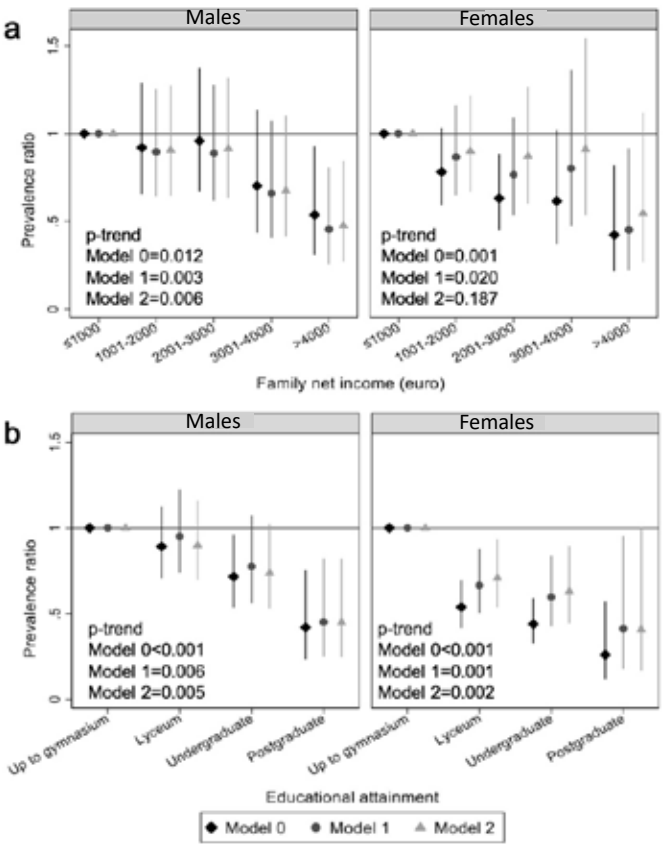

Figure 1 - Crude and adjusted obesity prevalence ratios (and 95% confidence intervals) for family-net income (a) and educational attainment (b), by gender.
Model 0: crude; Model 1: adjusted for age group, area, district, marital status and refugee status; Model 2: model 1 further adjusted for physical activity, alcohol consumption, smoking status and healthy diet index

After adjusting for demographic factors (model 1 in Figure 1; Supplementary Tables A.1-A.4), the inverse trend between family-net income and obesity remained robust in males (p-trend=0.003), while it slightly attenuated in females (p-trend=0.020). A similar picture was observed for educational attainment (p-trend: 0.006 males; 0.001 females).

Finally, after further adjustment for health behaviors to investigate mediation effects (model 2 in Figure 1; Supplementary Table A.1-A.4), the inverse trend between income and obesity prevalence remained robust among males (p-trend=0.006) but not females (p-trend=0.187). Conversely, the inverse trend between educational attainment and obesity prevalence was not further attenuated (p-trend: 0.005 males; 0.002 females). Overall, for both family-net income and educational attainment, a substantial difference in obesity prevalence by SES was still apparent even after full adjustment, when the lowest SES category was compared with the highest. OSC did not reveal any significant association with obesity in either males or females, in multivariable analysis (Supplementary Tables A.5-A.6).

Discussion

Summary of findings

Our study assessed the prevalence of obesity and investigated its association with socioeconomic characteristics in adult Cypriots. The lower prevalence of obesity in females (16.9%) compared to males (21.5%) observed in our study is in agreement with previous findings in Cyprus (5,6), and comparable to other high-income countries (14). Our survey also confirms the presence of an inverse socioeconomic gradient (as assessed via educational attainment and household income) in obesity as reported in other high-income countries (4, 15). This gradient remained robust to adjustment for demographic confounders and was not mediated by health behavious.

Our study also revealed that social inequalities in obesity are context-specific, depending on the SES indicator of choice and varying somewhat between genders.

Differential associations by SES indicator and by gender

Education, household income, and OSC are widely accepted indicators of SES. Although they often correlate, each indicator is specific to particular stages of the life-course and may capture different aspects of overall health risk (16, 17).

Education captures the long-term influences of both early life circumstances on adult health and the adult resources on health, while income comprises aspects such as buying power and social status. OSC is related to income and material resources, reflecting better access to health services, social positioning and networks, as well as work-related factors (16). Hence, SES indicators are not interchangeable (17) and each of them is worth investigating to better understand socioeconomic inequalities in health.

Furthermore, the impact of each SES indicator on obesity appears to differ across countries and also be gender-specific (2, 3, 18). In our study, the inverse social gradient observed for income and educational attainment are not identical between genders, with educational attainment showing a slightly stronger association in females, consistent with previous findings (15, 19).

In regards to family-net income, family members may have unequal access to household income, and gender inequalities have been previously highlighted, with a female disadvantage in household resource sharing (20). Noteworthily, we did not observe any substantial gender differences between family-net income and obesity, although the association using this specific indicator was slightly stronger in males.

The current literature on the association between OSC and obesity is mixed, with studies revealing inverse associations or inconsistent findings (21, 22). In our study, OSC was based on two classifications systematically used in the UK (12), in absence of a dedicated classification system for the Cypriot population. Unlike educational attainment and household income, we did not observe a clear gradient between OSC and obesity, but the association tended to be stronger among females. Notably, previous studies that used the UK NS-SEC classification did not show a significant association with mortality or no clear evidence of widening socioeconomic inequalities in self-reported health (23), compared to other social class scales (24). It is worth noting that the NS-SEC was not designed to classify individuals hierarchically (23), which may explain why for some health outcomes, there are no significant differences across the social classes. El Sayed *et al* highlight an overreliance on OSC in the investigation of social inequality in obesity in the UK, proposing the use of educational attainment and/or income as SES indicators (25). In addition, OSC does not include individuals outside of the active workforce (e.g. unemployed, retired adults and housewives), and further challenges arise for comparison across contexts in space and time, all of which potentially explaining the lack of association in our study (16, 25).

Mediation effect of health behaviors

We also investigated health behaviors as plausible mediators of social inequalities in health, as these are strongly socially patterned and independently related to several health outcomes (26).

Although people with higher education may have healthier lifestyles than those less educated (8, 27), when accounting for mediation by health behaviors (model 2) in the current study, estimates did not substantially change. Even though the association between income and obesity was attenuated among females, the overall inverse gradient for obesity by education and income remained robust, indicating no major role of health behaviors as mediators.

In a recent systematic review, investigating the role of diet, PA, alcohol consumption and smoking as mediators in the SES-health association, smoking turned out to be an important mediator in the inverse gradient between SES and risk of all-cause mortality and cardiometabolic disorders, with other health behaviors having a minor role. The contribution of health behavious was higher in studies conducted in high-income countries, among males, in younger individuals, and in longitudinal studies (28). The cross-sectional design of our study makes it more difficult to investigate mediation and could potentially explain the lack of a mediating effect. This lack of mediation by health behaviors has also been observed in prospective studies in other populations (29).

Strengths and limitations of the study

To our knowledge, the current study is the first that systematically investigated SES inequalities in obesity prevalence in Cyprus, using different SES indicators, revealing the presence of clear and substantial SES inequalities, in a recently developed high-income country. While the study enrolled a large sample and followed a rigorous sampling strategy, it has some limitations. First, we cannot establish a causal association between exposures and outcome due to the cross-sectional design. This is apparent in associations from univariate analysis in our study, such as higher prevalence of obesity among females following a healthy diet, but it does not appear to influence the main findings of our study, namely the association between SES indicators and obesity prevalence.

Second, the accuracy of BMI derived from self-reported measures may be biased, as some population sub-groups (e.g., females and those overweight/obese) tend

to underestimate their weight. However, it has been shown that self-reported height and weight highly correlate with objective measures, thus they could be used as proxy in research studies (30).

Third, socioeconomic indicators and lifestyle behaviours were also self-reported, increasing the possibility of misreporting and information bias. Nevertheless, besides dietary intake, all socioeconomic indicators and health behaviors showed the expected direction in their association with obesity prevalence, indicating that misreporting might not have affected our findings. Particularly, with regard to diet, a large body of evidence suggests that obese individuals tend to underreport their habitual food intake or selectively underreport intake of some food categories (31, 32) and that the degree of underreporting is positively correlated with their BMI (33). Furthermore, our healthy diet index was not calculated based on any comprehensive food frequency questionnaire and merely reflects a crude estimation of healthy diet adherence; thus its association with obesity, as well its mediation effect in our study, should be interpreted with caution. Further longitudinal research and a more robust dietary assessment tool, combined with dietary intake biomarkers, are needed to elucidate causality and directions of the association between diet and obesity across the life course, in our population.

Fourth, almost 5% of study participants did not report BMI-related information (i.e., outcome item non-response). On one hand, such proportion is considered acceptable and no further missing data imputation is needed (34); on the other hand, these participants belonged to the lowest categories of PA, healthy diet index, educational attainment and family-net income, which we have identified as reference categories for higher prevalence of obesity. Evidence suggests that non-respondents are usually single and less educated, while respondents in health surveys report better health status and more positive health-related behaviours than non-respondents, including self-rated health and chronic diseases, physical inactivity, and obesity (35, 36). In light of these findings, we cannot exclude selective response bias based on the outcome of interest, which might have further diluted the strength of the associations.

Conclusions

Our study reveals a clear inverse socio economic gradient in obesity prevalence in the adult Greek Cypriot population, mainly driven by inequalities in educational attainment and income and independent of differences in health behaviors. Our findings could act as a model on how socioeconomic inequalities are formed in recently developed societies and could potentially inform health policy, encouraging the use of comprehensive interventions focused on improving conditions early in life in order to increase educational attainment and empower children and young adults from lower socioeconomic backgrounds, as a means for tackling health inequalities in obesity.

Ethical approval: Ethical approval was obtained from the Cyprus National Bioethics Committee (28/4/2014, ΕΕΒΚ/ΕΠ/2014/01.56).
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Conflicts of Interests. The authors have no conflicts of interest to declare.

Riassunto

Disuguaglianze sociali nell'obesità in una popolazione del Mediterraneo orientale: evidenze da un'indagine nazionale a Cipro

Premessa. L'obiettivo dello studio è di esplorare i fattori socioeconomici associati all'obesità e di analizzare

il ruolo della disuguaglianza sociale nella prevalenza dell'obesità in una popolazione adulta della Repubblica di Cipro.

Disegno dello studio. Studio trasversale.

Metodi. Nell'indagine sono stati arruolati 3.021 Greco-Ciprioti di età compresa tra 25 e 64 anni. Le caratteristiche demografiche, socioeconomiche, antropometriche e i comportamenti di salute sono stati auto-riportati dai partecipanti. L'analisi univariata e multivariata (aggiustata per le caratteristiche demografiche e i comportamenti di salute) è stata condotta mediante regressione di Poisson, specifica per sesso, con varianza robusta; i rapporti di prevalenza aggiustata (adjusted prevalence ratios - aPR) e i relativi intervalli di confidenza (IC) al 95% sono stati riportati.

Risultati. La prevalenza dell'obesità è risultata del 22% tra i maschi e 17% tra le femmine. All'analisi univariata, una maggiore prevalenza dell'obesità era associata all'aumento dell'età, alla diminuzione dell'attività fisica e al ridotto consumo di alcol in entrambi i sessi. Inoltre, nei maschi l'obesità era associata allo status di rifugiato e all'essere ex fumatori; e nelle femmine ad un punteggio di dieta sana più alto. È stata osservata una chiara diminuzione lineare nella prevalenza dell'obesità ad ogni gradino della gerarchia socioeconomica in entrambi i sessi. Nel modello aggiustato, nelle femmine è stato osservato un gradiente inverso nella prevalenza dell'obesità sulla base del livello d'istruzione ($p = 0,002$), mentre nei maschi una prevalenza inferiore dell'obesità è rimasta significativamente associata al livello più alto di reddito familiare netto e del livello d'istruzione (rispettivamente: aPR: 0,48; 95% CI: 0,27-0,84; aPR: 0,46; 95% CI: 0,25-0,81). Non è stata rilevata nessuna associazione tra classe sociale professionale e obesità.

Conclusioni. Il presente studio evidenzia notevoli disuguaglianze sociali nell'obesità in una popolazione del Mediterraneo orientale, che solo recentemente ha avuto una transizione da rurale a livelli elevati di sviluppo. Si raccomanda che gli interventi di sanità pubblica affrontino le barriere legate all'istruzione e al reddito, come mezzo per contrastare le disuguaglianze di salute.

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SUPPLEMENTARY MATERIAL

Table A.1: Bivariate and multivariate analysis between family net income and obesity, in men

	Model 0				Model 1				Model 2			
	PR[1]	95%CI[2]		p	aPR[3]	95%CI[2]		p	aPR[3]	95%CI[2]		p
Family-net income (euro)												
≤1,000	1.00				1.00				1.00			
1,001-2,000	0.92	0.66	1.29		0.90	0.64	1.26		0.91	0.65	1.27	
2,001-3,000	0.96	0.67	1.38	**0.012**[4]	0.89	0.62	1.28	**0.003**[4]	0.91	0.63	1.32	**0.006**[4]
3,001-4,000	0.70	0.44	1.13		0.66	0.41	1.07		0.68	0.41	1.10	
>4,000	**0.54**	**0.31**	**0.93**		**0.45**	**0.26**	**0.81**		**0.48**	**0.27**	**0.84**	
Age												
25-34					1.00				1.00			
35-44					1.30	0.92	1.85	0.143	1.33	0.91	1.94	0.142
45-54					1.38	0.97	1.96	0.072	1.42	0.98	2.07	0.067
55-64					**1.42**	**1.00**	**2.00**	**0.048**	1.37	0.94	2.01	0.105
District												
Nicosia					1.00				1.00			
Limassol					**0.76**	**0.57**	**1.00**	**0.047**	0.80	0.59	1.09	0.156
Larnaka					0.85	0.61	1.17	0.312	0.94	0.68	1.30	0.700
Paphos					0.72	0.47	1.12	0.141	0.72	0.45	1.15	0.173
Famagusta					0.99	0.62	1.58	0.965	1.08	0.66	1.78	0.759
Refugee												
No					1.00				1.00			
Yes					0.82	0.66	1.02	0.077	0.83	0.66	1.04	0.097
Area												
Urban					1.00				1.00			
Rural					1.02	0.80	1.31	0.867	0.92	0.70	1.20	0.534
Marital status												
Single					1.00				1.00			
Married-engaged					1.28	0.87	1.88	0.216	1.22	0.81	1.84	0.331

Divorced	1.06	0.50	2.26	0.880	1.10	0.48	2.52	0.818
Widowed	1.77	0.83	3.78	0.141	1.65	0.80	3.42	0.177
Alcohol consumption								
No					1.00			
Low-risk					**0.70**	**0.55**	**0.89**	**0.003**
High-risk					**0.63**	**0.40**	**1.00**	**0.049**
Smoking status								
Never					1.00			
Former					**1.38**	**1.02**	**1.87**	**0.039**
Current					1.07	0.81	1.42	0.621
Physical activity								
Low					1.00			
Moderate					**0.70**	**0.52**	**0.94**	**0.017**
High					**0.59**	**0.41**	**0.85**	**0.005**
Diet index								
Low					1.00			
Moderate					1.00	0.76	1.31	0.992
High					1.16	0.86	1.56	0.321

[1]PR: prevalence ratio; [2] CI: Confidence interval; [3] aPR: adjusted prevalence ratio; [4:] p-for-trend
Significant PRs, 95%CIs and p values in bold font

Table A.2: Bivariate and multivariate analysis between family net income and obesity, in women

	Model 0				Model 1				Model 2			
	PR[1]	95%CI[2]		p	aPR[3]	95%CI[2]		p	aPR[3]	95%CI[2]		P
Family net income												
≤1,000	1.00				1.00				1.00			
1,001-2,000	0.78	0.59	1.03		0.87	0.65	1.16		0.89	0.66	1.20	
2,001-3,000	**0.63**	**0.45**	**0.89**	**0.001[4]**	0.77	0.54	1.09	**0.020[4]**	0.88	0.61	1.26	0.187[4]
3,001-4,000	0.62	0.37	1.02		0.80	0.47	1.36		0.95	0.55	1.63	
>4,000	**0.42**	**0.22**	**0.82**		**0.45**	**0.22**	**0.92**		0.55	0.27	1.13	
Age												
25-34					1.00				1.00			
35-44					**1.59**	**0.99**	**2.56**	**0.054**	1.52	0.95	2.46	0.083
45-54					**2.58**	**1.68**	**3.95**	**<0.001**	**2.60**	**1.70**	**4.00**	**<0.001**
55-64					**2.88**	**1.87**	**4.43**	**<0.001**	**2.80**	**1.81**	**4.31**	**<0.001**
District												
Nicosia					1.00				1.00			
Limassol					1.05	0.81	1.35	0.717	1.04	0.80	1.35	0.775
Larnaka					0.90	0.64	1.28	0.568	0.92	0.64	1.34	0.665
Paphos					0.66	0.41	1.06	0.084	0.71	0.44	1.15	0.165
Famagusta					0.47	0.21	1.09	0.079	0.51	0.20	1.31	0.164
Refugee												
No					1.00				1.00			
Yes					1.11	0.87	1.42	0.396	1.17	0.91	1.51	0.215
Area												
Urban					1.00				1.00			
Rural					**1.30**	**1.02**	**1.66**	**0.033**	1.16	0.89	1.51	0.261
Marital status												
Single					1.00				1.00			
Married-engaged					1.04	0.64	1.70	0.864	0.92	0.57	1.49	0.728
Divorced					1.10	0.62	1.95	0.749	0.98	0.55	1.74	0.941
Widowed					1.11	0.55	2.21	0.776	0.92	0.45	1.85	0.805
Alcohol consumption												

No		1.00			
Yes		**0.60**	**0.45**	**0.80**	**0.001**
Smoking status					
Never		1.00			
Former		1.11	0.65	1.89	0.706
Current		0.99	0.72	1.36	0.943
Physical activity					
Low		1.00			
Moderate		0.90	0.69	1.17	0.431
High		**0.60**	**0.40**	**0.92**	**0.018**
Diet index					
Low		1.00			
Moderate		1.04	0.77	1.40	0.796
High		1.06	0.78	1.45	0.693

[1]PR: prevalence ratio; [2] CI: Confidence interval; [3] aPR: adjusted prevalence ratio, [4:] p-for-trend
Significant PRs, 95%CIs and p values in bold font

Table A.3: Bivariate and multivariate analysis between educational attainment and obesity, in men

	Model 0				Model 1				Model 2			
	PR[1]	95%CI[2]		p	aPR[3]	95%CI[2]		p	aPR[3]	95%CI[2]		p
Educational attainment												
Up to gymnasium	1.00				1.00				1.00			
Lyceum	0.89	0.71	1.13		0.95	0.74	1.22		0.90	0.70	1.16	
Undergraduate	0.72	0.54	0.96	**<0.001**[4]	0.78	0.56	1.07	**0.006**[4]	0.74	0.53	1.02	**0.005**[4]
Postgraduate	**0.42**	**0.23**	**0.75**		**0.45**	**0.25**	**0.82**		**0.46**	**0.25**	**0.84**	
Age												
25-34					1.00				1.00			
35-44					1.18	0.84	1.67	0.342	1.23	0.85	1.77	0.270
45-54					1.26	0.89	1.78	0.196	1.28	0.88	1.85	0.192
55-64					1.31	0.91	1.86	0.144	1.24	0.84	1.83	0.283
District												
Nicosia					1.00				1.00			
Limassol					0.78	0.60	1.02	0.065	0.84	0.63	1.11	0.221
Larnaka					0.85	0.62	1.16	0.307	0.94	0.68	1.29	0.693
Paphos					0.78	0.51	1.20	0.257	0.80	0.51	1.25	0.328
Famagusta					1.01	0.64	1.61	0.953	1.12	0.69	1.82	0.650
Refugee												
No					1.00				1.00			
Yes					0.83	0.67	1.03	0.097	0.84	0.68	1.05	0.127
Area												
Urban					1.00				1.00			
Rural					1.02	0.79	1.30	0.903	0.91	0.70	1.19	0.505
Marital status												
Single					1.00				1.00			
Married-engaged					1.23	0.84	1.81	0.285	1.18	0.79	1.76	0.426
Divorced					1.02	0.48	2.16	0.965	1.03	0.46	2.33	0.943
Widowed					1.73	0.79	3.82	0.174	1.61	0.75	3.43	0.220
Alcohol consumption												

No		1.00			
Low-risk		**0.70**	**0.56**	**0.88**	**0.002**
High-risk		**0.61**	**0.39**	**0.97**	**0.038**
Smoking status					
Never		1.00			
Former		**1.36**	**1.01**	**1.83**	**0.040**
Current		1.05	0.80	1.39	0.716
Physical activity					
Low		1.00			
Moderate		**0.70**	**0.53**	**0.93**	**0.014**
High		**0.59**	**0.41**	**0.85**	**0.005**
Diet index					
Low		1.00			
Moderate		1.02	0.79	1.33	0.872
High		1.17	0.87	1.57	0.292

[1]PR: prevalence ratio; [2]CI: Confidence interval; [3] aPR: adjusted prevalence ratio; [4]: p-for-trend
Significant PRs, 95%CIs and p values in bold font

Table A.4: Bivariate and multivariate analysis between educational attainment and obesity, in women

	Model 0				Model 1				Model 2			
	PR[1]	95%CI[2]		p	aPR[3]	95%CI[2]		p	aPR[3]	95%CI[2]		p
Educational attainment												
Up to gymnasium	1.00				1.00				1.00			
Lyceum	**0.54**	**0.42**	**0.70**	**<0.001[4]**	**0.67**	**0.50**	**0.88**	**0.001[4]**	**0.70**	**0.53**	**0.93**	0.002[4]
Undergraduate	**0.44**	**0.33**	**0.59**		**0.60**	**0.43**	**0.84**		**0.63**	**0.45**	**0.89**	
Postgraduate	**0.26**	**0.12**	**0.57**		**0.41**	**0.18**	**0.95**		**0.40**	**0.16**	**1.00**	
Age												
25-34					1.00				1.00			
35-44					1.31	0.83	2.07	0.244	1.27	0.80	2.00	0.315
45-54					**2.04**	**1.33**	**3.11**	**0.001**	**2.05**	**1.34**	**3.13**	**0.001**
55-64					**2.05**	**1.32**	**3.18**	**0.001**	**1.99**	**1.28**	**3.09**	**0.002**
District												
Nicosia					1.00				1.00			
Limassol					0.97	0.75	1.24	0.779	0.97	0.75	1.26	0.824
Larnaka					0.92	0.66	1.29	0.627	0.93	0.66	1.33	0.704
Paphos					0.65	0.40	1.05	0.079	0.71	0.44	1.15	0.168
Famagusta					0.57	0.27	1.21	0.140	0.62	0.27	1.40	0.247
Refugee												
No					1.00				1.00			
Yes					1.15	0.91	1.46	0.252	1.21	0.94	1.54	0.134
Area												
Urban					1.00				1.00			
Rural					1.26	0.99	1.60	0.065	1.11	0.86	1.44	0.430
Marital status												
Single					1.00				1.00			
Married-engaged					0.89	0.56	1.44	0.647	0.84	0.53	1.33	0.456
Divorced					1.00	0.56	1.77	0.994	0.92	0.52	1.61	0.760
Widowed					1.04	0.52	2.06	0.915	0.90	0.45	1.78	0.751
Alcohol consumption												
No									1.00			

Yes		**0.61**	**0.46**	**0.81**	**0.001**
Smoking status					
Never		1.00			
Former		1.07	0.63	1.83	0.806
Current		1.01	0.74	1.38	0.959
Physical activity					
Low		1.00			
Moderate		0.86	0.66	1.11	0.250
High		**0.58**	**0.38**	**0.87**	**0.009**
Diet index					
Low		1.00			
Moderate		1.03	0.78	1.38	0.818
High		1.07	0.80	1.44	0.658

[1]PR: prevalence ratio; [2] CI: Confidence interval; [3] aPR: adjusted prevalence ratio; [4:] p-for-trend
Significant PRs, 95%CIs and p values in bold font

Table A.5: Bivariate and multivariate analysis between occupational social class and obesity, in men

	Model 0				Model 1				Model 2			
	PR[1]	95%CI[2]		p	aPR[3]	95%CI[2]		p	aPR[3]	95%CI[2]		p
Occupational social class												
Unskilled	1.00				1.00				1.00			
Skilled semi manual	1.21	0.81	1.79		1.24	0.83	1.85		1.18	0.78	1.78	
Skilled non-manual	0.83	0.54	1.27	0.176[4]	0.83	0.53	1.30	0.177[4]	0.72	0.45	1.15	0.088[4]
Intermediate	0.95	0.54	1.69		0.94	0.52	1.70		0.84	0.46	1.56	
Lower managerial	0.97	0.45	2.06		1.00	0.47	2.17		1.00	0.45	2.20	
Higher managerial	0.94	0.46	1.94		0.90	0.43	1.89		0.74	0.34	1.64	
Age												
25-34					1.00				1.00			
35-44					1.25	0.87	1.78	0.227	1.31	0.90	1.92	0.157
45-54					1.30	0.91	1.85	0.151	1.36	0.93	1.98	0.116
55-64					1.28	0.87	1.87	0.212	1.30	0.86	1.96	0.217
District												
Nicosia					1.00				1.00			
Limassol					0.85	0.64	1.13	0.251	0.92	0.67	1.27	0.608
Larnaka					0.92	0.65	1.31	0.656	0.99	0.69	1.40	0.935
Paphos					0.72	0.44	1.19	0.198	0.69	0.40	1.19	0.181
Famagusta					1.04	0.64	1.70	0.861	1.13	0.68	1.87	0.650
Refugee												
No					1.00				1.00			
Yes					0.84	0.67	1.06	0.147	0.83	0.65	1.05	0.116
Area												
Urban					1.00				1.00			
Rural					1.07	0.81	1.41	0.643	0.93	0.69	1.25	0.639
Marital status												
Single					1.00				1.00			
Married-engaged					1.35	0.89	2.05	0.161	1.31	0.83	2.04	0.244
Divorced					1.20	0.55	2.64	0.644	1.23	0.52	2.90	0.641

Widowed	2.19	0.93	5.16	0.073	**2.41**	**1.09**	**5.36**	**0.031**
Alcohol consumption								
No					1.00			
Low-risk					**0.66**	**0.51**	**0.85**	**0.001**
High-risk					**0.55**	**0.33**	**0.92**	**0.022**
Smoking status								
Never					1.00			
Former					1.27	0.91	1.77	0.160
Current					1.01	0.75	1.35	0.970
Physical activity								
Low					1.00			
Moderate					**0.64**	**0.47**	**0.87**	**0.005**
High					**0.64**	**0.44**	**0.95**	**0.026**
Diet index								
Low					1.00			
Moderate					1.12	0.85	1.49	0.414
High					1.14	0.82	1.59	0.445

[1]PR: prevalence ratio; [2] CI: Confidence interval; [3] aPR: adjusted prevalence ratio; [4:] p-for-trend
Significant PRs, 95%CIs and p values in bold font

Table A.6: Bivariate and multivariate analysis between occupational social class and obesity, in women

	Model 0				Model 1				Model 2			
	PR[1]	95%CI[2]		p	aPR[3]	95%CI[2]		p	aPR[3]	95%CI[2]		p
Occupational social class												
Unskilled	1.00				1.00				1.00			
Skilled semi manual	0.81	0.48	1.38		0.95	0.56	1.63		0.98	0.57	1.69	
Skilled non-manual	**0.65**	**0.43**	**0.98**		0.77	0.51	1.18	0.127[4]	0.81	0.52	1.27	0.185[4]
Intermediate	0.33	0.11	1.04	**0.025**[4]	0.40	0.13	1.24		0.32	0.08	1.21	
Lower managerial	0.65	0.21	1.98		0.77	0.25	2.39		0.80	0.26	2.47	
Higher managerial	0.53	0.14	2.08		0.65	0.17	2.51		0.76	0.20	2.88	
Age												
25-34					1.00				1.00			
35-44					1.63	0.93	2.86	0.087	1.58	0.90	2.77	0.110
45-54					**2.29**	**1.34**	**3.90**	**0.002**	**2.33**	**1.36**	**4.00**	**0.002**
55-64					**1.93**	**1.01**	**3.70**	**0.047**	**2.07**	**1.09**	**3.92**	**0.027**
District												
Nicosia					1.00				1.00			
Limassol					0.95	0.65	1.41	0.813	0.98	0.66	1.47	0.934
Larnaka					0.87	0.50	1.50	0.614	0.79	0.44	1.42	0.423
Paphos					0.97	0.54	1.75	0.928	0.98	0.55	1.76	0.948
Famagusta					0.33	0.08	1.28	0.108	0.46	0.12	1.81	0.267
Refugee												
No					1.00				1.00			
Yes					0.88	0.62	1.27	0.499	0.93	0.64	1.33	0.677
Area												
Urban					1.00				1.00			
Rural					1.39	0.96	2.01	0.078	1.23	0.83	1.82	0.312
Marital status												
Single					1.00				1.00			
Married-engaged					0.83	0.47	1.48	0.524	0.77	0.43	1.36	0.363

Divorced	0.52	0.21	1.29	0.160	0.42	0.17	1.08	0.073
Widowed	0.77	0.23	2.55	0.666	0.73	0.23	2.34	0.594
Alcohol consumption								
No					1.00			
Yes					**0.64**	**0.43**	**0.95**	**0.026**
Smoking status								
Never					1.00			
Former					0.72	0.30	1.70	0.449
Current					1.16	0.76	1.77	0.496
Physical activity								
Low					1.00			
Moderate					0.85	0.56	1.28	0.431
High					0.68	0.39	1.18	0.170
Diet index								
Low					1.00			
Moderate					0.80	0.53	1.19	0.269
High					0.93	0.62	1.42	0.747

[1]PR: prevalence ratio; [2] CI: Confidence interval; [3] aPR: adjusted prevalence ratio; [4:] p-for-trend
Significant PRs, 95%CIs and p values in bold font

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