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Urban living and obesity: is it independent of its population and lifestyle characteristics?

Carukshi Arambepola[1,2], Steven Allender[2], Ruvan Ekanayake[3] and Dulitha Fernando[1]

1 *Department of Community Medicine, Faculty of Medicine, University of Colombo, Colombo, Sri Lanka*
2 *Department of Public Health and Primary Health Care, University of Oxford, Oxford, UK*
3 *Coronary Care Unit, National Hospital of Sri Lanka, Colombo, Sri Lanka*

Summary

OBJECTIVES Living in an urban area influences obesity. However, little is known about whether this relationship is truly independent of, or merely mediated through, the demographic, socio-economic and lifestyle characteristics of urban populations. We aimed to identify and quantify the magnitude of this relationship in a Sri Lankan population.

METHODS Cross-sectional study of adults aged 20–64 years representing the urban (n = 770) and rural (n = 630) populations, in the district of Colombo in 2004. Obesity was measured as a continuous variable using body mass index (BMI). Demographic, socio-economic and lifestyle factors were assessed. Gender-specific multivariable regression models were developed to quantify the independent effect of urban/ rural living and other variables on increased BMI.

RESULTS The BMI (mean; 95% confidence interval) differed significantly between urban (men: 23.3; 22.8–23.8; women: 24.2; 23.7–24.7) and rural (men: 22.3; 21.9–22.7; women: 23.2; 22.7–23.7) sectors ($P < 0.01$). The observed association remained stable independently of all other variables in the regression models among both men (coefficient = 0.64) and women (coefficient = 0.95). These coefficients equated to 2.2 kg weight for the average man and 1.7 kg for the average woman. Other independent associations of BMI were with income (coefficient = 1.74), marital status (1.48), meal size (1.53) and religion (1.20) among men, and with age (0.87), marital status (2.25) and physical activity (0.96) among women.

CONCLUSIONS Urban living is associated with obesity independently of most other demographic, socio-economic and lifestyle characteristics of the population. Targeting urban populations may be useful for consideration when developing strategies to reduce the prevalence of obesity.

keywords urban, rural, obesity, body mass index, determinants, population-based study

Introduction

Over the past few decades in developing countries, there has been a major shift in the causes of death and disability from childhood infections to adult degenerative and non-infectious diseases (Yusuf *et al.* 2001). This 'epidemiologic' transition is characterized by a higher incidence of coronary heart diseases (CHD), particularly among South Asians (Beckles *et al.* 1986; McKeigue *et al.* 1989). There are various mechanisms that favour epidemics of CHD. Of them, alterations in lifestyle owing to urbanization play a critical role in promoting the acquisition of risk factors of CHD in previously traditional societies in Asia (Yao *et al.* 1993; Reddy 2001; Yusuf *et al.* 2001).

Obesity is an independent risk factor for CHD as well as a predisposing factor for hypertension, diabetes and dyslipidaemia (Berenson *et al.* 1998). There are a number of potential determinants of obesity (Misra & Vikram 2004; Subramanium & Davey Smith 2006) such as ethnicity, education, income, dietary patterns and physical activity. In addition, urban living has been consistently identified as a significant determinant of higher body mass index (BMI), particularly in developing countries (Singh *et al.* 1995; Yusuf *et al.* 2001; Reddy *et al.* 2002; Xu *et al.* 2005). Urban areas differ from rural areas not only in their physical-environmental properties but also in their typical population characteristics. For example, urban populations have higher household incomes, higher levels of education and more engagement in sedentary occupations and lifestyles (Singh *et al.* 1997; Misra *et al.* 2001). However, little is known about whether the association between urban living and obesity is truly independent of, or merely mediated through, these characteristics of urban populations.

Sri Lanka experienced a major transition in its economic, environmental and social structure during the last decade (Abeykoon 1998). Consequently, Sri Lankan populations have been predisposed to rapid and unplanned urbanisation (Ministry of Health 2002). Despite recent studies showing an increase in obesity (Fernando *et al.* 1994; Wijewardene *et al.* 2005), the determinants of obesity in Sri Lanka are poorly understood, particularly the influence of a shift from rural to urban environments. This quantification is an important step in defining and understanding the high-risk factors, which should be targeted for future modifications.

In this paper, we aim to identify the differences in BMI between urban and rural populations in the district of Colombo and to quantify the magnitude of this relationship independently of other population and lifestyle factors.

Methods

Study setting

The study was carried out in the district of Colombo, which is the commercial capital of Sri Lanka. Based on administrative and socio-economic factors, it is broadly divided into three sectors: 'urban' (areas governed by either Municipal or Urban Councils), 'estate' (plantation areas) and 'rural' (all other residential areas) (Central Bank of Sri Lanka 1999).

Poverty is more common in the rural sector (26%) than in the urban sector (15%). Land in the rural sector is dedicated to farming and dominated by paddy cultivation. It has a limited infrastructure for lifestyle comforts, such as availability of and access to supermarkets, convenience foods, motorized transport, in-house sanitation and the Internet. In contrast, urban settings are overcrowded and less likely to have enough space for home-grown food and recreation (Department of Census and Statistics 2001).

Study population

We undertook a community-based cross-sectional study of adults aged 20–64 years. Participants were those currently residing in urban or rural sectors in the district of Colombo (estate sector was excluded as it represented only 0.3% of the total population of Colombo) at least for a continued period of 1 year to ensure a stable lifestyle related to their residence in the area. Those with pathological or iatrogenic obesity (e.g. hypothyroidism, Cushing syndrome), ascites or pregnancy up to a postpartum period of 3 months were excluded by perusing diagnosis cards and medical records of participants.

Sampling method

We used multi-stage, stratified, probability sampling to identify 1400 subjects who were representative of the adult population of Colombo by age, sex and sector (Arambepola *et al.* 2007). The final stage of sampling included 40 Grama-Niladari (GN) divisions (smallest administrative units of approximately 4000 population) stratified by urban and rural sectors. In each GN division, 35 subjects were randomly identified by specific age proportions [20–34 (43%); 35–49 (34%); 50–64 (23%) years] of each sex (males 52%). The database of the 2001 census and updated electoral registers of Colombo served as sampling frames.

Data collection methods

Ethical clearance was obtained from the Ethical Review Board of the Faculty of Medicine, Colombo. We visited the participants at their homes and obtained two recordings of each standing height and body weight of participants by means of a calibrated microtoise steel tape and an electronic digital weighing scale. Height was measured to the nearest 0.5 cm and weight with an accuracy of ±100 g (WHO 1989). We used pre-tested questionnaires to obtain demographic and socio-economic data (age, sex, sector, ethnicity, religion, current marital status, level of education, monthly household income, employment status) and lifestyle descriptions (level of physical activity, consumption patterns of dietary-fibre, energy-dense food and alcohol, eating frequency, intake of large meals, eating out).

Definitions and data quality

Body mass index (BMI) was used as a continuous variable: weight in kg/height in m^2). Lifestyle variables were chosen on the basis of current literature on aetiological factors for weight gain (WHO 2003). Questions on dietary practices were based on the daily consumption pattern of meals during a 'routine' week of each participant. 'Increased eating frequency' was defined as having more than five meals a day on more than 3 days a week. 'Frequent intake of large meals' was defined as having at least one large meal a day on more than 5 days a week. A meal was defined as 'large', if its quantity exceeded that of an average meal of three complex carbohydrate exchangers (Ekanayake 2001).

We used a validated food-frequency-questionnaire (FFQ) (Arambepola 2004) to assess the inadequate consumption of dietary fibre (fruits, vegetables, pulses and legumes, whole-grain products) and over-consumption of energy-dense food (commercially baked products, deep fried food, sugar-sweetened beverages, red and processed meat, milk and dairy products, whole eggs and derived products). We used the International Physical Activity Questionnaire (IPAQ) that was culturally adapted and validated by triangulation (IPAQ 2002). Participants were classified as 'insufficiently active' and 'sufficiently active', based on scores of their overall level of activity, which required summation of the duration (in minutes) and frequency (days) of vigorous and moderate intensity physical activities and walking by each participant in relation to occupation, transportation, housework, recreation, sports and leisure time activities during the previous week.

Statistical analyses

Based on previous work that identified gender-specific determinants of obesity in the same population, the analyses were conducted separately for men and women (Arambepola *et al.* 2007). anova tests were used to compare the mean BMI levels and 95% confidence intervals (CI) between urban and rural sectors, and in a univariate analysis to compare the mean BMI levels of the strata of each of the population and lifestyle factors between these two factors.

Tests for potential confounding and effect modification were conducted as specified by Hills and Stavola (2002). Initially, regression models were developed with BMI as the dependent variable and sector plus one of the population and lifestyle factors included as the independent variables. Full models were then constructed for the relationship of BMI with urban/rural living with adjustments for potential confounding effects using a forward stepwise regression method (Altman 1991).

Results

The response rate within the study population was 96.3%. As shown in Table 1, there was no significant difference between urban and rural men or women with regard to age, ethnicity and completion of formal education.

Table 1 Characteristics of the study population

	Males			Females		
Characteristic	Urban	Rural	Total	Urban	Rural	Total
Age						
Mean (SD)	39.4 (11.9)	37.5 (12.0)	38.5 (11.9)	39.9 (11.8)	38.6 (12.6)	39.3 (12.2)
Ethnicity (%)						
Sinhalese	333 (84.1)	306 (94.4)	639 (88.8)	308 (82.4)	292 (95.4)	600 (88.2)
Non-Sinhalese	63 (15.9)	18 (5.6)	81 (11.3)	66 (17.6)	14 (4.6)	80 (11.8)
Education (%)						
Grade 0–5	28 (7.1)	15 (4.6)	43 (6.0)	32 (8.6)	26 (8.5)	58 (8.5)
Grade 6–OL	254 (64.1)	187 (57.7)	441 (61.3)	239 (63.9)	182 (59.5)	421 (61.9)
AL and above	114 (28.8)	122 (37.7)	236 (32.8)	103 (27.5)	98 (32.0)	201 (29.6)
Employment (%)						
Unemployed	91 (23.0)	103 (31.8)	194 (26.9)	286 (76.5)	234 (76.5)	520 (76.5)
Sedentary	95 (24.0)	67 (20.7)	162 (22.5)	43 (11.5)	29 (9.5)	72 (10.6)
Active	160 (40.4)	117 (36.1)	277 (38.5)	35 (9.4)	29 (9.5)	64 (9.4)
Highly active	50 (12.6)	37 (11.4)	87 (12.1)	10 (2.7)	14 (4.6)	24 (3.5)
Income (%)						
Rs. <2000	133 (33.6)	96 (29.6)	229 (31.8)	155 (41.4)	134 (43.8)	289 (42.5)
Rs. 2000–10 000	230 (58.1)	214 (66.0)	444 (61.7)	198 (52.9)	161 (52.6)	359 (52.8)
Rs. >10 000	33 (8.3)	14 (4.3)	47 (6.5)	21 (5.6)	11 (3.6)	32 (4.7)
Longstanding illness (%)						
No	293 (74.0)	265 (81.8)	558 (77.5)	279 (74.6)	246 (80.4)	525 (77.2)
Yes	103 (26.0)	59 (18.2)	162 (22.5)	95 (25.4)	60 (19.6)	155 (22.8)
BMI						
Mean (SD)	23.3 (4.7)	22.3 (3.8)	22.8 (4.3)	24.2 (4.8)	23.2 (4.1)	23.7 (4.6)
Lower CI	22.84	21.89	22.49	23.71	22.74	23.35
Upper CI	23.76	22.71	23.11	24.69	23.66	24.05
Total (*n*)	396	324	720	374	306	680

SD, standard deviation; OL, ordinary level; AL, advanced level; BMI, body mass index; CI, confidence interval.

However, the proportion with monthly household incomes greater than Rs. 10 000 was higher among both men and women in the urban sector. Unemployment was higher in rural (32%) than in urban (23%) men, in contrast to equal proportions (76%) among women (majority were housewives). Among the employed, there were more rural than urban women in relatively active occupations. There was no such difference among men.

There was a significant difference in mean BMI (mean; 95% CI) between urban (23.3; 22.8, 23.8) and rural (22.3; 21.9, 22.7) men ($P < 0.01$) (Table 1). In terms of clinical significance, this difference in BMI of 1 kg/m^2 was equivalent to a change in weight of 2.7 kg for a man of average height (165 cm) in this sample. There was a significant difference in mean BMI between urban (24.2; 23.7, 24.7) and rural (23.2; 22.7, 23.7) women ($P < 0.01$). This difference in BMI was equivalent to a change in weight of 2.3 kg for a woman of average height (153 cm) in this sample.

Significant univariate associations of mean BMI among men were observed with age, ethnicity, religion, marital status, income, education, status/type of employment, eating out, meal size, physical activity and alcohol intake (Table 2). From the lowest to highest income group, the mean BMI increased from 22.2 to 26.6 kg/m^2 among urban men and from 21.2 to 24.7 kg/m^2 among rural men. This equates a difference of more than 10 kg between the two income-groups in each sector. Among both urban and rural men, mean BMI was lowest among highly active occupations but showed varied patterns with other types of occupations. Although frequent eating out was associated with a higher mean BMI (24.1) among urban men, this was not the case among rural men.

Similar to men, significant differences in mean BMI were with: age, marital status and physical activity (Table 2). Having lived abroad was a unique factor associated with BMI among both urban and rural women. Though less marked in rural sector, higher BMI of women was significantly associated with insufficient level of physical activity.

Regression analysis of mediators for urban/rural sectors and BMI among men

The following variables were considered for regression analysis among men: age, religion, marital status, income, frequency of eating out, frequency of large meal intake, physical activity and alcohol intake. Religion and ethnicity, and income, education and status/type of employment were found to be co-linear and so only religion and income were considered.

In the initial model of BMI with only urban/rural sector, living in an urban area equated to an increase in BMI of 1.0 kg/m^2 (i.e. 2.7 kg) (Table 3). This coefficient was reduced to 0.6 kg/m^2 (i.e. 1.7 kg) but remained significant in predicting BMI after the models were adjusted for confounding effects. The strongest predictors once added to the model for BMI and urban/rural sector were income (coefficient 1.70; adjusted r^2 0.059), marital status (1.49; 0.035), consumption of large meals (1.46; 0.024) and religion (1.06; 0.018). Effects of age, eating out, physical activity and alcohol became less significant when other variables were considered in the model. Therefore, the final model for men was

$$\begin{aligned}\mathrm{BMI} = {} & 18.22 + 0.64(\mathrm{sector}) + 1.74(\mathrm{income}) \\ & + 1.48(\mathrm{marital}) + 1.53(\mathrm{meal\ size}) + 1.20(\mathrm{religion})\end{aligned}$$

In real terms, those who were at the lowest end for each of the elements of the model would have a BMI of 18.22 kg/m^2 while those who lived in an urban area, were in the highest income group, were married, ate large meals and were not Buddhists, had a predicted BMI of 26.56 kg/m^2. This difference in mean BMI of 8.34 equates an extra 23 kg weight for a man of average height.

Regression analysis of mediators for urban/rural sectors and BMI among women

For regression, analysis among women, we considered age, marital status, physical activity and having lived abroad. In the initial model of BMI with only urban/rural sector, living in an urban area equated an increase in BMI of 1.05 kg/m^2 (i.e. 2.4 kg) (Table 4). This coefficient remained stable at 0.95 kg/m^2 (i.e. 2.2 kg) and significant in predicting BMI after the models were adjusted. The strongest predictors once added to the model for BMI and urban/rural sector were age (coefficient 1.09; adjusted r^2 0.042), marital status (2.36; 0.058), and physical activity (0.76; 0.014). Effects of having lived abroad became insignificant when other variables were considered in the model. Therefore, the final model for women was

$$\begin{aligned}\mathrm{BMI} = {} & 23.29 + 0.95(\mathrm{sector}) \\ & + 2.25(\mathrm{marital}) + 0.87(\mathrm{age}) + 0.96(\mathrm{physical\ activity})\end{aligned}$$

In real terms, those who were at the lowest end for each of the elements of the model would have a BMI of 23.29 kg/m^2 while those who were married, in the oldest age group and physically inactive had a predicted BMI of 28.24 kg/m^2. This difference in mean BMI of 4.95 equates an extra 11 kg weight for a woman of average height.

Table 2 Association of BMI with population and lifestyle characteristics in males and females in urban and rural areas

	Urban men			Rural men			Urban women			Rural women		
Characteristic	*n*	%	Mean BMI (SD)	*n*	%	Mean BMI (SD)	*n*	%	Mean BMI (SD)	*n*	%	Mean BMI (SD)
Age group (years)						**						**
20–34	176	44	22.3 (4.3)	144	44	22.1 (3.9)	154	41	23.3 (4.9)	126	41	21.6 (4.3)
35–49	132	33	23.9 (4.8)	108	33	22.1 (3.2)	132	35	24.9 (4.6)	108	35	24.4 (4.3)
50–64	88	22	24.2 (5.0)	72	22	22.8 (4.2)	88	24	24.8 (4.9)	72	24	24.1 (4.1)
Ethnicity					0	**						
Sinhalese	333	84	23.0 (14.3)	306	94	22.3 (3.8)	308	82	24.2 (4.8)	292	95	23.2 (4.4)
Non-Sinhalese	63	16	24.6 (6.2)	18	6	21.9 (2.8)	66	18	24.4 (5.1)	14	5	23.1 (6.0)
Religion						**						
Buddhists	308	78	23.0 (4.3)	298	92	22.2 (3.8)	283	76	24.0 (4.8)	283	92	23.1 (4.4)
Non-Buddhists	88	22	24.3 (5.7)	26	8	22.5 (3.4)	91	24	24.7 (5.0)	23	8	23.4 (5.7)
Married			**	**								
No	294	74	23.7 (4.7)	212	65	22.6 (3.8)	275	74	24.8 (4.7)	225	74	23.8 (4.5)
Yes	102	26	21.9 (4.3)	112	35	21.5 (3.7)	99	26	22.5 (4.9)	81	26	21.4 (4.0)
Education						*						
Grade	0–5	28	7	23.4 (5.1)	15 5	20.6 (3.2)	32	9	23.6 (5.5)	26	8	23.7 (4.7)
Grade 6–O/L	254	64	22.9 (4.6)	187	58	22.0 (3.9)	239	64	24.2 (4.9)	182	59	23.4 (4.6)
A/L and above	114	29	24.1 (4.6)	122	38	22.8 (3.6)	182	49	24.4 (4.6)	98	32	22.7 (4.2)
Income						**						
Rs. <5001	133	34	22.2 (5.1)	96	30	21.2 (3.8)	155	41	24.2 (5.5)	134	44	22.7 (4.5)
Rs. 5001–10 000	230	58	23.4 (4.2)	214	66	22.6 (3.7)	198	53	24.1 (4.4)	161	53	23.5 (4.5)
Rs. >10 000	33	8	26.6 (4.5)	14	4	24.7 (2.7)	21	6	25.2 (3.8)	11	4	23.7 (2.5)
Employment						**						
Highly active	50	13	21.3 (3.9)	37	11	21.4 (3.4)	10	3	25.6 (4.2)	14	5	23.9 (4.0)
Moderately active	160	40	23.0 (4.3)	117	36	22.5 (3.7)	35	9	23.3 (5.3)	29	9	22.6 (4.8)
Sedentary	95	24	24.7 (4.1)	67	21	22.3 (3.3)	43	11	24.8 (5.1)	29	9	23.0 (5.6)
Not employed	91	23	23.2 (5.9)	103	32	22.2 (4.2)	286	76	24.2 (4.8)	234	76	23.2 (4.3)
Lived abroad												*
No	378	95	23.2 (4.7)	317	98	22.2 (3.8)	358	96	24.2 (4.9)	292	95	23.0 (4.5)
Yes	18	5	22.4 (4.3)	7	2	23.8 (4.2)	16	4	25.2 (4.7)	14	5	25.6 (4.1)

Table 2 *(Continued)*

	Urban men			Rural men			Urban women			Rural women		
Characteristic	*n*	%	Mean BMI (SD)	*n*	%	Mean BMI (SD)	*n*	%	Mean BMI (SD)	*n*	%	Mean BMI (SD)
HH members living abroad												
No	346	87	23.3 (4.7)	288	89	22.2 (3.7)	313	84	24.1 (4.8)	268	88	23.1 (4.5)
Yes	50	13	23.2 (5.0)	36	11	22.9 (4.3)	61	16	24.5 (5.0)	38	12	23.9 (4.5)
Eating out						**						
Not frequent	203	51	22.5 (4.2)	223	69	22.4 (4.0)	260 70	24.0	(4.8)	260	85	23.2 (4.4)
Frequent	193	49	24.1 (5.1)	101	31	22.0 (3.3)	114	30	24.7 (5.0)	46	15	23.1 (5.0)
Eating frequency of >5 meals/day												
0–3 days a week	310	78	23.3 (4.8)	244	75	22.1 (3.6)	301	80	24.2 (4.9)	249	81	23.3 (4.5)
>3 days a week	86	22	23.3 (4.5)	80	25	22.7 (4.3)	73	20	24.1 (4.8)	57	19	22.6 (4.2)
Large meal intake			**									
0–5 days a week	334	84	23.0 (4.6)	285	88	22.2 (3.7)	347	93	24.2 (4.8)	288	94	23.1 (4.5)
>5 days a week	62	16	24.9 (5.0)	39	12	22.9 (4.5)	27	7	23.7 (5.6)	18	6	23.5 (4.7)
No	294	74	23.2 (4.6)	262	81	22.3 (3.9)	294	79	24.0 (4.8)	258	84	23.3 (4.4)
Yes	102	26	23.4 (4.9)	62	19	22.1 (3.3)	80	21	24.8 (4.9)	48	16	22.5 (5.0)
Over-consumption of energy-dense food												
No	294	74	23.2 (4.6)	262	81	22.3 (3.9)	294	79	24.0 (4.8)	258	84	23.3 (4.4)
Yes	102	26	23.4 (4.9)	62	19	22.1 (3.3)	80	21	24.8 (4.9)	48	16	22.5 (5.0)
Inadequate fibre consumption												
No	209	53	23.4 (4.8)	217	67	22.0 (3.7)	214	57	24.4 (4.6)	198	65	23.4 (4.4)
Yes	187	47	23.1 (4.6)	107	33	22.8 (3.9)	160	43	24.0 (5.2)	108	35	22.7 (4.5)
Physical activity	*	*										
Sufficiently active	234	59	22.9 (4.5)	209	65	22.0 (3.7)	265	71	24.1 (4.8)	247	81	22.9 (4.2)
Insufficiently active	162	41	23.7 (4.9)	115	35	22.8 (3.9)	109	29	24.5 (5.1)	59	19	24.3 (5.3)
Alcohol intake		**										
0–7 units/week	188	47	22.4 (4.9)	177	55	22.1 (3.8)	366	98	24.3 (4.9)	303	99	23.2 (4.5)
8–14 units/week	140	35	23.9 (4.1)	102	31	22.7 (3.6)	7	2	21.9 (3.1)	3	1	21.9 (2.9)
>14 units/week	68	17	24.3 (4.8)	45	14	22.2 (4.2)	1	0	-	0	0	-
Total	396	100	23.3 (4.7)	324	100	22.3 (3.8)	374	100	24.2 (4.8)	306	100	23.2 (4.1)

*$P < 0.05$; **$P < 0.01$ (denotes the difference in mean BMI within population and lifestyle characteristics between urban and rural counterparts).

Table 3 Regression models for urban/rural living and BMI among males

Independent variables	Adjusted R^2*	Prob >F*	Coefficient	95% CI Lower	95% CI Upper	P-value
Models for sector and one other factor variable						
Sector	0.012	0.002	1.000363	0.366	1.634	0.002
Constant			22.270	21.799	22.741	0.000
Sector	0.027	0.000	1.000363	0.371	1.629	0.002
Age			0.711	0.313	1.109	0.000
Constant			21.006	20.158	21.854	0.000
Sector	0.018	0.0005	0.850	0.206	1.495	0.010
Religion			1.057	0.179	1.935	0.018
Constant			21.128	20.069	22.186	0.000
Sector	0.035	0.0000	0.869	0.239	1.499	0.007
Marital			1.487	0.801	2.172	0.000
Constant			21.297	20.651	21.943	0.000
Sector	0.059	0.0000	0.999	0.381	1.618	0.002
Income			1.703	1.158	2.247	0.000
Constant			19.295	18.239	20.352	0.000
Sector	0.018	0.0006	0.868	0.225	1.510	0.008
Eating out			0.755	0.104	1.405	0.023
Constant			21.280	20.307	22.254	0.000
Sector	0.024	0.0001	0.947	0.316	1.579	0.003
Large meals			1.458	0.554	2.362	0.002
Constant			20.637	19.521	21.752	0.000
Sector	0.018	0.0005	0.958	0.325	1.591	0.003
Physical activity			0.781	0.134	1.429	0.018
Constant			21.211	20.217	22.206	0.000
Sector	0.023	0.0001	0.932	0.299	1.564	0.004
Alcohol			0.657	0.229	1.084	0.003
Constant			21.881	21.349	22.413	0.000
Final models for sector adjusted by other variables						
Sector	0.105	0.000	0.642	0.023	1.262	0.042
Income			1.738	1.206	2.269	0.000
Marital			1.485	2.145	0.824	0.000
Large meals			1.534	0.666	2.401	0.001
Religion			1.202	0.362	2.042	0.005
Constant			18.216	16.270	20.162	0.000
Sector	0.108	0.000	0.609	.009	1.229	0.054
Income			1.679	1.145	2.213	0.000
Marital			1.482	2.142	0.823	0.000
Large meals			1.561	0.694	2.427	0.000
Religion			1.203	0.365	2.042	0.005
Physical activity			0.589	0.032	1.212	0.063
Constant			17.484		19.574	0.000

*The goodness of fit of the models.

Discussion

Our study revealed that the mean BMI of Colombo's urban population was approximately 1 kg/m^2 higher than that of the rural population. This finding was stable and significant in both men and women independently of other population and lifestyle variables under study. In addition to urban living, 11% of the variance in BMI was

Table 4 Regression models for urban/rural living and BMI among females

Independent variables	Adjusted R^2*	Prob >F*	Coefficient	95% CI		P-value
Models for sector and one other factor variable						
Sector	0.042	0.000	1.047	0.348	1.747	0.003
Age			1.089	0.645	1.532	0.000
Constant			21.186	20.225	22.146	0.000
Sector	0.058	0.000	1.047	0.354	1.741	0.003
Marital			2.362	3.144	1.579	0.000
Constant			26.158	25.044	27.273	0.000
Sector	0.015	0.002	1.053	0.343	1.762	0.004
Lived abroad			1.757	3.475	0.039	0.045
Constant			26.605	23.206	30.004	0.000
Sector	0.014	0.003	0.973	0.258	1.687	0.008
Physical activity			0.757	0.067	1.580	0.072
Constant			22.269	21.154	23.384	0.000
Final models for sector adjusted by other variables						
Sector	0.085	0.000	0.953	0.265	1.641	0.007
Marital			2.251	3.038	0.463	0.000
Age			0.868	0.428	1.308	0.000
Physical activity			0.959	0.157	1.762	0.019
Constant			23.289	21.655	24.924	0.000
Sector	0.089	0.000	0.958	0.272	1.645	0.006
Marital			2.254	3.039	1.468	0.000
Age			0.855	0.416	1.294	0.000
Lived abroad			1.642	3.295	0.011	0.052
Physical activity			0.953	0.152	1.754	0.020
Constant			26.535	22.884	30.187	0.000

*The goodness of fit of the models.

explained by income, marital status, meal size and religion among men whilst 9% of the variance was explained by age, marital status and physical activity among women.

A population-based study in Palestine (Abdul-Rahim *et al.* 2003) found a difference of 0.9 in the mean BMI between urban (27.4 kg/m^2) and rural (26.5 kg/m^2) men and a difference of 1.6 (30.3 and 28.6 kg/m^2) in women. In North India, Singh *et al.* (1997) found differences in mean BMI of 1.3 for men (22.9 and 21.6 kg/m^2) and 0.7 for women (22.7 and 22.2 kg/m^2). It is difficult to compare these results with ours as these studies have not adjusted for the effects of confounding variables. We report adjusted differences of mean BMI between urban and rural sectors of 0.64 for men and 0.95 for women.

In Asia, the prevalence of obesity is higher among people with higher household incomes (Mohan *et al.* 2001; Islam *et al.* 2004; Subramanium & Davey Smith 2006). In our study, higher BMI among urban men was independent of this effect, which could have otherwise been mediated via urban populations having higher household incomes. Interestingly, household income did not play any role in obesity among women. Contrary to our findings, most other studies have indicated that Asian women with higher socio-economic status had higher BMI. However, such women in these studies also represented women living in urban areas (Islam *et al.* 2004; Subramanium & Davey Smith 2006).

Another well-known association of obesity is with unhealthy lifestyles (Misra & Vikram 2004), which is also a characteristic feature of urban living. In our study, physical inactivity had a significant association with high BMI among women irrespective of their urban or rural living. This was in contrast to men who seemed to lose this effect when considered with other population variables in the regression model. Similarly, eating out and intake of alcohol lost their relationships with BMI among men. As for consumption of energy-dense food and dietary fibre, none showed any relationship with BMI. We therefore hypothesize that lifestyle factors, particularly among men, are probably mediated largely through urbanization in the area of residence.

Interestingly, variables not characteristic of urban living were also significant determinants of obesity. Being married was one such determinant in both sexes, consistent with the findings of Hu *et al.* (2002) and Aekplakorn *et al.* (2004). The higher risk among women (coefficient 2.25) was probably related to additional risk owing to their parity, as also shown by Wen *et al.* (2003). Another significant determinant in our study was age, but only among women. This is an unexpected finding not consistent with other studies, which have shown this relationship irrespective of gender (Chung *et al.* 2005). Religion influences the types of food consumed and thereby affects BMI (Berkow & Barnard 2006). However, its significance only among men in our study was inexplicable. But these facts may not have significant epidemiological implications as these demographic variables, unlike associated lifestyles and habits, cannot be modified.

In summary, individuals living in urban areas were at higher risk of obesity irrespective of their demographic, socio-economic and lifestyle characteristics. While some of those features characteristic of urban populations were able to show independent associations with obesity, some lost their relationships with obesity in the regression models. We therefore hypothesize that the association of urban living with increased BMI is largely through gender-specific multiple factors that are not examined here, but which act by complementing each other in a physical-environment conducive of obesity. Though we have not studied what these environmental factors in urban area are, we further postulate that these factors might be related to the infrastructure of urban settings that favours availability and accessibility to sedentary practices.

The strength of this study lies in obtaining a well-represented sample of adults in Colombo with a high response rate (96.3%). A further strength was that lifestyle factors pertaining to BMI were assessed using culturally adopted and validated tools.

The study may be hampered in reaching meaningful conclusions because it was a cross-sectional design and so is of limited value in assessing temporal relationships. For example, high BMI observed among adults with unhealthy lifestyles could be either due to a true association or due to lifestyle changes after obesity or obesity-related-disease diagnoses. Secondly, since the original classification of urban/rural sectors in the district of Colombo, many areas have undergone urbanization. This fact has not been taken into account in this study and therefore may have led to an underestimation of the effect of urban living on obesity. Finally, it should be acknowledged that the significant elements in the models such as income, marital status and religion could have been only proxies of other stronger determinants of obesity. Furthermore, 'urban living' may represent a number of different physical-environmental properties of an urban area. Therefore, further work that examines these environmental level exposures in more detail is needed to isolate and understand these elements of obesity for which urban living presents as a proxy.

Conclusion

Mean BMI of the urban population in the district of Colombo was 1 kg/m^2 higher than that of their rural counterparts. This effect was stable and significant in both men and women and independent of most other population and lifestyle variables. Our findings draw attention to the implications for weight gain associated with urban environments. This is important in view of the rapid and unplanned urbanization in Sri Lanka and other developing countries. Targeting urban populations, among whom the prevalence of obesity is high irrespective of their other characteristics, would be a useful strategy against obesity.

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Corresponding Author Carukshi Arambepola, Department of Public Health and Primary Health Care, University of Oxford, Old Road Campus, Headington, Oxford OX3 7LF, UK. Tel.: +44 1865 227 142; Fax: 0094 112694500; E-mail: carukshi@yahoo.com