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Exposure over the life course to an urban environment and its relation with obesity, diabetes, and hypertension in rural and urban Cameroon

Eugène Sobngwi,[1,2,3] Jean-Claude Mbanya,[1] Nigel C Unwin,[2,4] Raphael Porcher,[5] André-Pascal Kengne,[1] Léopold Fezeu,[1] Etienne Magloire Minkoulou,[1] Caroline Tournoux,[5] Jean-Francois Gautier,[3] Terence J Aspray[2,4] and Kgmm Alberti[2]

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Background This study aimed to assess the association between lifetime exposure to urban environment (EU) and obesity, diabetes, and hypertension in an adult population of Sub-Saharan Africa.

Methods We studied 999 women and 727 men aged ⩾25 years. They represent all the adults aged ⩾25 years living in households randomly selected from a rural and an urban community of Cameroon with a 98% and 96% participation rate respectively. Height, weight, blood pressure, and fasting blood glucose were measured in all subjects. Current levels of physical activity (in metabolic equivalents [MET]) were evaluated through the Sub-Saharan African Activity Questionnaire. Chronological data on lifetime migration were collected retrospectively and expressed as the total (EUt) or percentage (EU%) of lifetime exposure to urban environment.

Results Lifetime EUt was associated with body mass index (BMI) (r = 0.42; $P < 0.0001$), fasting glycaemia (r = 0.23; $P < 0.0001$), and blood pressure (r = 0.17; $P < 0.0001$) but not with age. The subjects who recently settled in a city (⩽2 years) had higher BMI (+2.9 kg/m^2; $P < 0.001$), fasting glycaemia (+0.8 mmol/l; $P < 0.001$), systolic (+23 mmHg; $P < 0.001$) and diastolic (+9 mmHg; $P = 0.001$) blood pressure than rural dwellers with a history of 2 years EU. EU during the first 5 years of life was not, on its own, associated with glycaemia or BMI. However, both lifetime EUt and current residence were independently associated with obesity and diabetes. The association between lifetime EUt and hypertension was not independent of current residence and current level of physical activity.

Conclusions This study suggests that for the study of obesity and diabetes, in addition to current residence, both lifetime exposure to an urban environment and recent migration history should be investigated.

Keywords Diabetes, hypertension, obesity, urbanization, life course epidemiology, Africa

[1] Cameroon Essential Non-communicable diseases Health Intervention Project, University of Yaoundé 1, Cameroon.

[2] Department of Diabetes and Metabolism, School of Clinical Medical Sciences, University of Newcastle, UK.

[3] Department of Endocrinology and Diabetes and Clinical Investigation Centre, Saint-Louis University Hospital (AP-HP), Paris 10, France.

[4] Department of Epidemiology and Public Health, University of Newcastle, UK.

[5] Department of Biostatistics and Medical Informatics, Saint-Louis University Hospital (AP-HP), Paris 10, France.

Correspondence: Prof. Jean-Claude Mbanya, Endocrine and Diabetes Unit, Department of Internal Medicine, Faculty of Medicine and Biomedical Sciences, University of Yaoundé 1, PO Box 8046 Yaoundé, Cameroon. E-mail: jean-claude.mbanya@camnet.cm

Epidemiological studies dealing with risk of developing chronic diseases have focused extensively on time, especially age and duration of exposure to identified or putative risk factors.[1] Physical activity and colon cancer, osteoporosis, and cardiovascular disease,[2,3] smoking habits and respiratory cancer,[4] and more recently duration of exclusive breastfeeding and subsequent development of asthma in children[5] are examples of risk factors previously studied on a simple exposed/non-exposed basis, where longitudinal cohorts subsequently provided evidence of the importance of duration and chronology of exposure. Thus, the life course approach appears particularly relevant to the study of chronic disease epidemiology.[6,7]

To date, urbanization has mostly been evaluated cross-sectionally by comparison between urban and rural dwellers.[8,9] Very few studies have emphasized aspects such as recent migration and have studied the effect of urbanization over a short period of time.[10,11] Thus, it is not known whether or not lifetime exposure to the urban environment is associated with a specific risk. To evaluate lifetime exposure to the urban environment and migration, and study their association, we developed a data collection procedure that allows retrospective study of chronology and duration of exposure and migration and analysed it within a mixed urban and rural population of Cameroon in relation to anthropometric characteristics, blood pressure, and blood glucose.

Methods

Study population

The study population was made up of subjects living in Biyem-Assi, a quarter of Yaoundé, the capital city of Cameroon and Bafut, a rural setting of the highlands of Western Cameroon, from the Cameroon Essential Non-communicable Diseases Health Intervention Project (ENHIP)—a cross-sectional population-based survey to determine the prevalence of hypertension, diabetes, asthma, and epilepsy.[12] The population of the Biyem-Assi health area is made up mainly of civil servants, businessmen, and students and is estimated, according to the 1996 National Census, to have 15 000 inhabitants. In Bafut, we conducted the study in the Manji and Nsem health areas that are estimated to have a population of 17 000 inhabitants whose main activity is subsistence farming. A preliminary census of households in these health areas was conducted before the study. The computerized lists of households formed the sampling frame for this study and for logistical and cultural reasons we used a random cluster sample based on households, selecting all the individuals aged ⩾15 years from the ENHIP study. A 'household' was defined here as 'a group of people who eat from the same pot'. In order to have a sample size of about 1000 subjects aged ⩾15 years at each study site, we estimated from the census list that about 400 households would have to be included in each selected site. Households were visited on up to three separate occasions in an effort to include all adult household residents. We recorded a participation rate of 96% in the urban area and 98% in the rural setting. In the present analysis, we focused on all adults aged ⩾25 years. This sample comprised 999 women and 727 men aged ⩾25 years. The National Committee of Ethics of the Ministry of Public Health, Cameroon, approved the study protocol. All subjects gave their informed consent to participate in the study.

Methods

Standardized measurements of weight and height with body mass index (BMI) calculated as weight/height^2, the average of two blood pressure measurements using a standard mercury manometer, following the recommendations of the British Hypertension Society,[13] and capillary blood glucose analysis using a Hemocue blood glucose meter (Angelholm, Sweden) after an overnight fast were recorded in all the subjects. Hypertension was defined based on current treatment by hypotensive medication or a systolic blood pressure (SBP) ⩾140 mmHg or diastolic blood pressure (DBP) ⩾90 mmHg.[14] Capillary blood glucose abnormalities were categorized according to the 1998 World Health Organization criteria (normal blood glucose <5.6 mmol/l, impaired fasting glycaemia 5.6–6.0, diabetes if fasting capillary glucose ⩾6.1 mmol/l or, use of hypoglycaemic treatment).[15]

All participants were interviewed about their smoking status (never smoked, ex-smoker, current smoker) and their daily alcohol intake (type and quantity). Alcohol intake was secondarily computed in g/day. We recorded the title of occupation and the type of activities performed, and recoded occupation into a three-level socio-professional category (low, intermediate, and high).

Urbanization data were collected retrospectively using a chart designed, piloted, and validated against educational and professional records for this purpose in a sub sample of 20 urban and 20 rural subjects from the target population (Appendix 1). The repeatability between two administrations at 10–14 days interval was satisfactory (rank correlation coefficient = 0.89 in urban and 0.92 in rural subjects). For each possible residence area, urban or rural, a one-year unit line was drawn, starting at birth year and ending at the time of data collection. Main residence and migration of duration of a year or more were considered. A resident was defined as an individual who had been living on the survey site for at least one year. We used Cameroon national demographic data[16] to define urban, semi-urban, and rural areas. Cameroon is divided into 10 administrative regions and the regions are subdivided in divisions and subdivisions. All regional capital cities, or cities of >100 000 inhabitants were considered urban, and the division headquarters as semi-urban. All other locations were considered rural. Time spent in westernized countries was entered as time spent in an urban area. Before 1960, only three locations in Cameroon were considered urban (Yaoundé, Douala, and Buea). Exposure to urban lifestyle (EU) was defined as the crude number of years (EUt) or the percentage of lifetime (EU%) spent in an urban area. Current levels of physical activity were evaluated by the means of the Sub-Saharan Africa Activity Questionnaire (SSAAQ) and expressed in metabolic equivalents (MET)/day.[17]

Statistical analysis

Data are presented as mean and standard deviation or medians and inter-quartile ranges (IQR) when skewed, or percentages. As age is known to affect the risk of diabetes and hypertension, the study sample was subdivided into 10-year age subgroups before analysis, and adjustment for age was done when necessary. Association between quantitative variables was assessed by means of Spearman correlation coefficients, within each age category. Partial ρ's adjusted for age (as a continuous variable)

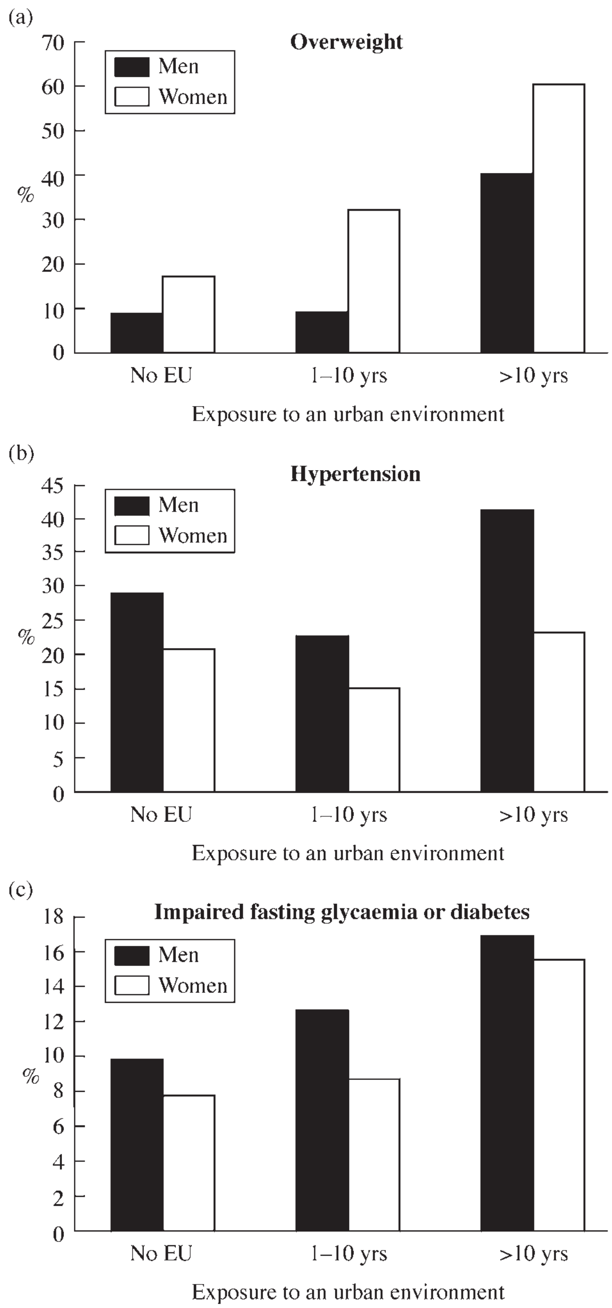

Figure 1 Prevalence of body mass index ⩾25 kg/m^2 (1a), blood pressure ⩾140/90 mmHg (1b), capillary blood glucose ⩾5.6 mmol/l (1c) by duration of exposure to urban lifestyle over the life course

were also computed. BMI, blood pressure, and fasting glycaemia were subsequently dichotomized into overweight or obesity (BMI ⩾25), hypertension (SBP ⩾140 mmHg or DBP ⩾90 mmHg to include hypertension and borderline hypertension) and impaired fasting glycaemia (fasting capillary glucose ⩾5.6 mmol/l). Age, BMI, fasting glycaemia, and blood pressure were compared between rural and urban dwellers, each with less or more than 2 years exposure to urban environment using analysis of variance (ANOVA), adjusted for gender and age if possible. Interaction with gender was tested and separate analyses for each gender performed if significant. *Post hoc* comparison between recent urban dwellers and the three other groups of patients were carried out using Tukey's correction for multiple testing. Association between exposure to urban environment and these outcomes was analysed using multiple logistic regression models, for male and females separately, with adjustment for age (25–34, 35–44, 45–54, 55–64, or ⩾65 years), current urban residence, socio-professional category (low versus intermediate or high), alcohol intake (low versus moderate or heavy), smoking status (non smoker or ex-smoker versus current smoker), and current level of physical activity. EU was categorized in 0, 1–10, and >10 years EUt, and physical activity was categorized according to sample quartiles. A backward stepwise model selection procedure was applied to remove non-significant adjustment covariates from the models, regrouping of variable categories with close regression coefficients was performed using a modified Akaike model selection criterion[18] and tests for interactions were carried out.[19] All tests were two-sided, at a 0.05 significance level. The analyses accounted for clustering effect by household. Analyses were performed using SAS v8.2 software (SAS Institute, Cary, NC).

Results

Study population

The study population comprised 999 women and 727 men aged 25–88 years, of whom 37% were residents of Yaoundé (urban). Impaired fasting glycaemia or diabetes was found in 10.4% of women and 12.7% of men. Of the women, 22%, and 34% of the men had blood pressure ⩾140/90 mmHg or had treated hypertension. The mean EUt was 9.6 years in women and 11.6 years in men (Table 1).

Correlations with exposure to urban lifestyle

EUt or EU% were associated with age only in the urban population. In the overall sample, lifetime EUt was associated with BMI ($\rho = 0.42$; $P < 0.0001$), blood glucose ($\rho = 0.23$; $P < 0.0001$), and blood pressure ($\rho = 0.17$; $P < 0.0001$). In all 10-year age groups, there was a significant positive correlation between lifetime exposure to urban environment and BMI, fasting capillary blood glucose, and blood pressure. BMI, fasting glycaemia, and blood pressure were significantly negatively correlated with the time spent in a rural environment (data not shown).

Early life exposure

After adjustment for age, exposure to urban environment during the first 1–5 years of life was not associated with BMI, blood glucose, or blood pressure.

Recent exposure

Twenty-nine urban residents were classified as recent urban dwellers (⩽2 years exposure). This group had higher mean BMI, fasting blood glucose, and blood pressure than rural subjects with ⩽2 years urban exposure. They also had higher mean BMI and blood pressure than rural subjects with >2 years urban exposure (Table 2). Similar trends were observed using 2–5 year cutoffs to define recent urbanization (data not shown).

Table 1 Characteristics of the study population

	Women		Men	
	Rural dwellers	Urban dwellers	Rural dwellers	Urban dwellers
N	637	362	448	279
Age (years)[a]	49 (14)	39 (11)	50 (14)	40 (11)
Age distribution (years) (%)				
25–34	18.8	37.9	17.6	36.2
35–44	22.5	36.2	16.5	27.2
45–54	22.8	16.3	25.0	26.2
55–64	18.7	5.3	24.3	8.6
⩾65	17.3	4.4	16.5	1.8
Height (cm)[a]	157 (7)	161 (6)	166 (7)	172 (8)
Weight (kg)[a]	55 (10)	70 (15)	59 (9)	73 (15)
Body mass index (kg/m^2)[a]	22 (4)	27 (45)	21 (3)	25 (4)
Systolic blood pressure (mmHg)[a]	119 (21)	127 (21)	125 (21)	136 (23)
Diastolic blood pressure (mmHg)[a]	76 (12)	80 (13)	81 (14)	86 (13)
High blood pressure (%)	18.7	25.1	27.0	42.1
Fasting blood glucose (mmol/l)[a]	4.6 (0.8)	5.0 (0.9)	4.8 (1.4)	5.1 (2.0)
Impaired fasting glycaemia and diabetes (%)	7.7	15.6	12.0	15.1
Urban place of birth (%)	0.5	29.0	1.6	26.5
Time spent in urban area (years)[a]	1.6 (4.7)	23.7 (12.1)	3.5 (7.4)	24.6 (13.2)
Time spent in rural area (years)[a]	45.0 (16.3)	7.7 (16.3)	41.9 (15.3)	7.8 (9.6)
Percentage of lifetime spent in a city (%)[b]	0 (0; 0)	62 (44; 87)	0 (0; 8)	58 (41; 83)
Socio-professional category (%)				
Low	90.7	30.3	68.8	17.3
Medium	7.3	52.2	25.2	50.9
High	2.0	17.5	6.1	31.8
Alcohol intake (g/day)[b]	21 (3; 57)	1 (0; 4)	59 (15; 130)	6 (1; 22)
Alcohol: moderate or heavy (%)	50.7	6.9	72.3	28.7
Current smokers (%)	8.1	1.7	14.4	9.0

[a] Mean (standard deviation).
[b] Median (1st; 3rd quartiles).

Multivariate analyses

We performed logistic regression analyses for males and females separately, including age, current urban residence, socio-professional category, alcohol intake, smoking status, current level of physical activity, and lifetime exposure to urban environment as covariates, and obesity, impaired fasting glycaemia, and hypertension as dependent variables as shown in Table 3. The independent factors associated with overweight or obesity were age, current urban residence, and socio-professional category in men and women, and physical inactivity and lifetime urban exposure to urban environment in men. Age and lifetime urban exposure were the only factors independently associated with impaired fasting glycaemia or diabetes in women. The independent factors associated with hypertension were age, current urban residence, and overweight in both men and women (Table 3).

Discussion

In this study, we show an association between lifetime exposure to urban lifestyle and BMI, blood pressure, and blood glucose. This association between lifetime exposure to urban environment and obesity or diabetes but not with hypertension is independent of age, current level of physical activity, socio-professional category, and current residence in the population studied.

Numerous studies have previously addressed urban–rural differences with regard to obesity, diabetes mellitus, and hypertension in similar populations,[20–23] but very few others have concentrated on recent migration.[10,11,24] To our knowledge this is the first report that has focused on both lifetime migration and chronology of exposure to urban environment as putative risk factors for non-communicable disease, using a simple tool designed to this effect and that displayed high reliability in the target population. Urbanization

Table 2 Comparison between recent urban dwellers and rural subjects with more or less than 2 years history of urban exposure

	Rural dwellers		**Urban dwellers**		***P***	***P***
	≤2 years EU[a]	>2 years EU	≤2 years EU (Recent dwellers)	>2 years EU	(Four groups comparison)	(Interaction with gender)
N	851	234	29	612		
Age (years)	50 (14)	48 (14)	51 (18)	39 (11)*	<0.0001[b]	0.011
Men	50 (14)	50 (14)	42 (20)	40 (11)	<0.0001	
Women	50 (15)	45 (12)*	54 (16)	38 (10)*	<0.0001	
Body mass index (kg/m^2)	21.7 (3.3)*	22.4 (3.5)*	24.6 (5.3)	26.0 (4.9)	<0.0001[c]	0.0002
Men	21.3 (2.8)	21.6 (3.0)	21.1 (2.2)	24.7 (4.1)*	0.042[d]	
Women	22.0 (3.6)*	23.6 (3.9)	25.8 (5.5)	27.0 (5.2)	0.060[d]	
Fasting blood glucose (mmol/l)	4.6 (0.9)*	4.8 (1.6)	5.4 (3.0)	5.1 (1.4)	< 0.0001[c]	0.012
Men	4.7 (1.0)*	4.9 (1.9)*	6.8 (6.0)	5.1 (1.8)*	0.013[d]	
Women	4.6 (0.7)	4.7 (1.1)	5.0 (0.7)	5.0 (0.9)	0.0046[d]	
Systolic blood pressure (mmHg)	122 (22)*	121 (19)*	145 (26)	130 (22)*	<0.0001[c]	0.023
Men	126 (21)	123 (20)	130 (17)	136 (23)	<0.0001[d]	
Women	120 (21)*	117 (17)*	149 (28)	125 (19)*	<0.0001[d]	
Diastolic blood pressure (mmHg)	78 (14)*	79 (12)*	87 (13)	83 (13)	<0.0001[c]	0.096
Men	81 (15)	81 (13)	81 (7)	87 (13)	–	
Women	77 (13)	77 (11)	89 (14)	80 (13)	–	

Results expressed as mean (standard deviation).

[a] Exposure to an urban environment.

[b] Gender-adjusted analyses.

[c] Age- and gender-adjusted analyses.

[d] Age-adjusted analyses.

* P <0.05 versus recent urban dwellers after Tukey's adjustment for multiple testing.

is associated with a drastic decrease in physical activity, changes in dietary habits, and additional psychological stress. These are often reported as factors associated with an urban and western lifestyle[25–27] and all participate in the progression towards overt cardiovascular disease and glucose intolerance and their associated metabolic alterations.[28–30] However, as we were able to measure reliably only the current level of physical activity using the Sub Saharan Activity Physical Activity Questionnaire, the present study suffers from lack of data on dietary and physical activity changes over the life course. In fact, it is difficult to accurately collect data on dietary habits[31] and psychological stress, and only rare attempts to study lifetime physical activity have been reported with acceptable reproducibility.[2] In addition, the present study would have been strengthened if the reason of recent migration had been recorded and subjects who migrated for medical reasons removed from the dataset before analysis.

Steyn *et al*.[32] analysed percentage of life spent in a city among a random sample of 986 exclusively urban residents of the Cape Peninsula, South Africa aged 15–64 years, in relation to blood pressure, body weight, and serum cholesterol. They found an association with hypertension but none with total serum cholesterol concentrations.[32] In another approach, in a study of Ethiopian immigrants in Israel, a significant +10 mmHg mean increase in both SBP and DBP and an impairment of serum lipid profile over the first 2 years following immigration was reported.[11,33] Likewise, in the Luo study of migration, changes in blood pressure were observed in people who migrated from a rural area to the capital city of Kenya (Nairobi) as early as 3–24 months.[24]

From these studies and from our data, whether the increased BMI, higher blood pressure, and blood glucose levels are related to the duration of exposure to urban lifestyle independently of current residence can be questioned. Steyn *et al*. studied an urban community composed of people who migrated from rural areas.[32] It is therefore difficult to address the effect of current residence in the Cape Peninsula study. The multivariate analyses that we undertook showed that both current residence and the lifetime exposure to urban environment were independently associated with obesity. The association between lifetime exposure to urban environment and hypertension was not independent of age, BMI, current residence, and current physical activity level. In addition, recent urbanization was associated with significant increases in BMI and blood pressure, whichever cutoff was used between 2–5 years to define recent urbanization (data not shown). These data are consistent with available evidence on the pathophysiology of diabetes and hypertension. In fact, physiological and metabolic changes preceding overt diabetes may develop over a long period of time, marked by progressive impairment of pancreatic β-cell function and insulin action as confirmed by follow-up studies.[34] Blood pressure might increase much more rapidly over time with change in dietary habits, stress, and obesity. In fact, despite the independent effect of exposure to urban lifestyle over the

Table 3 Stepwise logistic regression analyses

	Men			Women		
	OR[a]	95% CI	*P*	OR	95% CI	*P*
Overweight or obesity						
Age (years)						
25–34	1	–	–	1	–	–
35–44	1.51	0.77–2.96	0.23	2.48	1.65–3.72	<0.0001
45–54	3.77	1.99–7.16	<0.0001	1.87	1.18–2.98	0.0079
55–64	2.57	1.18–5.59	0.018	1.76	1.01–3.09	0.047
⩾65	2.05	0.73–5.78	0.17	1.08	0.54–2.14	0.84
Residence (urban)	2.30	1.09–4.87	0.029	5.56	3.60–8.61	<0.0001
Physical activity (MET[c])		–		NS[d]		
1st quartile (least active)	1	0.48–1.38	–			
2nd quartile	0.82	0.37–1.33	0.49			
3rd quartile	0.70	0.22–0.87	0.28			
4th quartile	0.43		0.013			
EUt (years)				NS		
No EU	1	–	–			
1–10	0.81	0.36–1.84	0.62			
>10	2.33	1.00–4.99	0.050			
Intermediate or high socio-professional category	3.18	1.83–5.55	<0.0001	2.28	1.55–3.37	<0.0001
Moderate or heavy alcohol intake	NS			1.64	1.11–2.42	0.012
Current smoker	NS			0.33	0.12–0.92	0.033
Impaired fasting glycaemia or diabetes[e]						
Age (years)	NS					
25–34				1	–	–
35–64				1.67	0.97–2.88	0.065
⩾65				3.01	1.42–6.38	0.0041
EUt (years)	NS					
No EU				1	–	–
1–10				1.40	0.68–2.87	0.36
>10				2.73	1.69–4.39	<0.0001
Hypertension						
Age (years)						
25–34	1	–	–	1	–	–
35–44	2.02	1.16–3.50	0.013	1.38	0.81–2.35	0.23
45–54	3.65	2.14–6.20	<0.0001	3.59	2.11–6.11	<0.0001
55–64	5.58	3.12–9.96	<0.0001	5.12	2.85–9.21	<0.0001
⩾65	6.06	3.13–11.71	<0.0001	7.67	4.24–13.87	<0.0001
Residence (urban)	2.46	1.63–3.70	<0.0001	1.64	1.09–2.47	0.019
Overweight	2.53	1.67–3.84	<0.0001	2.19	1.50–3.19	<0.0001

[a] Odds ratio.

[b] Exposure to an urban environment (total).

[c] Metabolic equivalents.

[d] Not selected in the model.

[e] No variable was found associated with this outcome in men.

life course, current levels of physical activity, current socio-professional category, and current urban residence are also independently associated with obesity.

In addition, early exposure to urban lifestyle in life (first 1–5 years) seemed not to be a determinant of deleterious effects on the outcome variables, raising the question of the reversibility of changes induced by exposure to urban lifestyle. In fact, putting together the possibility of changes in body weight, blood pressure, and glucose tolerance within a few months or years after settlement in an urban area and the absence of influence of early life exposure on final weight, blood pressure, and blood glucose, suggests that the changes induced by exposure to urban lifestyle might be reversible. However, apart from possible reversibility, the effect of residence on lifestyle at age 0–5 might be minimal. The improvement of insulin secretory response observed in urbanized Australian Aborigines 3 months after they had returned to their traditional lifestyle,[35] and the short-term beneficial effect of lifestyle intervention where increased physical activity and healthier diet tend to decrease body fat, serum lipids, blood pressure, and blood glucose[36–39] are supportive of the influence of current residence (and lifestyle). It might therefore be useful to approach exposure to urban lifestyle from both a lifetime perspective and as current residence and lifestyle.

However, it is not possible to avoid potential selection bias in the urban population since there is better access to health care facilities in the cities. Selective migration for medical reasons may thus confound the effect of urban lifestyle. Also surprising was the lack of significant correlation between age and EU. This might result from a merged urban and rural sample, with most rural subjects having very low EUt. However, there was an independent association of EU with the 45–54 and 55–65 year age groups but none with those aged ⩾65 years. It is therefore also possible that a selection of 'healthy' elderly people is made (with premature death of 'unhealthy' elderly subjects), explaining this lack of association. In fact, life expectancy at birth in Sub Saharan Africa is still low (around 55 years in Cameroon).

In conclusion, we report the development of a simple tool to retrospectively measure chronological history of lifetime exposure to urban lifestyle. This study suggests that both lifetime exposure to urban environment and recent migration or current residence are potential risk factor for obesity and diabetes mellitus. It might represent the cumulative effects over years of dietary changes, decrease in physical activity, and psychological stress. Ideally, epidemiological studies should henceforth include this lifetime approach when addressing the impact of urbanization on health-related outcomes. A shorter-term approach might be enough when focusing on hypertension.

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KEY MESSAGES

- Exposure to urban environment over the life course can be recorded using a simple tool.
- In the study population, exposure to urban environment over the life course was associated with current body mass index, fasting glycaemia, and blood pressure.
- The association of life course urban exposure with obesity and impaired fasting glycaemia or diabetes but not with hypertension was independent of current residence, physical activity level, and socio-professional category.
- This study suggests that, in addition to current residence, lifetime exposure to urban environment and recent migration are putative risk factors for obesity and diabetes.

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