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BMJ Open Association between duration of residence and prevalence of type 2 diabetes among male South Asian expatriate workers in the United Arab Emirates: a cross-sectional study

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ABSTRACT

Expatriates account for about 80% of the total population in the United Arab Emirates (UAE). This study aimed to evaluate the hypothesis that prevalence of type 2 diabetes in male South Asian expatriates increases with increased length of residence in the UAE.

Design, settings and participants This cross-sectional study recruited a representative sample (n=1375) of male South Asian expatriates aged ≥18 years in Al Ain, UAE. Sociodemographic, anthropometric and lifestyle data were obtained using a pilot-tested adapted version of the WHO STEPS instrument.

Main outcome measures Duration of residence was used as a marker for acculturation. Type 2 diabetes was defined as a self-reported physician diagnosis of diabetes or a glycosylated haemoglobin blood level ≥6.5%.

Results Mean (±SD) age of participants was 34.0±9.9 years. Overall, the prevalence of type 2 diabetes was 8.3% (95% CI 6.8% to 9.8%). Diabetes prevalence was positively associated with longer duration of residence in the UAE, 2.7%, <5 years; 8.2%, 5–10 years; and 18.8%, >10 years. After adjusting for age, nationality, and income and age, expatriates were more likely to develop diabetes if residing in the UAE for 5–10 years (OR=2.18; 95% CI 1.02 to 4.67) or >10 years (OR=3.23; 95% CI 1.52 to 6.85) compared with those residing for <5 years.

Conclusions After controlling for potential confounding factors, longer duration of residence was significantly associated with a higher prevalence of type 2 diabetes in male South Asian expatriate workers in the UAE.

BACKGROUND

Diabetes is a major cause of premature morbidity and mortality worldwide, and 1 in 10 adults have diabetes.¹ According to current estimates, diabetes will contribute to 11.3% deaths globally, ranging from 6.8% in the African Region to 16.2% in the Middle East and North Africa.² The Gulf countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates (UAE)) have

Strengths and limitations of this study

- This study is the first to evaluate the relationship between duration of residence and type 2 diabetes in male expatriate workers from India, Pakistan and Bangladesh in the United Arab Emirates (UAE).
- We found a significant increase in the prevalence of type 2 diabetes after 5 years of residence in the UAE.
- We carried out glycated haemoglobin in a subsample of study population due to budgetary limitations.
- We could not differentiate if some of the self-reported physician-diagnosed type 2 diabetes had pre-diabetes.
- Migrants from some of the South Asian countries (ie, Nepal, Sri Lanka) were not included in the study.

experienced a rapid improvement in socioeconomic status (SES) over the past 40 years leading to a lifestyle transition characterised by reduced physical activity and altered eating habits. Consequently, Gulf countries have some of the highest prevalence of diabetes in the world.^{3–5} In the UAE, the prevalence of diabetes has increased significantly in both the UAE nationals and in the expatriate population over the last 20 years.^{6,7}

Today, the expatriate population accounts for approximately 80% of the UAE population and about two-thirds of expatriates are South Asian (originating from India, Pakistan, Bangladesh, Nepal and Sri Lanka).⁸ Migrants from the Indian subcontinent including India, Bangladesh and Pakistan account for over 90% of the country's private workforce.⁹ A significant proportion of male migrants work in the construction industry as semiskilled labourers, scaffolders and carpenters, reporting low incomes.¹⁰ We previously documented a high prevalence of depressive



symptoms (25.1%) and suicidal ideation among male migrant workers from India, Bangladesh and Pakistan.¹⁰ Further, a review on migrants' cardiometabolic risk factors shows that migrants to countries in the Middle East carry over chronic non-communicable disease (NCD) risk factors during their migration journey which become intensified due to financial precarity, lack of access to healthy food and physical activity, and limited access to healthcare.¹¹

We noted a significant increase in unhealthy weight gain among male South migrants over 5–10 years after migration.¹² The prevalence of current cigarette smoking was 21%, 23% and 37% among study participants from India, Pakistan and Bangladesh, respectively.¹³ A high proportion of male South Asian migrants (30.5%) had hypertension, 62% of those had never had their blood pressure (BP) measured and over three-quarters (76%) classified as hypertensive were not aware of their condition.¹⁴ These findings have serious implications including premature mortality as a consequence of uncontrolled hypertension and economic strain on the healthcare system in the UAE.^{15 16} Moreover, there is no health policy in the home countries of immigrants for a pre-departure screening aimed to assess NCD risk factors, or any arrangements in the host countries, where screening tests are limited to selected communicable diseases (ie, tuberculosis (TB), sexually transmitted infections).¹¹

Studies in developed countries have shown higher prevalence of type 2 diabetes in immigrants as compared with native-born individuals.¹⁷ It has been suggested that acculturation or adoption of the attitudes, customs and unhealthy behaviours of the host culture results in an increased prevalence of diabetes and other cardiometabolic diseases with a greater acculturation as measured by length of residence in the host country.^{18–22}

Currently, there are no data on whether the duration of residence is associated with diabetes prevalence in male South Asian expatriate workers in the UAE. This study aimed at examining the hypothesis that acculturation (measured by residency duration) is associated with an increased prevalence of type 2 diabetes among male expatriates from India, Pakistan and Bangladesh living in the UAE.

RESEARCH DESIGN AND METHODS

Patient and public involvement

No patients were involved.

Study setting and participants

All expatriate workers seeking employment in the UAE are required by law to undergo health and communicable disease screening (ie, primarily pulmonary TB by chest X-ray and HIV and leprosy by serology) at a government 'visa screening center' before receiving a residency permit. Expatriates are required to undergo infectious disease screening on arrival and when they renew their visa, which is usually every 2–3 years depending on their

occupational category. The sampling frame in our study was a list of all male expatriate workers from India, Pakistan and Bangladesh who were enrolled for medical examination at the only visa screening centre in the city of Al Ain, Abu Dhabi.

The target study population consisted of all male South Asian migrant workers aged ≥ 18 years from India, Pakistan and Bangladesh. We used the formula for binomial distribution [$n = \frac{z^2 \alpha^2 p(1-p)}{d^2}$], where n = the desirable sample size, z = the critical value at 95% level of significance (1.96), p = proportion of male migrants with type 2 diabetes (0.50 as prevalence data were not available for male South Asian migrants from the study countries), d was the acceptable marginal error (0.05) to estimate the sample size ($n = 1200$) to identify the prevalence of diabetes in South Asian males and aimed at recruiting 1800 study participants to account for refusals. The study population and participant recruitment procedures have been described elsewhere.^{12–14}

Briefly, participants had to self-identify with a South Asian ethnicity of India, Pakistan or Bangladesh, be an adult aged ≥ 18 years, and be able to speak and/or read Urdu, Hindi or Bengali, and had to provide written informed consent to be eligible to participate in the study. We invited every third person on this list who was undergoing the screening examination for either a new residency visa or the renewal of an existing visa between January and June 2012 to participate in the study. Of the 1800 eligible participants, 1375 (76.4% participation rate) participated in the study. A substantial proportion of eligible participants (23.6%) did not participate due to time constraints as they were called on to undergo other visa-related procedures.

Data collection

We used an adapted version of the questionnaire used in the 'STEPS Methodology', developed by the WHO for the measurement and surveillance of NCD risk factors in populations.²³ Due to the low literacy rates among the South Asian expatriate population in the UAE, all interviews were conducted in Urdu, Hindi or Bengali and led by a native Urdu/Hindi or Bengali-speaking research assistant who had received appropriate training. Through the questionnaire, we collected information on demographic characteristics, modifiable lifestyle risk factors including tobacco use, alcohol consumption, and physical activity, family and personal disease history, home country of residence setting (rural, urban, semiurban), occupation, monthly salary in UAE dirham (AED1.00=US\$3.65) and current type of accommodation. Subjects were classified as current smokers if they answered yes to the question 'do you smoke cigarettes daily?'. Ever smokers included current and former smokers. Information on physical activity was obtained using the International Physical Activity Questionnaire (short version).²³ We measured the frequency (days/week) and duration (min/day) of moderate and vigorous-intensity physical activities in a period of 7 days prior to the survey. We used the US

guidelines for physical activity, recommended by the Centers for Diseases Control and Prevention. We identified participants reporting moderate-intensity physical activity for a minimum of 30 min on 5 days each week or vigorous-intensity physical activity for 20 min on 3 days each week as physically active.²⁴ Hypertension was defined as a mean systolic BP of ≥ 140.0 mm Hg, a mean diastolic BP ≥ 90.0 mm Hg or current hypertension treatment with prescription medication.¹⁴ To properly define the main exposure variable we examined methods used to evaluate the relationship between duration of residence and cardiometabolic diseases in migrants in the developed countries.^{18–22}

We used the total years of residence as the main exposure variable as a proxy for acculturation.²⁰ To evaluate any dose–response, we divided it in three categories: <5 years, 5–10 years and >10 years. Anthropometric data (body mass, height, waist and hip circumference) were collected using standardised equipment and measurement protocols.^{12,13,14} Body mass index (BMI, kg/m^2) was calculated by dividing body weight (kg) by height in metres squared. The WHO cut-offs for Asian adults were used to classify overweight ($23 \text{ kg}/\text{m}^2$) and obesity ($\geq 27.5 \text{ kg}/\text{m}^2$) in South Asian adults.²⁵ We used a waist to hip ratio (WHR; waist in centimetres/hip circumference in centimetres) ≥ 0.90 to define central obesity.²⁶

Duration of residence and diabetes

We used the duration of residence in years in the UAE as a marker of acculturation.²⁰ We ascertained type 2 diabetes mellitus (type 2 diabetes) as a self-report of physician-diagnosed diabetes and self-reported use of antidiabetic medication or a blood glycated haemoglobin (HbA1c) level of 6.5% or greater.²⁷ Due to limited resources, we collected a non-fasting venous blood sample to measure the HbA1c levels in a random subsample of the study population ($n=99$). Pre-diabetes in the subsample was defined as an HbA1c level of 5.7%–6.4%.²⁷

Statistical analysis

Data were entered into Microsoft Access software and then imported into Stata V.11.0 (StataCorp, College Station, Texas) for analysis. Data are presented as means \pm SDs for continuous variables, and as counts and percentages for categorical variables along with their 95% CI, which were calculated for descriptive purposes. χ^2 tests were used for categorical variables and analysis of variance for continuous variables. Prevalence of known/diagnosed diabetes and measured diabetes with duration of residence is presented graphically. We first compared recent (<5 years) male immigrants with those who had been in the UAE for 5–10 years and/or more than 10 years across sociodemographic, anthropometric and other lifestyle and clinical variables. The analyses were conducted with a χ^2 test to assess differences in categorical variables and analysis of variance test for continuous variables.

We used logistic regression analyses to evaluate the association of each independent variable with the main

outcome measure (type 2 diabetes), to estimate crude ORs and 95% CIs for each independent variable. A two-tailed alpha with $p<0.05$ was considered statistically significant in our bivariate analyses.

In our multivariable analysis, we first examined the association between duration of residency and diabetes and entered age in years as a continuous variable and then entered one by one those independent variables that were statistically significant in univariable analyses. We found a statistically significant relationship between a number of exposure variables including age, length of residence in the UAE, family history of diabetes, nationality, occupation, income, cigarette smoking, overweight, obesity, central obesity, physical activity and family history of diabetes and the outcome variable (type 2 diabetes) in our bivariate analyses (unadjusted or crude model).

We tested for effect modification of age on the relationship between length of residence and type 2 diabetes by including an interaction term (age \times length of residence). We used multivariable logistic regression analyses to determine the association between length of UAE residence and type 2 diabetes, adjusting for known confounding variables such as age, income, occupation and nationality. We did not find significant multicollinearity between independent variables including the duration of residence in the UAE and age by assessing the variance inflation factor.²⁸ We conducted sensitivity analysis in the subsample of the study population ($n=99$) to compare the difference in the prevalence of measured (HbA1c $\geq 6.5\%$) and physician-diagnosed, self-reported type 2 diabetes, and calculated the sensitivity and specificity.

RESULTS

Out of 1800 eligible males, 1375 (76.4%) participated in the study and were from India ($n=433$), Pakistan ($n=383$) and Bangladesh ($n=559$). Of the 1375 participants, 1218 had their years of residency data available. The mean age of the study population was 34.0 years (95% CI 33.4 to 34.5). More detailed information about the characteristics of study participants by nationality is available from our previously published study.¹² Overall, a significant proportion of participants (12.6%) had no formal schooling, 34.5% had secondary education and 52.9% had college or higher level of education. Education level varied by nationality; among Indians, 3.0% had no formal schooling, 22.9% had secondary education and 74.1% had college or higher level of education. Among Pakistani nationality, 23.6% had no formal education, 31.2% had secondary education and 45.1% had college or higher education. Among Bangladeshi nationals, 12.6% had no formal education, 45.8% had secondary education and 41.6% had college or higher education. The majority (70.0%) of subjects were married and 85.3% of married participants were living in the UAE away from their families in their home country. The study participants either shared rented accommodation (52.2%), lived with their sponsor (13.4%), in a labour camp (12.2%), in a

Table 1 Characteristics of male South Asian migrants in Al Ain, United Arab Emirates (n=1218)

Characteristics	All %	Duration of residency in UAE			P value
		<5 years	5–10 years	>10 years	
n	1218	547	257	414	
Age (years), mean (±SD)	34.0 (9.9)	29.3 (6.9)	32.6 (6.9)	43.3 (8.8)	<0.001
Nationality (%)					
Indian	31.5	30.9	34.2	34.8	<0.001
Pakistani	27.8	25.6	22.9	33.6	
Bangladeshi	40.7	43.5	42.9	31.6	
Occupation (%)					
Labourer	46.7	21.2	25.6	32.9	<0.001
Driver	23.1	57.4	46.2	37.1	
Professional, office work	11.3	10.1	13.5	15.6	
Other	18.9	11.3	14.7	14.4	
Education (%)					
None	12.6	13.7	6.6	12.9	0.002
High school	34.5	35.2	28.3	34.9	
College or university	52.9	51.1	65.1	52.2	
Income per month in Emirati dirham (AED)	1829.5	1472	1820	2509	<0.001
Original setting (rural vs urban)	68.6	68.4	71.1	63.3	0.088
Smoking status (%)					
Never	60.1	61.1	56.1	57.1	0.007
Former	12.6	10.6	12.1	18.1	
Current	27.3	28.3	31.8	24.8	
BMI (kg/m ²), mean (SD)	24.7 (4.7)	23.7 (4.6)	25.6 (4.1)	26.6 (4.5)	0.039
BMI categories (%)					
<18.5 kg/m ² , underweight	6.1	8.2	1.6	1.7	<0.001
18.5–22.9 kg/m ² , normal weight	32.6	39.8	28.9	18.1	
23.0–27.4 kg/m ² , overweight	39.2	38.1	43.3	44.7	
≥27.5 kg/m ² , obese	22.1	13.9	26.2	35.5	
Waist circumference (cm), mean (±SD)	89.1 (11.8)	85.8 (11.4)	91.1 (9.8)	95.4 (10.4)	<0.001
Central obesity (waist ≥90 cm)	63.4	52.5	70.8	83.6	<0.001
Moderate or vigorous activity	24.9	29.2	22.6	17.1	<0.001
Family history of diabetes	15	11.3	16.2	23.3	<0.001
Pre-diabetes (HbA1c, 5.7%–6.4%)	23.9	18.7	18.2	38.5	0.014
Diabetes, known or HbA1c ≥6.5%	8.3	2.7	8.2	18.8	<0.001

BMI, body mass index; UAE, United Arab Emirates.

rented single accommodation (11.1%) or with family members (11.1%). Most participants (68.6%) came from rural villages from their original countries. A substantial proportion of the study participants were overweight (39.2%), obese (22.1%) or had central obesity (63.4%).

The crude prevalence of known/physician-diagnosed diabetes ($n=110/1.375$) was 8.0%. Out of known/physician-diagnosed diabetics, 4.5% were on insulin injections and the remaining were using oral tablets. The prevalence of measured type 2 diabetes ($HbA1c \geq 6.5\%$) and pre-diabetes ($HbA1c 5.7\%–6.4\%$) was 9.3% and 23.9%, respectively, after excluding those with known diabetes ($n=3$) in the subsample of 99 participants. In our subsample sensitivity analysis, we found a specificity of 95.6%, sensitivity of 71.4% and the level of agreement between self-reported and HbA1c-measured diabetes was substantial (69.3%).

Table 1 shows sociodemographic, anthropometric and lifestyle characteristics of study participants by their duration of residence in the UAE. There was a significant ($p < 0.05$) increase in mean BMI and mean waist circumference in association with duration of residency in the UAE. The prevalence of obesity ($BMI \geq 27.5 \text{ kg/m}^2$) increased from 13.9% among recent migrants (<5 years) in the UAE to 26.2% and 35.5% among those living in the UAE for 5–10 or >10 years, respectively. Similarly, the proportion of central obesity ($WHR \geq 0.90$) also increased from 52.5% among recent migrants (<5 years) to 70.8% and 83.6% among those living in the UAE for 5–10 or >10 years, respectively.

Diabetes prevalence was higher with increased duration of residence in the UAE. The prevalence of measured pre-diabetes in the subsample who underwent blood testing ($n=99$) increased with duration of residence in the UAE, that is, 2.1% for <5 years, 18.2% for 5–10 years and 38.5% for >10 years. The prevalence of measured diabetes ($HbA1c \geq 6.5\%$) increased from 2.1% in those with less than 5 years' duration of residence in the UAE to 14.8% in 6–10 years of residence and 16.7% with the

duration of greater than 10 years of residence in the UAE, and among those who self-reported physician diagnosis of diabetes with current use of antidiabetic medications, the prevalence of diabetes was 2.6% for the duration of less than 5 years, 7.4% for the duration of 6–10 years and 18.6% for the duration of more than 10 years of residence in the UAE, respectively, as shown in figure 1.

In table 2, we present the prevalence of diabetes across sociodemographic, lifestyle and other variables including the duration of residence in the UAE. In addition to duration of residence in the UAE, age, type of occupation, nationality, smoking status, BMI, WHR, physical activity and a positive family history of diabetes were significant correlates of diabetes.

The results of the multivariable logistic regression analysis examining the relationship between duration of residence in the UAE and type 2 diabetes prevalence are shown in table 3. A comparison between the length of residence in unadjusted (crude model) and adjusted models is presented. After adjustment for nationality, monthly income, occupation, and after fitting an interaction term between age and length of residence, we observed a reduction in the magnitude of OR as compared with the crude model, indicating age as an effect modifier of the outcome of type 2 diabetes. Male migrants who had resided in the UAE for 5–10 years or more than 10 years have a higher odds of type 2 diabetes prevalence than those with <5 years of residence in the UAE.

DISCUSSION

In a sample of male South Asian expatriates from India, Pakistan and Bangladesh aged 18 years and over, we found that a longer duration of residence in the UAE was associated with a higher prevalence of type 2 diabetes. Our findings suggest a possible diminishing 'healthy migrant effect' due to acculturation in a relatively young population. South Asian migrants in Western developed countries may be selected on higher SES and a trajectory

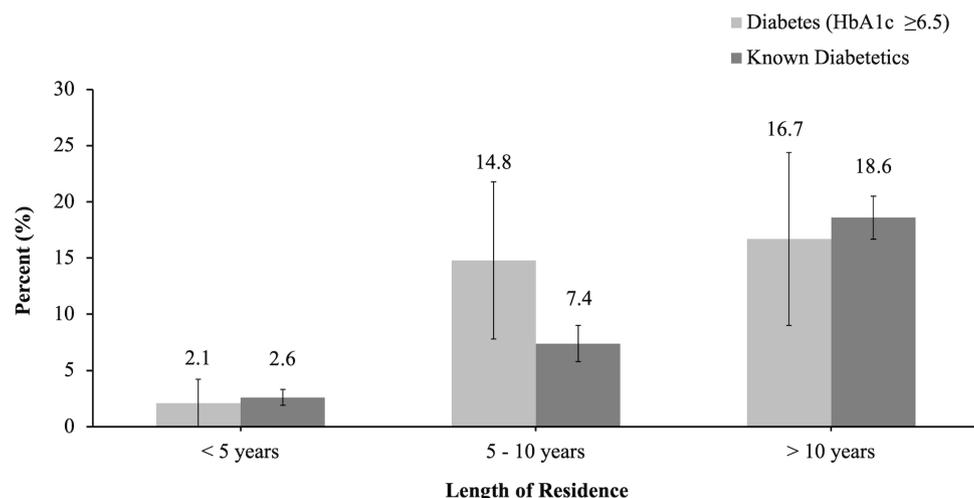


Figure 1 Prevalence of type 2 diabetes mellitus among South Asian immigrants by length of residence in the United Arab Emirates.

**Table 2** Prevalence and univariable ORs of correlates of type 2 diabetes in male South Asian expatriate workers

Characteristics	n	Type 2 diabetes	
		n (%)	Crude OR (95% CI)
Age (years)			
18–35	689	17 (2.5)	Ref
36–45	289	42 (14.5)	7.39 (4.14 to 13.21)
>45	197	51 (25.9)	15.96 (8.97 to 28.41)
Residency in UAE (years)			
<5	547	15 (2.6)	Ref
5–10	257	21 (7.4)	3.15 (1.59 to 6.23)
>10	414	78 (18.6)	8.23 (4.66 to 14.55)
Nationality			
Pakistani	338	25 (7.4)	Ref
Bangladeshi	479	40 (8.3)	1.10 (0.65 to 1.85)
Indian	401	49 (12.2)	1.83 (1.11 to 3.02)
Location in home country			
Rural village	809	72 (8.9)	Ref
Urban or semiurban	394	40 (10.1)	1.24 (0.82 to 1.85)
Occupation			
Labourer	552	39 (7.1)	Ref
Driver	299	32 (10.7)	1.57 (0.97 to 2.57)
Professional	145	18 (12.4)	1.86 (1.03 to 3.37)
Others	150	19 (12.7)	1.91 (1.07 to 3.41)
Education			
No formal schooling	145	9 (6.2)	Ref
High school	409	39 (9.5)	1.59 (0.75 to 3.37)
College or higher	660	66 (10.0)	1.67 (0.81 to 3.45)
Monthly income			
Lowest tertile	371	12 (3.2)	Ref
Middle tertile	290	17 (5.9)	1.86 (0.87 to 3.96)
Highest tertile	714	85 (11.9)	4.04 (2.18 to 7.50)
Smoking status			
Never	714	58 (8.1)	Ref
Current	340	25 (7.3)	1.11 (0.68 to 1.81)
Former	164	31 (18.9)	2.94 (1.67 to 5.16)
BMI (kg/m²)			
<23.0	422	28 (6.6)	Ref
23.0–27.5	504	56 (11.1)	2.08 (1.30 to 3.33)
>27.5	290	29 (10.0)	1.91 (1.11 to 3.27)
Waist circumference			
<0.90	781	7 (7.3)	Ref
≥0.90	437	57 (13.0)	1.90 (1.29 to 2.81)
Moderate vigorous activity			
Yes	289	17 (5.9)	Ref
No	929	97 (10.4)	1.86 (1.09 to 3.38)
Family history of diabetes			
No	787	78 (9.9)	Ref
Yes	146	27 (18.5)	2.06 (1.27 to 3.33)

BMI, body mass index; UAE, United Arab Emirates.

Table 3 Crude and multivariable adjusted odds of type 2 diabetes among South Asian expatriate workers (n=1375)

Characteristics	Crude model		Adjusted model	
	OR	95% CI	AOR	95% CI
Length of residence (years)				
<5	Ref		Ref	
5–10	3.15	1.59 to 6.23	2.18	1.02 to 4.67
>10	8.23	4.66 to 14.55	3.23	1.52 to 6.85
Family history of diabetes				
No	Ref			
Yes	2.06	1.27 to 3.33	3.01	1.72 to 5.24
Nationality				
Pakistani	Ref		Ref	
Bangladeshi	1.10	0.65 to 1.85	1.72	0.94 to 3.18
Indian	1.83	1.11 to 3.02	1.94	1.08 to 3.50
Waist to hip ratio				
<0.90	Ref		Ref	
≥0.90	1.90	1.29 to 2.81	1.03	1.00 to 1.06
Body mass index (kg/m²)				
<23.0	Ref			
23.0–27.5	2.08	1.30 to 3.27	1.12	0.64 to 1.93
>27.5	1.91	1.11 to 3.27	0.67	0.35 to 1.28
Occupation				
Labourer	Ref		Ref	
Driver	1.57	0.97 to 2.57	0.79	0.46 to 1.37
Professional	1.86	1.03 to 3.37	0.87	0.39 to 1.92
Others	1.91	1.07 to 3.41	0.92	0.46 to 1.85
Self-reported physical activity (moderate/vigorous)				
Yes	Ref		Ref	
No	1.86	1.09 to 3.38	1.26	0.70 to 2.29
Cigarette smoking				
Never	Ref		Ref	
Ever	1.51	1.03 to 2.2	1.34	0.85 to 2.11
Monthly income (AED)	1.00	1.00 to 1.00	1.00	0.99 to 3.18
Age × duration of residence (interaction term)	1.00	1.09 to 1.14	1.00	0.01 to 0.04

Model 2 after adjustment of nationality, income, occupation and interaction term of age and residency.
AOR, adjusted OR.

towards developing obesity and diabetes.¹⁷ Studies have shown that on arrival, US immigrants weigh less and have a lower prevalence of being overweight when compared with native-born individuals. This apparent health advantage is reduced with increased length of residence and changes in diet associated with acculturation which have been hypothesised as reasons for increasing weight and subsequent increases in diabetes in these immigrants.^{18–22}

In the present study, South Asian migrants came to the UAE for better job opportunities, with a higher proportion (68%) originating from rural areas, with a precarious SES, with Indian or Pakistani nationality earning AED1500 (Emirati dirham) per month and immigrants

with Bangladeshi nationality earning AED1000 per month.¹² Overall, the majority (70%) were married and of those, 85% lived away from their families.¹² South Asian migrants commonly work over extended daily work schedules and previously reported a high prevalence of depression and suicidal ideation.¹⁰ Few have opportunities to be physically active as free transportation was available to and from work and very hot weather (especially during the prolonged summer period) is an environmental barrier to ambulatory physical activity. Only 18.8% of Indian, 18.9% of Pakistani and 27.8% of Bangladesh migrant workers reported moderate or vigorous physical activity in the past week.



According to the WHO framework on the social determinants of health, socioeconomically disadvantaged groups are increasingly vulnerable to cardiometabolic diseases. About 52% of premature deaths from such diseases are in low and middle-income countries compared with 23% in established market economies.²⁹ Among male South Asian migrants, the prevalence of overweight and obesity was 34% for those with UAE residency of less than 6 years compared with 55% for those with UAE residency of 6–10 years.¹² Previously, we also found a statistically significant relationship between the duration of residence in the UAE and the prevalence of diabetes among female Filipino, Arab and South Asian migrants.³⁰ The overall prevalence of diabetes in female migrants (10.7%) was comparable to the study results (9.3%) in male migrants. However, the prevalence of diabetes in female expatriate workers with more than 10 years of residency in the UAE was much higher (40.7%) compared with male expatriate workers (18.6%). These prevalence estimates are comparable with 25% of diabetes and 30% of pre-diabetes (based on the fasting plasma glucose of 5.6–6.9 mmol/L or 2 hours after oral glucose tolerance test of 7.8–11 mmol/L) among native Emirati adults in Abu Dhabi.³¹ The trend of increased prevalence of diabetes among South Asian males residing in the UAE for longer durations (ie, 2.7% for <5 years, 8.2% for 5–10 years and 18.8% for >10 years) was steeper than seen among US Asians over a period of 10 years (6.2%–10.4%).³² Moreover, the prevalence of diabetes by duration of residence in the UAE was higher compared with the diabetes prevalence by duration noted in Asian migrants in the USA (3.3%, <5 years; 3.4%, 5 to <10 years; 4.5%, 10–15 years).¹⁸ According to a review of 49 studies conducted in Canada, time since migration was positively associated with BMI, and the prevalence of obesity among migrants was also found to increase with their duration of stay in Canada.³³ In addition, children who migrated to Canada or were of South Asian descent were at an increased risk of developing obesity and type 2 diabetes mellitus at an earlier age than native-born Canadians.³⁴ Compared with non-Hispanic whites in the USA, Asian Americans (including Indian immigrants) had a significantly higher risk of type 2 diabetes.²¹ Similarly, acculturation, as indicated by longer length of residence among migrant Indians living in Singapore, was associated with a higher prevalence of diabetes and diabetes-related eye complications.³⁵ Interestingly, a recent paper reported that there was a higher prevalence of diabetes among Indians living in urban India compared with Indian migrants living in the USA.³⁶ In view of these findings, we may not observe the ‘healthy migrant effect’ among South Asian migrants in the UAE for much longer.

Examining a subsample in our study, in which diabetes was based on blood test results (n=99), we found that the prevalence of pre-diabetes also increased with the duration of residence. The estimates in prevalence (18.7% for <5 years; 38.5% for >10 years) over a period of 10 years were much higher compared with Asians in the USA (6.8%–12.4%).²⁰ Similar findings have been reported in

other studies exploring the association between acculturation and glycaemic control in South Asian migrant populations in the USA.^{21 37} In these studies, sedentary behaviour, measured by time spent watching television, was positively associated with diabetes, while exercise was inversely associated with pre-diabetes. Early detection of pre-diabetes may allow individuals to adopt healthy lifestyle behaviours that can reduce the risk of progression to diabetes.³⁸

The majority of our study population migrated from a rural area and the nutritional transition and availability of transportation may explain the increase in diabetes associated with increased duration of residency in the UAE. Studies on rural to urban migration in India have also shown that compared with those who remain in their rural regions, the exposure to an urban environment promotes sedentary behaviour and less healthy nutritional habits.³⁹ Studies in developed countries have shown that South Asian migrants increased their consumption of processed foods and that their meals had more calories and a higher percentage of carbohydrates.^{40 41} The UAE has been previously defined as an obesogenic environment due to an accelerated nutrition transition moving away from traditional healthy foods and an abundance of ‘unhealthy’ energy-dense foods.⁴² In the study population, family history of diabetes was also independently associated with an increased risk of diabetes. This finding agrees with previous research highlighting family history as an important independent risk factor. A recent systematic review and meta-analysis exploring the association between diabetes and family history reported a pooled OR of 2.75 which is similar to the adjusted OR of 2.80 that we report in this study.⁴³

The vast majority of research articles exploring the relationship between acculturation and the development of type 2 diabetes among South Asians have focused on migrant populations living in Western developed countries. Our study shows a relationship between acculturation (assessed using duration of residency) and increased prevalence of diabetes in male South Asian expatriate workers living in a high-income Arab country. Our findings corroborate those of earlier studies, namely that South Asians, particularly when living in high-income countries, are at a substantially increased risk of developing type 2 diabetes compared with the indigenous populations of the host country. A recent comprehensive review of the literature has highlighted several factors that may increase the likelihood of South Asian migrants developing type 2 diabetes compared with other ethnicities.⁴⁴ South Asian migrants seem to be more insulin resistant all their life (at least compared with white Europeans) and potentially experience β -cell exhaustion at a younger age.⁴⁵ In addition, South Asians may have unique morphological features with respect to body composition and physical activity/fitness that contribute to the observed higher prevalence of diabetes.⁴⁵

The majority of migrants in our sample were low-skilled workers, and many received regular food rations from

their sponsors in the form of white rice and cooking oils. The dietary acculturation among South Asian expatriate workers in the UAE is characterised by the adoption of affordable low-quality food with high-energy content. Unhealthy food choices such as drinks and processed food with high sugar content are cheaper and this reinforces the unhealthy food choices among low-paid South Asian expatriate workers in the UAE. Finally, the UAE is characterised by a very hot weather for almost 9 months of the year and some individuals have limited opportunity to be physically active with outdoor activities.

We would like to acknowledge the limitations of our study. Migrant workers from other South Asian countries including Nepal and Sri Lanka were not part of our recruitment process and future studies need to address the gap in knowledge on cardiometabolic diseases in migrants from Nepal and Sri Lanka in the UAE. For chronic disease, duration of residence is also collinear with ageing. Although we adjusted for the effect of age by including the age variable in our multivariate analysis, it may not completely nullify the effect of ageing and results should be interpreted with caution.

The cross-sectional study design does not allow us to comment on temporality and/or causality between duration of residence in the UAE and diabetes. Nevertheless, it is unlikely that diabetes would lead to acculturation. Self-diagnosed diabetes was used to partially evaluate our outcome of interest. Therefore, those living in the UAE for longer periods may be more likely to be diagnosed due to increased access to healthcare. There is a possibility that people who remain in the UAE for a longer time are inherently different from those staying for a short time. This may be related to diabetes risk and may contribute to the duration-related differences observed. We used years of residence as a proxy for acculturation. There is some variation in the methods used by other studies to assess acculturation and measurement issues may account for some differences in the results in those studies. However, the majority of studies exploring the association between acculturation and diabetes have used residency as a proxy for acculturation.^{18–20} In addition, we recruited our study sample from the visa screening centre in the city of Al Ain, Abu Dhabi Emirate. However, we would not expect the socioeconomic and lifestyle characteristics of the study population to differ from male South Asian migrants living in other Emirates of the UAE.⁷ Furthermore, we measured HbA1c levels in a small subsample (n=99) of the study population due to funding limitations. Although self-reported diabetes is not a gold standard to diagnose diabetes, self-reported diagnosis of diabetes has been successfully used to evaluate the relationship between the duration of residence and diabetes, showing increased prevalence of diabetes with length of residence, independent of age and obesity, among US migrants.^{18–20} More recent studies have shown self-reported diabetes to be valid in evaluating an individual's diabetes status.^{19 45} However, caution is needed in the interpretation of cross-sectional studies as the subjects

may not be able to recall the diagnosis or misinterpret the diagnosis, resulting in underestimation or overestimation of the prevalence of diabetes.⁴⁶

The new WHO HbA1c criteria for the diagnosis of diabetes require two HbA1c levels $\geq 6.5\%$ unless unequivocal symptoms of diabetes are present. We could not use this definition for diabetes as we did not measure HbA1c level on two occasions. Instead, we used the American Diabetes Association criteria for diagnosis of diabetes and pre-diabetes based on a single measurement of HbA1c level. Out of study participants with physician-diagnosed diabetes (110), only eight reported the use of insulin injections, but we could not differentiate whether some of those had type 2 diabetes. Nearly a quarter (23%) of non-respondents did not participate in the study due to the time available to complete their visa health screening, and it is possible that this might have contributed to some non-response bias. Nonetheless, the study findings showing an association between duration of residence and the prevalence of diabetes among male South Asian migrants living in the UAE concur with our previous similar study among female migrants.³⁰

Migrants from the Indian subcontinent including India, Bangladesh and Pakistan account for over 90% of the UAE's private sector workforce.⁹ Moreover, a high proportion (55.6%) of identified cases of diabetes remained undiagnosed and untreated. We noted a similar finding in our previous study in this cohort, where 75% of migrants with hypertension were undiagnosed and untreated.¹⁴ These findings have serious policy implications for morbidity and mortality in this relatively young population as well as significant cost implications for the healthcare system in the UAE.⁴⁷ Furthermore, these potentially devastating complications will have serious implications on the quality of life of these migrant workers. Expatriate workers are required to undergo mandatory health screening to obtain a new visa or renew existing visa. There is an urgent need to make a policy decision to include screening aimed at identifying obesity, hypertension and type 2 diabetes to help mitigate the complications related to the delayed identification of common cardiometabolic diseases.

In conclusion, we found a significant association between duration of residency in the UAE and the prevalence of diabetes in a representative sample of male South Asian expatriate workers living in the UAE. The increase in prevalence of pre-diabetes and type 2 diabetes in association with increased duration of residence in the UAE was steeper than that observed among migrants in other Western developed countries. We speculate that length of residence is a proxy for acculturation whereby a migrant culture, in this case migrant workers from India, Pakistan and Bangladesh, acquires the habits of the host UAE culture. After 5 years of residence in the UAE, male South Asian expatriate workers may develop a penchant for sugary beverages, increased portion sizes, snacking and processed convenience foods. An energy-dense diet coupled with low levels of physical activity



may play a significant role in the pathogenesis of obesity and diabetes among long-term South Asian residents in the UAE, possibly via phenotypic expression of unfavourable levels and/or distribution of adiposity. As such, there is a clear need for culturally appropriate preventive and health-promoting strategies to be implemented in this subgroup that accounts for the largest proportion of the UAE migrant population. Such interventions should support the maintenance of an energy balanced and healthy diet, elevated levels of physical activity and a healthy body size.

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REFERENCES

- International Diabetes Federation. IDF atlas, 9th ED. Brussels, Belgium. International diabetes Federation, 2019. Available: <http://www.idf.org/diabetes-atlas>
- Saeedi P, Salpea P, Karuranga S, *et al*. Mortality attributable to diabetes in 20-79 years old adults, 2019 estimates: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Res Clin Pract* 2020;162:108086 [https:// doi.org/](https://doi.org/)
- Al-Rifai RH, Majeed M, Qambar MA, *et al*. Type 2 diabetes and pre-diabetes mellitus: a systematic review and meta-analysis of prevalence studies in women of childbearing age in the middle East and North Africa, 2000-2018. *Syst Rev* 2019;8:268.
- Hajat C, Harrison O, Al Siksek Z. Weqaya: a population-wide cardiovascular screening program in abu dhabi, United Arab Emirates. *Am J Public Health* 2012;102:909-14.
- Al-Adani A, Memon A, Suresh A. Pattern and determinants of dyslipidaemia in type 2 diabetes mellitus patients in Kuwait. *Acta Diabetol* 2004;41:41129-35.
- el Mugamer IT, Ali Zayat AS, Hossain MM, *et al*. Diabetes, obesity and hypertension in urban and rural people of bedouin origin in the United Arab Emirates. *J Trop Med Hyg* 1995;98:407-15.
- Sulaiman N, Albadawi S, Abusnana S, *et al*. High prevalence of diabetes among migrants in the United Arab Emirates using a cross-sectional survey. *Sci Rep* 2018;8:6862.
- United Arab Emirates Ministry of economy report. Available: <http://www.csc.unc.edu/uaee/public/UNLICOMMUAUE2005CensusResults07282008.pdf>
- Froilan T, Malit JR, AlYouha A. Labor migration in the United Arab Emirates: challenges and response. Available: <https://www.migrationpolicy.org/article/labor-migration-united-arab-emirates-challenges-and-responses>
- Al-Maskari F, Shah SM, Al-Sharhan R, *et al*. Prevalence of depression and suicidal behaviors among male migrant workers in United Arab Emirates. *J Immigr Minor Health* 2011;13:1027-32.
- Mishra SR, Ghimire S, Joshi C, *et al*. Cardio-metabolic disease risk factors among South Asian labour migrants to the middle East: a scoping review and policy analysis. *Global Health* 2019;15:33.
- Shah SM, Loney T, Dhaheri SA, *et al*. Association between acculturation, obesity and cardiovascular risk factors among male South Asian migrants in the United Arab Emirates--a cross-sectional study. *BMC Public Health* 2015;15:204.
- Ali R, Loney T, Al-Houqani M, *et al*. Cigarette smoking and smokeless tobacco use among male South Asian migrants in the United Arab Emirates: a cross-sectional study. *BMC Public Health* 2020;20:15.
- Shah SM, Loney T, Sheek-Hussein M, *et al*. Hypertension prevalence, awareness, treatment, and control, in male South Asian immigrants in the United Arab Emirates: a cross-sectional study. *BMC Cardiovasc Disord* 2015;15:30.
- Banegas JR, Ruilope LM, de la Sierra A, *et al*. Relationship between clinic and ambulatory blood-pressure measurements and mortality. *N Engl J Med* 2018;378:1509-20.
- Flack JM, Casciano R, Casciano J, *et al*. Cardiovascular disease costs associated with uncontrolled hypertension. *Manag Care Interface* 2002;15:28-36.
- Argeseanu Cunningham S, Ruben JD, Narayan KMV. Health of foreign-born people in the United States: a review. *Health Place* 2008;14:623-35.
- Oza-Frank R, Stephenson R, Narayan KMV. Diabetes prevalence by length of residence among US immigrants. *J Immigr Minor Health* 2011;13:1-8.
- Anderson C, Zhao H, Daniel CR, *et al*. Acculturation and diabetes risk in the Mexican American Mano a Mano cohort. *Am J Public Health* 2016;106:547-9.
- Commodore-Mensah Y, Ukonu N, Obisesan O, *et al*. Length of residence in the United States is associated with a higher prevalence of cardiometabolic risk factors in immigrants: a contemporary

- analysis of the National health interview survey. *J Am Heart Assoc* 2016;5:e004059.
- 21 Zheng Y, Lamoureaux EL, Ikram MK, *et al.* Impact of migration and acculturation on prevalence of type 2 diabetes and related eye complications in Indians living in a newly urbanised Society. *PLoS One* 2012;7:e34829.
 - 22 Goel MS, McCarthy EP, Phillips RS, *et al.* Obesity among US immigrant subgroups by duration of residence. *JAMA* 2004;292:2860–7.
 - 23 World Health Organization. Chronic diseases and health promotion: stepwise approach to surveillance. Available: <http://www.who.int/chp/steps/en>
 - 24 Haskell W, Lee IM, Pate RR, *et al.* Physical activity, and public health—updated recommendations for adults from the American College of sports medicine 2007;39:1423–34.
 - 25 World Health Organization Obesity. *Preventing and managing the global epidemic: report of a who consultation, world Health organization.* Geneva, 2000.
 - 26 World Health Organization Waist Circumference and Waist-Hip Ratio. *Report of a who expert consultation.* Geneva, 2008: 8–13.
 - 27 American Diabetes Association. 2. classification and diagnosis of diabetes. *Diabetes Care* 2015;38:S8–16.
 - 28 Hosmer DW, Lemeshow S. *Applied logistic regression.* New York: John Wiley & Sons, 1989.
 - 29 Reddy KS, Yusuf S. Emerging epidemic of cardiovascular disease in developing countries. *Circulation* 1998;97:596–601.
 - 30 Shah SM, Ali R, Loney T, *et al.* Prevalence of diabetes among migrant women and duration of residence in the United Arab Emirates: a cross sectional study. *PLoS One* 2017;12:e0169949.
 - 31 Hajat C, Harrison O, Shather Z. A profile and approach to chronic disease in abu Dhabi. *Global Health* 2012;8:18.
 - 32 Fan W, Lee DH, Billimek J, *et al.* The changing landscape of diabetes prevalence among first-generation Asian immigrants in California from 2003 to 2013. *BMJ Open Diabetes Res Care* 2017;5:e000327.
 - 33 Sanou D, O'Reilly E, Ngnie-Teta I, *et al.* Acculturation and nutritional health of immigrants in Canada: a scoping review. *J Immigr Minor Health* 2014;16:24–34.
 - 34 Kanaya AM, Herrington D, Vittinghoff E, *et al.* Understanding the high prevalence of diabetes in U.S. South Asians compared with four racial/ethnic groups: the MASALA and MESA studies. *Diabetes Care* 2014;37:1621–8.
 - 35 Narayan KMV. Type 2 diabetes: why we are winning the battle but losing the war? 2015 Kelly West Award Lecture. *Diabetes Care* 2016;39:653–63.
 - 36 Shah AD, Vittinghoff E, Kandula NR, *et al.* Correlates of prediabetes and type II diabetes in US South Asians: findings from the MASALA study. *Ann Epidemiol* 2015;25:77–83.
 - 37 Raj S, Ganganna P, Bowering J. Dietary habits of Asian Indians in relation to length of residence in the United States. *J Am Diet Assoc* 1999;99:1106–8.
 - 38 Knowler WC, Barrett-Connor E, Fowler SE, *et al.* Diabetes prevention program Research Group. reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med* 2002;46:393.
 - 39 Bowen L, Ebrahim S, De Stavola B, *et al.* Dietary intake and rural-urban migration in India: a cross-sectional study. *PLoS One* 2011;6:e14822 <https://doi.org/>
 - 40 Burden ML, Samanta A, Spalding D, *et al.* A comparison of the glycaemic and insulinaemic effects of an Asian and a European meal. *Pract. Diab. Int.* 1994;11:208–11.
 - 41 Novotny R, Williams AE, Vinoya AC, *et al.* Us acculturation, food intake, and obesity among Asian-Pacific hotel workers. *J Am Diet Assoc* 2009;109:1712–8.
 - 42 Ng SW, Zaghoul S, Ali H, *et al.* Nutrition transition in the United Arab Emirates. *Eur J Clin Nutr* 2011;65:1328–37.
 - 43 Jayawardena R, Ranasinghe P, Byrne NM, *et al.* Prevalence and trends of the diabetes epidemic in South Asia: a systematic review and meta-analysis. *BMC Public Health* 2012;12:380.
 - 44 Sattar N, Gill JMR. Type 2 diabetes in migrant South Asians: mechanisms, mitigation, and management. *Lancet Diabetes Endocrinol* 2015;3:1004–16.
 - 45 Yuan X, Liu T, Wu L, *et al.* Validity of self-reported diabetes among middle-aged and older Chinese adults: the China health and retirement longitudinal study. *BMJ Open* 2015;5:e006633.
 - 46 Li H-L, Fang J, Zhao L-G, *et al.* Personal characteristics effects on validation of self-reported type 2 diabetes from a cross-sectional survey among Chinese adults. *J Epidemiol* 2020;30:516–521.
 - 47 Al-Maskari F, El-Sadig M, Nagelkerke N. Assessment of the direct medical costs of diabetes mellitus and its complications in the United Arab Emirates. *BMC Public Health* 2010;10:679 <http://www.biomedcentral.com/1471-2458/10/679>