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Effects of dietary and lifestyle management on type 2 diabetes development among ethnic minority adults living in the UK: A generational shift

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ABSTRACT

Type 2 diabetes (T2D) is increasing among Asian, African, and Caribbean (AAC) populations in the UK, where diet and lifestyle are the main modifiable factors. The effect of generation on the onset of T2D in relation to dietary and lifestyle habits is unclear in these ethnic communities in UK. Thus, the study aims to investigate this issue along with whether generation of AAC, living in the UK differs in terms of the prevalence of T2D. The current study incorporated longitudinal self-reported data for 3459 AAC adults aged 25+ years using wave 7 (data collected in 2016) & 9 (data collected in 2019) from the UK Household Longitudinal Study data. A Chi-square test was used to examine the difference in prevalence of T2D among ethnic generations. Logistic regression was used to determine the risk of T2D in terms of dietary and lifestyle habits adjusting for covariates. Significantly higher prevalence of T2D existed in the first-generation (5.0%) than the second-generation (1.9%) ($p < 0.001$). Findings were consistent after adjusting for gender, residence type, country of residence, sleep quality, high blood pressure, long-standing illness, and age. Consuming two or less vegetables and more than two fruits portions per day with (odds ratio, OR 1.92, 95% confidence interval, CI 1.02, 1.64); (OR 3.72, 95% CI 1.08, 12.82) respectively, and walking weekly (OR 2.30, 95% CI 1.20, 4.41). However, the confounding effect of age in terms of more than two vegetable portions, two or fewer fruits portions, non-smokers, alcoholic and non-alcoholic respondents was non-significant. Findings suggest that people from first-generation, have higher odds of developing diabetes, despite having the same lifestyle as second-generation (fruit and vegetable consumption, exercise, non-smokers, and alcohol). Further research is required to examine these factors more specifically.

1. Introduction

Non-communicable diseases (NCD) contribute to most health problems worldwide and are the main drivers for causing disability (Global Burden of Disease Study, 2017). An increase in disability globally was observed due to metabolic conditions such as type 2 diabetes (T2D) (Global Burden of Disease Study, 2017). A rapid burden of diabetes in adults is observed in the UK, and the prevalence increases over time (Diabetes UK, 2019). The higher risk group of T2D includes ethnic populations such as Asian or African or Caribbean (AAC) people (Diabetes UK, 2019). Besides disability, diabetes is also one of the top ten causes of death worldwide today (Ahmed et al., 2020); thus, it has become a common disease that needs health emergencies.

Jointly genetic, epigenetic, and environmental factors are related to T2D (Ahmed et al., 2020; Prasad and Groop, 2015; World Health@Organization, 2021). Environmental means modifiable factors include dietary behaviour and physical activity (Prasad and Groop, 2015). Ethnic minorities such as Asians genetically carry fewer β-cells, and over the life-course failure of those cells leads to diabetes (Bhopal, 2013). Thus, to reduce cardio vascular disease (CVD) risk and improve health in adults, prevention of T2D demands priority by enhancing a healthy diet and lifestyle globally (Hu, 2011). It is because more than half of the T2D cases are possible to prevent or delay by maintaining a healthy lifestyle and dietary habits (Diabetes UK, 2019). South Asians develop T2D with lower BMI, at earlier age, and suffer from the complication of diabetes quickly. The lack of physical activity, sedentary behaviour, and low nutrition quality are some of the key factors for developing T2D (Hills et al., 2018). Diagnose of diabetes at earlier age increase the risk of vascular disease and all-cause mortality (Nanayakkara et al., 2021).

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Dietary habits are dynamic and are influenced by individual choice, health benefits, and culture, where the people grow and live for a long time (Pieroni et al., 2007). Thus, the choice of fruits and vegetables, the amount of daily consumption, and the cooking style differ due to acculturation and affect T2D prevention and development. In general, unhealthy dietary habits triggered the global burden of disease (GBD 2016 Risk Factors Collaborators, 2017), causing diabetes (Ueno et al., 2021), cardiovascular disease ("CVD") (Shan et al., 2020), and certain cancers, for example, Pancreatic cancer (Azeem et al., 2016), and esophageal cancer (Ye et al., 2021). Most Asian immigrants in the UK originally come from Bangladesh, India, and Pakistan. The staple food of those ethnic groups includes rice, chapatti, paratha, cereals, roti, vegetables, pulse, fish and meat. However, food habits and food processes varied due to their origin (Carlson et al., 1984; Gilbert and Khokhar, 2008).

The African Caribbean (AC) diaspora living in the UK are from different locations such as Caribbean islands or West Indies, Creoles, Jamaica, Barbados, St Kitts, St Lucia, Montserrat, and Trinidad (Sharma and Cruickshank, 2001). The food menu of this population varies by their origin, and primarily what they consume are starchy vegetables, potato, cassava, yam, rice, corn, and wheat as plant-based diets (Mennen et al., 2001). The dietary and food preparation also varies according to their origin. Some eat boiled vegetables, soups, curries, roast, and fried meat using lamb, beef, chicken, mutton, or goat (Sharma and Cruickshank, 2001). AC people changed their traditional dietary habits to the host countries' diets after migrating to different European countries. However, the level of deviation from a traditional diet to the host country level differs where they migrated. For example, those who live in Spain changed to host countries' dietary habits mostly (Gilbert and Khokhar, 2008). However, the immigrants who lived in the UK revealed little change in their traditional dietary habits (Sharma and Cruickshank, 2001).

The changing pattern of such modifiable factors like dietary behaviour for different generations in ethnic populations is unclear yet in literature, particularly in the UK, as most of the publications present the evidence for the immigrant population in the US. The evidence indicates that unhealthy dietary habits such as low fruit and high fast food existed due to long-time acculturation in Latina immigrants in the USA and the adoption of the local dietary trends (Kasirye et al., 2005). Acculturated first-generation Chinese Americans consume more sweets, fatty foods, and soft drinks, and thus were advised to reduce such unhealthy diets; while the second generation was advised to follow a healthy lifestyle including more fruit and vegetable consumption (Lv and Cason, 2004).

The fourth prominent risk factor for mortality worldwide is deemed as sedentary activity (Ranasingheet al., 2013). A lower level of physical activity is found to be in SA born outside the UK (first-generation) than those born inside the UK (second-generation). This difference can be partly explained by cultural differences (Williams et al., 2011). Past studies show that North African, AAC, and Mexican immigrants in Europe are less prone to taking sufficient physical exercise due to acculturation. Further, they are more likely to be overweight and obese and developing diabetes (Gilbert and Khokhar, 2008).

Socio-cultural factors influence the likelihood of becoming a smoker or drinker (Best et al., 2001). Among the Indians, Pakistanis, and African Caribbeans (AC), smoking and alcohol drinking habits are reported more by the second generation than the first generation (Wang and Li, 2019). Study reveals that either active or passive smoking and alcohol drinking enhance the earlier onset of T2D (Johnson et al., 2001a; Zhang et al., 2011).

There are only two studies (Farmaki et al., 2022; Wang and Mak, 2020) that focused on T2D risk in ethnic generations for the immigrant population in the UK. Farmaki et al. (2022) examined T2D risk in the second generation and the first generation AAC, European, mixed European/Asian, mixed European/African Caribbean aged 40-69 years. However, the authors did not include young adults though younger people are diagnosed with T2D, and the study was based on UK data from 2006 to 2010, as younger people are diagnosed with T2D, and they did not examine the effect of dietary and lifestyle habits separately. Moreover, they did not find any significant effect of diet on T2D risk in these populations and dropped dietary variables from the mediation analysis. The second study by Wang and Mak (2020) found no significant generational difference in T2D risk in AAC adults highlighting insignificant lower odds for the second-generation than the first-generation. The study did not consider analysing data stratified for smoking, physical activity, alcohol intake, and following recommended levels of fruits and vegetable consumption to examine the effect of dietary and lifestyle habits. Evidence suggests that South Asian, African and Filipino women and South Asian, African, Filipino, and Southeast Asian men were at higher risk of developing T2D at an earlier age than the UK individuals who live in Canada (Tenkorang, 2017).

Thus, the current study includes ethnic adults aged 25+ years to capture generational impact on T2D. Further, past studies (Wang and Mak, 2020) used cross-sectional design. Whereas our work is based on longitudinal design. The present study selected a healthy dietary group following the dietary recommendation of 2 or more servings per day of fruit and vegetable consumption separately (i.e. $\geq$400 g/day ($\geq$5 portions/day) combined f&v) by the WHO and England (Nasjonalt råd for ernæring, 2011). Data were analysed and stratified into two or more than two portions per day of fruits and vegetables and two or less portions of those elements per day following the UK dietary recommendation. Same procedure was followed for smoking, physical activity, and alcohol drinking as well to examine the effect of dietary and lifestyle habits on developing T2D in AAC adults.

The study thus aims to investigate whether generation has any effect on the onset of T2D in terms of these changing dietary and lifestyle habits. Moreover, whether the prevalence of T2D differs for generations among Asian, African and Caribbean, living in the UK.

2. Materials and methods

2.1. The data

This study incorporated longitudinal self-reported data for 3459 Asian, African and Caribbean adults aged 25+ years whose information are available in both waves, namely, wave 7 (data collected in 2016) and wave 9 (data collected in 2019), from a data size of 31668 respondents in total. It is a secondary data which was collected from Understanding Society, the UK Household Longitudinal Study (UKHLS) dataset. Moreover, to identify the new cases of T2D between 2016 and 2019, this study excluded respondents who had already T2D in wave 7. Thus, the analytical sample includes 2871 respondents who were free from T2D in the baseline period.

The UKHLS survey was initiated to collect data using a clustered and stratified probability sampling design in 2009–2010 from 40000 households who lived in the UK and visited them with new households each year to collect updated information (Knies, 2017; Jäckle et al., 2017). Kantar Public (formerly TNS BMRB) conducted fieldwork across Great Britain to the adults. Kantar Public research team asked to return the filled-up survey to them at the end of the fieldwork. The UKHLS used mixed mode (web, face-to-face and telephone) strategies using laptop, tab, telephone, and web questionnaire to collect data. The mixed mode reduces costs, enhances response rate and fieldwork efficiency. The fieldwork based on web-only ran from 4th May to 8th June, face-to-face interviews lasted from 7th June to 16th September and the final phase carried out from 16th September to 30th September. The final phase named as mop-up follow-up and facilitated individuals to respond through computer assisted personal interviewing (CAPI), computer assisted telephone interviewing (CATI) or Web interviewing. The response rate was the highest in wave 9. The overall household response rate was 84.7% and individual response rate was 76.8% in wave 9. Moreover, the longitudinal re-interview response rate for wave 7 refreshment sample was the highest in web 9 (82.7%) (Jäckle et al.,

2017). Wave 7 and wave 9 consists of all the information relevant to the studied variables and have the highest response rate, and thus the current study used these two waves' data in the analysis.

Economic and Social Council and several departments from England, Welsh, Scotland, and Ireland funded to Understanding Society (Knies, 2017). This study provides data to research longitudinally in health, social life, family, education, work, and income for the UK (including ethnic) population (Knies, 2017).

2.2. Data analysis

A Chi-square test was performed to examine the association between the prevalence of type 2 diabetes among ethnic first and second-generations. As the outcome variable T2D has two (binary) categories such as "yes" or "no", thus, binary logistic regression is appropriate. Therefore, multiple logistic regression was employed to quantify the risk of the onset of T2D in terms of dietary and lifestyle habits over the generations, adjusting for potential covariates. The authors examined the association between generation and the development of T2D with five models. These models were used to investigate whether this association was affected by other potential covariates by adding them step by step in models as mentioned below. Such model building strategy will help identifying any confounder. Dietary elements, such as fruit and vegetable intake were considered separately, ≤2 servings/day were set as the cut off for low intake levels in the current study following the dietary recommendation by the WHO and England (Nasjonalt råd for ernæring, 2011). The lifestyle habit elements are categorized keeping the original categorizations as the data collected namely walked weekly and not walked weekly, smoker and non-smoker, and alcoholic and non-alcoholic individuals. The five models were:

- Model 1: an unadjusted model,
- Model 2: adjusted for gender, residence type, country of residence,
- Model 3: adjusted for gender, residence type, country of residence, and sleep quality;
- Model 4: adjusted for gender, residence type, country of residence, sleep quality, high blood pressure and long-standing illness; and
- Model 5: adjusted for gender, residence type, country of residence, sleep quality, high blood pressure and long-standing illness and age.

A reference group is used to compare the results for each category of the exposure variables, such as, fruits and vegetables consumption, physical exercise, smoking and alcohol drinking habits. Following the methodology by Bruemmer et al. (2009) the reference group consists of the second^{+} generations individuals who had the lowest level of risk in developing T2D, and the first-generation individuals were compared with that reference group (Bruemmer et al., 2009). To keep all the studied independent variables free from multicollinearity Variance Inflation Factor (VIF) was calculated and found to be less than 5.0. Thus, these VIF values indicated no multicollinearity among the explanatory variables and satisfied the necessary condition for using binary logistic regression (Chatterjee and Hadi, 2006). Analysis was run by the statistical package for social sciences (SPSS) software version 28. The significance level was used at 5% level of significance.

3. Results and discussion

3.1. Background characteristics

The sociodemographic, dietary, lifestyle, and health status related characteristics with number of respondents and percentage of respondents in each category are revealed in Table 1. One-third of the studied respondents were from second and younger generations, consume recommended level, more than two portions per day, of fruits and vegetables. Every four in five respondents reported that they walk weekly, one in ten respondents reported they smoke, and 43.0% respondents reported that they drink alcohol in the last 12 months of the interview. The studied sample selected 39.0% young (25–40) respondents, while 61.0% of the respondents belong to more than forty years old. More than half (58.0%) of the respondents reported their gender as female. A very small proportion (2.0%) of the respondents were from rural, outside of England and suffering from high blood pressure. One in five respondents reported their sleep quality as bad. One-quarter of the respondents reported they had long-standing illness status at the time of the survey.

Table 1
Background characteristics of the studied variables.

Background characteristics	Number of respondents	Percentage
Generation		
First-generation	1928	67.2
Second- generation+	943	32.8
Fruits intake		
≤2 servs/day	1954	68.1
>2 servs/day	917	31.9
Vegetable intake		
≤2 servs/day	1884	65.6
>2 servs/day	987	34.4
Physical activity		
Walked weekly	2377	82.8
Not walked weekly	494	17.2
Smoking		
Yes	302	10.5
No	2569	89.5
Alcohol drinking		
Yes	1221	42.5
No	1650	57.5
Age		
25-40 years	1128	39.3
41-59 years	1292	45.0
60+ years	451	15.7
Gender		
Female	1665	58.0
Male	1206	42.0
Residence type		
Rural	62	2.2
Urban	2809	97.8
Country of residence		
England	2792	97.2
Wales/Scotland/Northern Ireland	79	2.8
Sleep quality		
Bad	569	19.8
Good	2302	80.2
High blood pressure		
Yes	70	2.4
No	2801	97.6
Long-standing illness		
Yes	752	26.2
No	2119	73.8
Total	2871	100.0

3.2. Prevalence of T2D in generations

The populations presented, demonstrated that there is a high prevalence of T2D. Table 2 shows that the prevalence of T2D is higher in the first-generation (5.0%) than the second-generation (1.9%) and this is significant at $p = 0.0001$). The overall prevalence of T2D is 4.0% in 25+ adults. Age-specific T2D prevalence for overall population was 2.0, 3.9 and 8.3% for the age groups 25–40, 41–59, and 60+ respectively (Chi-square = 58.27, $p < 0.0001$) [Table 3]. In line with our findings, adults in East London area showed their crude prevalence of T2D was 4.2% (Dreyer et al., 2009). A higher prevalence of T2D by age.and ethnicity was observed in UK South Asians (11.0%) and Black (8.0%) than the Caucasian population (3.5%) (Dreyer et al., 2009). In contrast, African origin adults who live in Cameroon, Jamaica and UK showed the prevalence of T2D 1.1%, 11.6% and 12.6%, respectively. These populations reported a beneficial effect of dietary elements on T2D development (Anderson et al., 2011).

Table 2
Difference in prevalence of type 2 diabetes among ethnic 1st and 2nd + generations using Chi-square test.

Disease condition	1st generation n (%)	2nd+ generation n (%)	Total n (%)	1st and 2nd+ generational difference using χ^2 analysis	
				χ^2 value	P value
Diagnosed Type 2 Diabetes	150 (5.0)	29 (1.9)	179 (4.0)	24.64	<0.0001
Not diagnosed Type 2 Diabetes	2857 (95.0)	1475 (98.1)	4332 (96.0)		

Note: n represents the number of respondents and values in the parenthesis indicates percentages.

Table 3
Difference in prevalence of type 2 diabetes among ethnic populations in terms of age group using Chi-square test.

Disease condition	Age group 25–40 n (%)	Age group 41–59 n (%)	Age group 60+ n (%)	Total n (%)	Difference in terms of age group using χ^2 analysis	
					χ^2 value	P value
Diagnosed Type 2 Diabetes	33 (2.0)	77 (3.9)	69 (8.3)	179 (4.0)	58.27	<0.0001
Not diagnosed Type 2 Diabetes	1650 (98.0)	1919 (96.1)	763 (91.7)	4332 (96.0)		

Note: n represents the number of respondents and values in the parenthesis indicates percentages.

Table 4 illustrates that physical activity, alcohol drinking, age, gender, and sleep quality are significantly associated with the T2D development. Moreover, more than six-in-ten respondents who developed T2D belong to the group who consume two or less portions of fruits and vegetable per day. Among the respondents who developed T2D around three-quarter of them walked weekly, non-alcoholic and belong to aged forty years and above. The studied sample of population covers 98% respondents from urban and from England. Among the respondents who developed T2D 66.0% reported good sleep quality, 96.0% had no high blood pressure, 90.0% were non-smoker, 45% had no long-standing illness, and 53% reported their gender as male.

3.3. Association between generation and the development of T2D in terms of vegetable and fruits consumption

The risk of developing T2D in relation to fruits and vegetables consumption was presented in Table 5. A significantly higher risk of developing T2D is found in first-generation than the second-generation respondents in those who intake two or fewer portions/day of vegetable (unadjusted Model 1: odds ratio, OR 2·50; 95% confidence interval, CI 1·38, 4·54), and in those who have an intake of more than two portions/day of vegetable (unadjusted model 1: OR 3·41; 95% CI 1·18, 9·84) (Table 5). However, these ORs revealed that first-generation respondents who consumed more vegetables had higher odds than those who consumed less. Moreover, this association remained significant even after the adjustments in Model 2 (OR 2·48; 95% CI 1·36, 4·51 for veg≤2 portions/day vs OR 3·45; 95% CI 1·20, 9·97 for veg>2 portions/day). The subsequent Model 3 (OR 2·62; 95% CI 1·44, 4·79 for veg≤2 portions/day vs OR 3·60; 95% CI 1·24, 10·47 for veg>2 portions/day) has remained significant. Model 4 (OR 2·32; 95% CI 1·27, 4·25 for veg≤2 portions/day vs OR 3·59; 95% CI 1·23, 10·48 for veg>2 portions/day) has also remained significant. The full adjusted Model 5 has also remained significant for less consumption of vegetables. The Model 5 is adjusted for gender, residence type, country of residence, sleep quality, high blood pressure, long-standing illness, and age, (OR 1·92; 95% CI @1·02, 1.64 for veg≤2 portions/day vs OR 2·65; 95% CI 0·87, 8·06 for veg>2 portions/day).

Thus, the above results clarified that first-generation respondents were more likely to develop T2D than the second generations in terms of less vegetable consumption. Similarly, in the case of fruits consumption, the unadjusted model revealed higher risk in first-generation than the second-generation on T2D development. This risk was more pronounced in respondents who intake more than two portions/day of fruits

Table 4
Percentage of different dietary and lifestyle habits in terms of type 2 diabetes development, n = 2871.

Variables	Type 2 diabetes		Difference in T2D development using χ^2 Test	
	Yes, n (%)	No, n (%)	χ^2 value	P value
Fruits intake				
>2 servs/day	31 (33.3)	886 (31.9)	0.09	0.770
≤2 servs/day	62 (66.7)	1892 (68.1)		
Vegetables intake				
>2 servs/day	26 (28.0)	961 (34.6)	1.76	0.185
≤2 servs/day	67 (72.0)	1817 (65.4)		
Physical activity				
Walked weekly	67 (72.0)	2310 (83.2)	7.80	0.005
Not walked weekly	26 (28.0)	468 (16.8)		
Smoking				
Yes	9 (9.7)	293 (10.5)	0.072	0.788
No	84 (90.3)	2485 (89.5)		
Alcohol drinking				
Yes	30 (32.3)	1191 (42.9)	4.15	0.042
No	63 (67.7)	1587 (57.1)		
Age				
25-40 years	20 (21.5)	1108 (39.9)	31.75	<0.0001
41-59 years	40 (43.0)	1252 (41.1)		
60+ years	33 (35.5)	418 (15.0)		
Gender				
Female	44 (47.3)	1621 (58.4)	4.50	0.034
Male	49 (52.7)	1157 (41.6)		
Residence type				
Rural	01 (1.1)	61 (2.2)	0.54	0.465
Urban	92 (98.9)	2717 (97.8)		
Country of residence				
England	01 (1.1)	78 (2.8)	1.01	0.315
Wales/Scotland/Northern Ireland	92 (98.2)	2700 (97.2)		
Sleep quality				
Bad	32 (34.4)	537 (19.3)	12.87	<0.0001
Good	61 (65.6)	2241 (80.7)		
High blood pressure				
Yes	04 (4.3)	66 (2.4)	2.38	0.123
No	89 (95.7)	2712 (97.6)		
Long-standing illness				
Yes	51 (54.8)	701 (25.2)	40.80	<0.0001
No	42 (45.2)	2077 (74.8)		

Table 5
The association between generation of Asians, Africans and Caribbeans and T2D new cases among adults aged 25+ years based on logistic regression. ORs for generation are for stratified data in terms of vegetable & fruit consumption, smoking, alcohol drinking, and physical activity level.

	Unadjusted Model 1		Adjusted Model 2		Model 3		Model 4		Model 5	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Generation (veg≤2 portions/day, n = 2211)										
2nd+ (ref.)	1.00		1.00		1.00		1.00		1.00	
1st	2.50	1.38, 4.54**	2.48	1.36, 4.51**	2.62	1.44, 4.79**	2.32	1.27, 4.25**	1.92	1.02, 1.64*
Generation (veg>2 portions/day, n = 1140)										
2nd+ (ref.)	1.00		1.00		1.00		1.00		1.00	
1st	3.41	1.18, 9.84*	3.45	1.20, 9.97*	3.60	1.24, 10.47*	3.59	1.23, 10.48*	2.65	0.87, 8.06
Generation (fruit≤2 portions/day, n = 2256)										
2nd+ (ref.)	1.00		1.00		1.00		1.00		1.00	
1st	2.22	1.22, 4.07**	2.20	1.20, 4.02*	2.32	1.27, 4.26**	2.17	1.18, 3.99*	1.75	0.92, 3.33
Generation (fruit>2 portions/day, n = 1009)										
2nd+ (ref.)	1.00		1.00		1.00		1.00		1.00	
1st	5.46	1.66,17.91**	5.42	1.65, 17.80**	5.72	1.74, 18.83**	5.11	1.54, 16.91**	3.72	1.08, 12.82*
Generation (non-smoker, n = 3057)										
2nd+ (ref.)	1.00		1.00		1.00		1.00		1.00	
1st	2.20	1.30, 3.71**	2.18	1.29, 3.69**	2.30	1.36, 3.90**	2.04	1.20, 3.46**	1.59	0.91, 2.77
Generation (Alcoholic, n = 1300)										
2nd+ (ref.)	1.00		1.00		1.00		1.00		1.00	
1st	2.74	1.17,6.41*	2.72	1.16,6.38*	2.85	1.21, 6.72*	2.80	1.18, 6.62*	2.29	0.93, 5.64
Generation (Non-alcoholic, n = 1816)										
2nd+ (ref.)	1.00		1.00		1.00		1.00		1.00	
1st	2.47	1.21, 5.02*	2.50	1.23, 5.08*	2.71	1.33, 5.53**	2.40	1.17, 4.93*	1.94	0.91, 4.18
Generation (Not walked weekly, n = 627)										
2nd+ (ref.)	1.00		1.00		1.00		1.00		1.00	
1st	2.53	0.96, 6.66	2.43	0.92,6.41	2.44	0.93, 6.42	1.93	0.72,5.17	1.77	0.62, 5.03
Generation (walked weekly, n = 2797)										
2nd+ (ref.)	1.00		1.00		1.00		1.00		1.00	
1st	2.93	1.58, 5.44***	2.91	1.57, 5.39***	3.20	1.72, 5.96***	3.06	1.64, 5.72***	2.30	1.20, 4.41*

Odds Ratio (OR), Confidence Interval (CI), Reference (Ref.) Group, Second and more (2nd+) generation, First (1st) generation, Model 1: Unadjusted. Model 2: Adjusted for Gender, residence type, country of residence. Model 3: Adjusted for Gender, residence type, country of residence and sleep quality. Model 4: Adjusted for Gender, residence type, country of residence, sleep quality, high blood pressure and long-standing illness. Model 5: Adjusted for Gender, residence type, country of residence, sleep quality, high blood pressure, long-standing illness and age. Statistically significant: ***p ≤ 0.001,**p ≤ 0.01, *p < 0.05.

(unadjusted model 1: OR 5·46; 95% CI 1·66, 17·91) compared to 2 or less portions/day of fruits (unadjusted Model 1: OR 2·22; 95% CI 1·22, 4·07) consumption. This association remained significant in adjusted Model 2 (OR 2·20; 95% CI 1·20, 4·02 for fruits≤2 portions/day vs OR 5·42; 95% CI 1·65, 17·80 for fruits>2 portions/day).

Similarly, Model 3 (OR 2·32; 95% CI 1·27, 4·26 for fruits≤2 portions/day vs OR 5·72; 95% CI 1·74, 18·83 for fruits>2 portions/day) has remained significant. Model 4 (OR 2·17; 95% CI 1·18, 3·99 for fruits≤2 portions/day vs OR 5·11; 95% CI 1·54, 16·91 for fruits>2 portions/day) has also remained significant. The full adjusted Model 5 showed significantly higher odds (OR 3.72; 95% CI 1·08, 12·82) for first-generation than the second-generation in those who consumed more than two portions fruits/day. However, those who consume two or fewer portions of fruits/day are found to be higher chance of developing T2D too albeit insignificant (OR 1.75; 95% CI 0.92, 3·33). Therefore, the above results demonstrate that first-generation respondents were more prone to develop T2D than the 2nd + generations in terms of more fruits consumption.

Higher odds to develop T2D in the respondents who intake recommended level of vegetable and fruits indicate that the difference in ORs might be due to their food quality, cooking style, or food processing. It increases the calories on food intake, for example, vegetables that are fried, have higher energy than steamed, SA cook using gee increasing obesity and risk of T2D (Simmons and Williams, 1997). If this interpretation is considered correct, the study recommends investigating further the effect of food process or cooking styles on T2D development over the generations. It emphasizes the quality of food and food preparation techniques maintaining health value. Thus, the recommended number of portions or amount of food is not enough to reduce the development of T2D but needs to maintain the health value of food.

Evidence suggests that diet is an essential factor in preventing diabetes (Pan et al., 1997). Fruits and vegetables are defensive against CVD (Hung et al., 2004). One study in Singapore among SA showed that vegetables as a total or specific kind of vegetables such as dark green leafy and cruciferous vegetables are protective against T2D (Chen et al., 2018). A higher prevalence and risk of diabetes was revealed in Pakistani individuals who live in the Netherlands than the native Dutch individuals (Raza et al., 2017). However, a contrasting result was revealed in terms of vegetable consumption in Pakistanis. Pakistani people reported higher consumption level of fruits, fruit juice and raw vegetable than the native Dutch individuals; nevertheless, native Dutch people reported higher consumption levels of cooked vegetables than the Pakistanis (Raza et al., 2017). In line with our interpretation, a study on immigrants who live in Madrid showed that the young generation intakes healthier diet (Montoya et al., 2003). Immigrants from these ethnic groups process their food in an unhealthy way, consume less-healthy food, pass the time under stress to get a settlement, and take less exercise, in addition to these factors, genetic factors are the main drivers of developing diabetes (Gilbert and Khokhar, 2008). Factors that reduce the risk of diabetes are related on quality of diet rather than quantity of dietary fat and carbohydrates. The risk to develop diabetes can be reduced by diet, including more fruits, vegetables, legumes and nuts; lowering the intake of red meat, sugar-sweetened beverages and moderate alcohol (Ley et al., 2014).

In line with our findings, a recent cross-sectional study (Farmaki et al., 2022) observed a lower risk of T2D in the second generation than the first-generation Asian and AC people who live in the UK. However, T2D development observed by Farmaki et al. (2022), did not find any significant effect of diet on T2D risk in these populations and dropped dietary variables from the mediation analysis. Farmaki et al. (2022) did not examine the effect of fruits and vegetables on T2D risk over ethnic generations, whereas the current study observed a significant effect of fruits and vegetables with a stratified analysis for a healthy dietary group following the dietary recommendation of 2 or more portions per

day of fruit and vegetable consumption separately (i.e. ≥400 g/day combined) by the WHO and England (Nasjonalt råd for ernæring, 2011). In contrast to our findings, Wang & Mak (2020) found insignificant lower odds for the second-generation than the first-generation in T2D risk in AAC adults.

There was no generational difference in fruits or vegetable consumption in different ethnic groups except Indians. However, the consumption level of fruits or vegetables was higher in UK Caucasians than all ethnic minority groups Wang & Li (2019). A study in UK used plasma vitamin C concentration levels to measure fruit and vegetable consumption levels and found lower fruit and vegetable intake among SA than Europeans (Carter et al., 2013). The study by Emadian et al. (2017) indicated that around three-quarters of the overweight, obese SA men consume sugar-sweetened beverages. Sugar-sweetened beverages are associated with T2D development. In contrast, in the USA, second and third-generation Asian individuals showed a higher meat intake than the first generation. Acculturation had an inverse association with vegetable and fibre intake. Dietary habits also vary in different ethnic groups, such as Southeast Asian Americans consume lower level of vegetables, and SA Americans consume higher dairy than the East Asian Americans (Ali et al., 2022).

Generational difference exists in knowledge about the culinary process regarding some specific food items, such as foods that taste bitter or aromatic – i.e., medicinal foods against diabetes, in Asian who live in Bradford, UK (Pieroni et al., 2007). Dietary modification or food habits differed in AC people in the UK based on cultural differences in their country of origin (Sharma and Cruickshank, 2001). In contrast, a review study reported that second-generation SA and AC tended to follow British dietary patterns. However, consumption of fruits and vegetables is reduced than the first-generation individuals (Landman and Cruickshank, 2001). An improved environment such as nutrition and public health which possess in second-generation than the first-generation SA who live in Glasgow resulting better height in second-generation and lowers the diabetes risk in them (Shams and Williams, 1997).

3.4. Association between generation and the development of T2D in terms of smoking

For non-smokers, higher ORs were observed for first-generation than the second-generation in developing T2D in unadjusted (model 1: OR 2·20; 95% CI 1·30, 3·71) as well as in other three adjusted models (for example, adjusted model 4: OR 2·04; 95% CI 1·20, 3·46) (Table 5). However, this association does not remain significant when Model 4 has adjusted for age (fully adjusted model 5: OR 1.59; 95% 0.91, 2.77). No significant results were found for smokers (data were not shown).

Second generation UK SA and BC showed higher smoking and alcohol drinking levels except for Bangladeshi and African in terms of smoking level. However, smoking and alcohol drinking were higher in UK Caucasians than all ethnic minority groups (Wang and Li, 2019). Asian, African and Caribbean population, in England and Wales, showed higher risk of T2D in those who smoke (Hippisley-Cox et al., 2009). A study in Southern California among American Indian adults found that smokers are at higher risk of T2D (Reid et al., 2010). However, those studies did not consider generational effect on T2D.

3.5. Association between generation and the development of T2D in terms of alcohol intake

Responders consuming or not alcohol have, higher ORs were for the first-generation than the second-generation in developing T2D in unadjusted and adjusted Models (1–5) (Table 5). For example, it is noted from the ORs that a higher odds was observed for alcohol consumption (Model 1: OR 2·74; 95% CI 1·17, 6·41 and adjusted Model 4: OR 2·80; 95% CI 1·18, 6·62) than the non-alcohol (Model 1: OR 2·47; 95% CI 1·21, 5·02 and adjusted Model 4: OR 2·40; 95% CI 1·17, 4·93) respondents. However, this association does not remain significant after adjusting Model 4 by age for both alcohol (model 5: OR 2·29; 95% CI 0.93, 5.64) and non-alcohol intake (Model 5: OR 1.94; 95% CI 0.91, 4.18) respondents.

Responders' intake or not intake alcohol had higher ORs for the first-generation than the second-generation in developing T2D in unadjusted and adjusted models (Models 1–4). For example, it is noted from the ORs that a higher odd was observed for those who intake alcohol (Model 1: OR 2·74; 95% CI 1·17, 6·41 and adjusted Model 4: OR 2·80; 95% CI 1·18, 6·62) than those who do not intake alcohol (Model 1: OR 2·47; 95% CI 1·21, 5·02 and adjusted Model 4: OR 2·40; 95% CI 1·17, 4·93). However, this association does not remain significant after adjusting Model 4 by age for these respondents.

In line to our findings Hispanic people in south central Los Angeles revealed an earlier onset of T2D in those who drink alcohol (Johnson et al., 2001b). The China Health and Nutrition Survey (1993–2011) demonstrates that T2D risk increases with heavy alcohol drinking. Moreover, this study violates the hypothesis of protective effect of moderate alcohol intake on T2D development observed by Ley et al. (2014) among Asian adults (Han et al., 2019).

3.6. Association between generation and the development of T2D in terms of physical activity

The generational difference was revealed in those who walked weekly with higher odds in first-generation than the second-generation in all 5 models (unadjusted model, Model1: OR 2·93; 95% CI 1·58, 5·44 and fully adjusted model, Model 5: OR 2·30; 95% CI 1·20, 4.41) (Table 5). One possible reason might be that second-generation SA do more physical activity, and thus they are more active than the first-generation individuals. Evidence suggests that physical activity levels differ in UK SA (Bhatnagar et al., 2015). Second-generation individuals indicate more positive attitudes in taking physical exercise than the first-generation, however, less than the White British. The positive attitude towards taking physical exercise was also noticed in second-generation SA adult women. The physical activity level was more prevalent in children than the SA adults. This finding indicates improved physical activity levels over the UK SA generations (Bhatnagar et al., 2015). SA do less physical activity than White Europeans (Biddle et al., 2019). SA in Scotland reported that long working hours, physically demanding work and household responsibilities are the barriers to taking required level exercise. Community-based intervention programmes might effectively overcome social and environmental difficulties (Morrison et al., 2014).

Admiraal et al. (2011) claimed that physical inactivity has a different effect on T2D in different ethnic groups. Those authors observed that physical inactivity was associated with T2D in the entire ethnic group and Dutch-Caucasians in the adjusted model; however, not in Hindustani and African Surinamese in the Netherlands. Similar findings were observed in the USA; physical activity is beneficial against T2D in Caucasian women. However, African American, Hispanic or Asian women showed no significant association in T2D development (Hsia et al., 2005). Sedentary lifestyles, such as more use of technological equipment, including cars, television viewing reduced energy expenditure, are the risk factors for T2D development (Nolan et al., 2011). A meta-analysis observed that lifestyle modification through diet and/or physical activity reduces T2D incidence by 35% in the SA population in Europe (Jenum et al., 2019). Lower risk of T2D was revealed in Korean adults who take a moderate level of sweat-inducing exercise. The authors suggested promoting such exercise in East Asians to prevent non-communicable diseases (Kim et al., 2019).

In contrast to our findings, a recent study found no effect of physical activity on T2D risk in SA and AC people who live in the UK, even though they observed a higher risk of T2D in the first generation than the second generation (Farmaki et al., 2022). The present study observed a significant effect of walking weekly in developing T2D in the studied ethnic generations.

3.7. Effects of confounders

The strength of the association between generation and T2D development was increased by more than 5.0% in Model 3 by the confounding effect of sleep quality. However, the strength of the association between generation and T2D development was decreased by around 10% in Model 4 by the confounding effect of high blood pressure and long-standing illness (Table 5). Further, the strength of the association between generation and T2D development was diminished more than 20.0% by the confounding effect of age in Model 5. Since the association between generation and T2D development in terms of dietary and lifestyle factors was affected by the inclusion of the covariates – sleep quality, high blood pressure, long-standing illness, and age in the regression model, thus, these covariates were identified as the strong confounders.

Type 2 diabetes risk is high in those who have an inadequate sleep and obstructive sleep apnoea problem, those who take daytime nap, less than 6 h per day sleep, those who go to bed at late night, and irregular timing to go to bed such as social jet leg (Larcher et al., 2015; Leng et al., 2016; Nolan et al., 2011).

Age and BMI are important issues for T2D; however, a recent (Farmaki et al., 2022) study did not focus mainly on particular dietary elements instead observed the social circumstances as the risk factor for T2D. This study did not include essential variables such as sleep quality and high blood pressure as the confounders (Farmaki et al., 2022). The current study observed a strong effect of sleep quality on T2D development in the studied ethnic generations. A study observed fewer adverse health behaviours or risk factors such as obesity, high blood pressure, HDL cholesterol to develop T2D in British born Pakistani women than the Pakistani immigrant women in the UK. The effect of early environment or variation in health behaviour might differentiate between these two groups (Pollard et al., 2008).

3.8. Strength and limitations

The strengths of the study are – first, it is based on longitudinal data, which allows for interpretation of the causal relationship between the studied variables. Second, there is a lower risk of reverse causation, and selection bias as the study used a prospective cohort. Third, the study used data for respondents with a wide range of ages, including young adults. Asian, African and Caribbean ethnic groups develop diabetes at a young age than the Caucasian population (Tenkorang, 2017). Thus, it will enable policymakers and health practitioners to plan for those young ethnic populations.

Limitations that could be considered are – first, self-reported data. Self-reported data are not free from bias (Ahmed et al., 2020). It is because the number of portions of fruits and vegetables consumption might be misclassified or have recall bias or social desirability bias. Second, the follow-up period is very short, only three years. Thus, the results' interpretation of causality has not been done, and the authors are cautious about it. Causality interpretation is more suitable for randomized control trials (Nettleton et al., 2008). Third, data are from two-time points: baseline data measured exposures and confounders and follow-up period measured outcome or T2D onset. Thus, it is limited to mediation analysis (Ahmed et al., 2020). There might have misclassification in T2D and T1D, and T2D and autoimmune diabetes for adults and vice versa (Olofsson et al., 2017). A lower risk and outcome misclassification might occur as around one-quarter of the diabetes cases are undiagnosed in the UK. It might result in lower prevalence and under-estimating this disease risk (Ahmed et al., 2020; Diabetes UK, 2019). The study measured physical activity as the respondents walked weekly. The length of the exercise was not reported. Thus, the study could not use recommended level of physical exercise due to a lack of data. It is a limitation how physical exercise-related information was handled. Met minutes (Ahmed et al., 2020) might provide better information to examine the effect of exercise on T2D development. Sixth, the study could not examine the effect of smoking due to the lack of a sufficient number of respondents in that stratified group. Thus, the study lacked information regarding quantifying the risk of smoking on T2D in different generations. Seventh, the study handled alcohol intake as either drinking alcohol or not—the lack of data limited to examining the effect of a specific amount of alcohol drinking per week. Eighth, the study could not examine the effect of dietary and lifestyle habits in different ethnic groups separately due to the lack of sufficient data for each ethnic population. Ninth, logistic regression provides ORs. There is a limitation in the interpretation of the odds. We often use odds as risk of the occurrence of an event, however, 'odds' does not represent the true risk. Odds exaggerates the association between the exposure and the outcome, that means, if relative risk, RR < 1 then odds is less than the RR, and if RR > 1 then odds is more than RR. Even though the RR and odds are interchangeable if the event rate is low (usually $<10\%$). Thus, interpretations of the results are not free from error (Ranganathan et al., 2015).

4. Conclusion

The current study confirms that first-generation immigrants (AAC) are at a higher risk of developing T2D than second-generation immigrants. The key factors leading to an increased risk for the development of T2D are dietary, lifestyle, sleep quality, high blood pressure, long-standing illness, and age. First generation respondents are more likely to develop T2D when the recommended level of fruits and vegetables are consumed. Although this paradox may appear confusing, the preparation of these fruits and vegetables is a significant factor to this outcome. The ORs might reflect the food quality, cooking style, the use of highly processed ingredients and high fat use. In reflection to the findings, the study recommends future research examines the effect of food processing and cooking techniques used by SA and AC that might contribute to T2D development in both generation groups. Moreover, future research is advised to investigate the quality of ingredients, and the methods they use to prepare their meals. Further, intervention studies about how can educate people to prepare their meals using healthier and more sustainable processes to improve their health through reducing the risk of developing T2D. Thus, the recommended number of portions or amount of food is not enough to reduce the development of T2D but instead a more holistic approach is required too to accurately ascertain the nutritional value of food consumed by participants.

Authors statement

Authors are declaring that the work described in this manuscript has not been published previously (except in the form of an abstract, a published lecture or academic thesis, see 'Multiple, redundant or concurrent publication' for more information), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright holder.

Implications for gastronomy

This study provides new information on the risk to develop T2D of immigrants in UK, where the second generation has lower risk to the first-generation from South Asian and African Caribbean people. The lifestyle is an important parameter that plays a role as well as the intake of fruits and vegetables. Contrary to the expected effect that the vegetable consumption do not give a protective factor to reduce the risk of T2D. Such an effect could be attributed to the way that those vegetables are prepared (cooking and processing techniques). Traditional ways of cooking include fried foods and vegetables that would increase the

calorie intake, as well as products like trans fatty acids formed during frying, which contributes to many cardiovascular diseases. Changes in traditional cooking should be implemented at restaurant setting as well as at educational level for chefs, food technologists. UK and across the world ethnic cuisine contribute to experiencing culture through dishes and local cuisine. Changing the cooking techniques that would achieve similar experiences to consumers, would improve healthy eating. Chefs would be able to influence people habit and teach through social media ways to cook culture appropriate foods that are healthy.

Declaration of competing interest

Authors have no conflict of interest.

Data availability

Data will be made available on request.

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