**The type 2 diabetes epidemic and key risk factors in Qatar: A mathematical modeling analysis**

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****Abstract****

**Introduction:** We aimed to characterize and forecast type 2 diabetes mellitus (T2DM) disease burden between 2021–2050 in Qatar where 89% of the population comprises expatriates from over 150 countries.

**Research Design and Methods:** An age-structured mathematical model was used to forecast T2DM burden and the impact of key risk factors (obesity, smoking, and physical inactivity). The model was parametrized using data from T2DM natural history studies, Qatar’s 2012 STEPwise survey, the Global Health Observatory, and the International Diabetes Federation Diabetes Atlas, among other data sources.

**Results:** Between 2021–2050, T2DM prevalence increased from 7.0%–14.0%, the number of people living with T2DM increased from 170,057–596,862, and the annual number of new T2DM cases increased from 25,007–45,155 among those 20–79 years of age living in Qatar. Obesity prevalence increased from 8.2%–14.6%, smoking declined from 28.3%–27.0%, and physical inactivity increased from 23.2%–26.9%. The proportion of incident T2DM cases attributed to obesity increased from 21.9%–29.9%, while the contribution of smoking and physical inactivity decreased from 7.1%–6.0% and 7.3%–7.2%, respectively. The results showed substantial variability across various nationality groups residing in Qatar—e.g., in Qataris and Egyptians, the T2DM burden was mainly due to obesity, while in other nationality groups it appeared to be multifactorial.

**Conclusions:** T2DM prevalence and incidence in Qatar were forecasted to increase sharply by 2050, highlighting the rapidly growing need of healthcare resources to address the disease burden. T2DM epidemiology varied between nationality groups, stressing the need for prevention and treatment intervention strategies tailored to each nationality.

**Keywords**: Non-communicable disease; body mass index; risk factor; forecasting model; mathematical modeling; expatriate; Middle East and North Africa; Asia

**Significance of this study**

**What is already known about this subject?**

* Diabetes has high prevalence among adult Qataris.
* Diabetes among Qataris is projected to increase substantially withing the coming decades.
* Diabetes burden among the expatriate resident population that constitutes 89% of the total population of Qatar is poorly characterized.

**What are the new findings?**

* By 2050, diabetes prevalence in Qatar is projected to double, while incidence is projected to increase by 80%, respectively.
* Diabetes burden and drivers of the epidemic varied substantially between the various nationalities residing in Qatar.
* While obesity is clearly the key driver of the diabetes epidemic among Qataris, this was not observed in most of the expatriate population in Qatar.

**How might it impact on clinical practice in the foreseeable future?**

* The characterization of diabetes in Qataris and the expatriate resident population informs prevention strategies and resource allocation.
* The high contribution of the expatriate population to incidence, but less so to prevalence, highlights the critical need for investment in prevention strategies.
* The mathematical model applied in this study can be used in future studies to assess impact of targeted prevention and intervention strategies.

****Introduction****

Diabetes mellitus (DM) is one of the fastest growing chronic conditions globally and is a key cause of cardiovascular diseases and premature death. Based on the 2019 International Diabetes Federation’s (IDF) Diabetes Atlas, 12.8% (4.8 million) of adults aged 20–79 years in the Middle East and North Africa (MENA) are estimated to be living with DM today, and this proportion is expected to reach 15.7% (25.2 million) by 2045[1](#_ENREF_1).

Type 2 DM (T2DM), which accounts for 90% of DM cases[1](#_ENREF_1), is linked to nonmodifiable (age, genetics, and socio-demographic factors, etc.)[1-4](#_ENREF_1) and modifiable (unhealthy diet, obesity, physical inactivity, tobacco use, and alcohol consumption, etc.)[3](#_ENREF_3)[5-7](#_ENREF_5) risk factors[8](#_ENREF_8)[9](#_ENREF_9). The risk of onset of T2DM increases with age. Incidence of T2DM accelerates for those 40-50 years of age[8](#_ENREF_8)[10](#_ENREF_10), but data are increasingly showing that it is occurring at younger ages in low-to-middle income countries compared to Western countries[10](#_ENREF_10). Evidence shows that the global epidemics of obesity and T2DM are closely linked, an association that has been consistent across populations and countries[7](#_ENREF_7)[8](#_ENREF_8)[11-13](#_ENREF_11). A systematic review and meta-analysis concluded that obesity increases the risk of T2DM by 7.2-folds (95% CI: 5.7–9.0)[7](#_ENREF_7). Studies have also reported lower T2DM prevalence in populations with higher levels of habitual physical activity[14](#_ENREF_14).

Qatar is part of MENA, with a population of 2.8 million in 2019, of which only 10.8% are Qataris and the remainder are expatriates from over 150 nationalities[15-18](#_ENREF_15). The sole DM nationally representative population-based survey (2012 Qatar STEPwise Survey[19](#_ENREF_19)) was conducted only among Qataris aged 18–64 years and estimated that DM, obesity, physical inactivity, and smoking prevalence were 10.4%, 41.5%, 40.0%, and 16.3%, respectively[20](#_ENREF_20). The DM burden and levels of DM risk factors among the expatriate resident population that constitutes 89.2% of the population remain poorly characterized. Though DM is recognized officially as the leading public challenge in Qatar [21](#_ENREF_21), we believe that governmental response has been challenged by the conspicuous absence of a thorough understanding of DM epidemiology, DM incidence, and drivers of incidence.

The objective of this study was to provide estimates and projections for DM prevalence among the major nationality groups residing in Qatar. Specifically, we investigated T2DM epidemiology and forecasted its evolution until 2050, by adapting and applying a published mathematical modeling approach to the total population of Qatar[22](#_ENREF_22). We provided levels and trends of T2DM prevalence and incidence, as well as of obesity, physical inactivity, and smoking prevalence between 2021–2050.

****Research Design and Methods****

**Mathematical model**

The Awad *et al.*[22](#_ENREF_22" \o "Awad, 2018 #443) model (for Qataris only) was extended and adapted to include all major nationality groups residing in Qatar. Model details, equations, and DM natural-history parametrization are in Awad *et al.*[22](#_ENREF_22). Briefly, the model is a population-based deterministic model consisting of a set of differential equations describing DM dynamics in the total population of Qatar (aged 0–99; Figure 1) and has been adapted and applied in several studies[23-26](#_ENREF_23).

The model stratified the population by nationality, sex, age, and T2DM status, as well as by the presence or absence of three major T2DM-related risk factors and their overlap: obesity, physical inactivity, and smoking. These risk factors were based on those identified as relevant and potentially modifiable through public health programs[20](#_ENREF_20)[22](#_ENREF_22)[24](#_ENREF_24). Data regarding these factors were available from population-level surveys[19](#_ENREF_19)[20](#_ENREF_20). Individuals were assumed to develop T2DM at rates that depend on their nationality, sex, age, and these risk factors.

**Data sources and model fitting**

Model input parameters were based on epidemiological and natural history data as listed in Figure 1 and Table S1 of Supplementary Material, or by fitting the model to existing data on T2DM, T2DM-related risk factors, and demographics for each nationality group. Sex- and age-specific T2DM incidence rate and risk factor-related transition rates were derived by obtaining the best model fit to the input data.

Eight nationalities representing the population of Qatar were included in the analysis: Bangladeshi, Egyptian, Filipino, Indian, Nepalese, Pakistani, Qatari, and Others (all remaining nationalities of Qatar residents). These eight groups each constitute >5% of Qatar’s total population[16](#_ENREF_16)[18](#_ENREF_18). The proportion of males, mean age, and overall proportion of Qatar’s total population for each expatriate resident population can be found in Table S2.

*DM and related risk factors for each nationality group*

*Qatari nationals:* Sex- and age-specific prevalence data for DM, obesity, smoking, and physical inactivity were obtained from the 2012 Qatar STEPwise Survey[19](#_ENREF_19)[20](#_ENREF_20).

*Expatriate nationality groups:* Given the absence of Qatar-specific data for the expatriate nationality groups, data were procured from their home countries. Sex- and age-specific DM prevalence in 2019 for each expatriate nationality group aged 20–79 years were assumed to be the same as those in the country of origin and were obtained from the 2019 IDF Diabetes Atlas[1](#_ENREF_1). Sex-specific obesity (between 1975–2016[27](#_ENREF_27)), smoking (between 2007–2008[28](#_ENREF_28)), and physical inactivity (in 2016[29](#_ENREF_29)) prevalence for each nationality group were also assumed to be the same as those in the country of origin and were obtained from the Global Health Observatory data repository.

To fit the actual obesity and smoking trends in the data, the rates for onset of these outcomes were parametrized to change over time using a logistic function. Meanwhile, given the availability of only one time point[29](#_ENREF_29), the physical inactivity rate was assumed constant—the population’s evolving demographic structure was the only driving factor of the temporal change in the physical inactivity prevalence.

*Demographics for each nationality group in Qatar*

The total population size by sex (including Qataris and expatriates) and its future projections were obtained from the database of the Population Division of the United Nations Department of Economic and Social Affairs[30](#_ENREF_30).

The proportion of Qataris out of the total population was assumed to change over time based on fitting of data reported in the Gulf Labour Markets, Migration, and Population Programme[31](#_ENREF_31) and Qatar’s Planning and Statistics Authority[16](#_ENREF_16)[18](#_ENREF_18) (Figure S1).

The proportion of each expatriate nationality group out of the total expatriate population was based on data from Qatar’s Planning and Statistics Authority[16](#_ENREF_16)[18](#_ENREF_18), and was assumed stable throughout the projected time horizon (Table S2). The age-specific population distribution for each nationality group (including Qataris) in 2019 was based on data of Qatar’s Planning and Statistics Authority[16](#_ENREF_16). Immigration and emigration were incorporated through age- and time-dependent rates that were derived by fitting the age-specific population size for each nationality group in 2019 and the total population by sex over time (Text S1 and Figure S2).

**Projecting the burden of T2DM and risk factors**

Using the best-fit parameters, sex- and age-specific prevalence of T2DM, obesity, smoking, and physical inactivity were projected between 2021–2050 in the population aged 20–79 years. Total numbers of prevalent and incident T2DM cases (i.e., the annual number of new cases) were also predicted. The effect of each risk factor on T2DM was also estimated through a population attributable fraction approach[22](#_ENREF_22)[32](#_ENREF_32). These estimates where reported for Qatar as a whole and for each nationality group.

**Sensitivity analyses**

To investigate the impact of population aging on projected T2DM burden (as opposed to other factors such as obesity), a sensitivity analysis was conducted where, from 2020 onwards, firstly, T2DM incidence rate was assumed independent of age (i.e., to control the effect of aging by using a uniform incidence rate for all ages). Secondly, to control the effect of obesity on the prevalence of T2DM, another sensitivity analysis was conducted. Here, as opposed to the predicted increase in obesity trend, the impact of a stable obesity prevalence between the years 2020 and 2050 was assessed. These analyses were only conducted for the Qatari population as the T2DM burden in this population is mainly driven by ageing and obesity[22](#_ENREF_22).

**Uncertainty analysis**

The 95% uncertainty intervals (UIs) around the projected T2DM outcomes were estimated with a multivariable uncertainty analysis of 1,000 model runs, applying Latin Hypercube sampling from a multidimensional distribution of the parameters[33](#_ENREF_33)[34](#_ENREF_34). In each run, we varied simultaneously the relative risk (RR) of mortality and of developing T2DM for individuals who are obese, smoker, and physically inactive. We used a ±30% uncertainty around the age- and sex-specific RRs of the mortality point estimates and a 95% confidence interval for the remaining parameters (Table S1). The T2DM model was refitted for each set of new input parameter values, and the 95% UIs were derived from the distribution of outcomes over the 1,000 model runs.

The mathematical model was implemented in, and all analyses were conducted using, MATLAB 2019a[35](#_ENREF_35).

****Results****

The model fitted population size, sex- and age-specific T2DM prevalence data, and data for the risk factors, obesity, smoking, and physical inactivity for each nationality. Figure S3 shows the model fits for Qataris and Figure S4 shows the model fits for the Indian nationality group as an example of one expatriate group.

**T2DM burden between 2021–2050**

T2DM prevalence among 20–79 years-old living in Qatar was projected to increase from 7.0% currently to 14.0% in 2050 (Figure 2A). That among Qataris increased from 17.1% to 29.5% in 2050. For expatriate groups, T2DM prevalence is lowest among Nepalese at 1.9% and highest among Egyptians at 13.2%, projected to reach 9.1% and 25.0% in those groups, respectively, in 2050 (Figure 2A and Table S3).

The number of T2DM cases in Qatar will increase from 170,057 to 596,862 in 2050 (Figure 2B). Most present cases were estimated among Indians (27% of all cases) followed by Qataris (14%), Bangladeshis (13%), Egyptians (10%), Nepalese (6%), and Pakistanis and Filipinos (5% each; Figure 2B). Other nationalities combined comprised 19% of cases (Figure 2B).

The annual number of new T2DM cases is expected to increase from 25,007 in 2021 to 45,155 in 2050 (Figure 3A). Throughout the next three decades, Indians are projected to comprise the largest number of new cases (34% of new cases), followed by Bangladeshis (16%), Egyptians (12%), Qataris (8%), Nepalese (8%), Filipinos (8%), and Pakistanis (5%; Figure 3B). Other nationalities combined comprised 10% of new cases (Figure 3B).

**Obesity, smoking, and physical inactivity from 2021-2050**

Obesity prevalence among persons 20–79 years-old living in Qatar increased from 8.2% in 2021 to 12.5% in 2050 (Figure 2C). Obesity prevalence among Qataris is substantially higher than that for other nationalities, 50.9% today and expected to reach 53.2% in 2050. In other groups, obesity prevalence was lowest among Bangladeshis at 3.0% in 2021 and 8.4% in 2050, and highest among Egyptians at 31.9% and 44.1%, respectively (Figure 2C).

Smoking prevalence among persons 20–79 years-old living in Qatar is expected to decline slightly from 28.3% in 2021 to 26.9% in 2050 (Figure 4A). Smoking prevalence among Qataris is lower than that of other groups, 17.6% presently, but increasing to 20.2% in 2050. In other nationality groups, smoking prevalence was lowest among Indians at 20.4% currently and 18.5% in 2050, and highest among Bangladeshis at 43.7% and 42.2%, respectively (Figure 4A).

Physical inactivity prevalence among those 20-79 years-old living in Qatar slightly increased from 23.1% today to 26.8% in 2050 (Figure 4B). Physical inactivity prevalence was highest for Qataris at 40.1%, rising to 45.3% by 2050. In other groups, physical inactivity prevalence was lowest among Nepalese at 12.2% in 2021 and expected to reach 17.7% in 2050. It was highest among Filipinos at 39.9% in 2021 and 44.0% in 2050 (Figure 4B).

**T2DM attributed to each risk factor between 2021-2050**

The proportion of incident T2DM cases attributed to obesity among those 20–79 years-old living in Qatar is expected to increase from 21.9% now to 29.9% in 2050. Among Qataris, the proportion of incident T2DM cases attributed to obesity should decrease slightly from 68.3% to 65.3% in 2050 (Figure 5). In other nationality groups in 2021, this proportion was lowest among Indians at 10.5% and highest among Egyptians at 56.9%. In 2050, this proportion is expected to be lowest among Nepalese at 14.9% and highest in Egyptians at 60.3% (Figure 5).

The proportion of incident T2DM cases attributed to smoking among those 20–79 years-old living in Qatar is anticipated to slightly decrease from 7.1% to 6.0% by 2050. For Qataris, the proportion of incident T2DM cases attributed to smoking may increase very slightly from 1.9% to 2.1% in 2050 (Figure 5). For other nationality groups in 2021, this proportion was lowest among Pakistanis at 4.8% and highest among Bangladeshis at 12.6%. In 2050, this proportion is projected to be lowest among Filipinos at 3.6% and highest among Bangladeshis at 10.7% (Figure 5).

The proportion of incident T2DM cases attributed to physical inactivity among those 20–79 years-old living in Qatar hovered around 7% between 2021-2050. In Qataris, the proportion of incident T2DM cases attributed to physical inactivity may increase very slightly from 4.2% in 2021 to 4.7% in 2050 (Figure 5). In other groups, this proportion at present is lowest among Nepalese at 4.2% and highest among Filipinos at 12.7%. In 2050, this proportion will be lowest among Egyptians at 4.0% and highest among Filipinos at 12.9% (Figure 5).

**Sensitivity analyses**

The two sensitivity analyses, conducted to investigate the impact of an aging population and obesity on the estimated T2DM trends, highlighted the role of aging on the increasing prevalence of T2DM. After the year 2020, when the T2DM incidence rate was assumed independent of age (to control the effect of aging), the prevalence of T2DM among Qataris increased only modestly from 17.1% to 19.3% (Figure S6A). However, when the obesity prevalence was held constant between the years 2020 and 2050 (to control the effect of obesity; Figure S6B), the prevalence of T2DM among Qataris increased substantially from 17.1% to 28.1% (Figure S6A). This outcome reflects the future role of ageing on the growing prevalence of T2DM in Qatar.

**Uncertainty analysis**

The uncertainty analysis results for the trend in T2DM prevalence between 2021–2050 in the 20–79-year-old population living in Qatar is shown in Figure S7. Despite the uncertainty in input parameters, the uncertainty range of the predicted T2DM prevalence was relatively small, supporting the consistency of the above estimates.

****Discussion****

T2DM prevalence in Qatar is currently estimated in this study at 7%, just below the global average of 9%[1](#_ENREF_1), but is projected to double by 2050, mainly due to population aging[9](#_ENREF_9) (Figure S6A), especially for Qataris who constitute the permanent population of this country (Figure S5 shows the increase in mean age for each nationality group in Qatar). Increasing T2DM prevalence coupled with population growth forecast a sharp increase of people living with T2DM from just over 170,000 at present to nearly 600,000 in 2050 highlighting the rapidly growing need for healthcare resources to address the diabetes disease burden in this country. Obesity was the leading driver of T2DM incident cases with a projected increase from 19% today, to 28% by 2050. Smoking and physical inactivity contributed to this incidence at around 8% each between 2021–2050.

This study is the first to estimate the burden of T2DM in the total population of Qatar, and its variation by nationality in this unique country where 89% of the resident population comprises expatriates (mainly males) from over 150 countries[15-18](#_ENREF_15). We found that the T2DM burden and drivers of the epidemic varied substantially by nationality. For instance, T2DM prevalence among Qataris and Egyptians was much higher than that among Nepalese and Filipinos, among others (Figure 2).

While obesity is clearly the key driver of the T2DM epidemic among Qataris, this was not observed in most of the expatriate population in Qatar (Figure 5). One-quarter of T2DM cases among expats were related to obesity, while more than half of the cases appeared to be related to other factors. Since the majority of expats are of Asian ethnicity, these factors could include reduced insulin secretory function/increased insulin resistance, increased visceral fat in people with low BMI, and young onset of DM[36-39](#_ENREF_36). Evidence suggests that people of Asian ancestry have about 5-6 times higher risk of developing DM than White Europeans[38](#_ENREF_38)[40](#_ENREF_40). Further research within Qatar is needed to understand the drivers behind the T2DM burden in the country, specifically in the expatriate population groups.

One key finding of this study is that, unlike in other permanent populations, the contribution of incidence versus prevalence is remarkably different and varies by nationality, as most expatriates do not typically reside more than two decades in Qatar[16](#_ENREF_16)[18](#_ENREF_18). This means that different contributions of individual nationality groups to incidence versus prevalence result from the interplay of immigration, emigration, and aging for each nationality. As illustrated in Figure S5, the mean age among the expatriates ranged within a small interval of 30-40 years between 2021 and 2050, as a consequence of expatriates staying for only a decade or so in Qatar, and thus the lower overall prevalence of T2DM in Qatar. For example, Qataris contributed only 8% of incident cases versus 14% of prevalent cases. Meanwhile, Indians contributed 34% of incident cases versus only 28% of prevalent cases, due to emigration at older ages (Figures 2B and 3). This is especially true for the expatriate craft and manual workers who comprise 60% of the population in Qatar[41](#_ENREF_41). These workers are typically single men, aged 20–49 years, recruited to work in development projects, and mostly of Bangladeshi, Indian, Nepalese, and Pakistani nationalities[18](#_ENREF_18)[41](#_ENREF_41). The high contribution of these expatriate groups to incidence, but less so to prevalence, highlights the critical need for investment in prevention strategies. Many will develop DM and be diagnosed in Qatar, but may live the rest of their life with DM elsewhere after the end of their employment in Qatar.

Based on the 2019 IDF Diabetes Atlas[1](#_ENREF_1), 15.5% of adults in Qatar were estimated to be living with T2DM, which is substantially higher than that estimated in the present study. Differences in the T2DM levels and projections are in part due to differences in input data and the modeling methodology used for the projections—IDF based their estimates and projections on data from Qatar’s neighboring countries and using a logistic regression method for projection as opposed to a dynamical population-level model for T2DM and its key risk factors[1](#_ENREF_1). Also of note, compared to previous projections for T2DM among Qataris[22](#_ENREF_22), the T2DM epidemic among Qataris in the present study was forecasted to progress faster reaching higher T2DM prevalence by 2050 (Figure 2A). The main reason for this increase is the higher mean age of Qataris projected by 2050 (Figure S5). While the previous study projected a mean age of 38 years by 2050[22](#_ENREF_22), the present study projected a mean age of 48 years, based on updated demographic data from Qatar[9](#_ENREF_9)[11](#_ENREF_11)[31](#_ENREF_31)(Figure S5).

Predictions in this study may be limited by the representativeness of the model input data for each nationality, particularly the data on current levels of DM, obesity, smoking, and physical inactivity. We had to procure data from home countries for the expatriate nationality groups, as we did not have Qatar-specific data for these populations. Living in Qatar, behavioral factors impacting T2DM among expats may differ from their home countries. This highlights the need for nationally representative surveys in Qatar that include all national groups in the country.

BMI ≥30 kg/m2 was used to define obesity for all nationalities because it is standard to obtain from existing data[42](#_ENREF_42). However, the application of current BMI cut-off points for Asians may underestimate the level and impact of obesity on T2DM in these groups[36](#_ENREF_36)[37](#_ENREF_37)[43](#_ENREF_43)[44](#_ENREF_44). Current data do not indicate a clear BMI cut-off point for obesity among Asians. However, the World Health Organization has recommended a BMI cut-off point of 27.5 kg/m2 to potentially represent obesity among Asian populations[37](#_ENREF_37). Other studies on Asian populations have shown that even lower values might be compatible with a BMI of 30 in white European populations[44](#_ENREF_44). Another limitation could be the representativeness of the RR estimates of T2DM with respect to risk factors and disease-related mortality for the various population groups in Qatar. However, given that these RRs were pooled from multiple settings worldwide[5-7](#_ENREF_5), they should represent biological mechanisms that are probably universal in effect. The data on physical inactivity levels was self-reported and potentially inflated relative to objective biomarkers[45](#_ENREF_45). We conducted a multivariable uncertainty analysis to factor these uncertainties in the parameters. The analysis indicated rather narrow uncertainty intervals around point estimates, affirming our predictions (Figure S7).

In conclusion, T2DM burden in Qatar is projected to increase substantially over the next three decades with obesity being a leading driver of the epidemic. Among Qataris specifically, population aging is also a main driver of the increasing burden. Given the unique demographics of Qatar, T2DM incidence, prevalence, and attributed risk factors varied substantially between different nationality groups highlighting the need to investigate drivers of T2DM in each group. The contribution of incidence versus prevalence also varied by group, reflecting the interplay of immigration, emigration, and aging for the various groups. These findings stress the need for prevention and treatment intervention strategies tailored to each group’s needs. Given these ongoing demographic and epidemiological health transitions, ensuring long-run financial sustainability for a T2DM response in Qatar could be challenging. Therefore, population-level prevention and intervention strategies should be a priority to alleviate the growing T2DM burden.

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****Conflict of Interests****

**The authors have declared that no competing interests exist.**

****Data availability****

**The model’s MATLAB codes can be obtained by contacting the authors.**

****Ethics Approval****

This is a mathematical modelling study. The study design does not require ethical approval, informed consent of patients, or an approved protocol for the research project.

****Author Contributions****

**SFA and LJA designed the model. SFA conducted the analyses, analyzed and interpreted the** results, and wrote the first draft of the article. LJA conceived the study and contributed to the analyses and their interpretations. All authors contributed to data collection and acquisition, database development, discussion and interpretation of the results, and to the writing of the manuscript. All authors have read and approved the final manuscript.

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**Figure 1.** Description of the mathematical modeling methodology applied in this study. A detailed description can be found in Awad *et al.*[22](#_ENREF_22).

**Figure 2.** Projected type 2 diabetes mellitus (T2DM) prevalence for various nationality groups in Qatar between 2020–2050; **A)** T2DM prevalence (proportion) and **B)** total number of people living with T2DM, among persons aged 20–79 years. **C)** Model projections for obesity prevalence among the various nationality groups in Qatar between 2020–2050.

**Figure 3.** Projected type 2 diabetes mellitus (T2DM) incidence among the various nationality groups in Qatar between 2020–2050. **A)** The annual number of new T2DM cases and **B)** the proportion of new T2DM cases by nationality group, among persons aged 20–79 years.

**Figure 4.** Model projections for key type 2 diabetes mellitus (T2DM) risk factors among the various nationality groups in Qatar between 2020–2050. The figure shows the projected prevalence of **A)** smoking and **B)** physical inactivity, for persons aged 20–79 years.

**Figure 5.** Model p**rojections for the proportions of type 2 diabetes mellitus incidence attributed to obesity, smoking, and physical inactivity** among the various nationality groups in Qatar **in A) 2021 and B) 2050.**

Supporting Information

**Text S1.** Population growth, immigration and emigration, and mortality rates.

**Table S1.** Model assumptions in terms of parameter values.

**Table S2.** Characteristics of the expatriate resident population in Qatar based on Qatar’s Planning and Statistics Authority.

**Table S3.** Projected prevalence of type 2 diabetes mellitus by sex and nationality group.

**Figure S1.** Proportion of the total population that are Qatari nationals.

**Figure S2.** Model predictions for the population age-distribution of each nationality group in Qatar.

**Figure S3.** Model fitting for data on Qataris.

**Figure S4.** Model fitting for Indians residing in Qatar.

**Figure S5.** Model prediction for the mean age of each nationality group in Qatar.

**Figure S6.** Two sensitivity analyses to investigate the impact of population aging on T2DM burden.

**Figure S7.** Uncertainty analysis for the prevalence of type 2 diabetes mellitus (T2DM) in Qatar between 2020-2050.