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Preventing type 2 diabetes among Palestinians: comparing five future policy scenarios

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ABSTRACT

Objective: This paper aims to provide estimates of future diabetes prevalence in the West Bank, occupied Palestinian territory (oPt), and to compare five future policy scenarios for diabetes prevention.

Design: We created and refined a mathematical Markov model that integrates population, obesity and smoking trends to estimate future diabetes prevalence. Model parameters were derived from the literature. Diabetes incidence was estimated using DISMOD software. We developed the model for the Palestinian population based on data available for the period 2000–2010, and validated the model by comparing predicted diabetes prevalence to subsequent actual observed diabetes prevalence rates.

Setting: West Bank oPt.

Results: Palestinian diabetes mellitus prevalence estimated by the model (for adults aged 25 or more) was 9.7% in 2000, increasing to 15.3% by 2010. Prevalence in men increased from 9.1% to 16.9% and in women from 10.2% to 13.6%. Comparisons of the model results with the observed prevalence in the Palestinian Family Health Survey showed a close fit. The model forecasts were 20.8% for 2020 and 23.4% for 2030. A 2.8% reduction in diabetes prevalence could be achieved if obesity trends start to decline by 5% in a 5-year period. If obesity prevalence was reduced by 35% in 10 years, as suggested by the WHO, diabetes prevalence might be decreased by 20%.

Conclusions: The model estimates an increase in the prevalence of diabetes which poses a large challenge to the health system. However, if bold but reasonable action is taken, effective interventions could reduce diabetes prevalence and hence the number of patients with diabetes.

Strength and limitations in this study

- The model may be appropriate for most low-income and middle-income countries because it is simple, does not require sophisticated statistical software nor huge amounts of specific data.
- Not all relevant risk factors, such as physical inactivity, were included in the current model. Body mass index was used as a measure of obesity and finally the limited data available to estimate obesity trends for the Palestinian population.
- The model can provide estimates for future diabetes prevalence which can inform policy using different intervention scenarios that can target the specific risk factors.

people with diabetes (85 million).[1] However, this predicted increase was mainly based on demographic changes and the assumption that urbanisation is a satisfactory proxy for risk factors such as obesity, smoking and physical activity.[2]

In Palestine, a few epidemiological studies have focused on non-communicable diseases including diabetes.[3] Most studies were cross-sectional in nature and provided estimates of the current prevalence for diabetes and obesity. However, the estimates of future prevalence which are urgently needed for proper planning are not available. Furthermore, the estimates reported by the IDF and the Global Burden of Disease study are broad and do not apply specifically to the Palestinian context.[1 2] Thus, this paper aims to provide estimates of future diabetes prevalence in the West Bank, occupied Palestinian territory (oPt), and offer a modelling platform for policy decision-making.

METHODS

The model integrates information on population, obesity and smoking trends at a given point of time to estimate diabetes prevalence in the future using a Markov model. The

INTRODUCTION

The International Diabetes Federation (IDF) suggested that there will be approximately 365 million people with diabetes worldwide in 2011. The MENA (Middle East and North Africa) region will have the highest prevalence of diabetes (12.5%) and the second largest proportional increase in the number of

model is implemented in MS Excel and can accommodate different diabetes definitions.

We assume that the population can be divided into several pools: diabetes mellitus, obese, smoker and 'healthy' (eg, non-obese, non-smokers and people without diabetes). A proportion of the population in each pool moves through pathways to other states.

Population demographic trends are used to inform the relative size of the 'starting states', and transition probabilities are used to estimate the proportion of persons moving from the starting states to the diabetes and death states. There are two 'absorbing states': diabetes mellitus (DM)-related death and non-DM-related deaths. In this way, mortality competing risks are modelled. Potential overlaps between the healthy, obese and smoking groups are managed by calculating the conditional probabilities of membership.

Data needed

The model requires data by 10-year age and gender bands, starting at 25, ending 75+. Data needed for the initial year include population size and age distribution, diabetes prevalence, obesity prevalence, smoking prevalence and total mortality. Data needed for subsequent years for forecasting purposes include population projections, obesity and smoking trends. Data needed for incidence calculation include diabetes prevalence, total mortality and case-fatality. The sources of data used for trend and validation are listed in table 1. The Palestinian Demographic and Health Surveys and Ministry of Health Information Centre were the main sources of data used. The use of these secondary data was not needed.

Diabetes incidence and specific mortality were estimated using the methods developed by Barendregt et al.[4] The methods for diabetes incidence and specific mortality are described in the technical appendix. Diabetes incidence, case-fatality and mortality stratified by age and sex were

calculated using DISMOD programme based on three inputs with the assumption that these parameters are constant over time. However, this was taken into account when calculating the incidence parameter using trends in DISMOD: first diabetes prevalence for the year 2004 obtained from the Palestinian Demographic Health Survey, diabetes mellitus remission rate which was assumed 0 and diabetes mellitus relative risk (RR) for mortality which was estimated as proposed by Barendregt et al,[4] and based on the usual RR for mortality. The formula is

$$RR_{ADJ} = \frac{RR}{pRR + 1 - p}$$

Model validation

Model validation is an important aspect of any modelling exercise, frequently overlooked.

We developed a model for the West Bank, oPt, over the period 2000–2020. During that period, subsequent surveys were conducted in DHS 2004, PFHS 2006, PFHS 2010, Stepwise Survey 2010 and we compared the model outputs with the observed prevalence estimates.

Sensitivity analysis

We used the analysis of the extremes method (Briggs), consisting of running the model with all parameters set to a minimum and maximum realistic values. This is a very conservative approach, but allows a more transparent understanding of the weight of each parameter regarding model outcomes.

'What if' policy questions	Reference
Given a 2010 baseline: What will be the impact of a 5% relative reduction in obesity prevalence by 2015 on diabetes burden in the West Bank?	Ministry of Health, Turkey[5]
What will be the impact of a 5% relative reduction in obesity prevalence by 2020 on diabetes burden in the West Bank?	Assumption
What will be the impact of a 10% relative reduction in obesity prevalence by 2020 on diabetes burden in the West Bank?	Assumption
What will be the impact of halting the rise in obesity prevalence (15%) by 2020 on diabetes burden in the West Bank?	WHO[6]
What will be the impact of 35% relative reduction in obesity prevalence by 2020 (baseline 2010) on diabetes burden in the West Bank?	WHO-EMRO

Table 1 Population and prevalence of diabetes, obesity and smoking prevalence for the starting year 2000

2000	Population	Diabetes prevalence	Obesity prevalence	Smoking prevalence
Men (n=336 965)				
25–34	138 888	0.0133	0.159	0.594
35–44	92 050	0.0871	0.195	0.561
45–54	46 207	0.1516	0.353	0.525
55–64	28 582	0.2451	0.324	0.422
65–74	19 508	0.2467	0.298	0.331
75+	11 730	0.1774	0.268	0.331
Women (n=343 260)				
25–34	133 095	0.0052	0.213	0.041
35–44	86 979	0.0386	0.401	0.071
45–54	47 457	0.1522	0.564	0.064
55–64	36 124	0.2833	0.602	0.054
65–74	25 670	0.3294	0.432	0.033
75+	13 935	0.3696	0.354	0.033

Policy scenarios

Since there are no current targets for adult obesity at the national level or for the West Bank, and since obesity is increasing and is predicted to continue to increase, we used a Mediterranean country, Turkey targets (scenario 1), WHO targets (scenario 4) and WHO regional targets (scenario 5). Further we proposed two targets which might be feasible (scenario 2) and ideal (scenario 3). These targets are set for population-based prevention.

RESULTS

Population characteristics at starting point

The prevalence of diabetes among the Palestinian population aged 25 and above, living in the West Bank in the year 2000 was 9.1% for men and 10.2% for women. The risk factors included in the study were obesity and smoking (table 2). Obesity is a common risk factor among the Palestinian population with 22.1% prevalence among men and 37.2% among women. Smoking prevalence was very high among men (53.7%) but very low among women (5.2%).

Risk factor trends 2000–2030

The changes in obesity and smoking prevalence were assumed to be linear with various degrees between men and women and within different age groups. Obesity prevalence was higher among women compared with men at 2000 with the highest prevalence observed for the ages 45–54 years and 55–64 years. The prevalence reached plateau at the age of 55–64 years and 65–74 years for women and 65–74 years for men. Obesity prevalence increased in men and women while smoking prevalence decreased in the period 2000–2030. The decrease in smoking prevalence varied between the age groups with a faster decrease among the older age groups.

Obesity prevalence has increased from 22.1% in men and 37.2% in women in 2000 to 29.1% in men and 39.6% women in 2010. Smoking trends decreased over 10 years period. Among men, smoking decreased from 53.7% in 2000 to 51.3% in 2004 and 49.4% in 2010. Among women, smoking prevalence almost halved between 2000 and 2010.

Diabetes incidence and total mortality

Diabetes incidence was estimated using DISMOD based on diabetes prevalence, total mortality, case-fatality and remission rate. The estimated incidence for the year 2004 ranged between 0.002 for those aged 25–34 years to 0.041 and 0.026 for men and women aged 55–64 years and 0.026 for men and 0.011 for women older than 65 years.

Model diabetes prevalence estimates

Palestinian diabetes prevalence estimated by the model (for those aged 25 or more) was 9.7% in 2000 (95% CI 7.9% to 11.6%), increasing to 15.3% (95% CI 12.3% to 17.6%) by 2010 (figure 1). Diabetes prevalence is predicted to increase rapidly between 2010 and 2020 and then the

increase starts to slow down. Prevalence in men increased from 9.1% (95% CI 7.3% to 11.0%) to 16.9% (95% CI 14.6% to 19.4%) and in women from 10.2% (95% CI 8.4% to 12.3%) to 13.6% (95% CI 11.3% to 15.8%).

Model validation

Comparisons of the model estimates with the observed prevalence in the Palestinian Family Health Survey showed a good fit. The observed prevalence was 10.6 versus 11.4% predicted in 2004, 11.8 versus 12.6% in 2006 and 13.8 versus 15.3% predicted using Stepwise survey results.

Diabetes prevalence projections

The forecasts were 20.6% (95% CI 18.5% to 23.7%) for 2020 and 21.5% (95% CI 20.7% to 25.8%) for 2030. The estimated number of patients with diabetes is expected thus to reach 215 000 in 2015, 289 000 in 2020 and 444 000 in 2030.

Policy scenarios

If trends in obesity start to decline by 5% starting in 2015, a reduction in diabetes prevalence of 8.3% could be achieved in 15 years (2030). If obesity declined by 10% in 10 years as a realistic target, a 5.3% reduction in diabetes prevalence of 11.1% might be expected. A more ambitious scenario assuming a 15% reduction in 10 years to achieve the WHO target might result in a 11.1%. However, achieving the EMRO-WHO target of a 35% obesity reduction in 10 years could result in 20.2% reduction in diabetes prevalence (table 2).

DISCUSSION

This paper provides, for the first time, Palestinian-specific future estimates for diabetes prevalence rather than just reporting point prevalence.

The predicted prevalence is worryingly high and is expected to increase by 35% from 2010 to 2020. This is entirely consistent with reports from the IDF.[2] The main factor fuelling this increase in diabetes prevalence is the expected continuing increase in obesity prevalence.[7] The starting point for obesity prevalence among women is relatively high and is higher than in men. However, men are catching up; their increase overtime is much faster than in women. Although in some countries obesity prevalence increases and then reaches plateau, this phenomenon is not observed in the Palestinian population yet. Hence obesity prevalence forecast was based on the past trend with the assumption of continuous increase.

The estimates of diabetes prevalence calculated from the model were comparable with actual diabetes prevalence measured in the period 2000–2010. The estimates of diabetes prevalence reported in this paper are believed to be more realistic compared with the estimates reported by the IDF and the Global prevalence of diabetes estimates which were critiqued for under estimating the prevalence of diabetes, probably as a result of using only demographic

Table 2 Prevalence of diabetes and the number of people with diabetes estimated for the period 2000 and 2030

Year	Baseline Estimated number		5% Obese reduction in 5 years Estimated number		Number	WHO target to halt obesity prevalence (15% in 10 years) Estimated number		Number	WHO-EMRO 35% obese reduction in 10 years Estimated number		Number	5% Obese reduction in 10 years Estimated number		Number	10% Obese reduction in 10 years Estimated number		Number
2015	215 042		211 219		3823	210 278		4764	206 673		8369	212 176		2866	211 219		3823
Min–Max	148 627	292 814	146 443	286 159		146 443	286 159		146 443	286 159		146 443	146 443		146 443	286 159	
2020	289 103		277 317		11 786	273 902		15 201	261 510		27 593	280 866		8236	277 317		11 786
Min–Max	207 052	398 856	198 010	372 107		198 010	372 107		198 010	372 107		198 010	198 010		198 010	372 107	
2025	365 597		342 837		22 760	335 582		30 015	310 687		54 910	350 552		15 045	342 837		22 760
Min–Max	272 271	515 599	251 930	456 947		251 930	456 947		251 930	456 947		251 930	251 930		251 930	456 947	
2030	444 296		407 308		36 988	394 879		49 416	354 622		89 674	420 837		23 458	407 308		36 988
Min–Max	342 629	641 053	307 266	541 257		307 266	541 257		307 266	541 257		307 266	307 266		307 266	541 257	

| Year	Estimated prevalence		Estimated prevalence		Per centage of reduction	Estimated prevalence		Per centage of reduction	Estimated prevalence		Per centage of reduction	Estimated Prevalence		Per centage of reduction	Estimated Prevalence		Per centage of reduction
2015	18.4		18.1		1.8	18.0		2.2	17.7		3.9	18.2		1.3	18.1		1.8
Min–Max	15.9	20.9	15.7	20.5		15.7	20.5		15.7%	20.5		15.7	20.5		15.7	20.5	
2020	20.6		19.8		4.1	19.6		5.3	18.7		9.5	20.1		2.8	19.8		4.1
Min–Max	18.5	23.7	17.7	22.1		17.7	22.1		17.7	22.1		17.7	22.1		17.7	22.1	
2025	21.6		20.2		6.2	19.8		8.2	18.3		15.0	20.7		4.1	20.2		6.2
Min–Max	20.1	25.3	18.6	22.5		18.6	22.5		18.6	22.5		18.6	22.5		18.6	22.5	
2030	21.5		19.7		8.3	19.1		11.1	17.1		20.2	20.3		5.3	19.7		8.3
Min–Max	20.7	25.8	18.5	21.8		18.5	21.8	2.2	18.5	21.8		18.5	21.8		18.5	21.8	
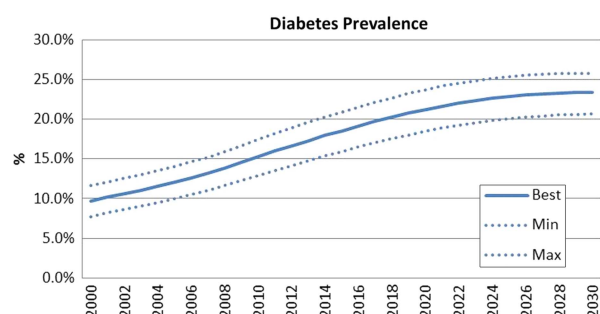
Figure 1 Diabetes prevalence forecasting between 2000 and 2030.

trends and urbanisation as a proxy for diabetes future incidence.[1] [2] [8] By contrast, our model used country-specific trends for diabetes risk factors including obesity and smoking in addition to the demographic trends, whereas the Global Burden of Disease (GBD) used urbanisation as a crude proxy measure for obesity and physical inactivity.[2] The estimates of the model and observed diabetes prevalence reported in national surveys were comparable.

We suggest that this model may be appropriate for most low-income and middle-income countries because it is simple, does not require sophisticated statistical software nor huge amounts of specific data. Furthermore, the model can provide estimates for future diabetes prevalence, which can inform policy using different intervention scenarios that can target the specific risk factors included in the model. Several estimates and projections for global or national diabetes prevalence studies are available.

This newly developed model has some limitations. First, models are simplifications of reality, and not all relevant risk factors, such as physical inactivity, were included in the current model. Reliable physical activity level measurements are difficult to obtain in most low-income and middle-income countries. However, the independent contribution of physical inactivity to diabetes incidence is low, suggesting that the impact of policies increasing physical activity levels in any case is likely to be modest. Second, BMI is an imperfect measure of obesity, visceral obesity (WHR) would be preferable, but its availability might not be as widespread as height and weight measurements. Third, limited data were available to estimate obesity trends for the Palestinian population. Having data on obesity for more than two points in time would improve the estimates for obesity trends. The model also assumes a constant incidence rate and case-fatality rates for the projections. These assumptions make the model estimates more conservative, as both will tend to underestimate the size of the prevalence pool. Despite these limitations, the model predictive ability, as compared with observed, independent estimates of diabetes prevalence seems to be good.

Policy scenarios and their importance

The paper discusses five population-based intervention policy options and assesses their impact on future diabetes prevalence. Since obesity prevalence is increasing and is predicted to continue to increase, we selected population-based interventions targeting obesity. The Palestinians have a national strategy for preventing the non-communicable diseases. However, this strategy did not set a target for obesity reduction, hence we used WHO, global and regional targets (EMRO), plus two additional targets, one feasible and one ideal. The ambitious targets set by the WHO (a 35% decrease in obesity) would achieve the highest reduction in diabetes prevalence, but might not be feasible. Setting a lower target initially followed by a higher target for longer term might be more realistic. The implementation of the proposed intervention needs to be investigated thoroughly.

Public health implications

The people in Palestine and the Middle East face an increasing prevalence of diabetes. Immediate action is needed to halt this public health disaster. Diabetes can be prevented mainly by policy interventions focusing on obesity reduction. A reduction in calorie intake was reinforced by increased physical activity.[9–11] The American Heart Association Council on Epidemiology and Prevention provided an ecological framework for obesity prevention that emphasised the importance of the social, environmental and political context and their powerful influence on the behaviour of families and individuals.[12]

Finally, this model has provided reasonably close estimates of diabetes prevalence for oPt over the 2000–2010 period, compared with values observed in contemporary independent surveys in the same population. The model also estimates a worrying increase in the future prevalence of diabetes and this will cause huge economic and healthcare problems.

However, if bold action is now taken, a substantial reduction in the diabetes prevalence and consequently the number of patients with diabetes could still be achieved.

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Ethics approval The Central Birzeit University's ethics committee has set out the rules for ethical conduct which we abide by very closely. Those entail maintaining confidentiality (and full disclosure to participants of the study and its importance), informed consent, maintaining the dignity of participants and doing no harm. Birzeit University wide rules stipulate in item 5 under General Guidelines that "Research entailing the use and/or analysis of already collected data, such as, for example, the Palestinian Central Bureau of Statistics data sets and other such data which was collected by various institutions and researchers; or research entailing reading texts and analysing for content, do not need ethics

reviews". As such, ethical review for this study was waived, given that the data was collected by others and did not reveal the identity of participants in any way.

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