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

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

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Key Words: Diabetes Prevalence, Modelling, Risk factor, Palestinian, West Bank

Article Summary

Article focus: This paper aims to provide estimates of future diabetes prevalence using simple mathematical model in oPt and to compare five future policy scenarios for diabetes prevention

Key messages:

- The prevalence of obesity and smoking among Palestinians is high
- The prevalence of diabetes will increase in 20 years resulting in a large number of diabetics.
- The target set by the WHO will result in major reduction in diabetes prevalence. However, there targets are not realistic given the time frame.
- Reducing obesity prevalence by 5% as a target is feasible and realistic.

Strength and limitation

- Strength: The model may be appropriate for most low and middle income countries because it is simple, does not require sophisticated statistical software nor huge amounts of specific data
- Limitation: Not all relevant risk factors, such as physical inactivity, were included in the current model. BMI was used as a measure of obesity and finally the limited data available to estimate obesity trends for the Palestinian population

Abstract

Objective: This paper aims to provide estimates of future diabetes prevalence in 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-Occupied Palestinian Territory

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 five-year period.. If obesity prevalence was reduced by 35% in 10 years, as suggested by the WHO, diabetes prevalence might be decreased by some 20%.

Conclusions: The model is estimating an increase in the prevalence of diabetes which will pose 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 diabetic patients.

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

In Palestine, 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. Further, the estimates reported by the IDF and the Global Burden of Disease study are broad and do not apply specifically to the Palestinian context. Thus, this paper aims to provide estimates of future diabetes prevalence in oPt and offer a modeling platform for policy decision making.

Methods

The model integrates information on population, obesity and smoking trends at a given point in time to estimate diabetes prevalence in the future using a Markov model. The model is implemented in MS Excel and can accommodate different diabetes definitions.

We assume that the population can be divided in several pools: Diabetes mellitus, Obese, Smoker and "healthy" (e.g.: non obese, non smokers, non diabetics). 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 includes: population size and age distribution, diabetes prevalence, obesity prevalence, smoking prevalence and total mortality. Data needed for subsequent years for forecasting purposes includes: population projections, obesity and smoking trends. Data needed for incidence calculation includes: 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 2000(4). The methods for diabetes incidence and specific mortality are described in the **Technical Appendix**. Diabetes incidence was calculated using DISMOD program based on three inputs. First, Diabetes prevalence for the year 2004 obtained from the Palestinian Demographic Health Survey. Diabetes mellitus remission rate which was assumed zero. And diabetes mellitus relative risk for mortality which was estimated as proposed by Barendregt et al (2000), 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 oPt, over the period 2000 to2020. 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.

Policy scenarios

Since there are no current national targets for adult obesity and in the West Bank, we used a Mediterranean country- Turkey targets (Scenario 1), World Health Organization targets, (Scenario 4), WHO regional targets (Scenario 5). Further we proposed two targets which might be feasible (Scenario 2) and ideal (Scenario 3).

'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 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

Results

Population characteristics at starting point

The prevalence of diabetes among the Palestinian population aged 25 and above, living 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 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 the different age groups. Obesity prevalence increased in both men and women while smoking prevalence decreased in the period 2000-2030.

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 to 34 years old to 0.041 and 0.026 for men and women aged 55 to 64 years old 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%-11.6%), increasing to 15.3% (95% CI:12.3%-17.6%) by 2010 (Figure 1). Prevalence in men increased from 9.1% (95% CI: 7.3%-11.0%) to 16.9% (95%: CI 14.6%-19.4%) and in women from 10.2% (95% CI: 8.4%-12.3%) to 13.6% (95% CI: 11.3%- 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% vs. 11.4% predicted in 2004, 11.8% vs. 12.6% in 2006 and 13.8% vs. 15.3% predicted using Stepwise survey results.

Diabetes Prevalence Projections

The forecasts were 20.6% (95% CI: 18.5%-23.7%) for 2020 and 21.5% (95% CI: 20.7%-25.8%) for 2030.The estimated number of diabetic patients is expected thus to reach 215 thousand in 2015, 289 thousand in 2020 and 444 thousand 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 a11.1%. 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 International Diabetes Federation (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.

The estimates of diabetes prevalence calculated from the model were comparable with actual diabetes prevalence measured in the period 2000 to 2010. The estimates of diabetes prevalence reported in this paper are believed to be more realistic compared to estimates reported by the International Diabetes Federation 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 trends and urbanization 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 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 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, it 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. Firstly, 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 and middle income countries. However, the independent contribution 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. Secondly, 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. Thirdly, the limited data 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 they 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 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 World Health Organization (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 longer term might be more realistic.

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 reinforced by increased physical activity(9-11).The American Heart Association Council on Epidemiology and Prevention provided an ecological framework for obesity prevention that emphasized 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 the occupied Palestinian territories 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 health care problems.

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

Acknowledgment

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NMEAR and MOF were responsible for adapting the Diabetes model to the Palestinian context. NMEAR drafted this paper. MOF, SC and AH contributed to the writing and finalisation of the manuscript.

Dr. Niveen Abu-Rmeileh is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis

Conflicts of interest

We declare that we have no conflicts of interest.

Ethics Statement

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 analyzing 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 didn't reveal the identity of participants in any way.

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Figure 1: Diabetes Prevalence forecasting between 2000 and 2030

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

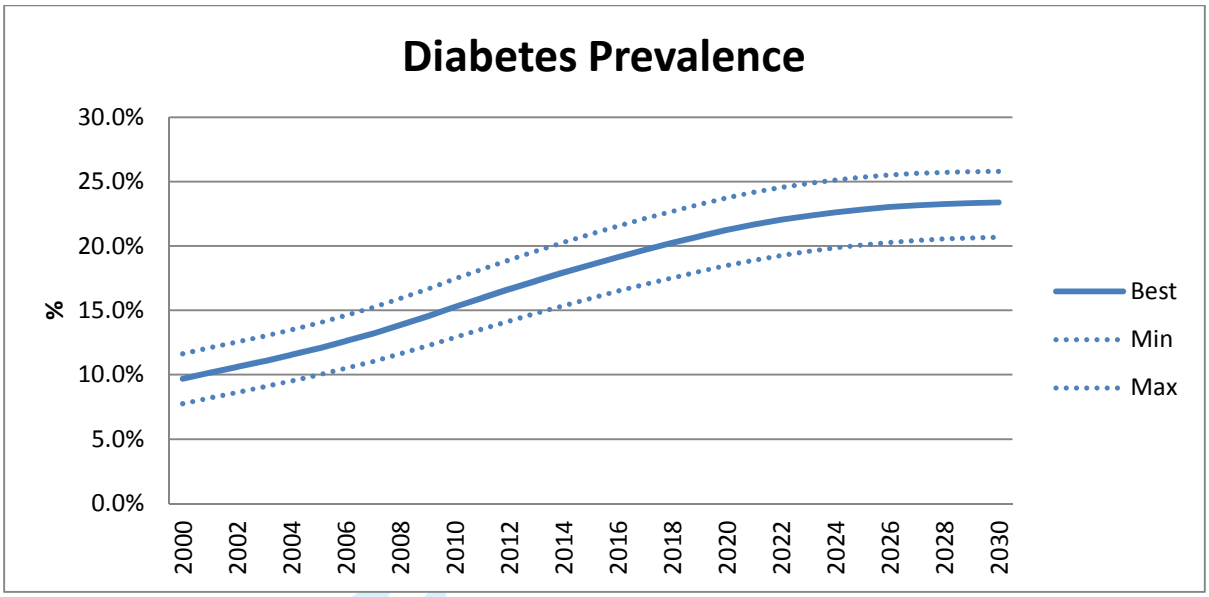
2000		Population	Diabetes Prevalence	Obesity Prevalence	Smoking Prevalence
men	**25-34**	138888	0.0133	0.159	0.594
	35-44	92050	0.0871	0.195	0.561
	45-54	46207	0.1516	0.353	0.525
	55-64	28582	0.2451	0.324	0.422
	65-74	19508	0.2467	0.298	0.331
	75+	11730	0.1774	0.268	0.331
	Add totals				
women	**25-34**	133095	0.0052	0.213	0.041
	35-44	86979	0.0386	0.401	0.071
	45-54	47457	0.1522	0.564	0.064
	55-64	36124	0.2833	0.602	0.054
	65-74	25670	0.3294	0.432	0.033
	75+	13935	0.3696	0.354	0.033

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

Year	Baseline		5% Obese reduction in 5 years			WHO target to halt obesity prevalence (15% in 10years)			WHO-EMRO 35% Obese reduction in 10 years			5% Obese reduction in 10 years			10% Obese reduction in 10 years		
	Estimated Number		Estimated #		#	Estimated #		#	Estimated #		#	Estimated #		#	Estimated #		
2015	215042		211219		3823	210278		4764	206673		8369	212176		2866	211219		3823
Min-Max	148627	292814	146443	286159		146443	286159		146443	286159		146443	146443		146443	286159	
2020	289103		277317		11786	273902		15201	261510		27593	280866		8236	277317		11786
Min-Max	207052	398856	198010	372107		198010	372107		198010	372107		198010	198010		198010	372107	
2025	365597		342837		22760	335582		30015	310687		54910	350552		15045	342837		22760
Min-Max	272271	515599	251930	456947		251930	456947		251930	456947		251930	251930		251930	456947	
2030	444296		407308		36988	394879		49416	354622		89674	420837		23458	407308		36988
Min-Max	342629	641053	307266	541257		307266	541257		307266	541257		307266	307266		307266	541257	

%

Year	Baseline		5% Obese reduction in 5 years			WHO target to halt obesity prevalence (15% in 10years)			WHO-EMRO 35% Obese reduction in 10 years			5% Obese reduction in 10 years			10% Obese reduction in 10 years		
	Estimated Prevalence		Estimated Prevalence		%	Estimated Prevalence		%	Estimated Prevalence		%	Estimated Prevalence		5	Estimated Prevalence		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%	



Supplementary data

Table 1: Sources of data used in the model.

Parameter	Source
Population (structure and trend)	Census 1997, 2007 projections
Obesity (prevalence and trend)	Demographic Health Survey 2000
Smoking (prevalence and trend)	Palestinian Family Health Survey 2000,2004,2006, & 2010
Diabetes incidence rate for "healthy" people"	DISMOD calculation (mortality Data- Ministry of Health)
Diabetes Specific mortality	DISMOD calculation (mortality Data- Ministry of Health)
All cause mortality	Ministry of Health
RR DM (obesity)	Guh et al (BMC Public Health 2009)
RR DM (smoking)	Willi et al (JAMA 2007)

Table 2: Sources of data used in the model.

Data Item	Source	Comments
1. Initial year:		
1.1. Population	1997 census , 1997 census projections, 2007 and 2007 projections. Data obtained from The Palestinian Central Bureau of Statistics.	Matching between 1997 census projections and 2007 actual data were obtained and then projections based on 1997 and 2007 census linear increase, projections were made for up to 2020. The data were double check by PCBS demographer to validation.
1.2. Diabetes prevalence	Palestinian Demographic Health Survey 2000	Self reported diabetes. The prevalence was corrected for self reporting and for sampling weights.

1.3. Obesity prevalence	Cross-sectional study in urban and rural areas in Ramallah districted conducted in between 1996-98. Stepwise Survey using national sample.	Standardised weight and height measurements were obtained by trained nurses.
1.4. Smoking prevalence (current smokers)	Palestinian Demographic Health Survey 2000 and 2004, Palestinian Family Health Survey 2006 and 2010.	Proxy-self reported cigarette smoking.
1.5. Total mortality (needed for DISMOD based estimation of incidence rate)	Health information center-Ministry of Health. Data available for 1997, 1999-2009.	Moderate quality based on WHO criteria. ICD-10 codes for underlying cause of death. Mortality for 1998 was calculated as the average mortality for 1997-1999.
2. <u>Subsequent years for validation and forecasting purposes</u>		
3.1. Population trends	Same as above	
3.2 Diabetes trend	Palestinian Demographic Health Survey 2004,	

	Palestinian Family Health Survey 2006 and 2010. Stepwise survey.	
3.3. Obesity trends	Same as above	
3.4. Smoking trends	Same as above	

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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.

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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 five-year period. If obesity prevalence was reduced by 35% in 10 years, as suggested by the WHO, diabetes prevalence might be decreased by some 20%.

Conclusions: The model is estimating an increase in the prevalence of diabetes which will pose 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 diabetic patients.

Article Summary

Article focus: This paper aims to provide estimates of future diabetes prevalence using simple mathematical model in West Bank, oPt and to compare five future policy scenarios for diabetes prevention

Key messages:

- The prevalence of obesity and smoking among Palestinians is high
- The prevalence of diabetes will increase in 20 years resulting in a large number of people with diabetes.
- The target set by the WHO will result in a major reduction in diabetes prevalence. However, there targets are not realistic given the time frame.
- Reducing obesity prevalence by 5% as a target is feasible and realistic.

Strength and limitation

- Strength: The model may be appropriate for most low and middle income countries because it is simple, does not require sophisticated statistical software nor huge amounts of specific data
- Limitation: Not all relevant risk factors, such as physical inactivity, were included in the current model. BMI was used as a measure of obesity and finally the limited data available to estimate obesity trends for the Palestinian population

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

In Palestine, 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. Further, 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, oPt and offer a modeling platform for policy decision making.

Methods

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Diabetes incidence and specific mortality were estimated using the methods developed by Barendregt et al 2000(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 program 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 zero. And diabetes mellitus relative risk for mortality which

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Diabetes Prevalence Projections

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

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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 a11.1%. 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).

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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 International Diabetes Federation (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 increase and then reaches plateau, this phenomenon is not observed in the Palestinian population yet. Hence obesity prevalence forecast was based on 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 to 2010. The estimates of diabetes prevalence reported in this paper are believed to be more realistic compared to estimates reported by the International Diabetes Federation 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 trends and urbanization 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 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 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, it 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. Firstly, 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 and middle income countries. However, the independent contribution 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. Secondly, 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. Thirdly, the limited data 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 they 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 assess 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 World Health Organization (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 longer term might be more realistic. The implementation of the proposed intervention need 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 reinforced by increased physical activity(9-11).The American Heart Association Council on Epidemiology and Prevention provided an ecological framework for obesity prevention that emphasized 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 the occupied Palestinian territories 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 health care problems.

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

Acknowledgment

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007–2013) under grant agreement n°223075 – the MedCHAMPS project and RESCPAPS Med grant agreement n° 281640.

Contributorship

NMEAR and MOF were responsible for adapting the Diabetes model to the Palestinian context. NMEAR drafted this paper. MOF, SC and AH contributed to the writing and finalisation of the manuscript.

Dr. Niveen Abu-Rmeileh is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis

Conflicts of interest

We declare that we have no conflicts of interest.

Ethics Statement

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 analyzing 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 didn't reveal the identity of participants in any way.

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Figure 1: Diabetes Prevalence forecasting between 2000 and 2030

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	**25-34**	138888	0.0133	0.159	0.594
	35-44	92050	0.0871	0.195	0.561
	45-54	46207	0.1516	0.353	0.525
	55-64	28582	0.2451	0.324	0.422
	65-74	19508	0.2467	0.298	0.331
	75+	11730	0.1774	0.268	0.331
	Add totals				
women	**25-34**	133095	0.0052	0.213	0.041
	35-44	86979	0.0386	0.401	0.071
	45-54	47457	0.1522	0.564	0.064
	55-64	36124	0.2833	0.602	0.054
	65-74	25670	0.3294	0.432	0.033
	75+	13935	0.3696	0.354	0.033

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

Year	Baseline		5% Obese reduction in 5 years			WHO target to halt obesity prevalence (15% in 10years)			WHO-EMRO 35% Obese reduction in 10 years			5% Obese reduction in 10 years			10% Obese reduction in 10 years		
	Estimated Number		Estimated #		#	Estimated #		#	Estimated #		#	Estimated #		#	Estimated #		
2015	215042		211219		3823	210278		4764	206673		8369	212176		2866	211219		3823
Min-Max	148627	292814	146443	286159		146443	286159		146443	286159		146443	146443		146443	286159	
2020	289103		277317		11786	273902		15201	261510		27593	280866		8236	277317		11786
Min-Max	207052	398856	198010	372107		198010	372107		198010	372107		198010	198010		198010	372107	
2025	365597		342837		22760	335582		30015	310687		54910	350552		15045	342837		22760
Min-Max	272271	515599	251930	456947		251930	456947		251930	456947		251930	251930		251930	456947	
2030	444296		407308		36988	394879		49416	354622		89674	420837		23458	407308		36988
Min-Max	342629	641053	307266	541257		307266	541257		307266	541257		307266	307266		307266	541257	

%

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	Estimated Prevalence		Estimated Prevalence		% reduction	Estimated Prevalence		% reduction	Estimated Prevalence		% reduction	Estimated Prevalence		% reduction	Estimated Prevalence		% 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	

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

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Key Words: Diabetes Prevalence, Modelling, Risk factor, Palestinian, West Bank

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-Occupied Palestinian Territory

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 five-year period. If obesity prevalence was reduced by 35% in 10 years, as suggested by the WHO, diabetes prevalence might be decreased by some 20%.

Conclusions: The model is estimating an increase in the prevalence of diabetes which will pose 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 diabetic patients.

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

In Palestine, 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. Further, 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, oPt and offer a modeling platform for policy decision making.

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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 International Diabetes Federation (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 increase and then reaches plateau, this phenomenon is not observed in the Palestinian population yet. Hence obesity prevalence forecast was based on 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 to 2010. The estimates of diabetes prevalence reported in this paper are believed to be more realistic compared to estimates reported by the International Diabetes Federation and the Global prevalence of diabetes estimates which were critiqued for under estimating the prevalence of diabetes, probably as a result of using only

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demographic trends and urbanization 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 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.

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We suggest that this model may be appropriate for most low 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, it 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. Firstly, 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 and middle income countries. However, the independent contribution 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. Secondly, 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. Thirdly, the limited data 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 they 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 assess 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 World Health Organization (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 longer term might be more realistic. The implementation of the proposed intervention need to be investigated thoroughly.

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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 reinforced by increased physical activity(9-11).The American Heart Association Council on Epidemiology and Prevention provided an ecological framework for obesity prevention that emphasized the

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importance of the social, environmental and political context and their powerful influence on the behaviour of families and individuals(12).

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Finally, this model has provided reasonably close estimates of diabetes prevalence for the occupied Palestinian territories 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 health care problems.

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

Article Summary

Article focus: This paper aims to provide estimates of future diabetes prevalence using simple mathematical model in West Bank, oPt and to compare five future policy scenarios for diabetes prevention

Key messages:

- The prevalence of obesity and smoking among Palestinians is high
- The prevalence of diabetes will increase in 20 years resulting in a large number of ~~diabetics~~people with diabetes.
- The target set by the WHO will result in a major reduction in diabetes prevalence. However, there targets are not realistic given the time frame.
- Reducing obesity prevalence by 5% as a target is feasible and realistic.

Strength and limitation

- Strength: The model may be appropriate for most low and middle income countries because it is simple, does not require sophisticated statistical software nor huge amounts of specific data
- Limitation: Not all relevant risk factors, such as physical inactivity, were included in the current model. BMI was used as a measure of obesity and finally the limited data available to estimate obesity trends for the Palestinian population

Acknowledgment

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NMEAR and MOF were responsible for adapting the Diabetes model to the Palestinian context. NMEAR drafted this paper. MOF, SC and AH contributed to the writing and finalisation of the manuscript.

Dr. Niveen Abu-Rmeileh is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis

Conflicts of interest

We declare that we have no conflicts of interest.

Ethics Statement

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 analyzing 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 didn't reveal the identity of participants in any way.

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Figure 1: Diabetes Prevalence forecasting between 2000 and 2030

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

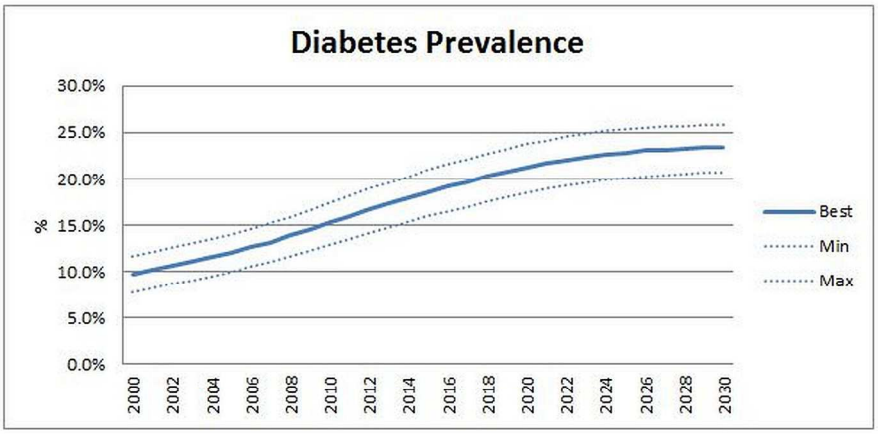
2000		Population	Diabetes Prevalence	Obesity Prevalence	Smoking Prevalence
men	**25-34**	138888	0.0133	0.159	0.594
	35-44	92050	0.0871	0.195	0.561
	45-54	46207	0.1516	0.353	0.525
	55-64	28582	0.2451	0.324	0.422
	65-74	19508	0.2467	0.298	0.331
	75+	11730	0.1774	0.268	0.331
	Add totals				
women	**25-34**	133095	0.0052	0.213	0.041
	35-44	86979	0.0386	0.401	0.071
	45-54	47457	0.1522	0.564	0.064
	55-64	36124	0.2833	0.602	0.054
	65-74	25670	0.3294	0.432	0.033
	75+	13935	0.3696	0.354	0.033

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

Year	Baseline		5% Obese reduction in 5 years			WHO target to halt obesity prevalence (15% in 10years)			WHO-EMRO 35% Obese reduction in 10 years			5% Obese reduction in 10 years			10% Obese reduction in 10 years		
	Estimated Number		Estimated #		#	Estimated #		#	Estimated #		#	Estimated #		#	Estimated #		
2015	215042		211219		3823	210278		4764	206673		8369	212176		2866	211219		3823
Min-Max	148627	292814	146443	286159		146443	286159		146443	286159		146443	146443		146443	286159	
2020	289103		277317		11786	273902		15201	261510		27593	280866		8236	277317		11786
Min-Max	207052	398856	198010	372107		198010	372107		198010	372107		198010	198010		198010	372107	
2025	365597		342837		22760	335582		30015	310687		54910	350552		15045	342837		22760
Min-Max	272271	515599	251930	456947		251930	456947		251930	456947		251930	251930		251930	456947	
2030	444296		407308		36988	394879		49416	354622		89674	420837		23458	407308		36988
Min-Max	342629	641053	307266	541257		307266	541257		307266	541257		307266	307266		307266	541257	

%

Year	Baseline		5% Obese reduction in 5 years			WHO target to halt obesity prevalence (15% in 10years)			WHO-EMRO 35% Obese reduction in 10 years			5% Obese reduction in 10 years			10% Obese reduction in 10 years		
	Estimated Prevalence		Estimated Prevalence		% reduction	Estimated Prevalence		% reduction	Estimated Prevalence		% reduction	Estimated Prevalence		% reduction	Estimated Prevalence		% 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	



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Supplementary data

Table 1: Sources of data used in the model.

Parameter	Source
Population (structure and trend)	Census 1997, 2007 projections
Obesity (prevalence and trend)	Demographic Health Survey 2000
Smoking (prevalence and trend)	Palestinian Family Health Survey 2000,2004,2006, & 2010
Diabetes incidence rate for "healthy" people"	DISMOD calculation (mortality Data- Ministry of Health)
Diabetes Specific mortality	DISMOD calculation (mortality Data- Ministry of Health)
All cause mortality	Ministry of Health
RR DM (obesity)	Guh et al (BMC Public Health 2009)
RR DM (smoking)	Willi et al (JAMA 2007)

Table 2: Sources of data used in the model.

Data Item	Source	Comments
1. Initial year:		
1.1. Population	1997 census , 1997 census projections, 2007 and 2007 projections. Data obtained from The Palestinian Central Bureau of Statistics.	Matching between 1997 census projections and 2007 actual data were obtained and then projections based on 1997 and 2007 census linear increase, projections were made for up to 2020. The data were double check by PCBS demographer to validation.
1.2. Diabetes prevalence	Palestinian Demographic Health Survey 2000	Self reported diabetes. The prevalence was corrected for self reporting and for sampling weights.

1.3. Obesity prevalence	Cross-sectional study in urban and rural areas in Ramallah districted conducted in between 1996-98. Stepwise Survey using national sample.	Standardised weight and height measurements were obtained by trained nurses.
1.4. Smoking prevalence (current smokers)	Palestinian Demographic Health Survey 2000 and 2004, Palestinian Family Health Survey 2006 and 2010.	Proxy-self reported cigarette smoking.
1.5. Total mortality (needed for DISMOD based estimation of incidence rate)	Health information center-Ministry of Health. Data available for 1997, 1999-2009.	Moderate quality based on WHO criteria. ICD-10 codes for underlying cause of death. Mortality for 1998 was calculated as the average mortality for 1997-1999.
2. <u>Subsequent years for validation and forecasting purposes</u>		
3.1. Population trends	Same as above	
3.2 Diabetes trend	Palestinian Demographic Health Survey 2004,	

	Palestinian Family Health Survey 2006 and 2010. Stepwise survey.	
3.3. Obesity trends	Same as above	
3.4. Smoking trends	Same as above	

Diabetes incidence and specific mortality

Incidence, mortality and prevalence are closely related to each other, in a way that only some values for each parameter are consistent with the other parameters at a given time. This property has been used by Barendregt et al to estimate diabetes mellitus incidence in the Netherlands (Epidemiology Volume 11(3), May 2000, pp 274-279).

The technique use as input whatever parameters that are known and using a multistate generic disease model using a lifetable Markov approach, estimate revised parameters for the inputed ones and estimates for those unknown. This method has been implemented in a software called DISMOD II (ref)

it is expected that the only available parameter is probably diabetes mellitus prevalence (either self reported or using ADA/WHO/NHANES definitions). However, diabetes excess mortality can be estimated form total mortality data (See Barendregt) using literature based estimates of mortality relative risk and disease prevalence, and we can safely assume that the remission rate for diabetes in effectively 0. Thus, the only parameters needed (by age and gender) are diabetes mellitus prevalence, population structure and population general mortality.

An important assumption is that this method requires a population in equilibrium, since the consistency between epidemiological estimates depends on the underlying trends in each parameter. However it is difficult to disentangle these effects from data inaccuracy. The robustness of the approach to violations of this assumption is not known.

This method produces a “population incidence”, e.g. the incidence both for exposed and unexposed people to diabetes risk factors.

However, the MEDCHAMPS diabetes model needs incidence in the non exposed, since incidence for obese persons and smokers is derived from that baseline incidence by using literature based relative risks.

It has been proposed that the incidence of a disease in a population is a weighted sum of the incidence among the exposed and the incidence among the unexposed to a risk factor(Epidemiology By Moyses Szklo, F. Javier Nieto, equation 3.8 in page 101) (equation 1).

(Equation 1)

$$i_p = i_e \times p + i_u \times (1 - p) \mathrm{i_p} = \mathrm{i_e} \times \mathrm{p} + \mathrm{i_u} \times (1\text{-}\mathrm{p}) ,$$

Where i_p is the population incidence, i_e is the incidence amongst the exposed, i_u is the incidence amongst the unexposed and p is risk factor prevalence.

Since the incidence in the exposed is the incidence in the unexposed times the relative risk (RR) (Equation 2),

(equation 2)

$$i_e = RR \times i_u ,$$

it is possible to derive from this two ideas the value for the unexposed incidence from the incidence in the population. Replacing equation 2 in equation 1

(Equation 3)

$$i_p = RR \times i_u \times p + i_u \times (1 - p)$$

And then extracting I_u (Equation 4)

(Equation 4)

$$i_u = \frac{i_p}{(p \times RR - p) + 1}$$

Estimation of the incidence, case fatality and mortality parameters for West Bank, 2004

Estimation of the population incidence:

This section describes the method used to estimate diabetes mellitus type II incidence for the Palestinian population in 2004 living in the West Bank.

DISMOD need at least 3 inputs. For this case, we used diabetes mellitus prevalence, diabetes mellitus remission rate and diabetes mellitus relative risk for mortality.

Diabetes prevalence was obtained from the Palestinian Demographic Health Survey 2004[1]. Diabetes and smoking data were proxy self reported. And the International Diabetes Federation correction factor was use. The data was further corrected for sampling methodology.

We can safely assume that diabetes mellitus remission rate is 0, and diabetes mellitus relative risk for mortality can be estimated as proposed by Barendregt et al (2000), based in the usual RR for mortality (mortality in diseased/mortality in non diseased) and disease prevalence. The formula is

(Equation 5)

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

Where RR adj is the relative risk mortality , RR is the usual relative risk for mortality (mortality diseased/mortality healthy) and p is disease prevalence. The Verona Study (REF) provide age and gender specific values for RR.