Distribution Agreement

Growth in global diabetes prevalence attributable to population aging,
Adults 20-79, 2003 to 2010

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An abstract of
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Abstract

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Introduction
The burden of diabetes has grown tremendously in the past 30 years due to more people developing the disease and surviving to older ages. Major global diabetes studies estimate an additional 150-200 million people will develop diabetes by the year 2030. Parallel with diabetes growth, life expectancy has also grown remarkably in the past 30 years. We report the prevalence of diabetes in 2003 and 2010 and decompose the growth in diabetes between the 2 time-points into the increase in prevalence attributable to changes in the age-composition and the increase in prevalence attributable to changes in the age-specific prevalence of diabetes.
Data
Cross-sectional data on age-specific cases of diabetes for 212 countries were collected from the International Diabetes Federation Diabetes Atlases for 2003 and 2010. Cross-sectional data on age-specific population counts for 230 countries were collected from the United Nations World population Prospects, 2010 report.
Methods
We performed a decomposition analysis to split the difference in crude prevalence between the 2003 and 2010 populations into the change in prevalence attributable to differences in the age-composition between 2010 and 2003, and the change in prevalence attributable to differences in the age-specific prevalences.
Results
The prevalence of diabetes has grown between 2003 and 2010 for all age groups in both developed and developing countries. Diabetes prevalence has grown by 1.57 percentage points globally between 2003 and 2010. Globally, only 8.59% of the growth in diabetes between 2003 and 2010 is due to age-composition changes, with 91.41% of the growth attributable to increases in the age-specific prevalence of diabetes. In developed countries, only 5.91% of diabetes prevalence growth is attributable to age-composition changes. In developing countries, 11.23% of the growth of diabetes prevalence between 2003 and 2010 can be attributed to changes in the age-composition.
Conclusion
Based on our analysis, population aging is only responsible for a small percentage of the growth in diabetes prevalence between 2003 and 2010. To adequately quell the rising population risk of diabetes, further research is needed to investigate and quantify the contribution of the social, economic, and behavioral determinants of diabetes.

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Table of Contents

INTRODUCTION

The Burden of Diabetes

The burden of diabetes has grown tremendously in the past 30 years due to more people developing the disease and surviving to older ages (Amos, McCarty, & Zimmet, 1997). Globally, Danaei et al. estimate that 194 million people developed diabetes between 1980 and 2008 (Danaei et al., 2011). The rate of diabetes incidence is also increasing. Major global diabetes studies estimate an additional 150-200 million people will develop diabetes by the year 2030 (King, Aubert, & Herman, 1998; Shaw, Sicree, & Zimmet, 2010; Whiting, Guariguata, Weil, & Shaw, 2011; Wild, Roglic, Green, Sicree, & King, 2004).

Although estimates of the number of people with diabetes are meaningful for health planning, measuring the burden of diabetes as counts of people with diabetes obscures the relationship between diabetes growth and population growth. Measuring the prevalence of diabetes, by dividing the number of people with diabetes by the population at risk for diabetes, presents diabetes growth in relation to population growth, aging, and increases in life expectancy. The prevalence of diabetes also provides an estimate of the population risk of diabetes. Estimates published by the International Diabetes Federation, World Health Organization, and the Global Burden of Disease studies report a global prevalence of diabetes among adults of 4.0% in 1995, 6.4% in 2010, and project prevalence in the year 2030 to vary between 4-7.7% (King et al., 1998; Shaw et al., 2010; Wild et al., 2004). All the studies show pronounced growth in the global prevalence of diabetes and project this growth to continue over the next few decades. The increasing prevalence of diabetes reflects a growing population risk of diabetes and an increase in the number of people with diabetes in excess of diabetes growth due solely to population growth.

Distribution of Diabetes

The global growth of diabetes is not equally distributed across regions and countries. Low to middle income countries (LMIC) have seen the largest growth in the number of people with diabetes. This trend is projected to continue to the year 2030 (Shaw et al., 2010; Whiting et al., 2011). However, the number of people living with diabetes does not necessarily correspond with a higher population risk of diabetes. Although LMICs have the highest absolute number of people with diabetes, they also have larger population sizes and lower life expectancies; therefore, high income countries actually have a higher prevalence of diabetes despite having a lower number of people with diabetes (King et al., 1998).

Health Consequences of Diabetes

Diabetes has significant health consequences globally. In 2010, almost 4 million global deaths could be attributed to diabetes—making diabetes responsible for 6.8% of global all-age mortality (Roglic & Unwin, 2010). In the United States, diabetes "accounts for at least 3.6% of all deaths and 5.2% of [cardiovascular disease] deaths." (Saydah, Eberhardt, Loria, & Brancati, 2002). The mortality attributable to diabetes is often underestimated because of the relationship between diabetes and cardiovascular disease (C. J. L. Murray & Lopez, 1997a). People could die as a direct result of diabetes or die of cardiovascular disease perpetuated by diabetes, but the diabetes doesn't always get recorded and counted as the underlying cause of death. Globally, "diabetes mellitus accounted for 580,000 deaths in 1990, and with adjustment for the heightened risk of death from other causes, 2.8 million deaths in 1990 were attributable to diabetes" (C. J. L. Murray & Lopez, 1997b).

Mortality alone does not capture the true burden of chronic disease, since chronic conditions often lead to disability and other morbid conditions prior to death. The disability adjusted life year (DALY) is useful for quantifying the burden of chronic diseases because it measures both the mortality and morbidity caused by a disease (C. J. Murray, 1994). Diabetes is the 17th leading cause of DALYs globally, however, diabetes increases the risk of both ischemic heart disease and cerebrovascular disease, which are the 2nd and 3rd cause of DALYs (C. J. L. Murray, Jamison, Lopez, Ezzati, & Mathers, 2006). Diabetes is also one of the three greatest contributors to years lived with disability (Vos et al., 2013).

Population Aging

Parallel with diabetes growth, life expectancy has also grown remarkably in the past 30 years (United Nations, 2011). Numerous studies have shown that almost all the countries in the world are living longer and aging, which is defined as a greater proportion of the population living in the older age ranges (Anderson & Hussey, 2000; Bloom, Canning, & Fink, 2011; Christensen, Doblhammer, Rau, & Vaupel, 2009; Lutz, Sanderson, & Scherbov, 2008). Specifically, Bloom et al. predict that "between 2005 and 2050, the share of the population aged 60 and over is projected to increase in nearly every country in the world" (Bloom et al., 2011). Lutz et al. claim that "all our measures indicate continuous ageing of the world's population throughout the century" with the "speed of ageing … likely to increase over the coming decades". They predict the median "age of the world's population [will increase] from 26.6 years in 2000 to 31.1 in 2050" (Lutz et al., 2008). Population aging is being driven by a combination of reduced mortality and declining fertility in younger cohorts: reduced mortality in the form of increased life expectancy results in more people living to older ages, while declining fertility in the younger cohorts results in fewer people being born and living in the younger age ranges (Anderson & Hussey, 2000; Christensen et al., 2009; Coale, 1973; Lutz et al., 2008). This results in populations with a growing proportion of people living in older age groups.

Diabetes Growth and Population Aging

Many studies reference the impact of population aging on the growth of diabetes without actually quantifying the effect of aging (Boyle, Thompson, Gregg, Barker, & Williamson, 2010; Chittleborough, Grant, Phillips, & Taylor, 2007; Fendrich & Hoffmann, 2007; Whiting et al., 2011). General statements such as "population ageing … will further increase the burden of diabetes"(Chittleborough et al., 2007) or "diabetes is increasing, as a consequence of increasing incidence due to demographic change such as ageing" (Whiting et al., 2011) are presented with no measure of the effect of aging on diabetes prevalence. We only found 3 studies that quantified the growth of diabetes attributable to population aging. Boyle et al., found that "of the projected 18 million increase in the number of cases of diabetes [in the United States] in 2050, 37% are due to changes in demographic composition, 27% are due to population growth, and 36% are due to increasing prevalence rates" (Boyle et al., 2001). Leibson et al., found that "aging of the population accounted for only a small proportion of [the 51% increase in the crude prevalence of adult-onset diabetes mellitus among Rochester residents aged 45 years or more between 1970 and 1990] " (Leibson, O'Brien, Atkinson, Palumbo, & Melton, 1997). Danaei et al., looked at the contribution of aging to the global growth in diabetes and concluded, "Of the nearly 194 million additional cases of diabetes between 1980 and 2008, 70% were attributable to population growth and ageing and the other 30% to a rise in age-specific prevalences" (Danaei et al., 2011).

These 3 studies have significant limitations despite providing a numerical estimate on the contribution of population aging to diabetes growth. Boyle et al., and Leibson et al., use projected data to derive their estimates of age-related diabetes growth rather than using retrospective observational data. Furthermore, the results of these studies cannot be externalized to a global population because they were both conducted in small regional populations. Danaei et al., use global observational data but they aggregate the effect of population growth and population aging into one estimate, preventing direct interpretation of the contribution of aging alone.

Understanding the drivers of global diabetes prevalence is paramount to creating effective strategies for managing and preventing the health, economic, and social strains of the disease. For example, if a process such as population aging were the main driver of diabetes, bolstering health infrastructure to cope with an inevitable rise of diabetic patients and the other co-morbidities exhibited among the elderly would be the most important health policy priority. However, if aging is only a minor determinant of diabetes growth, behavioral and preventive policies might be able to slow the growth of diabetes by addressing preventable risk factors. Furthermore, projecting the number of people who will develop diabetes in the future is an important way to estimate the impact of diabetes on health systems. Without knowing the contribution of aging to diabetes growth, models for future predictions may either over- or under predict the number of future people with diabetes, and the health systems capacity needed to help manage them.

Our study seeks to understand the demography of diabetes and quantify the growth in global diabetes attributable to changes in population age-composition. We report the prevalence of diabetes in 2003 and 2010 and decompose the growth in diabetes between the 2 time-points into the increase in prevalence attributable to changes in the age-composition and the increase in prevalence attributable to changes in the age-specific prevalence of diabetes. Our ultimate goal was to estimate the growth in the global prevalence of diabetes due to population aging.

DATA

Cross-sectional data on age-specific cases of diabetes for 212 countries were collected from the International Diabetes Federation (IDF) Diabetes Atlases for 2003 and 2010 (International Diabetes Federation, 2004, 2011). The IDF extracted cases of diabetes from various studies published after 1979, registry reports, hospital statistics, and other government estimates. Sources with large sample sizes, high response rates, and diabetes confirmed by oral glucose tolerance test were preferred. The number of people with diabetes for countries with missing data was extrapolated by applying the prevalence rates of "socio-economically, ethnically, and geographically … similar" countries to the population distribution of the country with missing data. For countries with only self-reported cases of diabetes, undiagnosed cases were corrected for by multiplying by a factor "in accordance with findings…based on data from a number of countries." For countries with missing data within the 20-79 age groups, logistic regression models were used to smooth the number of cases of diabetes over the 20-79 age range. Age-specific cases of diabetes were reported for the age ranges 20-39, 40-59, and 60-79. Data were not available for people below the age of 20 or above the age of 80.

Cross-sectional data on age-specific population counts for 230 countries were collected from the United Nations (UN) World population Prospects, 2010 report. Counts of population were extracted from a combination of national censuses, official government estimates, and surveys. The United Nations Department of Economic and Social Affairs, Population Division corrected the data for misreporting, missing data, and other errors. Counts of population were reported for all ages and then aggregated into three groups: 20-39, 40-59, and 60-79. Data for people below the age of 20 and above the age of 80 were not used.

36 countries and areas did not match between the IDF and UN data sources and were dropped from our sample. The samples were not restricted by any other criteria. The final analytic sample had 195 countries for the years 2003 and 2010. Countries were classified as either “developed” or “developing” based on their classification in the UN World Population Prospects report.

METHODS

We analyzed our data in three samples: globally, developing countries only, and developed countries only. We generated counts for the number of people with diabetes and total number of people within the age groups of 20-39, 40-59, and 60-79 for the 2003 and 2010 global populations. We then performed a decomposition analysis to split the difference in crude prevalence between the 2003 and 2010 populations into the change in prevalence attributable to differences in the age-composition between 2010 and 2003, and the change in prevalence attributable to differences in the age-specific prevalences.

This process involved the following steps. First, we calculated diabetes prevalence for each age range by dividing the number of people with diabetes by the number of people in that age-range. We then calculated age-specific population weights for each age range by dividing the number of people in an age-range by the total number of people aged 20-79 for that year. The decomposition equation consists of two parts: (1) the growth in diabetes attributable to age-composition changes and (2) the growth in diabetes attributable to age-specific prevalence changes (Preston, Heuveline, & Guillot, 2001). The decomposition equation is shown below:

$$\Delta = \sum_i (C_i^{2010} - C_i^{2003}) \cdot \left[\frac{P_i^{2010} + P_i^{2003}}{2}\right] + \sum_i (P_i^{2010} - P_i^{2003}) \cdot \left[\frac{C_i^{2010} + C_i^{2003}}{2}\right]$$

Where Δ is the change in crude prevalence between 2010 and 2003, C is the population weight, P is the prevalence of diabetes, and i represents the age-range. The first part of the equation is the change in prevalence attributable to age-composition changes and the second part is the change in prevalence attributable to age-specific prevalence changes. The two parts of the equation were then individually divided by the change in crude prevalence between the two years to get the percentage of the total growth in diabetes prevalence attributable to changes in age-composition and age-specific prevalence. This analysis was then repeated among the developed and developing countries separately. All analyses were conducted in STATA 12 and Microsoft Excel.

We were not required to gain approval from the Institutional Review Board (IRB) because we did not conduct human subjects research.

RESULTS

Table 1 Age-specific cases of diabetes and total adult population between 2003 and 2010, ages 20-79

	2003	2010	Growth (% Growth)
Cases of Diabetes (Thousands)			
World			
20-39	27890.7	43971.68	16080.98 (57.7%)
40-59	87500	131457.5	43957.5 (50.2%)
60-79	77345.7	107543.2	30197.5 (39.0%)
Total	192736.4	282972.38	90235.98 (46.8%)
Developing			
20-39	21900.7	36844.26	14943.56 (68.2%)
40-59	61432.2	99612.63	38180.43 (62.2%)
60-79	41033.2	60153.45	19120.25 (46.6%)
Total	124366.1	196610.34	72244.24 (58.1%)
Developed			
20-39	5990	7127.417	1137.417 (19.0%)
40-59	26067.8	31844.84	5777.04 (22.2%)
60-79	36312.5	47389.79	11077.29 (30.5%)
Total	68370.3	86362.047	17991.747 (26.3%)
Population (Thousands)			
World			
20-39	1987044	2138768	151724 (7.6%)
40-59	1283578	1509000	225422 (17.6%)
60-79	566669.1	643873.6	77204.5 (13.6%)
Total	3837291.1	4291641.6	454350.5 (11.8%)
Developing			
20-39	1645502	1799846	154344 (9.4%)
40-59	951973.3	1167498	215524.7 (22.6%)
60-79	364116.7	434153.9	70037.2 (19.2%)
Total	2961592	3401497.9	439905.9 (14.9%)
Developed			
20-39	341542.2	338921.7	(2620.5) (-0.8%)
40-59	331604.3	341502.1	9897.8 (3.0%)
60-79	202552.4	209719.7	7167.3 (3.5%)
Total	875698.9	890143.5	14444.6 (1.6%)

Notes: Total population represents total population between ages 20-79 and not overall population. Numbers in parentheses are negative.

Source: UN World Population Prospects 2010; International Diabetes Federation Diabetes Atlas 2003, 2010

Table 1 shows the total and age-specific counts of people with diabetes and adult persons for the years 2003 and 2010. Between 2003 and 2010, the number of people with diabetes within all age groups has grown in both developed and developing countries. Globally, the largest increase in people with diabetes was for people aged 40-59. This trend was consistent for developing countries as well. For developed countries, the largest increase in people with diabetes was in the 60-79 age range.

Simultaneous with diabetes growth, population counts have grown for all ages in developing countries. Within developed countries, the population of people aged 40-79 has grown while the population of people aged 20-39 has declined due to lower fertility in the younger cohorts (Christensen et al., 2009). The largest growth in population was in the 40-59 age range for developed and developing countries. Due to overall growth in both population and number of people with diabetes, comparing the overall and age-specific prevalences between the two years provides a better approximation of the growth in global diabetes risk.

Table 2 Age-Specific Prevalence of Diabetes for 2003 and 2010, ages 20-79

	2003	2010	Change
World			
20-39	1.4%	2.1%	0.7%
40-59	6.8%	8.7%	1.9%
60-79	13.6%	16.7%	3.1%
Total	5.0%	6.6%	1.6%
Developing			
20-39	1.3%	2.0%	0.7%
40-59	6.5%	8.5%	2.0%
60-79	11.3%	13.9%	2.6%
Total	4.2%	5.8%	1.6%
Developed			
20-39	1.8%	2.1%	0.3%
40-59	7.9%	9.3%	1.4%
60-79	17.9%	22.6%	4.7%
Total	7.8%	9.7%	1.9%

Notes: Change is in percentage points.

Source: UN World Population Prospects 2010; International Diabetes Federation Diabetes Atlas

2003, 2010

Table 2 shows the age-specific prevalence of diabetes for the years 2003 and 2010. The prevalence of diabetes has grown between 2003 and 2010 for all age groups in both developed and developing countries. Developed countries have a higher prevalence of diabetes and have experienced a greater increase in diabetes prevalence than developing countries. In both developed and developing countries, diabetes prevalence is the greatest for people aged 60-79. This group also has the greatest growth in diabetes prevalence between 2003 and 2010. With a diabetes prevalence of 22.6%, people in developed countries aged 60-79 have the highest overall prevalence of diabetes.

Table 3 shows the decomposition of global diabetes growth between 2003 and 2010 into the percentage of growth attributable to changes in the age-composition and percentage of growth attributable to changes in age-specific prevalence.

Table 3 Decomposition of adult diabetes prevalence between 2003 and 2010

Region	2003 Prevalence	2010 Prevalence	Growth	% Change due to age composition	% Change due to age specific prevalence
World	0.0502	0.0659	0.0157	8.59%	91.41%
Developed	0.0781	0.0970	0.0189	5.91%	94.09%
Developing	0.0420	0.0577	0.0158	11.23%	88.77%

Notes: Crude prevalence shown. Countries were classified as developed or developing based on assignments in UN World Population Prospects, 2010

Source: UN World Population Prospects 2010, International Diabetes Federation 2003, 2010

Diabetes prevalence has grown by 1.57 percentage points globally between 2003 and 2010, with a 1.89 percentage point growth in developed countries and a 1.58 percentage point growth in developing countries. Globally, only 8.59% of the growth in diabetes between 2003 and 2010 is due to age-composition changes, with 91.41% of the growth attributable to increases in the age-specific prevalence of diabetes. The effect of aging is even smaller for developed countries with only 5.91% of diabetes prevalence growth attributable to age-composition changes. In developing countries, 11.23% of the growth of diabetes prevalence between 2003 and 2010 can be attributed to changes in the age-composition.

DISCUSSION

Globally, diabetes prevalence increased by 1.57 percentage points between 2003 and 2010, indicating that diabetes growth has outpaced population growth. Consistent with published predictions (Whiting et al., 2011), developing countries saw the greatest absolute increases in people with diabetes between 2003 and 2010. However, the growth in diabetic cases inaccurately characterizes the population risk of diabetes because developing countries are also undergoing rapid population growth and more sizeable increases in life expectancy than developed countries. Although developing countries had a larger increase in people with diabetes, the prevalence of diabetes is higher in developed countries. Furthermore, developed countries saw a larger increase in the prevalence of diabetes between 2003 and 2010. Our results reveal disparities in the risk of diabetes by development level, potentially indicating a correlation between economic development and population diabetes risk.

In both developed and developing countries, the prevalence of diabetes was highest in the 60-79 age range. This validates prior studies that find that older age groups have the greatest prevalence of diabetes (Boyle et al., 2001; Fendrich & Hoffmann, 2007). Between 2003 and 2010, the greatest growth in population was in the 40-59 age range. Within the next 20 years, these cohorts will age into the high risk 60-79 age range. Quantifying the contribution of aging to global diabetes risk will therefore be useful to estimate the future diabetes risk for aging global cohorts. Our decomposition of diabetes growth between 2003 and 2010 shows that only 8.59% of the global growth in diabetic prevalence can be attributed to changes in the age-compositions of populations, and aging in particular. Therefore, 91.41% of the growth in global diabetic prevalence is due to increasing age-specific diabetes prevalence.

The effect of aging varies by developed and developing countries. In developing countries, aging is responsible for 11.23% of the growth in diabetes prevalence between 2003 and 2010. Strikingly, only 5.91% of the growth in diabetes prevalence in developed countries is due to populating aging. These results have large implications for population aging and diabetes policy. In developed countries, the growth in diabetes risk is nearly all due to increasing population risk of diabetes across all age groups. The aging of the population has a very small contribution to the growth in diabetes risk, possibly because life expectancy is already quite high in most developed countries and increases in life expectancy over the past decade have been small. In developing countries, populations are still rapidly aging, so the effect of aging is greater. However, almost 90% of the growth in diabetes in developing countries is also due to increasing age-specific risk of diabetes. These results hint at diabetes risk being driven by behavioral, rather than demographic, changes. Rising rates of obesity, sedentary lifestyles, and poor diets may be driving the population risk of diabetes (Siegel et al., 2011)—indicating the need for policy and interventions that target the behavioral drivers of diabetes risk.

Knowing the growth in cases of diabetes is still an important metric for understanding the population health system impact of new diabetes cases and the progression of diabetes to morbidity, high health care costs, and eventually mortality. However, our results indicate that simply bracing health systems for a growth in cases of diabetes ignores the social, behavioral, and economic factors that are driving the increasing risk of diabetes globally.

Our analysis improved on previous estimates of the growth in diabetes attributable to aging by using retrospective observational data rather than projected data. We were also able to disaggregate the contribution of aging from the contribution of population growth, providing an individual value for the effect of population aging.

However, our 7-year time frame of 2003 to 2010 is relatively short and may not capture the full historical impact of population aging. We were not able to gender standardize or disaggregate diabetes prevalence by gender to isolate the effect of population aging by gender. We did not have data for people above the age of 80, which could have biased our estimation of the effect of aging by ignoring the number of people with diabetes in the older ages and the people who aged into the 80+ age range between 2003 and 2010. We used three 20-year age-ranges that may underestimate the contribution of aging by ignoring the prevalence variation within our age groups. For our method of decomposition, 5-year age intervals would have provided a more accurate decomposition result. Finally, a number of countries were dropped due to missing data for both years. This could potentially affect the generalizability of our main effects. We do not believe these countries would greatly change our result since most were small island countries with relatively low contributions to our overall sample. We would ideally also like to examine or at least adjust for varying pace of economic development across the countries included as this may offer more insights about differences in how societal and environmental changes may be contributing to growth in diabetes.

CONCLUSION AND PUBLIC HEALTH IMPLICATIONS

The global prevalence of diabetes is growing yearly. Understanding the determinants of diabetes growth is essential for planning the prevention and management of the global diabetes epidemic. With populations across the world living longer and growing older, quantifying the contribution of population aging to diabetes growth is key to setting funding priorities and preparing health systems for aging populations. Based on our analysis, population aging is only responsible for a small percentage of the growth in diabetes prevalence between 2003 and 2010. To adequately quell the rising population risk of diabetes, further research is needed to investigate and quantify the contribution of the social, economic, and behavioral determinants of diabetes.

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