Computational Methods in Official Statistics with an Example on Calculating and Predicting Diabetes Mellitus [DM] Prevalence in Different Age Groups within Australia in Future Years, in Light of the Aging Population

D. Hilton

Abstract—An analysis of the Australian Diabetes Screening Study estimated undiagnosed diabetes mellitus [DM] prevalence in a high risk general practice based cohort. DM prevalence varied from 9.4% to 18.1% depending upon the diagnostic criteria utilised with age being a highly significant risk factor. Utilising the gold standard oral glucose tolerance test, the prevalence of DM was 22-23% in those aged >= 70 years and <15% in those aged 40-59 years. Opportunistic screening in Australian general practice potentially can identify many persons with undiagnosed type 2 DM. An Australian Bureau of Statistics document published three years ago, reported the highest rate of DM in men aged 65-74 years [19%] whereas the rate for women was highest in those over 75 years [13%]. If you consider that the Australian Bureau of Statistics report in 2007 found that 13% of the population was over 65 years of age and that this will increase to 23-25% by 2056 with a further projected increase to 25-28% by 2101, obviously this information has to be factored into the equation when age related diabetes prevalence predictions are calculated. This 10-15% proportional increase of elderly persons within the population demographics has dramatic implications for the estimated number of elderly persons with DM in these age groupings. Computational methodology showing the age related demographic changes reported in these official statistical documents will be done showing estimates for 2056 and 2101 for different age groups. This has relevance for future diabetes prevalence rates and shows that along with many countries worldwide Australia is facing an increasing pandemic. In contrast Japan is expected to have a decrease in the next twenty years in the number of persons with diabetes.

Keywords—Epidemiological methods, aging, prevalence.

I. INTRODUCTION

THE Australian Diabetes Screening Study estimated the prevalence of undiagnosed diabetes mellitus [DM] in patients with symptoms and risk factors of DM whom attended general practice clinics [1]. Hilton and colleagues sub-cohort analysis using different criteria for diagnosis also included a risk factor analysis. Age, overweight and hypertension in addition to having multiple risk factors were significant associations with a diagnosis of DM [2].

DM is increasing worldwide, becoming a global pandemic

D. Hilton was with the Baker Heart Research Institute, Melbourne, Australia. She is now with Deborah Hilton Statistics Online (http://sites.google.com/site/deborahhilton/), Melbourne, Australia (phone: 61 3 9830 8514; e-mail: deborah.hilton@gmail.com).

[3]. As such reliable prevalence statistics are necessary in order to plan and predict. In addition they are necessary for the allocation of vital and necessary resources and services. The diabetes atlas is a valuable research tool and resource to understand and view current and future diabetes prevalence statistics.

The diabetes atlas estimates that currently worldwide there are an estimated 382 million people living with diabetes [3]. A further 316 million people have impaired glucose tolerance, people whom are at risk of developing the disease in the future. The prevalence of diabetes is on the rise worldwide and unless this rise is prevented, then in 25 years there will be a staggering 592 million people with the disease. Differing world regions are affected to varying degrees, with the Western Pacific region having more persons with diabetes than any other region. Other world regions of concern are the Middle East, sub-Saharan Africa and South-East Asia. Prevention strategies including a healthy diet and adequate physical activity, in addition to effective drug therapies, technical advances and information dissemination are all crucial in the attempt to halt the alarming rise in numbers. Not only is the toll for the person diagnosed cumbersome but the financial burden worldwide is great, estimated to be USD 548 billion dollars. This equates to 11% of the total dollars spent worldwide on healthcare.

II. PREVALENCE STATISTICS

A. The Global Burden of Disease Project

This project calculated and published prevalence statistics from the years 1980 to 2008 using a complex multi-level approach [4].

B. The Diabetes Atlas

The International Diabetes Federation [IDF] has published the Diabetes Atlas since 2000 and each new edition every three years builds upon previous publications [3]. The atlas divides the world into seven regions and 219 countries. Within the atlas prevalence rates are calculated and these include the national prevalence and the comparative prevalence. The prevalence is the proportion of individuals in the population at the particular time [be it a point in time or a time period] who

have a disease and it is a proportion or number not a rate. The comparative prevalence assumes that each country or region has the same age profile (the age profile of the world population is used). This makes country comparisons possible, reducing the effect of differences in age between countries and regions. The comparative prevalence should not be used for assessing the proportion of people within a country or region whom have diabetes. The national or regional prevalence indicates the percentage of each country's or region's population that have diabetes. It is appropriate for assessing the burden of diabetes for each country or region.

C. Updates

Updates based upon the IDF report have also been produced using the analytic hierarchy process which selects studies from each country that are most appropriate, then modelling occurs for those countries without data [n=216 countries] [5]. If a proxy is used, a study is selected from the data region which is a combination of the IDF region, the world bank country income group and the most common ethnicity. A logistic regression model was used to generate smoothed age specific estimates which were applied to the United Nations population estimates for 2011.

D. AusDiab Study

The AusDiab study being the Australian diabetes, obesity and lifestyle study is the largest Australian longitudinal based study of diabetes, pre-diabetes, heart and kidney disease [6]. The baseline study was conducted in 1999 to 2000 and the 2nd phase was completed in Dec 2005. Included were 11 247 persons 25 years or over and the prevalence of diabetes was 7.4% overall.

E. Comparison

The estimates published in the atlas and the updates using the method above are similar to those of the global burden of disease study in that they are within the uncertainty intervals of the burden of disease study [3]-[5].

III. POPULATION PROJECTIONS

The Australian Bureau of Statistics population projections are not predictions or forecasts, they are to illustrate growth and change in population if certain assumptions about future levels of fertility, mortality, internal migration and overseas migration were to prevail over the years included [7], [8]. Projections include population size and growth, the changing age structure and population distribution. There are three series of projections (Series A, B and C) and series B mostly reflects current trends in fertility, life expectancy at birth and net overseas migration, while Series A has higher assumptions and Series C lower.

IV. OVERWEIGHT / OBESITY

Hilton and colleagues reported in the analysis of the Australian Diabetes Screening Study that overweight / obesity is significantly associated with a diagnosis of diabetes in those with symptoms and risk factors for the disease [2].

Urbanization is associated with lifestyle changes that include increased sedentary behavior so acts as a proxy measure [5]. Hence the incorporation of changes in risk factor status into future diabetes prevalence statistics is difficult as accurately determining the impact and relationship is complex. However it is known that within Australia the prevalence of obesity has more than doubled in the past 20 years [9]. There is a strong positive association between reduced physical activity and obesity. This highlights the importance of reducing sedentary behavior and increasing physical activity. Risk factor analysis that includes age, overweight, physical activity and hypertension is important but can be difficult due to confounding and interaction.

V. TABLES AND FIGURES

Fig. 1 is the Australian Bureau of Statistics projected population, aged 15 to 64 years.
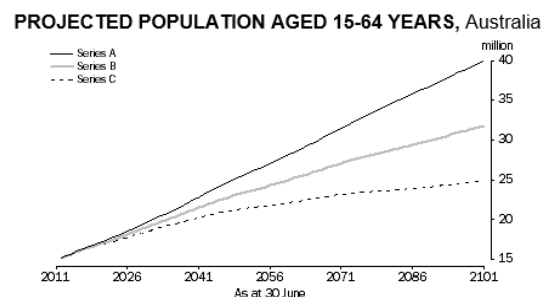

Fig. 1 Australian Bureau of Statistics projected population [8]

Table I shows the numbers of persons with diabetes in differing age groups at two different time points [3]. The country details tables from this book detail the numbers of persons in specific age groups in addition to the numbers with undiagnosed diabetes.

TABLE I
DIABETES ATLAS COUNTRY DETAILS
NUMBER OF PERSONS WITH DIABETES AUSTRALIA: 2013 AND 2035

Year	Age group			Undiagnosed diabetes (20-79)
	20-39	40-59	60-79	
2013	62 829	601 948	984 084	814 538
2035	71 175	714 577	1 526 363	1 142 185

Table II details the national prevalence in Australia, and the percentage increase firstly in the number of persons, then the number of persons with diabetes from 2013 to 2035 [5].

TABLE II
NATIONAL PREVALENCE, PERCENTAGE CHANGE IN POPULATION AND
DIABETES PREVALENCE AUSTRALIA: 2013 AND 2035

Year	National prevalence (%)	Proportional change in adult persons 2013 to 2035	Proportional change in number with diabetes 2013 to 2035
2013	10.0	24.1	40.2
2035	11.3		

A. Undiagnosed Diabetes

Table III shows the number of persons whom were

diagnosed with diabetes from the Australian Diabetes Screening Study. These persons had risk factors and symptoms of diabetes [2]. Table IV documents the percentage of subjects from this analysis with and without a diagnosis of DM according to whether or not they have the risk factor of obesity or hypertension.

TABLE III
UNDIAGNOSED DIABETES IN THE AUSTRALIAN DIABETES SCREENING STUDY
SUB-COHORT ANALYSIS

Diagnostic Criteria	Number with diabetes	Percentage with diabetes
American diabetes association (ADA)	555	9.4 (8.7%–10.1%)
Australian diabetes society (ADS)	945	16.0 (15.3%–16.7%)
World health organization (WHO)	1068	18.1 (17.1%–19.1%)

TABLE IV
UNDIAGNOSED DIABETES IN THE AUSTRALIAN DIABETES SCREENING STUDY
SUB-COHORT ANALYSIS AND THE SIGNIFICANCE OF HYPERTENSION, AGE AND
OVERWEIGHT PERCENTAGE OF PERSONS WITH OR WITHOUT THE DIAGNOSIS
WITH THE RISK FACTOR WITHIN EACH AGE GROUPING

AG	Risk factor	DM ADA/ WHO	WHO 1999 DM only	No DM	Total	Pearson Chi-Squared	p value
1	Over-weight	89.4	88.9	81.5	82.2	2.4	.298
2		85.5	81.8	73.5	75.5	10.2	.006
3		75.0	75.2	63.2	65.5	15.6	.000
4		55.3	50.2	50.3	50.8	2.0	.369
1	HBP	51.1	41.2	42.2	42.9	1.4	.469
2		61.2	54.4	50.8	51.8	4.9	.089
3		66.1	65.0	65.3	65.3	0.1	.977
4		76.8	78.7	72.6	73.8	5.7	.058

AG = age group. 1= ≥40-<50 years, 2= ≥50-<60 years, 3= ≥60-<70 years, 4= ≥70 years. HBP – hypertension

B. Proportional Change in the Population

Fig. 2 is the percentage increase in persons from years 2013 to 2035 for age groups (0 – 64 years) and (> = 65 years).
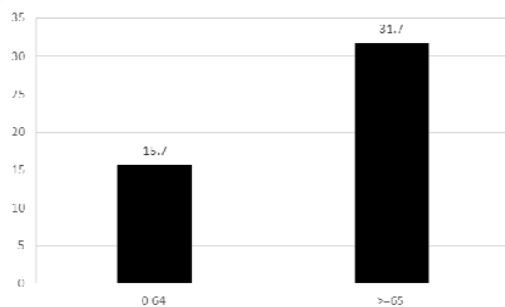

Fig. 2 Population projections – percentage increase from 2013 to 2035

Fig. 3 is the percentage increase in persons from years 2013 to 2056 for age groups (0 – 64 years) and (> = 65 years).
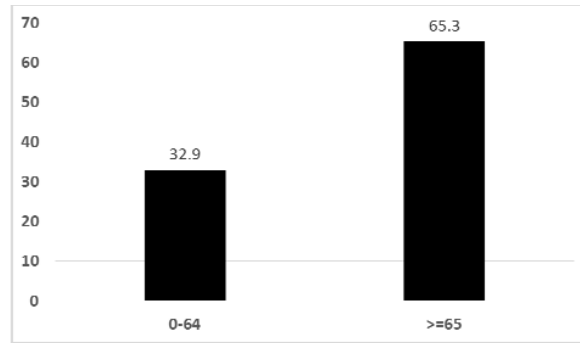

Fig. 3 Population projections – percentage increase from 2013 to 2056

Fig. 4 is the percentage increase in persons from years 2013 to 2101 for age groups (0 – 64 years) and (> = 65 years).
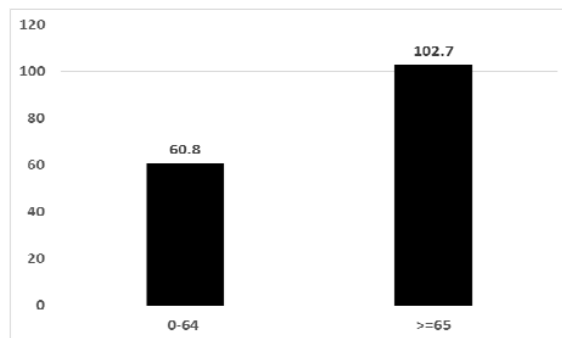

Fig. 4 Population projections – percentage increase from 2013 to 2101

Fig. 5 is the percentage increase in persons from years 2013 to 2035, 2013 to 2056 and 2013 to 2101; age group (20- 79 years).
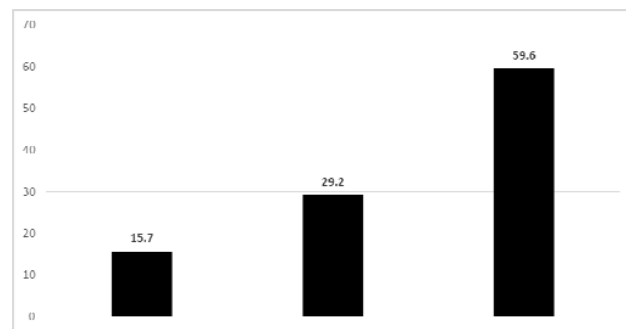

Fig. 5 Population projections - percentage increase from years 2013 to 2035, 2013 to 2056 and 2013 to 2101; age group (20 to 79 years)

The formulae for calculating percentage increase over time are given below.

Population projections, by age and sex, Australia – Series B of the population projections was utilised which is the middle estimate datasheets 1 and 2 [7], [8].

X= Sum [Number of persons at age 0 + Number of persons at age 1 + continuing to + number of persons at age 64] at year 2035

Y = Sum [Number of persons at age 0 + Number of persons at age 1 + continuing to + number of persons at age 64] at year 2013

Z = X-Y

S = Z/Y

This equates to the overall percentage increase from year 2013 to year 2035 for each respective age group.

The basic formulae is utilized for each analysis, altering the years and/ or ages as appropriate.

The equation in Microsoft Excel is as follows [10].

This example in Excel is given for Fig. 2.

This example is for ages 0-64 years.

Cell B48 = number of persons aged 0 years [ie <1 year] at year 2013.

Cell BN48 = number of persons aged 64 years at year 2013.

Cell B49 = number of persons aged 0 years [ie <1 year] at year 2035.

Cell BN49 = number of persons aged 64 years at year 2035.

Cell B51 = Number of persons in total aged from 0 years to 64 years at year 2013 = Sum B48:BN48

Cell B52 = Number of persons in total aged from 0 years to 64 years at year 2035 = Sum B49:BN49

Cell B53 = B52-B51

Cell B54 =B53/B51

Cell B54 = percentage increase in persons aged 0-64 years from year 2013 to 2035.

This is based upon a basic percentage change equation:

$$\frac{\%}{change} = \left(\frac{V_2 - V_1}{V_1}\right) 100 \tag{1}$$

where V_1 is the starting number and V_2 is the ending number.

VI. CONCLUSIONS

This paper details and documents the findings of already published research reporting on prevalence statistics; the AusDiab study, the Australian Diabetes Screening Study, the Diabetes Atlas and various updates. This shows that within Australia there is an alarming number of people whom currently have diabetes and / or whom have undiagnosed diabetes in addition to many whom are at risk of developing the condition in the future. Additional analysis in this paper includes population projection age breakdown showing the increase from years 2013 to 2035, 2013 to 2056 and 2013 to 2101. The diabetes atlas documents in the country summaries table/s prevalence statistics for people of ages 20-79. It states there will be an increase of approximately 40% in terms of the number of persons with diabetes from the year 2013 to 2035. This results in the numbers rising from approximately 1 649 000 in 2013 to 2 312 000 in 2035. Population demographic changes are the main factor used to develop future projections. Given that there will be a further increase in the adult population numbers beyond this to years 2056 and 2101,

means there will most likely be a flow on effect of a further increase in diabetes prevalence.

This highlights in itself without mathematically defining numbers or percentages given that these are difficult to estimate precisely, that there will more than likely be a further corresponding increase in diabetes prevalence over and above the current estimates for 2035 in the atlas given the strong association with demographics that has been shown. Prevalence is difficult to define precisely, given the interaction and confounding that occurs with risk factor analysis which not only makes mathematical extrapolation difficult in terms of weeding out the exact causal factors which is problematic, but as a result of the fact these may alter in the Australian population in the next 50-100 years. These are factors such as obesity, sedentary behavior and hypertension which are also often interrelated. Regardless of the causal factors, or the exact numbers, the upward trend is alarming for the Australian healthcare system, the community and the economy and this paper which has documented the future age group increase highlights the need for concerted action in terms of prevention. This includes not only healthcare professionals and researchers whom are striving for results, but political and funding agencies / departments whom have to focus on priorities and allocation systems. By contrast Japan is expected to have a decrease in the number of persons aged 20-79 with diabetes from years 2013 to 2035 [11]. Australia has much to learn from this lovely country.

REFERENCES

[1] T. A. Welborn, C. M. Reid, and G. Marriott, "Australian diabetes screening study; impaired glucose intolerance and non-insulin dependent diabetes mellitus," *Metabolism*, vol. 46, Suppl 1, pp. 35-39, 1997.

[2] D. Hilton, P. K. O'Rourke, T. A. Welborn, and C. M. Reid, "Diabetes detection in Australian general practice – a comparison of diagnostic criteria," *Medical Journal of Australia,* vol. 176, pp. 104-107, 2002.

[3] International Diabetes Federation. *Diabetes Atlas,* 6th ed., Brussels, Belgium: International Diabetes Federation; 2013.

[4] G. Danaei, M. M. Finucane, Y. Lu, G. M. Singh, M. J. Cowan, C. J. Paciorek, *et al*, "National, regional and global trends in fasting plasma glucose and diabetes prevalence since 1980: systematic analysis of health examination surveys and epidemiological studies with 370 country-years and 2.7 million participants," *Lancet,* vol. 378, pp. 31-40, 2011.

[5] D. R. Whiting, L. Guariguata, C. Weil, J. Shaw. "IDF Diabetes Atlas: Global estimates of the prevalence of diabetes for 2011 and 2030," *Diabetes Research and Clinical Practice*, vol. 94, pp. 311-321, 2011.

[6] D. W. Dunstan, P. Z. Zimmet, T. A. Welborn, M. P. De Courten, A. J. Cameron, R. A. Sicree *et al*, "The rising prevalence of diabetes and impaired glucose tolerance: the Australian Diabetes, Obesity and Lifestyle Study," *Diabetes Care*, vol. 25, pp. 829-834, 2002.

[7] D. Trewin, Australian Bureau of Statistics, "*Population Projections. 1999 – 2101*," ABS catalogue number 3222.0. Canberra: Commonwealth of Australia, 2000.

[8] Australian Bureau of Statistics, "*Population Projections. 2012 (base) – 2101*," ABS catalogue number 3222.0. Canberra: Commonwealth of Australia, 2000.

[9] A. J. Cameron, T. A. Welborn, P. Z. Zimmet, D. W. Dunstan, N. Owen, J. Salmon *et al*, "Overweight and obesity in Australia: the 1999-2000 Australian Diabetes, Obesity and Lifestyle Study (AusDiab)," *Medical Journal of Australia,* vol. 178, pp. 427-432, 2003.

[10] Microsoft Office. *Microsoft EXCEL.* Redmond; Washington, 2013.

[11] L. Guariguata, D. R. Whiting, I. Hambleton, J. Beagley, U. Linnenkamp and J. E. Shaw, "Global estimates of diabetes prevalence for 2013 and projections for 2035," *Diabetes Research and Clinical Practice*, vol. 103, pp. 137-149, 2014.