The Australian Diabetes, Obesity, and Lifestyle Study—Profiling Diabetes and Cardiovascular Disease Risk in the Nation

a report by

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The Australian Diabetes, Obesity, and Lifestyle (AusDiab) study is an ongoing national, longitudinal, population-based study designed to examine the prevalence, natural history, and risk factors of diabetes, pre-diabetes, heart disease, and renal disease in Australia. The AusDiab study is one of the few national diabetes surveys to use an oral glucose tolerance test (OGTT), and the only study of its kind in the developed world. Therefore, it is an important resource not only to Australia but also to the rest of the world.

The AusDiab study resulted from observations of a global pattern suggestive of an emerging diabetes epidemic, about which little was known in Australia. The project began with a baseline study of 11,247 Australians conducted throughout 1999 and 2000 that provided benchmark national data on the prevalence of diabetes, obesity, hypertension, and kidney disease. The second phase of the AusDiab study, completed in December 2005, was a five-year follow-up of the cohort established in 2000 and provided a unique picture of the incidence of diabetes, cardiovascular disease, and kidney disease over five years. The planned 10-year follow-up of the AusDiab cohort will also involve a new prevalence survey in order to track changes in the magnitude of the diabetes epidemic in Australia.

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Local Needs for Data and a National Survey

The AusDiab study was the first national Australian study to measure the prevalence of diabetes using an OGTT. Previous estimates of diabetes prevalence in Australia came from regular self-reported National Health Surveys,[1] a National Heart Foundation survey in 1983 that measured fasting blood glucose but was conducted only in large cities,[2] and two studies that used an OGTT—one in the rural Western Australian town of Busselton in 1981[3] and the other a small study from rural Victoria.[4] The national prevalence of undiagnosed diabetes, as well as the pre-diabetic states of impaired fasting glucose (IFG) and impaired glucose tolerance (IGT), could only be guessed at when the first AusDiab study was conducted. It had been over a decade since any national blood survey had been conducted in Australia to allow estimation of the prevalence of dyslipidemia. The impetus for a national diabetes study increased with the decision by Australian health ministers in 1996 to include diabetes as one of six national health priority areas, the signing by the health ministers in 1999 of the Australian Diabetes Declaration, and the endorsement of the National Diabetes Strategy 2000–2004. Politicians, health planners, and researchers had all recognised the need for accurate diabetes data and the AusDiab study was established in order to fill this need.

What Is The Australian Diabetes, Obesity, and Lifestyle Study?

The sample frame for the AusDiab study included all non-institutionalized adults above 25 years of age who were residents in any of the 42 randomly selected census collection districts throughout Australia (six in each of the seven Australian States and Territories). Testing at each location typically lasted two weeks, with an average of 37 participants attending the baseline survey each day. A written invitation to attend the survey was delivered to all households around six weeks prior to testing, and all eligible individuals in a household were invited to attend during a household interview in the weeks leading up to testing. The baseline and follow-up AusDiab surveys closely followed the World Health Organization (WHO)-recommended model for non-communicable disease field surveys,[5] and up to 15 staff (three core and 12 casual staff) were hired to undertake the testing at each location.

An OGTT was conducted on all non-pregnant participants, and testing also involved anthropometric (waist, hip, height, weight, and bioimpedance) and blood pressure measurements, testing for diabetes complications (among those who had diabetes, IFG, or IGT plus a selection of normals), and electrocardiogram (ECG) measurement. Extensive questionnaires were conducted. These concerned diet, physical activity, demographic and socioeconomic characteristics, smoking, alcohol, health and wellbeing, diabetes knowledge, family history of diabetes, and the use of medications. During the 2005 study, an additional questionnaire on self-reported cardiovascular disease was included. Blood (both fasting and two hours post-administration of oral glucose load 75g) and urine sampling completed the testing, and most participants were able to leave the site after 2.25–2.5 hours. Results letters detailing all of the physical and biochemical measurements were sent to participants, as well as to their doctors if requested, shortly after the completion of testing.

Key Findings

Diabetes Prevalence

The key finding from the baseline AusDiab survey was a diabetes prevalence of 7.4%, which translated to almost one million Australians. This figure gave Australia the dubious honour of joining the group of Westernized countries with the highest prevalence of diabetes. Compared with the only previous estimate using an OGTT in Australia, the prevalence in 2000 was double what it had been two decades earlier; in human terms this translated to three times as many people with diabetes. Importantly, the AusDiab study was able to estimate the number of undiagnosed cases of diabetes, with the finding that for every known case, another case went undiagnosed.[6] In combination with the pre-diabetic states of IFG and IGT (combined prevalence of 16.4%), one in four Australians had either diabetes or its precursors, hinting at the potential for a considerable future burden of diabetes complications, cardiovascular disease, and the associated social and economic costs.

Obesity Prevalence

One of the catalysts for the large increase seen in type 2 diabetes prevalence is the bulging waistlines of many Australians, resulting from an increasingly modern and inactive lifestyle. The finding from the AusDiab study that almost 60% of Australians were either overweight or obese (measured using either waist circumference or body mass index [BMI]) led to considerable media interest and has helped focus the efforts of the Australian Government and others on curtailing and hopefully even reversing the obesity epidemic.[7] Comparing these figures with previous data reveals that there has been a more than two-fold increase of the prevalence of obesity since 1980.[7]

Relationships of Physical Activity, Inactivity, and Sedentary Behaviors to Metabolism

A feature of the AusDiab study has been the focus on the influence of sedentary behavior and physical inactivity on glucose metabolism and obesity. Cross-sectional analyses of the baseline data were able to demonstrate the important and independent effects of physical activity (as measured using the Active Australia physical activity questionnaire)[8] and television viewing on the presence of undiagnosed abnormal glucose metabolism (diabetes or its precursor states) and obesity, particularly among women.[7,9,10] In addition to the somewhat unreliable use of questionnaire data to measure physical activity, two objective measures were applied to subsets of the AusDiab sample to more accurately quantify the relationship between physical (in)activity and both glucose metabolism and obesity.

Data from pedometers (worn for two weeks by all AusDiab participants from the State of Tasmania at the time of baseline AusDiab testing) have been used to demonstrate a strong and logarithmic association between number of steps taken per day and obesity,[11] while accelerometer data have been used to more precisely define the impact of sedentary behavior on outcomes such as obesity and dysglycemia. This work supported the earlier findings from questionnaire data of a strong relationship between physical inactivity and both obesity and post-load glucose measurement, but added important additional insights in that the gender difference observed for questionnaire data was not seen using objective techniques, and strong relationships were observed between not only the time in physical activity, but also the time spent being sedentary, and obesity, dyslipidemia, and post-load glucose.[12] The key lessons from this work are that while the amount of time spent in physical activity is important, the deleterious effects of sedentary behavior such as watching television, and the nature of how this time is accumulated, may have equally or more important associations with measures of diabetes, obesity, and dyslipidemia.

Figure 1: Trends in the Age-specific Prevalence of Diabetes in Australia (%) 1981–2000[6]

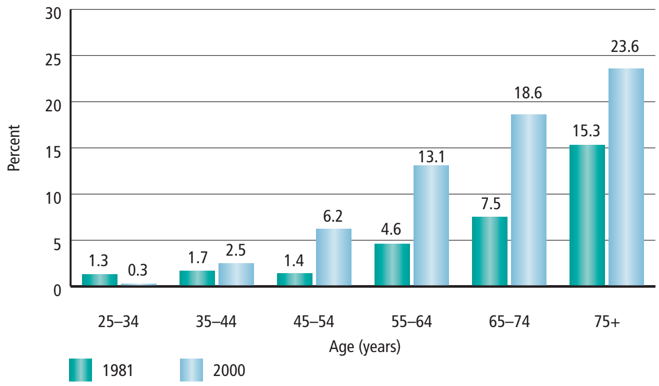
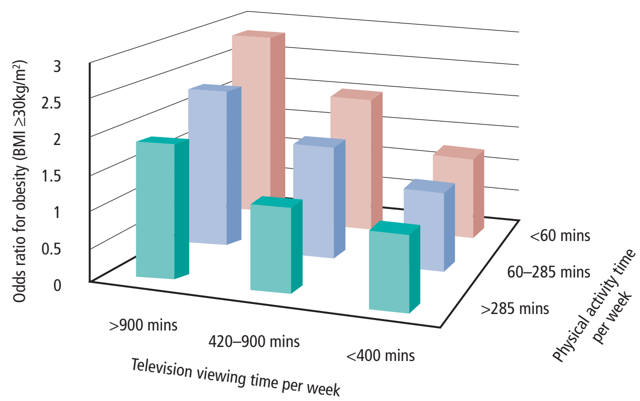


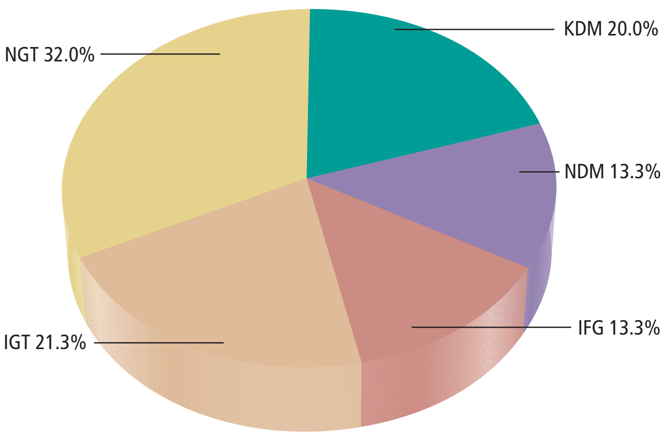
Figure 2: Odds Ratios for Obesity—Television Viewing versus Physical Activity[7]



Complications of Diabetes and Diabetes Management

The cohort of around 470 individuals in the AusDiab sample with previously diagnosed diabetes, and a similar number who were newly diagnosed at the time of the survey, provided an opportunity to examine the extent of the impact that diabetes has on complications such as retinopathy, neuropathy, and renal disease, as well as the way in which these patients are managed in the healthcare system. Testing for diabetic complications was conducted for all subjects diagnosed with any type of abnormal glucose metabolism, as well as a selection of people with normoglycemia. Results from the baseline study showed that 21.9% of those with diagnosed diabetes and 6.2% of those who were undiagnosed had retinopathy at the time of testing.[13] Around 10% of retinopathy among those with diagnosed diabetes was proliferative diabetic retinopathy. Albuminuria, present in 6% of the

Figure 3: Cardiovascular Disease Deaths According to Glucose Tolerance Status at Baseline[30]



** Prevalence in total Australian population:*
Diabetes: 7.4%
IFG/IGT: 16.4%

total Australian population,[14] was also highly prevalent among those with diabetes (25.3%), as well as those with IFG and IGT (9.3 and 11.0%, respectively). When considering multiple measures of kidney disease (proteinuria, hematuria, or reduced glomerular filtration rate), the prevalence of those showing some signs of kidney damage in the total Australian population was as high as 16%.[15]

Foot complications such as peripheral vascular disease and neuropathy are a frequent manifestation of long-standing diabetes, and are the main cause of non-traumatic lower-limb amputations. Both the magnitude of these conditions and their management have been investigated using the AusDiab cohort, with around 13% of those with diagnosed diabetes suffering from one or both of these conditions, and only half of all those with previously diagnosed diabetes having had their feet examined by a healthcare practitioner in the 12 months prior to the survey, compared with almost 80% who reported having had their eyes examined within the previous two years (Australian guidelines recommend a minimum screening frequency of two years for retinopathy).[16,17] As the results of studies such as the UK Prospective Diabetes Survey (PDS) and the Heart Protection Study (HPS) have demonstrated, tight control of glucose, lipids, and blood pressure can significantly reduce the risk of diabetic complications.[18–21] However, among people with diabetes in the AusDiab cohort, only half achieved national targets[22–24] for each of these parameters, and only one in seven people met all three targets. Achievement of the more stringent American Diabetes Association (ADA) targets[25–27] was naturally worse, with only one in five achieving suggested lipid or blood pressure levels and only 2% meeting US targets for all three parameters.[28]

Incidence of Diabetes

The primary aim of the five-year follow-up of the AusDiab cohort was to provide a unique examination of the natural history of diabetes and lesser states of abnormal glucose tolerance in a population-based national sample. Therefore, one of the key findings from the follow-up study was the incidence of diabetes, with 0.8% of the Australian adult population developing diabetes each year. This translates to 275 new cases each day. As expected, most of these new cases came from the pre-diabetes categories of IFG and IGT (incidence of 2.5 and 3.5% per year, respectively, which was between 10- and 20-fold higher than that from normoglycemia), providing further evidence of the burden that their high prevalence detected in the 1999–2000 survey will have on diabetes rates in the future.[29] Obesity, hypertension, dyslipidemia, physical inactivity, and metabolic syndrome all increased the risk of developing diabetes.

Mortality and Glycemia

The AusDiab cohort has been linked annually to the Australian National Death Index (NDI) since 2004, providing a means of assessing the mortality risk associated with the various states of glucose intolerance in a national population-based sample. While the association between diabetes and mortality is well established, less is known about the risk associated with IFG and IGT. After a median follow-up of 5.2 years, 298 deaths had occurred in the AusDiab cohort (88 of these including cardiovascular disease [CVD] as a cause of death). Compared with those with normal glucose tolerance, the adjusted all-cause mortality hazard ratios (HRs) (95% confidence interval [CI]) for previously diagnosed diabetes mellitus and newly diagnosed diabetes mellitus were 2.3 (1.6–3.2) and 1.3 (0.9–2.0), respectively. The risk of death was also increased in those with IFG (HR 1.6, 1.0–2.4) and IGT (HR 1.5, 1.1–2.0). Demonstrating the link between diabetes, CVD, and death, 65% of all those who died of CVD had some form of glucose abnormality at baseline. After adjusting for known CVD risk factors (including age and sex), previously diagnosed diabetes mellitus (HR 2.6, 1.4–4.7) and IFG (HR 2.5, 1.2–5.1) remained as independent predictors for CVD mortality; however, IGT did not (HR 1.2, 0.7–2.2), perhaps reflecting the impact of treatment following diabetes diagnosis at baseline.[30]

Key Challenges

Recruitment and Response Rates

One of the most challenging aspects of a project such as the AusDiab study is achieving an adequate response among the eligible population. Several features of the study make recruitment difficult, including the minimum two and a half hours that participants are required to sacrifice in order to attend, the requirement to fast for at least 10 hours, the small window of time (two weeks) that the team is in a certain area, and the absence of any financial reward for participants. The response of around 55% to the baseline study (this is the percentage of those who participated in a household interview and then attended for physical testing) was seen by some as realistic given the constraints of the study. However, others saw this as indicative of a study that was national and population-based but not representative.

In an analysis of responders and non-responders to the study, responders were found to be slightly more educated (58.2 versus 51.3% with higher education), more likely to have been born in the UK (10.3 versus 8.8%), more likely to speak English at home (96.1 versus 93.6%), and more likely to suspect they had diabetes (1.5 versus 0.5%). However, these differences were small and unlikely to materially affect prevalence estimates. Of particular note was the higher percentage among responders who suspected they had diabetes. Of this group, fewer than 10% actually tested positive using an OGTT (compared with 4% who did not suspect diabetes), meaning that even this disparity would have made little difference to the final diabetes prevalence estimates.[31]

After the baseline survey between 1999 and 2000 and the follow-up five years later, we implemented several strategies designed to keep participants involved in the study and maximize response at follow-up. These included sending annual mailings to the entire AusDiab cohort, including a pre-paid envelope for updating address and contact details, as well as the details of two next of kin not living at the same address. Response to these mailings has been in excess of 90% and, in combination with matching of the AusDiab database to the Australian Electoral Commission (AEC), has ensured that we are able to contact as many people as possible at the time of re-survey. In addition, we have published an annual AusDiab newsletter for participants in an attempt to instill in them the feeling that they are taking part in important health research for the benefit of all Australians, and to keep them informed of the latest results of the study.

Response to the five-year follow-up study in 2004 and 2005 was similar to baseline, with around 60% of participants returning for re-testing five years later. A further 19% provided self-report diagnosis (by phone questionnaire) of various conditions including diabetes and CVD. Comparing the self-reported diabetes incidence of those who returned for physical testing and those who only completed a phone interview revealed little difference, suggesting that despite a moderate response the diabetes incidence figures are likely to be a valid national estimate. As it was designed to provide national estimates only, an acknowledged limitation of the AusDiab study is the inability to draw any conclusions about the magnitude of the diabetes epidemic in indigenous Australians and any rural/urban differences in health and healthcare provision. Separate studies have since been conducted in an attempt to address these two important issues.[32]

Funding

The AusDiab study is funded primarily by the Australian Government through the Department of Health and Aging and a National Health and Medical Research Council (NHMRC) grant that was awarded for the five-year follow-up study, as well as support from individual state governments, academic institutions, and industry partners.

Future Plans

As the baseline AusDiab survey is now almost seven years old, there is a growing need for more up-to-date figures to map the trends in the prevalence of diabetes and other non-communicable diseases in Australia. The AusDiab survey has clearly demonstrated the value of accurate national estimates, and in particular the value of conducting an OGTT for the diagnosis of diabetes. For these reasons, planning has begun for a new Australian prevalence survey to be conducted in 2010, involving the recruitment of a new cohort and with the primary aim of determining the extent to which the prevalence of diabetes and related conditions has changed since 2000.

In addition, the unique nature of the established AusDiab cohort, being the only active longitudinal national diabetes survey in the developed world, means that the establishment of a new cohort would present the perfect opportunity to also complete a 10-year follow-up of the baseline AusDiab participants. This would be particularly valuable for assessing the impact of diabetes on outcomes such as stroke, heart disease, kidney disease, diabetic complications, and death. With the completion of two national prevalence surveys 10 years apart and 10-year follow-up data, the AusDiab study promises to continue to be a valuable tool for research and health planning well into the future. ■

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