Diabetes Care in an Australian Population

Frequency of screening examinations for eye and foot complications of diabetes

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Abbreviations: ABPI, ankle brachial pressure index; AusDiab, Australian Diabetes, Obesity, and Lifestyle Study; NDS, neuropathy disability score; NSS, neuropathy symptom score; PVD, peripheral vascular disease; VIP, Visual Impairment Project.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

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OBJECTIVE — The aim of this work was to study the frequency of examining for diabetic eye and foot complications in an Australian population and to study factors associated with regular screening.

RESEARCH DESIGN AND METHODS — The Australian Diabetes, Obesity, and Lifestyle Study (AusDiab) was a population-based study of 11,247 people from randomly selected areas of Australia. Participants identified as having previously diagnosed diabetes (n = 475) were invited to participate in the complications study. Measures included foot examination, retinopathy photography, and self-report use of health care services.

RESULTS — Seventy-seven percent of participants reported having an eye examination within the previous 2 years, and 50% reported having their feet examined by a health professional in the previous year. Type of diabetes treatment (odds ratio 1.46, 95% CI 0.85–2.50 for tablets versus diet alone and 4.17, 1.71–10.17 for insulin or insulin and tablets versus diet alone) and visiting a diabetes nurse educator in the previous 12 months (2.14, 1.18–3.87) were independent predictors of having had an eye examination. Duration of diabetes (1.33, 1.06–1.67 per year) and visiting a diabetes nurse educator in the previous 12 months (1.89, 1.20–2.95) were independent predictors of a foot examination.

CONCLUSIONS — This study has shown that retinopathy screening is performed more frequently than foot screening in Australia. This may be due to the implementation of eye screening programs and awareness campaigns. Foot screening appears to be poor, with less than one-half of the population reporting a regular examination for foot complications. In Australia, diabetes nurse educators play a key role in promoting screening for diabetes complications.

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D iabetic retinopathy, neuropathy, and peripheral vascular disease (PVD) are frequent complications of diabetes. Up to 15% of those with newly diagnosed diabetes may already have some evidence of retinopathy (1–3), and the majority of individuals with diabetes have evidence of retinopathy within 20 years of diagnosis (4). Diabetes is one of the most common causes of visual loss and amputation despite the availability of effective health care interventions. Currently available treatment such as laser therapy, when used in a timely fashion, is usually effective in preventing severe visual loss (5,6), whereas regular screening and foot care education can dramatically reduce the number of people requiring amputation (7).

Screening for diabetic retinopathy and foot complications has been shown to not only reduce the numbers of people who develop visual loss or require amputation but also to be extremely cost effective (8,9). The costs of providing preventative eye care and foot screening are much lower than the costs associated with ongoing support and rehabilitation required for a person with established disability due to visual loss, chronic foot ulceration, or amputation. The American Diabetes Association recommends that people with type 1 diabetes have an eye examination within 3–5 years of diagnosis of diabetes and thereafter have an annual eye examination (10). For type 2 diabetes, it is recommended that people undergo an eye examination at diagnosis and annually thereafter. Australian guidelines recommend screening every 2 years for those with normal retinal examination (11). It is further recommended that people with diabetes undergo an annual foot examination to assess protective sensation of the feet, foot structure, biomechanics, circulation, and skin integrity (12–14).

Previous studies in Australia and overseas suggest that only approximately one-half of those with diabetes undergo...
regular screening for diabetes complications (15–17). Within Australia, no national study of diabetes complications has previously been undertaken. The prevalence of diabetes is reaching epidemic levels worldwide (18,19), and unless the current trend of increasing diabetes incidence is curbed, morbidity and the cost of providing health care services to treat the related complications will continue to rise. In the first national population-based diabetes survey of Australia in 1999–2000 (the Australian Diabetes Obesity and Lifestyle study [AusDiab]), diabetes was found in 7.4% of adults aged ≥25 years (20). Of those with previously diagnosed diabetes, retinopathy was present in 24.5% (proliferative in 3.3%), neuropathy in 12.6%, and PVD in 13.1% (3,21).

The aim of this study was to assess the use of eye and foot care services by people with diabetes in the Australian population.

RESEARCH DESIGN AND METHODS — The population sample, methods, and response rates of the AusDiab study are detailed elsewhere (22). In brief, the AusDiab study was a population-based study of 11,247 people from randomly selected areas of Australia. A stratified cluster sampling method was used involving seven strata (the six states and the Northern Territory), and clusters were based on census collector districts. The sample size was based on estimates to identify a national diabetes prevalence of 7% (an estimate based on the results of previous surveys and the expectation that the diabetes rate had increased over time). Of those who completed the household interview, 55.3% (n = 11,247) attended the biomedical examination and had an oral glucose tolerance test. Previously diagnosed diabetes was based on self-report together with either current treatment with hypoglycemic medication or a fasting plasma glucose ≥7.0 mmol/l and/or a 2-h plasma glucose ≥11.1 mmol/l (23). Participants identified as having previously diagnosed diabetes (n = 475) were invited to participate in the complications study. Measures included foot examination, retinopathy photography, and self-reported use of health care services.

Retinal photographs were taken using a nonmydriatic retinal camera (Canon CR6–45NM) with an adapter fitted with a Sony three-chip CCD color camera and OptoMise PRO software on a Pentium 2 processor-based computer. Images were stored as uncompressed tagged image format files giving resolution of 768 × 576 pixels with a 24-bit color displayed on a standard 17-inch monitor. Photographs were taken in two fields per eye, macula centered, and nasal to disc. No dilating drops were used. One assessor, masked to all participant information, graded the photographs. The level of retinopathy was defined according to a simplified version of the Wisconsin grading system (24), and final classification was based on the grading of the worst eye. Nonproliferative diabetic retinopathy was defined as the presence of at least one definite retinal hemorrhage or microaneurysm. Macular edema was defined as hard exudate within one disc diameter of the center of the macula. Vision threatening retinopathy was defined by the presence of proliferative retinopathy or macular edema.

Neuropathy and PVD were measured using the neuropathy symptom score (NSS) (25), neuropathy disability score (NDS) (25), monofilament test, postural blood pressure drop, and the ankle brachial pressure index (ABPI). The NSS included questions about burning, numbness, tingling, aching, and cramp-like pain or discomfort in legs or feet (25). The NDS examined ankle reflexes, vibration perception on the great toe, pin-prick perception (using standard neurotips) on the dorsal surface of the great toe, and temperature perception on the dorsal surface of the metatarsal heads (25). Pressure perception was assessed using a 10-g monofilament. Three sites were tested on the planter surface of each foot—the great toe and first and fifth metatarsal heads (26). If the monofilament was not felt, the test was repeated twice, and a score of sensate was only recorded if both retests were correct. Areas of callus were avoided. All sensory testing was demonstrated on the forearm, and eyes were closed throughout. Lying blood pressure was measured on the right arm with a standard sphygmomanometer after the participant had rested in a supine position for 10 min. The arm was measured to ensure the correct sized cuff was used. Blood pressure was measured again after standing for 60 s. Blood pressure was assessed with the first and fifth Korotkoff sounds to the nearest 2 mmHg (27). Neuropathy was defined as present if two or more of the four scales were abnormal, NSS >4, NDS >5, monofilament test <6 (each site scored as 1 if normal and 0 if abnormal), and fall in systolic blood pressure of ≥20 mmHg. These cutoffs were determined from previously published data (25–27).

The ABPI was used to classify PVD (28,29). The ABPI was defined as ankle pressure/arm pressure (normal ≥0.9) and measured on the right side using a standard sphygmomanometer and a doppler probe (model D900; Huntleigh Diagnostics, Cardiff, U.K.) after resting for 5 min. The systolic pressure was measured at the brachial artery and then at the posterior tibial or dorsal pedis artery of the foot (two recordings were taken at each site, and the average of the two readings were used in the analyses). History of foot ulceration was determined through an interviewer-administered questionnaire. Foot risk was defined using three definitions: 1) the presence of any one of neuropathy, ABPI <0.9, or history of foot ulceration; 2) the presence of two or more abnormalities of neuropathy, ABPI <0.9, or history of foot ulceration; and 3) insensitivity to monofilament.

Information on history of diabetes, diabetes knowledge, and use of health care services was obtained by interview. Participants were asked if they had ever had the back of their eyes examined and when their last examination was. They were asked if a health professional had examined their feet in the previous 12 months and if they had examined their own feet in the previous week. They were also asked if they thought that eye problems, heart disease, amputations, and kidney disease were associated with diabetes. The study was approved by the ethics committee of the International Diabetes Institute. Informed consent for the study was obtained from all participants.

Statistical methods

The data analysis was performed with SPSS Version 10.0.5 for Windows (1999; SPSS, Chicago, IL). Descriptive information for each of the variables was derived and distribution assessed. Univariate associations with retinopathy and foot screening were assessed using Student’s t tests for metric variables (Mann-Whitney test was used for diabetes duration) and χ² tests for categorical variables. From the univariate analyses, variables with P values ≤0.25, as well as established predictors, were considered for entry into
logistic regression models to predict retinopathy and foot screening.

**RESULTS**—Of the 475 participants with previously diagnosed diabetes, 396 completed the diabetes knowledge questionnaire. Responders (those with complete diabetes knowledge data) were younger (63 vs. 60 years, *P* = 0.029) than nonresponders (incomplete data or non-attendance). However, there were no differences in sex or the type of diabetes treatment between responders and nonresponders. The median duration of diabetes was 5 years (interquartile range 2–12 years). There were 26.8% who reported being treated with diet only, 54.6% reported using tablets, 14.3% reported being treated with diet only, 85% (171/201) of those on tablets, 95% (53/56) of those on insulin, and 100% (16/16) of those on both insulin and tablets had their eyes examined at least once. Seventy-seven percent of all participants had undergone an eye examination in the previous 2 years. Among those with a diabetes duration ≥1 year, 75% (67/90) of those on diet alone, 85% (171/201) of those on tablets, 95% (53/56) of those on insulin, and 100% (16/16) of those on both insulin and tablets had their eyes examined in the previous 2 years (*P* = 0.002). Diabetes duration of ≥1 year was selected, as those with a short duration of diabetes may not have had time to undergo screening.

Table 1 shows the univariate association of factors with having an eye examination in the previous 2 years. Diabetes treatment, age, diabetes duration, sex, and HbA1c were entered into a logistic regression model to determine independent predictors of reporting an eye examination (in the previous 2 years). Type of diabetes treatment and visiting a diabetes nurse educator in the previous 12 months were independent predictors of having had an eye examination (Table 2).

Fifty percent of participants reported a health professional had examined their feet in the previous 12 months. Fifty-nine percent of participants reported having visited a diabetes nurse educator in the previous 12 months (interquartile range 2–12 years). There were 26.8% who reported being treated with diet only, 54.6% reported using tablets, 14.3% reported being treated with diet only, 61% (101/205) of those on diet alone, 61% (35/57) of those on insulin, and 56% (9/16) of those on both insulin and tablets reported a foot examination by a health professional in the previous 12 months (*P* = 0.353). Figure 1 shows the percentage reporting foot examination by foot risk status.

Table 1 shows the univariate association with having feet examined by a health professional in the previous 12 months. Diabetes treatment, age, diabetes duration, sex, and HbA1c were entered into a logistic regression model to determine independent predictors of foot ulceration (Table 2).

Table 2 shows the factors associated with regular screening.
ucator in the past 12 months, type of doctor treating diabetes (general practitioner versus specialist), and HbA1c were entered into a logistic regression model to determine independent predictors of foot examination by a health professional. This identified duration of diabetes and visiting a diabetes nurse educator in the past 12 months as independent predictors of foot examination (Table 2). Sixty percent of those who had seen an educator in the previous 12 months (versus 47% who had not seen an educator) had had a foot examination, and 86% had had an eye examination in the previous 2 years (versus 73%).

Ninety percent of participants were aware that diabetes was associated with eye trouble and blindness, 6% thought it was not, and a further 4% did not know. Eighty-five percent thought amputations/gangrene were associated with diabetes, 73% heart disease, and 68% kidney disease, respectively.

CONCLUSIONS — This is one of the first national studies of diabetes complications in a developed nation and one of the few studies to assess frequency of routine examination for diabetes complications and to assess predictors of regular screening. Health care practices in screening were different for retinopathy and foot risk. A substantial proportion of the individuals with diabetes (overall 77%: 91% insulin treated, 74% noninsulin treated) had undergone an eye examination in the previous 2 years. Previous studies have shown varying results in the number of people who have reported having an eye examination in the past 2 years, largely dependent upon the type of diabetes treatment. The Melbourne Visual Impairment Project (VIP) study found that 70% of people on insulin and only 48% of people not on insulin reported having the back of their eyes examined in the previous 2 years (30). The report from the Tasmanian Diabetes Register showed that 90% of participants treated with insulin (aged ≥25 years) recalled having the back of their eyes examined in the previous 2 years (17). The Melbourne VIP study, the Tasmanian Diabetes Register study, and the current study all asked the same question about fundus examination (“have you ever had the back of your eyes examined?”). However, the Melbourne VIP study asked a further series of questions related to eye examination. This slight difference in questioning may have impacted on how people responded to the question, as the questioning by the Melbourne VIP study was more specific (clearly distinguishing between a test of visual acuity and a dilated fundus examination). It is possible that the current study and the Tasmanian Diabetes Register study have overestimated the frequency of examinations reported, as the distinction between an eye examination and a dilated fundus examination may have been less clear. Therefore, further validation of these results would be needed to draw any firm conclusions. Nevertheless, over the past few years in Australia, education and awareness programs for diabetic retinopathy have been implemented, and the role of primary care providers in screening for retinopathy has been developed (31). This could explain the increase in screening between the current and previous studies. However, it is of concern that 18% of the total diabetic population, including a substantial proportion of those not on insulin, reported never having had an eye examination. This does suggest that those who are diet controlled are not seen as having a serious condition warranting careful monitoring.

Independent factors associated with having had an eye examination were type of diabetes treatment (participants were more likely to have had an eye examination if they were treated pharmaceutically compared with diet only) and having visited a diabetes nurse educator in the past 12 months. Other factors, including duration of diabetes, age, sex, type of doctor treating diabetes (general practitioner versus specialist), and HbA1c, were not associated with having had an eye examination in this population. A study of 2,405 diabetic patients in the U.S. showed that older age, higher socioeconomic status (higher income and education level), and having attended a diabetes education class were associated with having an annual eye examination (15). Diabetes treatment could be seen as a surrogate for disease severity. Those with a more advanced disease are therefore seen as being more likely to develop dia-

Figure 1—Percentage reporting foot examination by foot-risk status. A: Health professional examined feet in the previous 12 months. B: Examined own feet in the previous week. C: Examined own feet in the previous week (restricted to those reporting foot examination by a health professional in the previous 12 months). 1, normal; 2, abnormal on one or more scales (neuropathy, ABPI <0.9, or history of foot ulceration); 3, abnormal on two or more scales (neuropathy, ABPI <0.9, or history of foot ulceration); and 4, insensitivity to monofilament.
Diabetic retinopathy and sent for screening more frequently than those with diet-controlled diabetes. Diabetes nurse educators (who can variably be accessed directly, or through primary or secondary care) may play several important roles in promoting regular eye screening; improving patient knowledge base, enquiring about eye screening, and directing patients to appropriate services.

A substantial proportion of the diabetic population in Australia had not had their feet examined by a health professional in the previous 12 months (overall 50% of participants had had a foot examination, 61% insulin treated, 48% non-insulin treated). Studies assessing the frequency of foot examination among people with diabetes are scarce. One of the few studies with data on the frequency of foot screening, which was from Australia, found similar results to the current study. The Tasmanian Diabetes Register of people with insulin-treated diabetes asked a less specific question about regular foot screening. Nevertheless, the study showed that only 49% of people (aged ≥23 years) had undergone a regular foot examination by a doctor and only 66% had examined their own feet weekly (17). In the current study, there was no increased awareness of foot care among those at risk of foot ulceration compared with those with normal foot sensation (Fig. 1A). Even among those with severe foot risk (abnormal on two or more scales) who reported a foot examination by a health professional in the previous 12 months, there appeared to be no improvement in foot care practices (Fig. 1C). Furthermore, the frequency of foot screening was similarly inadequate across all diabetes treatment groups. This suggests that foot screening and education are inadequate in this population, and as a result, foot care practices among those at high risk of future foot ulceration are poor. It should be noted that recommendations for those with neuropathy or PVD include daily self-examination, but we only asked about self-examination in the previous week. Independent factors associated with having a foot examination were duration of diabetes and a visit to a diabetes nurse educator in the past 12 months. No previous studies have assessed predictors of attending for regular foot screening.

Prevention of visual loss and amputation are possible through regular screening and treatment (6,7). In this study, 90% of participants were aware that eye problems and blindness were associated with diabetes. Programs designed to increase the awareness of the association have been implemented in Australia and may explain the increased awareness of diabetic retinopathy between the current and previous studies. A previous study assessing the awareness of diabetes complications in Australia found that only 37% of the diabetic population was aware of the association between diabetes and eye disease (32), whereas a study from the U.S. found that 65% of people with diabetes where aware of the association between diabetes and eye disease (33). Many people with diabetes were also aware of the association between diabetes and amputation, which again was much higher than reported in previous studies (32,33). However, the increased awareness of the association between diabetes and amputation did not translate into regular foot screening. This is probably because systems for implementation of foot screening programs in Australia are not well developed. However, it is well recognized that knowledge does not equate to behavior. Knowledge of the link between diabetes and its complications does not equate to knowledge of the benefit and need for screening. These data do suggest that many people remain unaware that diabetes complications are often asymptomatic. This theme should be developed in future awareness campaigns.

The current study has certain limitations. The frequency of examination for diabetes complications was based on self-report. Studies have shown that self-report data are likely to lead to an overestimate in the frequency of screening (34). There may have been differences between the accuracy of recall of foot examinations and eye examinations. Foot examinations are usually performed in the context of a standard medical visit, but eye screening in Australia is usually performed by ophthalmologists or optometrists, which necessitates a specific medical visit. Therefore, the reporting of foot examinations may have been underestimated in comparison to eye examinations.

This study has shown that retinopathy screening is performed more frequently than foot screening in Australia. This may be due to the implementation of eye screening programs and awareness campaigns. Foot screening remains inadequate with only one-half of the diabetic population reporting regular screening for foot complications. This is well below the 80% screening target set by the National Diabetic Foot Disease Management Program (13). Screening programs similar to those established for eye screening need to be implemented. Diabetes nurse educators play a key role in promoting screening for diabetes complications. The complications of diabetes extract a high cost to the community, and foot care and eye screening programs have been shown to be cost-effective apart from their impact on quality of life for people with diabetes.

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**APPENDIX**

The Australian Diabetes Obesity and Lifestyle Study Steering Committee: Dr. B. Atkins, Dr. S. Bennett, Dr. S. Chadban, Prof. S. Colagiuri, Dr. M. de Courten, Dr. M. D’Embden, Dr. D. Dunstan, Prof. T. Dwyer, Dr. D. Jolley, Dr. P. Magnus, Prof. J. Mathews, Dr. D. McCarty, Prof. K. O’Dea, Dr. P. Phillips, Dr. P. Popplewell, I. Kemp, Prof. H. Taylor, Prof. T. Welborn, and Prof. P. Zimmet.
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