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Determinants and costs of community nursing in patients with type 2 diabetes:

The Fremantle Diabetes Study

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Abstract

Objective: To determine the incidence, predictors and costs of community nursing provision to patients with type 2 diabetes.

Design: Prospective observational study utilising data linkage.

Setting: Metropolitan teaching hospital.

Participants: Patients with type 2 diabetes enrolled in the Fremantle Diabetes Study between 1993 and 1996.

Methods: Eligible patients were followed from July 1997, when home nursing data first became available, to death or census in November 2007. Home nursing data from the major community nursing service provider were linked with data from the Fremantle Diabetes Study. Cox and zero-inflated negative binomial (ZINB) regression modelling was used to identify predictors of incident home visits and visit frequency, respectively. Direct costs were estimated from the service provider's unit costs.

Results: During a mean±SD 8.6±2.9 years of follow-up, 27.8% of 825 patients (aged 65.2±10.3 years at study entry; 51.2% male) received 21,878 home nursing visits (median frequency 31 [interquartile range 9-85] visits, range 1-1,446 visits). In Cox and ZINB models, predictors of home nursing included older age, physical disability measures and macrovascular and microvascular complications. Insulin use was an important predictor of the frequency of visits whilst ethnic and economic factors predicted lower frequency. The

estimated cost of home nursing, extrapolated nationally, adds 5% to the total Australian direct health care costs of diabetes.

Conclusions: Home nursing is frequently utilized in the management of type 2 diabetes with considerable individual variation in the use of this service. Given the associated costs, further research into how home nursing can best be employed is indicated.

## Introduction

Type 2 diabetes mellitus is a chronic disabling condition [1] because of the impact of diabetic complications plus common co-morbidities [2, 3]. Patients with type 2 diabetes have an increased risk of developing functional impairments that include reduced vision, balance and mobility problems, falls-related injury, cognitive impairment and mood disorders [4, 5]. These impairments interfere with the individual's ability to perform basic and instrumental activities of daily living and lead to the requirement for assistance from family members or community resources. Skilled nursing care provided in the community frequently contributes to the management of older or disabled patients with diabetes, often through assistance with treatment regimes or because of the need for wound care and there is considerable potential to augment patient education or treatment adherence [6, 7]. Patients with diabetes present a substantial work load and are a high priority for organisations that provide community nursing services [8, 9].

In Australia, home-based community nursing is provided by registered nurses for community-dwelling aged and disabled people organised by district nursing organisations funded mostly by government grants [9]. Despite its potential importance, few studies have examined the determinants or cost-effectiveness of community nursing [10]. According to literature reviews, nursing interventions can lead to improved patient outcomes in diabetes but studies have not specifically examined community nursing [11, 12]. A US study estimated that "home health" costs comprised ~10% of the health costs attributable to diabetes but did not separate out the costs of home nursing [13].

In Western Australia (WA), the majority of community nursing services are provided by, Silver Chain and they maintain a database of all the nursing services they provide. The

Fremantle Diabetes Study (FDS) is a longitudinal observational study of a community-based cohort of patients with known diabetes who are representative of the urban Australian diabetes community. In the present study, we linked the Silver Chain and FDS databases to determine the incidence, predictors and costs of community nursing in FDS patients with type 2 diabetes.

## Patients and Methods

The FDS cohort was recruited between April 1993 and July 1996 from a postcode defined region, with study participants comprising 63% of all identified cases of diabetes within the region [14, 15]. All FDS participants underwent a detailed assessment at baseline and were invited to attend repeat assessments annually for at least 5 years. Each assessment comprised a standardised questionnaire, physical examination, and relevant investigations including routine biochemical tests on fasting blood and urine samples. Recruitment and assessment procedures including methods used to diagnose diabetes types and complications have been previously described [14, 15]. Follow-up procedures included data linkage to hospital and related databases for incident conditions and death records [16]. The FDS protocol was approved by the Human Rights Committee at Fremantle Hospital and all subjects gave informed consent before participation. The present study was approved by the Human Research Ethics Committee of the Southern Metropolitan Area Health Service, the Silver Chain Human Research Ethics Committee, and the Confidentiality of Health Information Committee at the WA Department of Health.

Silver Chain records client and service details and data were available from July 1997 following the implementation of an upgraded system. The first recorded home nursing visit

to a FDS participant occurred on 22 July 1997 which was taken as the commencement date for data linkage. Of the original FDS cohort (1,426 participants), 1,294 had type 2 diabetes of whom 1,177 (91.0%) were alive in July 1997 (2 subjects were lost to follow up). Of these potential participants, 825 (70.1%) had attended for annual review during 1996 and comprise the baseline for the current study. These subjects were followed from 22 July 1997 until death or 8 November 2007 (mean±SD 8.6±2.9 (range 0.07-10.3) years of follow-up).

Cost of home nursing

The direct cost of home visits was estimated from the perspective of Silver Chain. The cost of a visit was defined as the sum of the provider's wage and travel costs. Other costs such as overheads, accrual type items (e.g. superannuation, fringe-benefit tax, building depreciation), indirect care costs including referral, scheduling and case management, and the opportunity costs of volunteers, were not estimated due to their complexity. Therefore the present costings are less than the true unit cost for this service. The Silver Chain database contains details of the time spent by the provider on the visit (including travel) and in support meetings as a result of the visit and a provider code, task code and service code were available for each visit. The hourly wage rates for providers were provided by Silver Chain for the period 2009-2010. Travel costs were estimated from the Australian Tax Office rates per business kilometre for a medium-sized car (1601-2600cc) for the tax year 2009-2010 (A$0.74/km) assuming an average speed of 30 km/h.

Statistical analysis

The computer packages SPSS for Windows (version 18.0, SPSS Inc. Chicago, Illinois, USA) and Intercooled Stata (version 10.0, StataCorp, College Station, Texas, USA) were used for statistical analyses. Data are presented as proportions, mean±SD or, in the case of variables

which did not conform to a normal distribution, median and inter-quartile range [IQR]. The bias-corrected 95% confidence intervals (CI) for the mean cost of home visits were obtained using the bootstrap method [17]. Two-sample comparisons were by Fisher's exact test for proportions, Student's t-test for normally distributed variables, and Mann-Witney U-test for other variables.

Cox proportional hazards modelling with forward conditional variable entry ($P<0.05$) and removal ($P>0.10$) was used to determine independent predictors of the first episode of home nursing during follow-up. Predictors of frequency of home nursing were assessed using zero-inflated negative binomial (ZINB) regression models. Clinically plausible baseline variables with a significance level ≤0.20 in bivariate analysis were entered into a multiple logistic regression model using forward conditional modelling ($P<0.05$ for entry, >0.10 for removal) to determine independent associates of zero subsequent home nursing visits. These variables were considered for entry into the ZINB inflate models, which predict whether or not a patient would be a certain zero (those assumed never to be at risk of requiring home nursing), whilst the count models were constructed from consideration of all other clinically plausible variables with a significance level ≤0.20 in bivariate analysis.

## Results

### Baseline patient characteristics and home nursing visits

At initial recruitment to the FDS and in comparison with those who had died or were lost to follow-up or did not attend for the 1996 assessment (n=467), the present sample of 825 participants was significantly more likely to be male (51.2% vs. 44.6%, $P=0.024$), was younger (63.3±10.2 vs. 65.4±12.8 years, $P=0.003$), had shorter diabetes duration (median [IQR]: 3.3 [0.7-8.0] vs. 4.4 [1.8-10.0] years, $P<0.001$), was more likely to be married (68.6%

vs. 60.7%, *P*=0.005) and educated beyond primary school level (76.4% vs. 69.9%, *P*=0.012), less likely to be using insulin (10.1% vs. 15.2%, *P*=0.007), and had lower prevalence of cerebrovascular disease (CVD; 8.7% vs. 12.6%, *P*=0.035), peripheral arterial disease (PAD; 25.3% vs. 36.5%, *P*=0.035), peripheral neuropathy (28.3% vs. 35.7%, *P*=0.008), retinopathy (13.9% vs. 21.1%, *P*=0.001), and microalbuminuria (or worse; 36.8% vs. 49.7%, *P*<0.001), but not coronary heart disease (26.5% vs. 29.4%, *P*=0.27).

At the 1996 assessment, the baseline for the present study, the study sample had a mean age of 65.2±10.3 years, 51.2% were male and their diabetes duration was a median of 5.4 [2.7-10.0] years. During 7,099 patient-years (8.6 ± 2.9 years) of follow up, 229 (27.8%) received at least one home nursing visit. In total, 21,878 home visits were made, a crude rate of 3.1 visits per patient-year, but there was wide variation in the number of visits made to individuals (range 1-1446 visits per patient; mean 96; median [IQR] 31 [9-85] visits).

Predictors of first home nursing visit

A wide range of demographic, social, functional and diabetes-related measures including diabetic complications were significantly associated with future home nursing provision (see Table 1 for bivariate associations). In Cox regression modelling, older age, longer diabetes duration, higher BMI, $HbA_{1c}$, albumin:creatinine ratio, the presence of PAD, impaired renal function, and any difficulty with activities of daily living each independently predicted the time to first home nursing episode (Table 2).

Predictors of frequency of home nursing visits

In the ZINB model (Table 3), participants who had no visits were younger, had a lower BMI, lower urinary albumin:creatinine ratios and less PAD at baseline. After adjustment for those

who received no nursing visits, independent baseline predictors of an increased frequency of home nursing visits were use of insulin, higher systolic blood pressure, antihypertensive medication and a history of cerebrovascular disease, whilst taking regular aspirin, Asian ethnicity and having an annual household income >A$12,000 predicted use of home nursing at lower frequency.

Cost of home nursing visits

The total cost of home nursing visits for the study period was A$363,037. The total per patient cost of home nursing visits was a mean A$440 (95% bias-corrected CI: A$336-A$580), with a range of A$0-A$24,776. Including the entire sample, the annual per patient cost was on average A$67 (95% bias-corrected CI: A$48-A$95), range (A$0-A$6,035). Including only the 229 patients who had received at least one home nursing visit, the annual per patient cost was on average A$240 (95% bias-corrected CI: A$187-A$334).

Nationally, the Australian National Diabetes Services Scheme had 796,560 registrants classified as having type 2 diabetes (http://www.ndss.com.au/Australian-Diabetes-Map/Map accessed 22 February 2011). Assuming this number reflects the prevalence of type 2 diabetes in Australia and if the FDS experience for home nursing is projected nationally, the total annual cost is over A$53 million.

Discussion

Our study provides the first estimate of the extent and direct costs of community nursing for supporting patients with type 2 diabetes in an urban Australian setting. During an average 8.6 years of follow up, almost 30% of our sample received treatment from the community

nursing service and the majority received a substantial number of visits. However, the range was large and some patients received nurse visits for a prolonged time period. Not surprisingly, the estimated cost was also high and the per patient cost varied considerably. When extrapolated to the Australian diabetes community, community nursing was estimated to cost an additional A$53 million annually to the health service. Community nursing is likely to confer many benefits including cost savings e.g. by preventing or delaying the need for expensive residential care. Given that our cost estimates are conservative, there is a need for more research into the current and potential effectiveness of home nursing in the management of type 2 diabetes.

Although we have no data on the specific reasons for home nursing visits in our sample, a recent Silver Chain survey examined nursing task allocation to their population over a single month [6]. Wound care (66%) and medication related tasks (25%) comprised the great majority of all nursing activities and other tasks occurred at low frequencies (<3.9%). The results from the present study probably reflect this experience given that risk factors for diabetes-related wounds [18] and the use of insulin were prominent in our risk prediction models. Visual, mechanical or cognitive difficulties with self-administering insulin doses are likely to underlie the association between home nursing and insulin use.

That albuminuria was a risk factor for home nursing rather than peripheral neuropathy, a risk factor for diabetic foot problems, requires consideration. Microvascular disease often affects multiple vascular beds simultaneously in diabetes, hence the continuous variable albuminuria could be acting as a surrogate marker for neuropathy that was dichotomised in our models. Aspirin use, Asian ethnicity and greater income were associated with a lower frequency of home nursing visits and, notably, indigenous patients were non-users of home

nursing although their numbers were small in our sample. Aspirin could be acting as a marker for vascular disease risk in this situation (bias by indication). The role of cultural and economic factors in influencing usage patterns of home services might reflect family or other support and deserves further study.

Our cost estimates are based on a sample from an urban community and are conservative for the following reasons. First, community nursing is more expensive in rural and remote areas [19, 20]. Second, the participants who are recruited to cohort studies and return for repeat assessments are generally healthier and likely to have a reduced requirement for home nursing than those who choose not participate or fail to return. Third, our cost estimates did not include several indirect costs. Fourth, we only studied patients with type 2 diabetes and the extrapolated total costs do not include community nursing for other types of diabetes [21]. Finally, some home nursing services in WA are provided by private providers. In 2000/2001, the Australian health system spent an estimated A$784 million on people with diabetes [22]. Extrapolating to 2009/2010 costs by adjusting for annual health inflation [23], the total annual cost of diabetes reached A$1,041 million that financial year. Our conservative estimate of the national cost of home nursing care adds an additional 5% minimum to this figure.

The strengths of our study include the large sample size, the representative nature of the cohort, the detailed clinical assessment plus the ability to access data from an organisation that provides the majority of local community nursing services. The limitations of the study include the lack of patient-level data on the reasons, content and outcomes of the nurse intervention. We also lacked data on important co-morbid disabling conditions including cognitive impairment and arthritis, which means that our community nursing costs might

over-estimate the direct costs of diabetes. We were only able to study a sub-sample of the original FDS cohort for technical reasons related to when Silver Chain commenced their updated data collection and the study sample was younger and had fewer complications than the original cohort indicating that these data provide underestimates of the need for community nursing.

In summary, community nursing is a substantial and potentially expensive component of the management of patients with type 2 diabetes. There is a large variation in its use with some patients receiving extensive services. A wide range of demographic, socio-economic and clinical variables are associated with use of community nursing. The effectiveness of this important form of service provision requires more research, especially as the need for community nursing will inevitably increase with the ageing of the population and the increase in diabetes incidence.

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Table 1. Characteristics of 825 FDS participants with type 2 diabetes at their 1996 assessment defined by use of home nursing services between 22 July 1997 and 8 November 2007

| | No home nursing visit | ≥1 home nursing visits | *P*-value |
|---|---|---|---|
| N | 596 | 229 | |
| *Demography* | | | |
| Age (years) | 63.7±10.6 | 68.9±8.4 | <0.001 |
| Male (%) | 52.5 | 47.6 | 0.21 |
| Education beyond primary level (%) | 76.7 | 75.4 | 0.71 |
| Not fluent in English (%) | 13.3 | 15.3 | 0.50 |
| Ethnic background (%): | | | 0.11 |
| Anglo-Celt | 63.1 | 69.9 | |
| Southern European | 17.1 | 15.3 | |
| Other European | 9.4 | 7.0 | |
| Asian | 4.7 | 2.2 | |
| Indigenous | 1.0 | 0 | |
| Mixed/other | 4.7 | 5.7 | |
| Married/de facto relationship (%) | 71.3 | 59.3 | 0.001 |
| Household income ≤ A$12,000 | 23.4 | 34.1 | 0.003 |
| *Risk factors* | | | |
| Smoking status (%): | | | 0.39 |
| Never smoked | 42.2 | 47.4 | |
| Ex-smoker | 44.3 | 39.5 | |
| Current smoker | 13.5 | 13.2 | |
| Daily alcohol consumption (standard drinks/day) | 0.1 [0-0.4] | 0 [0-0.8] | 0.65 |
| Any exercise in past two weeks (%) | 71.1 | 64.2 | 0.06 |
| BMI ($kg/m^2$) | 29.3±4.8 | 29.8±5.2 | 0.19 |
| Waist (%obese) | 64.6 | 70.0 | 0.16 |
| Systolic BP (mmHg) | 145±23 | 152±26 | 0.001 |
| Diastolic BP (mmHg) | 77±11 | 77±13 | 0.89 |
| Blood pressure-lowering medication (%) | 50.7 | 62.3 | 0.003 |
| Total cholesterol (mmol/L) | 5.5±1.1 | 5.6±1.1 | 0.28 |
| HDL-cholesterol (mmol/L) | 1.07±0.32 | 1.11±0.37 | 0.86 |
| Serum triglyceride (mmol/L) | 2.0 (1.2-3.4) | 2.1 (1.2-3.6) | 0.29 |
| Lipid-modifying treatment (%) | 20.1 | 21.1 | 0.77 |
| Regular aspirin use (%) | 23.9 | 34.1 | 0.004 |
| *Diabetes* | | | |
| Diabetes duration (years) | 5.0 [2.5-8.7] | 7.1 [3.3-14.0] | <0.001 |
| Fasting glucose (mmol/L) | 8.6 [7.1-10.6] | 9.1 [6.9-11.1] | 0.50 |
| $HbA_{1c}$ (%) | 7.3 [6.4-8.2] | 7.4 [6.5-8.6] | 0.16 |
| Diabetes treatment (%): | | | 0.11 |
| Diet alone | 30.7 | 26.6 | |
| Oral agents | 56.9 | 55.7 | |
| Insulin (± oral agents) | 12.4 | 17.9 | |
| *Diabetic complications and co-morbidities* | | | |
| Cerebrovascular disease (%) | 9.7 | 14.4 | 0.06 |
| Coronary heart disease (%) | 26.3 | 33.2 | 0.06 |
| Peripheral arterial disease (%) | 15.1 | 36.4 | <0.001 |
| Retinopathy (%) | 23.3 | 30.2 | 0.046 |
| Neuropathy (%) | 37.2 | 53.7 | <0.001 |
| Foot ulcer (1996 assessment or hospitalisation; %) | 0.5 | 3.5 | 0.002 |
| Hospitalised for foot ulcer before 1996 (%) | 0.2 | 2.2 | 0.007 |
| Estimated GFR <60 ml $min^{-1}(1.73m^2)^{-1}$ (%) | 38.0 | 54.4 | <0.001 |

| | | | |
|---|---|---|---|
| Urine albumin:creatinine ratio (mg/mmol) | 2.0 (0.4-8.9) | 3.6 (0.6-20.4) | <0.001 |
| Depression (%) | 31.0 | 32.8 | 0.58 |
| *Physical limitations* | | | |
| Difficulty with activities of daily living (%) | 6.1 | 14.7 | <0.001 |
| Any mobility problems (%) | 15.8 | 31.2 | <0.001 |

**Table 2.** Most parsimonious Cox regression model of time from the 1996 FDS assessment to first home nursing visit

| | Hazard Ratio (95% CI) | *P*-value |
|---|---|---|
| Age (per 10 years) | 1.74 (1.45-2.09) | <0.001 |
| Diabetes duration (per 5 years) | 1.12 (1.02-1.23) | 0.018 |
| BMI (per 1kg/$m^2$) | 1.05 (1.02-1.09) | 0.001 |
| $HbA_{1c}$ (per 1%) | 1.12 (1.01-1.24) | 0.027 |
| Peripheral arterial disease present | 2.03 (1.50-2.75) | <0.001 |
| Estimated GFR<60 ml $min^{-1}(1.73m^2)^{-1}$ | 1.34 (1.01-1.78) | 0.046 |
| $Log_e$ (ACR (mg/mmol))[a] | 1.19 (1.09-1.29) | <0.001 |
| Any difficulty with activities of daily living | 1.99 (1.31-3.02) | 0.001 |

[a]A 2.72-fold increase in urinary albumin:creatinine ratio (ACR) corresponds to an increase of 1 in $log_e$ (ACR)

Table 3: Model of independent baseline risk factors for the number of subsequent home nursing visits using the zero-inflated negative binomial (ZINB) method

| | ZINB model | |
|---|---|---|
| | NB [a] | Inflate [b] |
| | IRR (95% CI)[c] | Odds Ratio (95% CI) |
| Age (per 10 years) | | 0.58 (0.46-0.73) |
| BMI (per 1kg/$m^2$) | | 0.95 (0.92-0.99) |
| Peripheral arterial disease present | | 0.39 (0.24-0.63) |
| $Log_e$ (ACR (mg/mmol))[d] | | 0.87 (0.78-0.98) |
| Using insulin | 2.14 (1.18-3.88)) | |
| Systolic blood pressure (per 1mmHg) | 1.01 (1.002-1.02) | |
| On antihypertensive medication | 1.54 (1.02-2.34) | |
| Cerebrovascular disease present | 2.73 (1.29-5.78) | |
| Taking regular aspirin | 0.58 (0.37-0.88) | |
| Asian | 0.03 (0.01-0.09) | |
| Annual household income ≥A$12,000 | 0.62 (0.41-0.93) | |

Combined model: [a] count model to predict counts of nurse visits for patients who received any visits; [b] logit model for patients who are certain zeros (received no visits)

[c] IRR=incidence rate ratio, robust standard errors used to calculate confidence intervals (CIs)

[d] A 2.72-fold increase in urinary albumin:creatinine ratio (ACR) corresponds to an increase of 1 in $log_e$ (ACR)