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**Abstract**

Primary health care (PHC) is known to be essential services for local communities. This study aims to assess the relationship between PHC visits and episodes of hospital admission to determine if access to. Using individual level linked health centre and hospital data, a cross-sectional study was conducted to estimate annual hospital admission rate by number of clinic visits in the Northern Territory of Australia, stratified by age group, sex and with/without significant found that the relationship between PHC visits and hospitalisations in diabetes care appeared to be a U-curve. Low levels of PHC visits were associated with increased level of hospitalisations amongst people with diabetes. The overall level of hospitalisation for diabetic patients appeared to be minimised when the PHC visits were 10.1 per person-year (95% confidence interval 7.6-12.6). These findings highlight the need for remote Indigenous patients with diabetes to have adequate access to PHC and hospital care, with an “optimal” annual visits to health centres.

**Key words**

Primary Care, Acute Inpatient Care, Diabetes, Rural Health, Administrative Data Uses

**Introduction**

Understanding the relationship between primary up to 30-40% of Indigenous Australians.2-4 Diabetes death rates in the Northern Territory (NT) Indigenous people increased by a factor of six between 1977-1981 and 1997-2001, and were approximately ten times the Australian rates.5 In the NT, the Medicare Benefits Schedule per capita payments in Indigenous population were less than 50% of their non-Indigenous peers.6 This lack of PHC access coincided with higher hospitalisation rates in the NT Indigenous population, which were 7.7 times higher than those in the NT non-Indigenous population.7 The hospital admissions for diabetes related complications also increased dramatically.8 The high hospitalisation rates amongst people from remote Indigenous communities suggest that lower accessibility to PHC services may result in higher preventable hospital admissions.9

The evidence on whether or not improved PHC access reduces diabetes related hospitalisations is mixed. There is substantial evidence to support negative associations between PHC and hospitalisation in diabetic care,10-12 suggesting that the number of PHC visits is linked to lower hospitalisation rates. An increase in availability and intensity of PHC is associated with decreased hospitalisations and savings in hospital costs, as a result of improvements in health outcomes. Conversely, several studies found positive associations, showing improved PHC for diabetic patients actually increase early detection of diabetes related complications, referrals to hospitals and admissions.13, 14 There were also studies that found no associations between the two types of care.15, 16 Explicitly or implicitly, previous studies assumed a linear relationship between PHC and hospitalisation, whereas the actual relation may be curvilinear or nonlinear. Large scale empirical studies based on in remote Indigenous settings. This study aims to assess the relationship between PHC visits and hospitalisations for people with diabetes in remote Indigenous communities.

The remote area of the NT, over 1.3 million square kilometres (five times the size of the United Kingdom), only has approximately 40 medical practitioners providing PHC for about 51 000 Indigenous residents.17 The majority of PHC providers are nurses and funded Aboriginal community controlled health services. Majority of hospital services are provided by five public hospitals. Both PHC and public hospital services are provided free–of–charge to patients.

**Method**

This is a cross-sectional study on association of different level of PHC visits with different level of hospitalisations, using deterministic linkage of individual level PHC and hospital data between 1 July 2007 and 30 for utilisation of acute care. A PHC visit is defined as a face-to-face encounter with a medical doctor, nurse, Aboriginal health worker or other type of PHC provider. This study draws together PHC records and hospitalisation data from the primary care information system (PCIS) and the hospital information system linked by a unique patient identifier - the hospital registration number.18 The inclusion criteria were Indigenous resident in the remote NT communities, who visited the remote health centres or were admitted to one or more of the five public hospitals. Diabetes and complications are defined through the International Classification of Primary Care (ICPC) or the Australian Refined Diagnosis Related Groups (AR-DRG). The ICPC codes for diabetes are F83, T87, T88, T89, T90; ischemic heart disease (IHD) K74, K75, K76, K89; renal disease U88, U90, U95. The AR-DRG codes for diabetes are F11A, F11B, F13Z, K01Z, K60A, K60B; IHD F08A, F08B, F14A, F14B, F14C, F12Z, F01A, F01B, F02Z, F66A, F66B, F74Z, F72A, F72B, F05A, F05B, F06A, F06B, F17Z, F18Z; renal disease L65A, L65B, L67A, L67B, L67C, A09A, A09B, L02A, L02B, L60A, L60B, L60C, L61Z. Number of PHC visits and number of hospitalisations were available at individual level by age group, sex, locality and indicators for the diseases. Same-day haemodialysis separations were excluded, because haemodialysis is not believed to be avoidable by improving PHC for patients with end stage renal failure.19 PHC records with invalid ICPC or the ICPC Component 67 (referral to physician / specialist / clinic / hospital) were excluded from the analysis. Age was derived using date of birth and date of first contact. Accuracy and completeness of the hospital patient demographic data were around 95%.20

Hospitalisations per person per year (person-year) is used to describe the hospitalisation risks by PHC visits. The data are analysed by using descriptive statistics including mean and confidence interval. A bubble diagram was applied to show the association between PHC visits and hospitalisations with bubble area representing the number of patients. The relationship between PHC and hospital service was further explored using multivariate quadratic spline regression models.21

Let and represent the number of PHC visits and the number of hospitalisations respectively for patient *i*, and  be *p*+1 covariates of interest with . The covariates in this study are indicators for aged 40 years and over (*x*1: 0=no, 1=yes), sex (*x*2:0=male, 1=female), IHD (*x*3: 0=no, 1=yes) and renal disease (*x*4: 0=no, 1=yes).

The quadratic spline model is in the form of21



with representing intercept parameter ,  and shape parameters, *εi* the error term, and *di* a dummy variable defined by a free unknown knot andlocation parameters , where



The spline model glues together two quadratic equations with different shape parameters and a shared vertex, whose x–coordinate is the PHC visits pertaining to the minimum or maximum level of the y–coordinate hospitalisations, derived by assuming zero first derivative of estimated *h* with respect to *v*:



evaluated at estimated parameters ,  and . Reexpression yields the quadratic vertex estimate of PHC visits . The sum of estimated  may be used for assessing the total impact of the PHC visits, namely the impact index . The impact index reflects the marginal changes in hospitalisations, if every observation has increased PHC visits by one unit. The unknown parameters *a*, *b*, *c* and *k* were estimated using the weighted least squares. The unknown parameters and standard errors were calculated in Microsoft Excel Solver and add-in package SolverStat (version 3.3). Stepwise model selection was performed using *F* value and analysis of variance at the 0.05 level. Sensitivity analysis was undertaken to re-examine the models by removing outliers with more than 60 visits annually or including admissions for same-day haemodialysis. This study has been approved by the Human Research Ethics Committee of DOH and Menzies School of Health Research (Reference number: HREC–2012–01723).

**Results**

There were 2686 remote Indigenous patients diagnosed with diabetes included in this study, with 66025 PHC visits and 2434 non-haemodialysis hospital admissions (Table 1). At the aggregate level, 63% of patients were female, with 17% being aged 60 years and over, 51% 40-59, and 31% 15-39 years of age. It also revealed that 9.6% (257) of all patients with diabetes never visited health centres during the four years. The average number of PHC visits per person-year was 24.6, and the average number of hospitalisations per person-year was 0.91. The diabetic patients account for 11.4% of the total number of remote Indigenous patients (23620) registered at one of the health centres using PCIS.

**Table 1. Primary health care (PHC) visits and hospitalisations by age and sex, remote Indigenous patients with diabetes, Northern Territory, Australia, 2007-2011**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sex** | **Age (years)** | **Persons** | **PHC visits** | **Hospitalisations** | **Annual visits per person** | **Annual hospital admissions per person** |
| **Male** | **0-14** | 9 | 48 | 5 | 5.33 | 0.53 |
|  | **15-39** | 273 | 4273 | 154 | 15.65 | 0.56 |
|  | **40-59** | 543 | 12164 | 454 | 22.40 | 0.84 |
|  | **60+** | 171 | 4330 | 129 | 25.32 | 0.76 |
|  | **Total** | **996** | **20816** | **742** | 20.90 | 0.74 |
|  |  |  |  |  |  |  |
| **Female** | **0-14** | 23 | 315 | 13 | 13.70 | 0.55 |
|  | **15-39** | 557 | 12482 | 620 | 22.41 | 1.11 |
|  | **40-59** | 818 | 23185 | 815 | 28.34 | 1.00 |
|  | **60+** | 292 | 9227 | 245 | 31.60 | 0.84 |
|  | **Total** | **1690** | **45209** | **1692** | 26.75 | 1.00 |
|  |  |  |  |  |  |  |
| **Person** | **0-14** | 32 | 363 | 18 | 11.34 | 0.55 |
|  | **15-39** | 830 | 16755 | 773 | 20.19 | 0.93 |
|  | **40-59** | 1361 | 35349 | 1269 | 25.97 | 0.93 |
|  | **60+** | 463 | 13558 | 375 | 29.28 | 0.81 |
|  | **Total** | **2686** | **66025** | **2434** | 24.58 | 0.91 |

The relationship between PHC visits and hospitalisation in diabetic care appeared a U-curve or inverted J-curve (see fitted dots in Figure 1). The hospitalisation rate was 2.3 admissions per person-year for those diabetic patients who never sought PHC (Figure 1). For a patient with diabetes who visited a health centre less than eight visits annually, provision of PHC was associated with a reduction of hospitalisations. This association was nonlinear dependant upon the frequency of PHC visits. The impact index of marginal changes in PHC on hospitalisations ranged from -0.45 to 0 (see grey dots in Figure 1). The hospitalisation rate decreased with the increased number of PHC visits to the minimum of 0.68 hospitalisation a year, when a patient visited health centre eight times annually. The hospitalisation rate increased slightly with the number of PHC visits for those who visited health centres more than eight times a year. Table 2 provides the parameter estimates and 95% confidence intervals (CI) of the quadratic spline regression models. It was estimated that the overall level of hospitalisation for the total diabetic patients appeared to be minimised when the PHC visits was 7.9 visits per person-year (95%CI 5.8-10.0, see Table 2). The total impact index *I*= –181.91, indicating if every patient was provided with one more PHC visit, the total marginal impact would be a reduction of 181.91 hospitalisations. It was necessary to undertake further analysis by key demographic factors and complications. It was found that females attended health centre more frequently to achieve the lowest rate of hospitalisation than males (panel a, Figure 2), and there were significant differences in both the location and intercept parameter estimates between males and females (Table 2). Patients aged 40 and over required more PHC visits to minimise hospitalisations (see Table 2 and panel b Figure 2). Diabetic patients with IHD needed 19.8 more PHC visits than those without IHD (P<0.05, see Table 2), whereas patients with renal disease required 17.1 more visits (P<0.05) to minimise hospitalisations. Of these patients who visited PHC clinic less than 24 times annually, 9% and 15% had IHD and renal disease, whereas the diabetic patients who visited PHC clinic 24 times or more annually these figures increased to 16% and 25%. This indicates that PHC visits were positively related to the severity of diabetes.

Figure 1. Relationship between primary health care visits and hospitalisations fitted with the spline model



**Table 2. Parameter estimates and confidence intervals of the spline models**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **Parameter estimate** | |  |  |  | **95% Confidence interval** | |  |
|  |  | **a (intercept)** | **b (shape 1)** | **c (shape 2)** | **k (location)** |  | **a (intercept)** | **b (shape 1)** | **c (shape 2)** | **k (location)** |
| **Diabetes** |  | 0.6801\* | 0.0284\* | 0.0001\* | 7.9316\* |  | 0.5956-0.7645 | 0.0126-0.0442 | 0-0.0002 | 5.8239-10.0394 |
|  |  |  |  |  |  |  |  |  |  |  |
| **Sex** | **Male** | 0.4561\* | 0.0531\* | 0.0002\* | 5.9102\* |  | 0.3429-0.5692 | 0.0152-0.091 | 0.0001-0.0003 | 3.8902-7.9302 |
|  | **Female** | 0.3444\* | -0.0407\* | -0.0001 | 5.9815\* |  | 0.1967-0.4921 | -0.0791--0.0022 | -0.0003-0.0001 | 2.3269-9.6362 |
|  |  |  |  |  |  |  |  |  |  |  |
| **Age** | **<40 years** | 0.7722\* | 0.0576 | 0.0002\* | 5.314\* |  | 0.6414-0.9031 | -0.0096-0.1247 | 0-0.0004 | 2.4161-8.2119 |
|  | **>=40 years** | -0.1931\* | -0.0452 | 0.0000 | 6.9829\* |  | -0.3621--0.0241 | -0.1127-0.0223 | -0.0002-0.0002 | 2.5791-11.3868 |
|  |  |  |  |  |  |  |  |  |  |  |
| **Complications** |  |  |  |  |  |  |  |  |  |  |
| **IHD** | **No** | 0.6336\* | 0.0521 | 0.0001 | 5.2344\* |  | 0.5269-0.7403 | -0.002-0.1062 | 0-0.0002 | 2.6271-7.8417 |
|  | **Yes** | 0.357 | -0.0458 | 0.0004 | 19.781\* |  | -0.0274-0.7406 | -0.1001-0.0085 | -0.0005-0.0013 | 11.5521-28.0099 |
|  |  |  |  |  |  |  |  |  |  |  |
| **Renal disease** | **No** | 0.6188\* | 0.0660 | 0.0001\* | 4.1673\* |  | 0.5258-0.7117 | -0.015-0.1471 | 0-0.0002 | 1.6983-6.6364 |
|  | **Yes** | 0.198 | -0.0557 | 0.0003 | 17.1026\* |  | -0.0507-0.4461 | -0.1369-0.0254 | -0.0002-0.0007 | 12.2384-21.9669 |

Note: \* P<0.05; IHD=ischemic heart disease

Figure 2. Relationship between clinic visits and hospitalisations by key demographics and complications, fitted with the multivariate spline model



Sensitivity analysis reveals that removing outlier and including same-day haemodialysis patients did not significantly alter the results. A higher polynomial model showed slightly improved model fit, but overall the high order coefficients were statistically insignificant (data not shown)

**Discussion**

Health centres play a vital role in providing PHC for patients with diabetes in remote Indigenous communities. Health centres incorporate numerous health related disciplines and services, which are normally provided separately in mainstream PHC services by general practitioners, community health nurses, pharmacists, environmental health officers or other PHC providers in non-remote settings. While lack of access to PHC is not the only cause of Indigenous health disparity, this study reveals that Indigenous diabetic patients with less than the “optimal” level of PHC services have higher risk of hospitalisation, and those attending at optimal level of PHC have the lowest risk. Diabetic patients receiving much higher levels of PHC appear also likely to have a slightly higher level of hospitalisation. The relationships between PHC and hospitalisation for the diabetes patients seem to be U-shaped functions, with an optimal level of PHC service required to minimise hospitalisation (see Figures 1 and 2). The reduction in hospitalisation is dependent upon the frequency of PHC visits. Figure 1 indicates that if PHC is less than 4 visits a year, an increase by one PHC visit can lead to a significant reduction in hospitalisations. This new result is demonstrated by using linked individual level PHC and hospital service data, gathered in the remote Indigenous communities and public hospitals for the period 2007 through 2011. This study indicates that the frequency of PHC services determines the relations between PHC and hospital care. The intuition is as follows. If PHC visits are very low, hospital plays a major role in managing diabetes complications and this model limits opportunities to manage risk factors and prevent complications. In this situation increasing PHC investment can avert or delay the need for hospital care. This negative relationship is consistent with the majority of literature, especially those obtained from the under-resourced areas. 10-12, 22  Patients receiving PHC beyond the population estimated optimal level may be at the more severe end of clinical spectrum and hence require both more PHC and hospital services. In this case, hospital care is not a substitute for PHC, but a complement.23 But it is also possible that increased contacts with general practitioners will increase the likelihood of detection of possible comorbidities, leading to more hospital referrals.

This result is recognised by previous research, which indicate appropriate access to PHC can improve health as well as lower health care cost.13, 14, 24-26 While this interpretation requires further investigation, the curvilinear relation may explain why PHC activity is not a consistent linear predictor of hospitalisation.

This analysis overcame some of the methodological problems of small scale studies by examining routinely collected health service data under a wide range of different levels of PHC service delivery. This study provides useful empirical information and an understanding of how to distribute funding between PHC and hospital care to improve population health and use resources effectively and efficiently. The impact index may be useful for assessing marginal effect of PHC investments. It contributes positively to the development of a strong evidence base concerning cost-effectiveness of PHC in remote Indigenous communities. However, there are several limitations to this study which should be noted. Firstly, this study is a cross sectional observation in nature rather than longitudinal and experimental. This limits the extent to which causal relations can be drawn from this study. Many influential factors on hospitalisations such as socio-economic status and disease distribution were not considered in this study. Impacts of PHC on preventable hospitalisations have been reported elsewhere.27 There are theoretical reasons to believe that appropriate level of PHC leads to lower level of hospitalisations. This study provided empirical data for this hypothesis. Secondly, the strength of the evidence is limited by the reliability of PHC and hospital data. The NT and national hospital data quality survey showed that the demographic data quality is 95% accurate.20 Thirdly, the study did not include people never visiting the health centres and never using the public hospitals. Because the total study population (with or without diabetes) was close to the total Indigenous resident population in the selected remote areas,17 the potential under estimation of the population was believed to be minimal. Finally, due to data restriction, mortality health outcome was not analysed in this study. Further research in this regard seems warranted.

In conclusion, providing adequate level of primary care is important for people with diabetes. Identifying and case managing the small group of patients with diabetes, who never or seldom used PHC, may be useful to curve high hospitalisation rates for remote Indigenous people. Effectiveness and efficiency of diabetes care may largely hinge on a fine balance between primary care and hospital care.

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