Acute circulatory complications in people with Diabetes Mellitus Type 2: how admission varies between urban and rural Victoria

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Abstract

Objective – The aim the study is to identify the extent rurality influences the admission and mortality rates for acute circulatory complications among people with T2DM.

Design – Retrospective study.

Setting – All Victorian hospitals.

Participants – State-wide hospital admissions from 1 July 2010 to 30 June 2015 using the Victorian Admitted Episodes Dataset. Data included patients with Type 2 Diabetes Mellitus and a diagnosis of acute cardiovascular events, acute cerebrovascular haemorrhage or infarction, acute peripheral vascular events, or hypertensive diseases.

Main outcome measure – Rates of admission and mortality were calculated for Local Government Areas and Department of Health regions. Regression analysis identified the influence between admission rates and various predictor variables.

Results: 5785 emergency hospital admissions occurred during the study period with the highest and lowest mortality and admission rates occurring in rural areas. Moderately high admission rates were identified in urban areas. Cardiovascular events far outnumbered

other acute circulatory admissions. Regression analysis identified a number of significant socioeconomic variables, primarily for metropolitan residents. Socioeconomic disadvantage was the only significant factor in rural areas.

Conclusion: Victorian admission and mortality rates for acute circulatory complications are greatest in rural areas, yet there is considerable heterogeneity in admission rates within both rural and metropolitan areas. Furthermore, socioeconomic status is more influential than remoteness in determining emergency admissions. Further research needs to investigate the particular variables that lead to poorer outcomes rurally, investigate socioeconomic disadvantage in rural areas and have greater emphasis on peripheral vascular disease prevention.

Keywords

Type 2 Diabetes Mellitus, circulatory complications, rural, urban, admission, mortality

What is already known on this subject?

- Diabetes is continuing to place an increasing burden on the Australian healthcare system.
- Rural health outcomes for remain less favourable than that of metropolitan people.
- No previous research has examined the influence between T2DM and acute circulatory complications between rural and metropolitan areas.

What does this study add?

- Significant heterogeneity in health outcomes exists between different geographic areas of similar rurality.
- Region of residence does not always influence the admission rates for circulatory complications among diabetics.
- In Victoria socioeconomic factors exert a greater influence on management of T2DM circulatory complication rates and hospital utilisation.

Introduction

Chronic disease is a major contributor to morbidity and premature mortality in Australia.[1] Of the major non-communicable chronic diseases, Type 2 Diabetes Mellitus (T2DM) poses one of the greatest public health challenges.[2] According to the 2016 WHO Global Report on diabetes, in 2014 422 million people globally were living with diabetes and it will be largest health burden in Australia by 2023.[3]

T2DM has one of the greatest systemic impacts of any condition, and if poorly managed can result in the development of retinopathy, neuropathy, renal, cardiovascular, cerebrovascular or peripheral vascular disease.[4] Further, T2DM significantly influences mortality; an estimated 3.96 million deaths globally attributed to diabetes in 2010.[5] However, there are concerns this figure is underestimated given often when patients with T2DM die from cardiovascular, cerebrovascular and peripheral vascular disease, the primary cause of death is attributed solely to these circulatory complications, failing to recognise the underlying contribution of T2DM.[5]

Previous research identified that diabetes mellitus (DM) consultations, hospitalisation for complications and DM related deaths remain higher in rural and remote areas of Australia.[6, 7] However, no previous research has used the influence between T2DM and acute circulatory complications, to identify any differences in admission and mortality rates between rural and metropolitan patients. This knowledge is critical, as T2DM continues to place burden on the Australian healthcare system, and rural health outcomes for T2DM remain less favourable than metropolitan populations. In keeping with this, and the documented issues with access to primary care, rural and remote utilisation of tertiary health services for acute circulatory complications from T2DM would be expected to be higher.[8]

The aims of this study are to identify the extent which rurality influences the admission and mortality rates for acute circulatory complications among people with T2DM residing across Victoria. The study seeks to identify which geographic areas are experiencing greater emergency health care utilisation and direct both policy and future research to augment the current challenges. Given that a number of variables drive health outcomes, particularly in rural areas, the research sough to also identify the specific variables within rural and

metropolitan Victoria that drive emergency hospital admissions for circulatory complications from T2DM.

Methods

Victoria is the second largest state by population in Australia with 6.1 million residents.[9] This population has access to over 300 public and private hospitals spread over an area of 227,495 km^2 that is divided into 79 Local Government Areas (LGA).[9] Hospital admission data from 1 July 2010 to 30 June 2015 was obtained from the Victorian Admitted Episodes Dataset (VAED) and included gender, age (5-year age group), LGA of residence, patient type (public or private), admission type (elective, emergency or statistical), hospital type (public or private), length of stay, discharge outcome, and admission diagnoses. All patients admitted to a Victorian hospital under a primary or secondary ICD-10-AM diagnosis of T2DM (E11) and a primary or secondary diagnosis of cardiac arrest (I46), Ischemic heart diseases (I20-I25), acute cerebrovascular haemorrhage or infarction (I60-I69), peripheral vascular disease (I70-75, I77-79) or Hypertensive diseases (I10-I16) were included.

Emergency admissions, defined as an admission to a health service through the Emergency Department were included for analysis. However, all elective and statistical admissions (patients being clerically readmitted when requiring a new episode of hospital care) were excluded on the basis they do not have a similar mortality profile or need for urgent medical care. Also patients of overseas or interstate residence were also excluded. This resulted in 5785 patients being identified who were residing in Victoria and required emergency medical care.

Additional data were obtained from the 2011-2015 Census of Population and Housing, specifically, the Victorian and Regional Health Profile 2012 data[10] which contains amalgamated data from the Australian Bureau of Statistics (ABS), Commonwealth Department of Health and Ageing, Department of Health, Department of Planning and Community Development, VicHealth, and the Medical Directory of Australia. This pool of data contained information on each LGA, including percentage of Aboriginal and Torres Strait Islanders (ATSI), average income, unemployment rate, percentage of current smokers and rates of general practitioners (GP) per 1000 population.

Additional data included the four subsets of the Socio-Economic Indexes for Areas (SEIFA) which include Index of Relative Socio-Economic Disadvantage (IRSD), Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD), Index of Economic Resources (IER), and Index of Education and Occupation (IEO). Lastly, the Accessibility and Remoteness Index of Australia 2011 (ARIA+) was also used. The ARIA+ measures the level of geographic remoteness of local government areas by examining road distance to goods and services with respect to population size, and the key data sources outlined provided the specific LGA measures required for data analysis.[11, 12] The mean ARIA+ scores were used for each individual LGA and were scored as highly accessible (0-0.2), accessible (0.2 -2.4), and moderately accessible (2.4 - 5.92).[11, 12]

Data analysis

Admission rates for each LGA were calculated using Microsoft Excel (Version 15.20). Given each of the 79 LGAs in Victoria fell within eight larger Department of Health regions, this population data were then used to calculate admission and mortality rates in each region. Lastly, the admission rates for the three circulatory complication categories were calculated for each Department of Health region.

Specific population predictor variables were then analysed in accordance with hospital admission rates using Statistical Package for the Social Sciences (SPSS, Version 22.0). Hierarchical multiple regression was used to examine the influence between people with T2DM that experience acute circulatory complications and the predictor variables. IRSD was entered at step 1 after which all other variables were entered into step 2. In addition, multivariable weighted least squares regression was also performed to account for any violations of assumption of equal variance of observations between LGA populations. The initial analysis was conducted to ensure there was no violation of the assumptions of normality, homoscedasticity, multicollinearity, and liberality[13]. After controlling for Age and IRSD, it was indicated that other variables explained 46.8% and 42.2% of the variance in hospitalisations among metropolitan males and females respectively. Significance was determined at two tailed $p \leq 0.05$.

Results

As evidenced in Table 2, of the 5785 patients, 72.10% (n=4177) resided in urban locations, 80.30% (n=4641) were public hospital admissions and 36.90% (n=2133) were female. The age group with the highest number of admissions was the 70-79 year age group. It was identified that 3.30% (n=193) of all admissions resulted in death, 65.20% (n=3770) were discharged to private residence, and 1.30% (n=75) left against medical advice.

Demographic data aside, Figure 1 reveals that the highest admission rates were in rural LGAs. Yarrimbiak had the highest admission rate (85.80 admissions per 100,000 population) followed by Hindmarsh (73.73 per 100,000 population), Horsham (56.95 per 100,000 population) Loddon (56.51 per 100,000 population), and Glenelg (56.32 per 100,000 population). Conversely, the lowest admission rates were in the metropolitan LGAs of Stonnington (5.42 per 100,000), Melbourne (7.15 per 100,000) and Boroondara (7.97 per 100,000). When examining Figure 1 further it was observed that admission rates do not always increase with increasing distance from metropolitan Melbourne.

In Table 2, the crude admission numbers for each of the three circulatory complication experienced by people with T2DM are highlighted. As such, there were 3684 cardiac events documented compared to 428 cerebrovascular events and 1398 acute peripheral vascular events. Table 3 illustrates that the Eastern Metro region had the highest admission rates for cardiac events followed by the Hume region. Southern Metro residents had the highest admission rate for cerebrovascular events whilst Barwon/South West residents recorded the lowest admission rates in Victoria for cerebrovascular disease and peripheral vascular events.

When examining hospital separations among males and females the IRSD score was the only statistically significant factor identified as influencing admission rates for Victorian residents, regardless of sex or place of residence (Table 4). There were no statistically significant relationships identified between ARIA+ scores and admission rates for metropolitan and rural residents. Among metropolitan females there was a statistically significant relationship between admission rates and IER and household income. For metropolitan males household income was the only other significant variable associated with admission rates. No other factors were significant.

Discussion

Given the greatest admission and mortality rates for T2DM circulatory complications occurred in rural areas, the findings support previous research that identified remoteness is associated with an increase in poorer health outcomes.[7, 8, 14, 15] However, many rural areas in this study also experienced some of the lowest rates, which may be reflective of the lower population numbers or improved primary health care approaches that reduce hospital admissions in certain LGAs. Regardless, the findings mirror research conducted by Wilkinson et al.[16] and Phillips[5] who found that the rural-urban divide in health outcomes is not absolute and there is often significant heterogeneity in health outcomes between different geographic areas of similar rurality. Furthermore, some metropolitan areas, where greater geographic access to tertiary health services occurs, experienced admission rates much higher than many rural areas.

Thus in Victoria, it is demonstrated that whilst region of residence does influence the admission rates for circulatory complications, it does so heterogeneously. Why this occurs is multifactorial. It may be due to many factors including the socioeconomic profile of each LGA, or due to health care access issues such as the quality, efficacy and acceptance of primary care in towns within specific LGAs. Further, reduced access to primary health care providers in these areas may exacerbate feelings of rural marginalisation and foster a reticence to seek care that results in poor management of T2DM, increased rates of circulatory complications, and subsequently increased admission rates.[17]

Building on this, socioeconomic variables rather than ARIA+ are more influential in Victoria where geographic distance alone does not determine admission rates. For metropolitan males IRSD and household income were found to be significant predictor for decreased admission rates. For metropolitan females, IRSD, IER and household income were significant predictor variables.[18] This is in accordance with other studies that have established the association between socioeconomic status and poorer outcomes with DM and its complications.[19, 20] This previous research also supports the finding that economic resources and household income were found to influence admission for metropolitan females.[19, 20]

It is important to note that a limitation of the study was the spatial scale used, lower number of rural females in the sample, and under what diagnosis coding patients were admitted to hospital may have implications for the interpretation of the findings.

Notwithstanding, other than IRSD for rural males and females, no other predictor variables were significant among rural residents. This is despite previous studies that have identified that rural and remote areas often have greater socioeconomic disadvantage.[7, 21] Given the multifactorial influence of socioeconomic status on health outcomes it is possible that this study may have overlooked key contributing variables leading to admissions among rural residents. Alternatively, the heterogeneity of individual LGAs may have had some impact on the ability of this study to elucidate key contributing factors; however, other studies using similar variables have found meaningful results.[22, 23]

The identification of rural influences and specific socioeconomic factors on hospital admission rates in Victoria is important for public health understanding, as no previous studies on T2DM like this have been conducted in Victoria. The only studies that closely mirror this research were conducted by Glover et al.[19] and Ansari et al.[15]; however, these studies fail to differentiate Type 1 Diabetes Mellitus and T2DM. Moreover, both studies fail to examine the three leading circulatory complication categories. As to why socioeconomic disadvantage translates into worse outcomes for chronic conditions including T2DM, no consensus can be reached as to what remains the single most important factor. The interrelationship between socioeconomic disadvantage and rurality is complex and it is likely due to individual factors such as income, education, health behaviours and how they interplay with external factors in the community such as transportation, prevalence of primary care and health risks.[19, 21]

Also interesting is the number of cardiovascular, cerebrovascular and peripheral vascular events identified. The number of cardiovascular events grossly outweighed other circulatory admissions. This is important when considering future direction for research given that the significant body of research into diabetic complications tends to focus on either cardiovascular disease or hypoglycaemic/hyperglycaemic events.[4, 24-26] There is limited evidence that focuses on acute peripheral vascular disease in patients with T2DM with only a few international papers in circulation,[2, 20, 27] and no papers studying the Australian population. Further research needs to investigate the particular variables that lead to poorer outcomes rurally, investigate socioeconomic disadvantage in metropolitan and rural areas, with greater emphasis on peripheral vascular disease prevention.

In Victoria there is significant heterogeneity in admission rates for T2DM circulatory complications between rural areas. This study highlights the importance for health professionals in understanding that in Victoria geographical remoteness is not the most important factor determining poor health outcomes in people with T2DM. Rather socioeconomic factors appear to exert a greater influence on management of chronic disease, complication rates and hospital utilisation.

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Table 1: Emergency admissions for Victorian residents with DMT2 and acute circulatory complications during 2010-11 to 2014-15.

Factor	Number	Percentage
Age (years)		
20-29 years	4	0.02
30-39 years	29	0.1.60
40-49 years	222	6.10
50-59 years	758	13.10
60-69 years	1424	24.60
70-79 years	1727	29.80
80-89 years	1370	23.70
90+ years	250	4.30
Gender		
Females	2133	36.90
Males	3652	63.1
Residence		
Urban	4177	72.20
Rural	1611	27.8
Patient Type		
Public	4641	80.30
Private	1093	18.90
Other	51	0.80
Discharge Disposition		
To private residence	3770	65.20
Left against medical advice	75	1.30
To other care	1640	28.30
Deaths	193	3.30
Length of stay	Mean	6.53
	Median	3.00
	Minimum	1
	Maximum	320

Table 2: Admission and mortality rates for cardiac, cerebrovascular and peripheral vascular events by region of residence.

	Cardiac Event		Peripheral Vascular Event		Cerebrovascular Event		Mortality	
Region of Residence	**Admissions**	**Admission rate per 100,000***	**Admissions**	**Admission rate per 100,000***	**Admissions**	**Admission rate per 100,000***	**Crude Mortality**	**Mortality Rate per 100,000**
Barwon/South West	479	9.15	82	21.87	15	4.00	12	0.64
Eastern Metro	263	19.97	262	25.03	75	7.16	25	0.48
Gippsland	210	18.28	75	28.48	13	4.94	13	0.99
Grampians	218	16.06	58	25.25	18	7.83	16	1.39
Hume	300	19.11	60	22.1	20	7.37	16	1.18
Loddon Mallee	1105	11.97	81	25.79	17	5.41	15	0.16
North-West Metro	819	11.79	454	24.59	140	7.58	59	0.85
Southern Metro	479	9.15	326	23.46	130	9.36	35	0.12
Total	3684	12.84	1398	24.37	428	7.46	191	0.67

*Adjusted for gender and index of relative socioeconomic disadvantage.

Table 3: Hierarchical Multiple Regression model summary

	Model	R Squared	Percentage of variance	ANOVA
Metropolitan males	1	.679	67.9%	F(1,30)= 61.278, p = .001
	2	.922	92.3%	
Rural Males	1	.214	21.4%	F(1,47)= 12.503, p = .001
	2	.390	39.0%	
Metropolitan Females	1	.548	54.8%	F(1,29)= 35.130, p = .001
	2	.840	84.0%	
Rural Females	1	.100	10.0%	F(1,47)= 5.125, p = .028
	2	.407	40.7%	

Table 4: Hierarchical Multiple Regression of Victorian residents experiencing DMT2 with acute circulatory complications during 2011-2015

	Females					
	Metropolitan			Rural		
Predictor	**Adj OR**	**95% CI**	**p-value**	**Adj OR**	**95% CI**	**p-value**
IRSD	0.920	0.894-0.947	0.000*	0.838	0.717-0.981	0.028*
Percentage 45+ year of age	0.00	0.00-24105773.062	0.534	0.00	0.00-15174194.000	0.759
IRSAD	0.811	0.564-1.167	0.243	0.882	0.174-4.483	0.877
IER	1.139	1.023-1.267	0.020*	0.708	0.407-1.231	0.213
IEO	1.095	0.943-1.273	0.219	0.812	0.467-1.414	0.452
GPs per 1000	526.178	0.160-173115.380	0.122	0.133	0.000-287811.855	0.781
GP attendance per 1000	1.002	0.999-1.005	0.238	1.002	0.994-1.011	0.549
Household income	0.984	0.972-0.995	0.009*	0.971	0.875-1.078	0.577
Unemployment rate	0.363	0.124-1.064	0.063	0.011	0.000-4.684	0.139
ARIA score	0.054	0.000-16.850	0.300	43.627	0.014-137284.892	0.348
Percentage smokers	0.971	0.579-1.628	0.905	0.396	0.101-1.545	0.176
Percentage ATSI	7.064	0.001-79901.757	0.666	0.315	0.000-2629.541	0.797
	Males					
	Metropolitan			Rural		
Predictor	**Adj OR**	**95% CI**	**p-value**	**Adj OR**	**95% CI**	**p-value**
IRSD	0.882	0.854-0.912	0.000*	0.711	0.586-0.863	0.001*
Age	0.00	0.00-245978.644	0.215	0.00	0.00-364412.000	0.489
IRSAD	1.154	0.820-1.623	0.391	1.678	0.189-14.927	0.634
IER	1.023	0.925-1.131	0.643	0.837	0.398-1.761	0.630
IEO	0.933	0.810-1.074	0.314	0.798	0.379-1.680	0.542
GPs per 1000	39.114	0.019-79177.062	0.326	0.072	0.000-23783.755	0.787
GP attendance per 1000	1.001	0.998-1.004	0.614	1.006	0.995-1.017	0.259
Household income	0.980	0.970-0.991	0.001*	0.962	0.836-1.107	0.580
Unemployment rate	1.150	0.419-3.159	0.776	0.340	0.000-1238.118	0.791
ARIA score	0.021	0.000-4.733	0.152	923.434	0.018-460386.672	0.209
Percentage smokers	1.439	0.885-2.339	0.133	0.652	0.104-4.068	0.638
Percentage ATSI	0.010	0.000-66.821	0.289	1.427	0.000-267116.102	0.953

*p≤0.05

Figure 1: Admission rates for Victorian a) rural and b) metropolitan local government areas