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# Cross-sectional study of area-level disadvantage and glycaemic-related risk in community health service users in the Southern.IML Research (SIMLR) cohort

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# Cross-sectional study of area-level disadvantage and glycaemic-related risk in community health service users in the Southern.IML Research (SIMLR) cohort

## Abstract

**Objectives.** The aim of the present study was to determine the association between area-level socioeconomic disadvantage and glycaemic-related risk in health service users in the Illawarra-Shoalhaven region of New South Wales, Australia. **Methods.** HbA1c values recorded between 2010 and 2012 for non-pregnant individuals aged 18 years were extracted from the Southern.IML Research (SIMLR) database. Individuals were assigned quintiles of the Socioeconomic Indices for Australia (SEIFA) Index of Relative Socioeconomic Disadvantage (IRSD) according to their Statistical Area 1 of residence. Glycaemic risk categories were defined as HbA1c 5.0-5.99% (lowest risk), 6.0-7.49% (intermediate risk) and 7.5% (highest risk). Logistic regression models were fit with glycaemic risk category as the outcome variable and IRSD as the study variable, adjusting for age and sex. **Results.** Data from 29 064 individuals were analysed. Higher disadvantage was associated with belonging to a higher glycaemic risk category in the fully adjusted model (most disadvantaged vs least disadvantaged quintile; odds ratio 1.74, 95% confidence interval 1.58, 1.93;  $P < 0.001$ ). **Conclusion.** In this geocoded clinical dataset, area-level socioeconomic disadvantage was a significant correlate of increased glycaemic-related risk. Geocoded clinical data can inform more targeted use of health service resources, with the potential for improved health care equity and cost-effectiveness.

## Keywords

cohort, (simlr), cross-sectional, research, southern.iml, users, service, health, community, risk, glycaemic-related, disadvantage, area-level, study

## Disciplines

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## **A cross-sectional study of area-level disadvantage and glycaemic related risk in community health service users in the SIMLR Cohort**

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### **Abstract**

#### **Objectives**

To determine the association between area-level socioeconomic disadvantage and glycaemic related risk in health service users in the Illawarra-Shoalhaven region of NSW, Australia.

#### **Methods**

HbA1c values recorded between 2010 and 2012 for non-pregnant individuals  $\geq 18$  years of age were extracted from the Southern.IML Research (SIMLR) database. Individuals were assigned SEIFA quintiles of the Index of Relative Socioeconomic Disadvantage (IRSD)

according to their Statistical Area 1 of residence. Glycaemic risk categories were defined as HbA1c 5.0-5.99% (lowest risk), 6.0-7.49% (intermediate risk) and  $\geq 7.5\%$  (highest risk).

Logistic regression models were fit with glycaemic risk category as the outcome variable and IRSD as the study variable, adjusting for age and sex.

## **Results**

Data from 29,064 individuals were analysed. Higher disadvantage was associated with belonging in a higher glycaemic risk category in the fully adjusted model (most disadvantaged vs. least disadvantaged quintile - OR 1.74, 95% CI 1.58, 1.93;  $p < 0.001$ ).

## **Conclusion**

In this geocoded clinical dataset, area-level socioeconomic disadvantage was a significant correlate of increased glycaemic related risk. Geocoded clinical data can inform more targeted use of health service resources, with the potential for improved health care equity and cost-effectiveness.

## **What is known about the topic?**

The rapid increase in Type 2 diabetes (T2D) prevalence, both globally and nationally, is a major concern for the community and public health agencies. Individual socioeconomic disadvantage is a known risk factor for Abnormal Glucose Metabolism (AGM), including T2D. While small area level socioeconomic disadvantage is a known correlate of AGM in Australia, less is known of the association of area level disadvantage and glycaemic related risk in individuals with AGM.

## **What does this paper add?**

This study demonstrates a robust association between small-area level socioeconomic disadvantage and glycaemic related risk in regional New South Wales. The study demonstrates that it is feasible to use geocoded, routinely collected clinical data to identify communities at increased health risk.

### **What are the implications for practitioners?**

The identification of at-risk populations is an essential step towards targeted public health policy and programs aimed at reducing the burden of AGM, its complications and the associated economic costs. Collaboration between primary care and public health in the collection and use of data described in this study has the potential to enhance the effectiveness of both sectors.

## **INTRODUCTION**

Type 2 diabetes (T2D) is a serious concern for our population, clinical services and public health agencies, with a marked increase in national prevalence over recent decades.<sup>1</sup> Diabetes is among the leading causes of morbidity and death in Australia,<sup>1</sup> with the health impacts also translating into significant direct and indirect economic costs for the community.<sup>2</sup> However, the disease burden associated with abnormal glucose metabolism (AGM) is not limited to those with glucose levels above the threshold for a formal diagnosis of T2D. Prospective research has demonstrated significantly increased risks of all-cause mortality with impaired fasting glucose and impaired glucose tolerance, and increased risk of cardiovascular-related mortality with impaired fasting glucose.<sup>3</sup> In addition, the risks of developing diabetes,<sup>4</sup> cardiovascular disease (CVD)<sup>4-6</sup> and all-cause mortality<sup>4,7</sup> are increased in adults with elevated glycated haemoglobin (HbA1c) levels below diabetes diagnostic thresholds. It is recognised that the risks for development of abnormal glucose metabolism (AGM) are complex, and include individual, (e.g. age, body mass index, education, ethnicity, and

immigrant status)<sup>8</sup> lifestyle (e.g. smoking and exercise)<sup>9,10</sup> and environmental (e.g. place of residence)<sup>11,12</sup> factors. The importance of individual level socioeconomic status as a risk factor for developing T2D in high-income countries has been widely observed.<sup>13,14</sup> Additionally, Australian research has demonstrated that area level socioeconomic status is associated with the risk of developing AGM<sup>11</sup> and the prevalence of T2D in population-based studies.<sup>12</sup>

The geographic distribution of glycaemic related risk is of major importance to health policy. In those with impaired glucose tolerance, the risk of progression to T2D can be significantly reduced through lifestyle modification, in particular improving diet quality and increasing exercise levels.<sup>15,16</sup> Tight glycaemic control in diagnosed T2D, achieved through attention to lifestyle management<sup>17</sup> and medical care,<sup>18</sup> is associated with significant secondary prevention of T2D complications, reducing the personal and societal costs of serious sequelae such as visual impairment, myocardial infarction, stroke, renal impairment and death.<sup>18</sup> Current international evidence demonstrates that small-area socioeconomic disadvantage is associated with higher risk of T2D<sup>19</sup> and poorer measures of T2D control,<sup>20</sup> coupled with variable quality in process measures of clinical T2D care.<sup>20</sup> Identifying at a small-area level those communities and neighbourhoods with highest glycaemic related risk would facilitate targeted use of health promotion and clinical resources<sup>21</sup> with the prospect of more cost-effective interventions than blanket approaches might achieve. Thus, areas of socioeconomic deprivation represent strong candidates for health service investment to reduce the impact of AGM.<sup>11,22</sup> We recently demonstrated the feasibility of using routinely collected, geocoded clinical data (coded to include Statistical Area identifiers of individual's residence) to assess at small area level the associations between area level disadvantage and obesity to inform health service commissioning.<sup>23</sup> The feasibility of using geocoded clinical data has also been

demonstrated in the UK to identify inner-urban neighbourhoods at increased risk of T2D.<sup>21</sup> However, to our knowledge, there are no reports in Australia of health service wide linkage of glycaemic control to area level disadvantage at sufficiently small statistical area units to identify neighbourhoods at risk. Therefore, the primary aim of this paper was to investigate the relationship between small-area level socioeconomic disadvantage and glycaemia in a cohort of health service users by utilising routinely collected clinical data, referenced to glycaemia-related CVD risk, in order to identify neighbourhoods at risk to enable more targeted health service commissioning. The secondary aim was to assess the feasibility of using geocoded clinical data more broadly to inform health service commissioning.

## **METHOD**

### ***Study area and population***

The study area was the Illawarra-Shoalhaven region of NSW, which had an estimated resident population of 389,157 persons at the time of the 2011 Australian Census of Population and Housing.<sup>24</sup> Data were extracted from the Southern.IML Research (SIMLR) Study database. This community-derived longitudinal pathology cohort is comprised of internally-linked and geocoded data for residents of the Illawarra-Shoalhaven Area (ISA) aged 18 years and over presenting for pathology testing on or after 1 January 2003. The SIMLR Cohort is updated and refreshed annually, and provides a near-census of private pathology services provided in the ISA. Socioeconomic data were obtained from the 2011 Australian Census of Population and Housing at the Statistical Area 1 (SA1) level and matched to individual level data using SA1 codes present in both data sets. SA1 was the smallest geographic statistical unit used by Australian Bureau of Statistics for reporting output of the 2011 Census, with each SA1 area containing on average 400 residents with a range designed to be between 200 and 800 residents.<sup>25</sup> Across the four Local Government

Areas in the study area, exact address matching for geocoding was achieved for 95.7–97.7% of the SIMLR database and exact street matching for the remaining 2.3–4.3%. Geocoding accuracy, data integrity and record inclusion criteria are checked prior to each annual update being included in the SIMLR database.

### ***Study sample***

All non-pregnant persons with  $\geq 1$  HbA1c test between 2010 and 2012 were identified as the study sample. For each person in this cohort, their most recent HbA1c pathology test prior to 31 December 2012 was extracted along with test collection date, age at test collection date and sex. During the study period HbA1c was only eligible for a Medicare Benefits Schedule (MBS) rebate for monitoring glycaemic control in diagnosed diabetes.<sup>26</sup> However, the study period did coincide with the release of endorsed recommendations for the use of HbA1c for diagnosing diabetes in Australia.<sup>27</sup> Thus, we anticipated that the sample was comprised of individuals diagnosed with diabetes according to glucose-based criteria and a proportion of non-Medicare rebatable HbA1c tests. We excluded cases with HbA1c  $< 5.0\%$  as there is evidence of increased all-cause mortality associated with abnormally low HbA1c in this range in non-diabetic adults,<sup>4</sup> which was beyond the scope of this study.

### ***Study and outcome variables and statistical analysis***

The study variable was the individual's IRSD category. Geocoded data were used to assign Socioeconomic Indices for Australia (SEIFA) Index of Relative Socioeconomic (IRSD) quintiles<sup>28</sup> to individuals based on their Statistical Area 1 (SA1) of residence at their most recent HbA1c test result prior to 31 December 2013. The IRSD is an aggregate measure of socioeconomic disadvantage derived from the 2011 Australian Census, including measures of income, education, unemployment, overcrowding, English proficiency and disability.<sup>28</sup>

The outcome variable was the individual's glycaemic risk category according to HbA1c. HbA1c is a measure of glycaemia which is not subject to the day-to-day fluctuations of blood sugar levels.<sup>27</sup> Pooled analyses demonstrate a 10-20% increase in CVD risk (coronary heart disease and stroke) for each 1% increase in HbA1c% above a threshold of 4.6-5.0%; both in the general population and those with diabetes, controlling for other classical CVD risk factors.<sup>6</sup> Based on longitudinal studies,<sup>4,18</sup> Australian guidelines,<sup>29</sup> and to allow comparison with international studies,<sup>30,31</sup> we defined glycaemic CVD risk categories as HbA1c 5.0-5.9% (lowest glycaemic CVD risk), 6.0-7.4% (intermediate glycaemic CVD risk) and  $\geq 7.5\%$  (highest glycaemic CVD risk: sub-optimal diabetes control). If not previously diagnosed, HbA1c  $\geq 6.5\%$  is in the diagnostic range for diabetes according to Australian and international guidelines.<sup>32</sup>

Continuous variables were described with means and standard deviations (SD) and where appropriate, proportions in percentages with 95% confidence intervals (CI). Within a generalised estimating equation (GEE) framework, we fit unadjusted and sex- and age-adjusted ordinal logistic regression models with the 3-level glycaemic risk variable as the outcome and the study variable the IRSD quintile of the individual's SA1: 1 = most disadvantaged, 5 = least disadvantaged. We then collapsed the lowest and intermediate risk categories to create a binary outcome variable of HbA1c  $< 7.5\%$  and  $\geq 7.5\%$ . GEE binary logistic models were fit for the binary outcome with IRSD quintiles as the study variable, adjusted for age and sex. This model allowed comparison with previous international research investigating area-level socioeconomic disadvantage and diabetes control that used a single cut-point of HbA1c  $< 7.5\%$  to define acceptable control.<sup>30,31</sup> The lowest glycaemic risk category and the least disadvantaged IRSD quintile were used as the reference levels in all

models. All analyses were controlled for clustering of individuals within SA1 arising from the hierarchical data structure. Within cohort associations were expressed as odds ratios (ORs) and 95% CIs to provide estimates of exposure-outcome relationships applicable to the target population.<sup>33,34</sup> Two-sided statistical significance was set at  $p < 0.05$ . R version 3.3.1 (R Foundation for Statistical Computing, Vienna, Austria) was used for statistical analyses.

This study was approved by the Joint University of Wollongong and Illawarra Shoalhaven Local Health District Human Research Ethics Committee (Health and Medical) (HE13/496).

## **RESULTS**

### ***Sample description***

We identified 29,702 SIMLR records with  $\geq 1$  HbA1c test result between 01 January 2010 and 31 December 2012. Of these, 638 (2.1%) were excluded as their most recent HbA1c test result in the study period was  $< 5.0\%$ , resulting in a study sample of 29,064 persons. The median age of individuals in the sample was 67 years (IQ range 18 years) and mean age 65.2 years (SD 14.0) with a range of 18-101 years. The gender distribution was approximately equal with 47.4% of the sample female. The proportion of the sample in IRSD quintile 5 (least disadvantaged) was 14.1% ( $n=4085$ ) and in IRSD 1 (most disadvantaged) 25.9% ( $n=7527$ ). The mean HbA1c of the sample was 6.69% (SD 1.39) with median of 6.30% and range of 5.0-17.9%. The age groups with the highest proportion of  $\text{HbA1c} \geq 7.5\%$  were 18-19 years and 20-29 years. The proportion of the sample with  $\text{HbA1c} \geq 7.5\%$  was higher in the most disadvantaged compared with the least disadvantaged IRSD quintile. Sample characteristics are summarised in Table 1.

*Insert Table 1*

In both the unadjusted and adjusted ordinal logistic models, there was a significant increase in the odds of membership in a higher glycaemic risk category for each of IRSD quintiles 1 - 4 in comparison with quintile 5. There was a significant increase in the odds of membership in a higher risk glycaemic category associated with male gender in comparison with female gender. There was no independent association of age with glycaemic risk category. Results of the unadjusted and adjusted regression models are presented in Table 2.

*Insert Table 2*

The binary logistic models demonstrated similar socioeconomic gradients with a significant increase in the odds of  $HbA1c \geq 7.5\%$  in each of the IRSD quintiles 1 - 4 in comparison with quintile 5. Male gender was associated with increased risk of  $HbA1c \geq 7.5\%$ , while increasing age was associated with reduced risk. Results for the binary logistic models are summarised in Table 3.

*Insert Table 3*

Alternative binary and ordinal models were tested with age as a quadratic term and with a term for the interaction between age and IRSD. No substantial improvement in model fit was found.

## **DISCUSSION**

It has been previously reported in Australian research that small area-level socioeconomic disadvantage is associated with increased risk of developing AGM.<sup>11</sup> This study extends those findings by demonstrating that small area-level disadvantage is also associated with higher glycaemic-related risk. We found in this sample of health service users that residents of the most disadvantaged neighbourhoods had over one and a half times the odds of  $HbA1c$

in the highest glycaemic risk category in comparison with health service users resident in the least disadvantaged neighbourhoods. Among the implications of this multiplier effect, of both higher incidence of AGM and higher risk glycaemia with AGM, is a high burden of potentially preventable CVD among the most vulnerable members of the community. Our finding of an association between younger age and increased glycaemic risk supports previous international studies from community-based cohorts.<sup>31,35</sup> In addition, we have demonstrated that it is feasible to use geocoded clinical data to inform health service commissioning, where the goal is to improve equity in health care.

Previous research in Australia has focused on the prevalence of diabetes<sup>12</sup> or incidence of AGM<sup>11</sup> in relation to area-level disadvantage, preventing direct local comparison with our findings. However, our analyses of routinely collected clinical data are consistent with research using clinical data collected in the UK, prior to the introduction in 2004 of pay for performance mechanisms under the Quality and Outcomes Framework (QOF).<sup>30,35</sup> In particular, pooled general practice data from a large regional cohort in the UK demonstrated reduced odds of HbA1c < 7.5% in persons with diabetes resident in the most disadvantaged quintile of neighbourhoods.<sup>30</sup>

Our findings, in conjunction with previous international<sup>19</sup> and Australian<sup>11,12</sup> studies, have significant implications for the resourcing of community-level health services. We can expect an increased prevalence of AGM, and patients at higher risk, in the most disadvantaged neighbourhoods. However, there is cause for optimism that appropriately constructed processes of care can make a difference for these at-risk populations<sup>36</sup> and act as a moderator of the adverse associations of socioeconomic disadvantage and glycaemic related risk.<sup>37</sup> For example, a systematic review of interventions for diabetes in disadvantaged populations

reported that cultural tailoring, use of community educators, one-to-one, individualised assessment and reassessment, use of treatment algorithms by nurses and doctors and high intensity (>10 sessions) interventions, delivered over extended periods (> six months) were features of interventions with increased likelihood of positive outcomes.<sup>36</sup> There is also evidence to suggest that financial incentives promoting consistency in quality diabetes care processes and outcomes are associated with reduced socioeconomic disparities in diabetes. Research from the UK following introduction of QOF, demonstrated a significant improvement in reported uniformity of diabetes care processes and levelling of the socioeconomic gradient in measures of diabetes control, including the odds of having HbA1c < 7.5% in residents of the most disadvantaged quintile of neighbourhoods.<sup>31</sup>

Thus, there is evidence to support collaborations between state funded community health services, federally funded primary health networks and general practices to develop contextually tailored and targeted interventions to improve diabetes outcomes in disadvantaged neighbourhoods. However, this would require policy changes to provide increased, outcome contingent resources. Such policy change is supported by the recent Australian Diabetes Care Project, a randomised controlled trial which piloted a suite of quality improvement measures for primary care management of diabetes, including pay for performance incentives. This trial demonstrated a significant improvement in diabetes care process measures and HbA1c in the intervention arm, with HbA1c improvements most marked in those with the poorest HbA1c levels at the commencement of the trial.<sup>38</sup> Our findings indicate that those with the greatest socioeconomic disadvantage are more likely to have the poorest glycaemic control. While assessing measures of quality of care were beyond the scope of this study, the relationships between area-level disadvantage, access to and quality of primary care, funding policy and diabetes outcomes are an important area for

future Australian research. Given the very high cost of diabetes-related complications,<sup>39</sup> and the increased risk of these complications in disadvantaged localities as demonstrated in our study, an immediate focus of research should be on the marginal health and cost benefits of interventions targeted to areas of greatest area-level socioeconomic disadvantage.<sup>37</sup>

### ***Limitations***

The results of this study should be interpreted in light of its limitations. The data were sourced from those already accessing the health system and the prevalence rates in our study should not be applied to the general population. The within-cohort relative risks we have reported are more robust.<sup>33,34</sup> However, we were not able to discriminate between type 1 diabetes and T2D. Additionally, we were not able to identify the proportion of non-Medicare rebatable HbA1c tests in the sample which were performed on patients who did not have a diagnosis of diabetes. Due to the nature of the data, we were not able to provide an estimate of the absolute CVD risk associated with HbA1c levels in our sample. Our data were also sourced from a single region of Australia and, as yet, not compared with other regions. However, given the large sample size, the diverse nature of the region from which the data were sourced (metropolitan and rural) and consistency with previous Australian research concerning prevalence of diabetes and area-level disadvantage,<sup>12</sup> we believe our findings provide a credible demonstration of the area-level socioeconomic gradient in glycaemic related CVD risk and warrant further investigation.

### ***Conclusion***

This study has demonstrated that in regional Australian health service users, individuals from neighbourhoods with the highest socioeconomic disadvantage are at highest risk of poorly controlled glycaemia. We have also demonstrated that routinely collected clinical data, when

geocoded, can be used to identify neighbourhoods at higher risk from glycaemia and the ensuing macro- and microvascular complications. This information is particularly relevant for federal health funding policy and state and local government health promotion initiatives, in addition to increasing awareness among local healthcare providers. Such data are imperative for effective collaboration between the public health and primary care sectors of our health system. An immediate avenue of application of the data is through Primary Health Networks (PHNs), the Australian federally funded geographically based bodies responsible for coordination of primary care. By identifying discrete areas of diabetes risk with routinely collected data, PHNs, in collaboration with state-funded entities (e.g. Local Health Districts in NSW), may be able to more efficiently target health promotion and service commissioning for those areas most likely to benefit from intervention.<sup>21</sup> This study supports the large international body of work demonstrating that providing accessible and quality health care services to those in the most disadvantaged communities should be a priority for health policy and research.<sup>20</sup>

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