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The effect of deprivation and HbA_{1c} on admission to hospital for diabetic ketoacidosis in type 1 diabetes

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Abstract

Aims—Diabetic ketoacidosis is a potentially life threatening complication of diabetes which has a strong relationship to HBA1c. We examined how socioeconomic group affected the likelihood of admission to hospital for diabetes ketoacidosis.

Methods—The Scottish Care Information – Diabetes Collaboration, a dynamic national register of all cases of diagnosed diabetes in Scotland, was linked to national data on hospital admissions. We identified 24,750 people with type 1 diabetes during January 2005 to December 2007. We assessed the relationship between HbA_{1c} and quintiles of deprivation with hospital admissions for diabetes ketoacidosis in people with type 1 diabetes adjusting for patient characteristics.

Results—We identified 23,479 people with type 1 diabetes who had complete recording of covariates. Deprivation had a substantial effect on odds of diabetes ketoacidosis admission (odds ratio 4.51, 95% confidence interval 3.73-5.46 in the most deprived quintile compared with the least deprived). This effect persisted after the inclusion of HbA_{1c} and other risk factors (OR 2.81, 95%CI 2.32-3.39). Males had a reduced risk of diabetes ketoacidosis admission (OR 0.71, 95%CI 0.63-0.79) and those with a history of smoking increased odds of diabetes ketoacidosis admission by 1.55 (95%CI 1.36-1.78).

Conclusion—Females, smokers, those with high HbA_{1c} and living in more deprived areas have an increased risk of diabetes ketoacidosis admission. The effect of deprivation was present even after inclusion of other risk factors. This work highlights that those in poorer areas of the community with high HbA_{1c} represent a group who might be usefully supported to try to reduce admissions.

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Keywords

deprivation; diabetes; diabetic ketoacidosis; HbA_{1c}; record linkage

We have previously demonstrated that, among people with type 1 diabetes, HbA_{1c} is an important indicator of risk of admission independently of other predictors with a particularly strong relationship to admissions coded as diabetic ketoacidosis [1]. Deprivation is a further important potential indicator of disease risk in the population, however previous analysis of data from a smaller Scottish population suggests that deprivation has a relatively weak relationship with HbA_{1c} in people with type 1 diabetes [2].

This study examines how socioeconomic group affects likelihood of admission to hospital for diabetes ketoacidosis among people with type 1 diabetes, and whether this relationship is explained by HbA_{1c}.

Research Design and Methods

Data

The Scottish Care Information – Diabetes Collaboration (SCI-DC) database is a dynamic national clinical information system of all diagnosed cases of diabetes in Scotland (www.diabetesinscotland.org.uk). SCI-DC contains records for over 99% of diagnosed cases of diabetes [3] with detailed clinical information including body mass index (BMI), creatinine, age, sex, and HbA_{1c}. HbA_{1c} was measured using a variety of clinical methods, all of which were DCCT aligned. Type 1 diabetes was identified using an algorithm which incorporated age, drug prescription and clinical description of the type of diabetes. Those whose type diagnosis was not known were excluded from the analysis. Deprivation was defined using the Scottish Index of Multiple Deprivation [4], which provides a composite index of relative area deprivation across Scotland. Smoking status was defined as current or ex-smoker.

Information on hospital admissions was obtained using Scottish Morbidity Records (SMR01), national data on hospital admissions from Information Services Division (ISD) of NHS National Services, Scotland. The SMR01 records contain over 95% of Scotland's hospital admissions and include administrative data and demographic information such as age, gender, and postcode of the patient. Individual episodes of care are recorded within each admission with up to six International Classification of Disease (ICD) diagnosis codes (1997-present: ICD 10^{th} revision).

Data were linked within ISD using probabilistic methods based on name, sex, date of birth and postcode, as previously described [5]. No personal identifiers were released to researchers and all subsequent analyses were conducted on anonymised datasets.

Statistical analysis

The outcome of interest was recording of diabetes ketoacidosis as a reason for admission to hospital at least 180 days after the diagnosis for diabetes. Outcome was determined if ICD codes for diabetes ketoacidosis were present in any position of diagnosis. Parametric

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relationships between mean HbA_{1c} (as measured between 2005-2007) and diabetes ketoacidosis admission were investigated using the fractional polynomial methods in Stata version 11. Natural log of mean HbA_{1c} was found to provide the best fit to the data. Logistic regression models were used to estimate the association between diabetes ketoacidosis admissions, log mean HbA_{1c}, deprivation quintiles (referent quintile 1, least deprived), and history of smoking. Analysis was adjusted for potential confounding factors including age, sex, previous vascular disease (ICD-9: 410-414, 430-438, 443; ICD-10: I20-I25, I60-I69, I73), creatinine, BMI and diabetes duration.

Results

Between January 2005 and December 2007, we identified 24,750 people with type 1 diabetes (Scottish population 5.1million) of whom 23,479 had complete recording of all covariates; 64% were either a current or ex-smoker. There were a total of 4577 admissions coded for diabetes ketoacidosis during the study period (79% of these admissions were single admissions for different people and 21% were multiple admissions). The number of admissions per 1000 persons per year was significantly higher in the most deprived fifth of socioeconomic group (175 admissions per 1000 persons per year compared with 60 admissions per 1000 persons per year in the least deprived fifth). The Figure shows that some of this effect may be explained by HbA_{1c}, but the effect of deprivation is evident in all thirds of HbA_{1c} (range of HbA_{1c} in: tertile 1=4.4-8.15; tertile 2=8.16-9.26; tertile 3=9.27-18.3). Compared to those who did not have an admission mentioning diabetes ketoacidosis, the HbA_{1c} values in those with an admission mentioning diabetes ketoacidosis were greater for all socioeconomic groups

Deprivation was an independent predictor of admission with an increase in odds of admission of 4.51 (95%CI 3.73-5.46) in the most deprived fifth compared to least deprived. After adjustment for HbA_{1c} (expressed as $Ln(HbA_{1c})/0.09531$, where one unit increase is equivalent to 10% increase in HbA1c), the increase in odds of admission in all deprivation quintiles was reduced (for most deprived compared to least deprived: OR 3.41; 95%CI 2.54-3.71). After adjusting for the other covariates, younger patients, females (not including maternity admissions), and people with history of vascular disease had a higher risk of admission (Table). History of smoking also had a substantial effect, increasing odds of admission by 1.55 (95%CI 1.36-1.78). The size of the effect of deprivation was reduced by the inclusion of other covariates; however, there remained a substantial increase in odds of admission in the most deprived fifth compared with the least deprived fifth of deprivation (OR 2.82, 95%CI 2.32-3.39).

Discussion

There was a strong association between deprivation and odds of diabetes ketoacidosis admission with people in more deprived areas having odds of admission 4.5 times higher than those in the least deprived areas. Higher HbA_{1c} also increase the odds of admission. Although the inclusion of HbA_{1c} and other risk factors showed a reduction in the size of the effect of deprivation, a substantial effect remained. This suggests that only some of the effect of deprivation can be explained by these other risk factors in people with type 1

diabetes. Those who have a history of smoking, previous vascular admissions and females also had an increase in risk of admission associated with diabetes ketoacidosis.

We have taken advantage of the linked data for both hospital admissions (SMR-01) and clinical information (SCI-DC), providing almost 100% coverage of all data for people with diagnosed type 1 diabetes in Scotland during 2005-2007. This allowed us to avoid under-reporting in hospital discharge information as found in other studies [6;7]. Some limitations of our study have also been identified. Firstly, an algorithm which incorporated age, drug prescription and clinical description of the type of diabetes was used to determine the type of diabetes. As with nearly all cohorts of this size and type, there is potential for misclassification of diabetes type. However, we believe those misclassified will be an extremely small percentage. Second, we have used the annual average of HbA_{1c}, chosen as the best measure of prevailing HbA_{1c} for each person. This yearly average does not capture the variability of HbA_{1c} and a measurement prior to admission for diabetes ketoacidosis could be argued to be more appropriate. However, HbA1c was measured locally in diabetes clinics during routine clinic visits. Using the last measurement of HbA1c instead of the average did not change the conclusions of our study. Additionally, the number of recordings of HbA1c per person was not significantly associated with odds of admission for diabetes ketoacidosis. Third, in determining the reason for admission we rely on hospital admission data to detect each type of admission. These data are dependent on the accuracy of coding of ICD in hospital diagnosis codes, which is around 90% (see http://www.isdscotland.org/isd/2737.html). However, hyperglycaemia codes are often underused in discharge coding [6]. The codes used do not include people admitted with coma (ICD10 E10.0, E14.0) as these categories include but do not distinguish between, those with ketoacidosis, hyperosmolar or hypoglycaemic coma. We also do not include those with multiple complications potentially including ketoacidosis (ICD10 E10.7, E14.7) since ketoacidosis cannot be separately identified within these codes.

Our results show that people in more deprived areas are at a greater risk of admission for diabetes ketoacidosis, but it is important to discuss why this effect exists. We can speculate that those in more deprived areas have poorer control of their diabetes resulting in increased risk of hospital admission for diabetes ketoacidosis. As discussed, however, deprivation score is not a strong predictor of HbA1c in our population, and much of the effect of deprivation score appears independent of HbA1c.

Despite universal health coverage, free at point of care, social deprivation is also associated with reduced engagement with health services such as retinal screening [8] and deprivation is in turn associated with higher risk of complications [9]. Admission for diabetes ketoacidosis will also relate to other comorbidities, social and medical support and relevant education in diabetes management of during intercurrent illness and other crises. In that context, the relationship with smoking is of interest. This is unlikely to be causal but may be acting as a marker of other health behaviours and thus increased risk of admission for diabetes ketoacidosis.

There is an increasing emphasis on structured education programmes as a means of improving health outcomes in type 1 diabetes. Our analysis shows that socioeconomic group

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carries risk of diabetes ketoacidosis admission over and above that predicted by HbA1c. An important implication of our work is that where programmes are directed towards prevention of expensive and distressing complications, such as diabetes ketoacidosis, consideration of their relevance to those patients with diabetes who are most at risk (including consideration of socioeconomic group) will be important.

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Abbreviations

BMI	Body Mass Index
CHI	Community Health Index
ICD	International Classification of Disease
ISD	Information Services Division
SCI-DC	Scottish Care Information – Diabetes Collaboration
SDRN	Scottish Diabetes Research Network
SHIP	Scottish Health Informatics Programme
SIMD	Scottish Index of Multiple Deprivation
SMR-01	Scottish morbidity records

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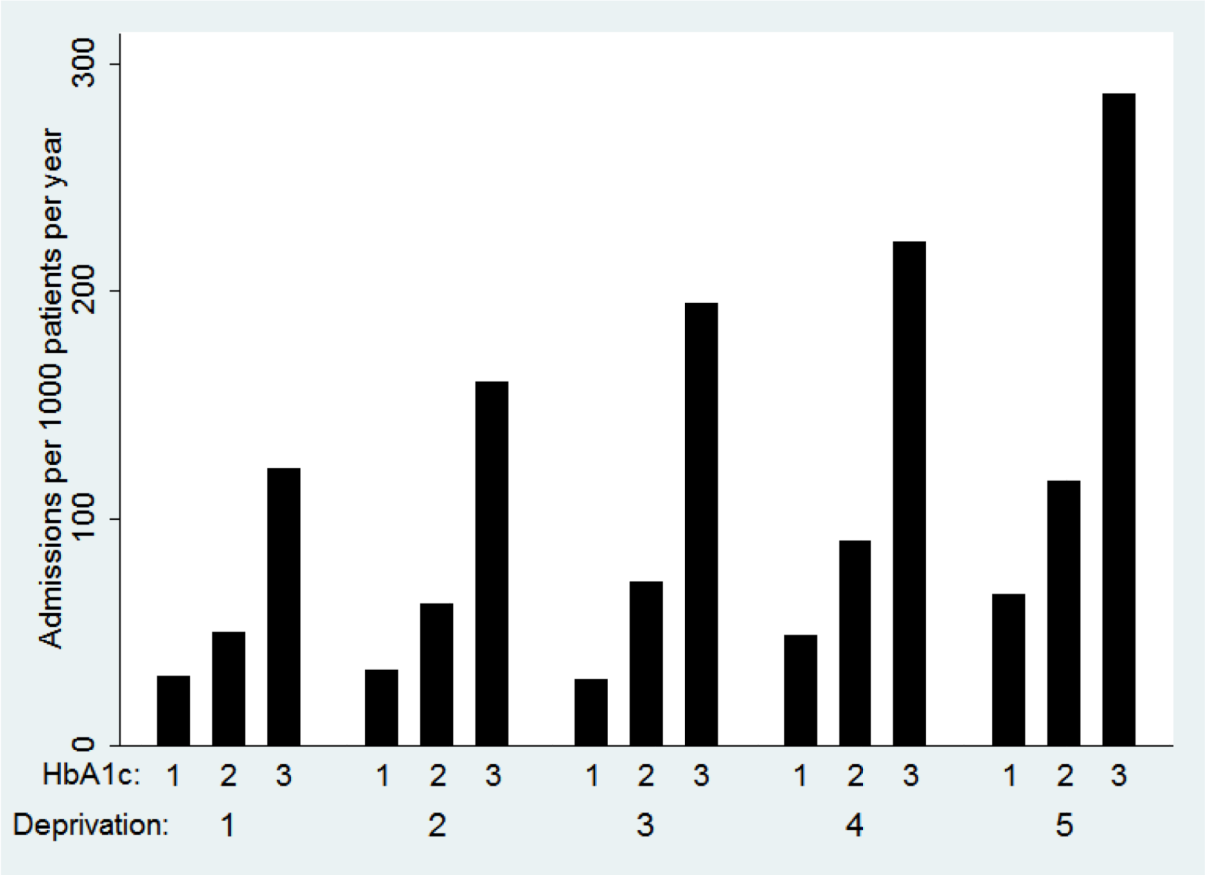

Figure. Number of admissions per 1000 persons per year in groups defined by tertiles of HbA_{1c} (range of HbA_{1c} in: tertile 1=4.4-8.15; tertile 2=8.16-9.26; tertile 3=9.27-18.3) and quintiles of deprivation.

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Table

Coefficients, odds ratios and 95% confidence intervals obtained from the logistic regression model for diabetes ketoacidosis admissions

Risk factor	Coefficient	Odds ratio (95%CI)
Male	−0.348	0.71 (0.63-0.79)
Age, years [a]	−0.033	0.97 (0.96-0.97)
Previous vascular admission	0.961	2.61 (1.96-3.49)
Creatinine, μmol/L [ab]	0.003	1.003 (1.002-1.004)
Body mass index, kg/m^2 [ab]	−0.059	0.94 (0.93-0.95)
Diabetes duration, years [ab]	−0.015	0.98 (0.98-0.99)
Smoking	0.439	1.55 (1.36-1.78)
Ln(HbA_{1c})/0.09531 [ab]	0.458	1.58 (1.53-1.63)
Deprivation [c]		
quintile 1 – least deprived	Reference	Reference
quintile 2	0.266	1.31 (1.05-1.62)
quintile 3	0.515	1.67 (1.38-2.03)
quintile 4	0.691	2.00 (1.64-2.42)
quintile 5 – most deprived	1.038	2.82 (2.33-3.42)

[a] Per one unit increase. For ln(HbA1c)/0.09531, equivalent to 10% increase in HbA1c (expressed as %)

[b] Mean of any values recorded between January 2005/date of diagnosis and December 2007/date of death.

[c] Multivariate analysis results for model including all factors in table