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Factors influencing hospital conveyance following ambulance attendance for people with diabetes: A retrospective observational study

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Abstract

Aim: To assess variables contributing to hospital conveyance for people with diabetes and the interactions between them. A secondary aim was to generate hypotheses for further research into interventions that might reduce avoidable hospital admissions.

Methods: A national retrospective data set including 30 999 diabetes-related callouts from the Scottish Ambulance Service was utilized covering a 5-year period between 2013 and 2017. The relationship between diabetes-related hospital conveyance and seven potential risk factors was analysed. Independent variables included: age, gender, deprivation, paramedic attendance, treatment at the scene, first blood glucose measurement and day of the week.

Results: In Scotland, hyperglycaemia was associated with a higher number of people being conveyed to hospital than hypoglycaemia (49.8% with high blood glucose vs. 39.3% with low glucose, $P \leq 0.0001$). Treatment provided in pre-hospital care was associated with reduced conveyance rates (47.3% vs. 58.2% where treatment was not administered, $P \leq 0.0001$). Paramedic attendance was also associated with reduced conveyance to hospital (51.4% vs. 59.5% where paramedic was not present, $P \leq 0.0001$). Paramedic attendance in hyperglycaemic cases was associated with significantly reduced odds of conveyance (odds ratio 0.52, $P \leq 0.001$).

Conclusions: A higher rate of conveyance associated with hyperglycaemic cases indicates a need for more resources, education and training in this area. Higher conveyance rates were also associated with no paramedic being present and no treatment being administered. This suggests that paramedic attendance may be crucial in reducing avoidable admissions. Developing and validating protocols for pre-hospital services and treatment may help to reduce hospital conveyance rates.

1 | INTRODUCTION

In 2018, over 3.8 million people in the United Kingdom (UK) had a diagnosis of diabetes mellitus, with 304 375 diagnosed in Scotland.[1–3] This represents a prevalence rate of around 5.6% of the population. Diabetes UK estimates that 0.9 million people with the condition remain undiagnosed so the real prevalence may be higher.[4]

Prevalence of Type 2 diabetes in Scotland increased from 190 772 in 2008 to 267 615 in 2018 and the number of people with diabetes mellitus overall more than doubled between 1998 and 2018.[3,4] The total number of adults with diabetes is projected to rise by 9.5% by 2030.[2] This trend presents a growing problem for people with diabetes, healthcare professionals, National Health Service (NHS) commissioners and UK policymakers.

Diabetes complications such as hypoglycaemia/hyperglycaemia, ketoacidosis, limb amputations and retinopathy result in a high rate of emergency hospital admissions.[5] In 2017, an estimated 9600 people required emergency treatment following acute hypoglycaemia in the UK; 2200 people suffered from ketoacidosis[6] and one in six hospital beds were occupied by a person with diabetes.[7] According to the Joint British Diabetes Society, the conveyance rate to hospital for people with acute hypoglycaemia, foot disease and ketoacidosis is 21–35.3 %. This translates as an estimated 32 500 people being conveyed to hospital following callout per annum in the UK, including around 11 579 cases of acute hypoglycaemia per year.[8]

According to previous research, nearly half (43%) of ambulance attendances for diabetes-related problems do not result in conveyance to hospital. This is often because people are treated at the scene ('see, treat and leave').[8] Knowledge of the circumstances in which treatment at the scene works, what treatment is most effective, and for which types of people, is crucial in understanding the factors associated with hospital conveyance and admission in pre-hospital care. Possible improvements in pre-hospital care include the use of ketone meters and flash glucose monitors ('see, treat and monitor'), providing easily accessible telephone advice from NHS 24 or general practitioners ('hear and treat'), and increased transport to alternative pathways.[9–11] There is also wide-ranging evidence that autonomous assessment and management of people by paramedics could reduce emergency department conveyance.[12] These strategies all have potential to reduce hospital conveyance and admission.[13]

'See, treat and leave' protocols for hypoglycaemia are in operation in several ambulance trusts across the UK.[8,11] Where applied, only 2–7% of people receiving emergency services contact them again within 48 h, and the protocols therefore appear relatively safe.[14–16] Good quality data on the various factors influencing pre-hospital care outcomes for people with diabetes are required, as well as data on how paramedics and emergency medical technicians (EMTs) make clinical decisions in these contexts. Analysis of how factors, in interaction, influence hospital conveyance rates is also needed.

What's new?

- Here we highlight several risk factors for conveyance to hospital in diabetes-related pre-hospital care that are currently underexplored in the literature.
- The roles that paramedic attendance and treatment at the scene play in determining hospital conveyance are elucidated.
- Analysis of data covering the whole of Scotland over a 5-year period between 2013 and 2017 reveals that cases of hyperglycaemia represent a greater risk of hospital conveyance, and a higher proportion of actual conveyances, than cases of hypoglycaemia.
- A higher rate of conveyance where only ambulance technicians are present indicates that paramedic attendance in diabetes-related cases may be crucial in reducing avoidable admissions.

In hospital, people with diabetes are at higher risk of infection, stay 1–3 days longer than people with other conditions, and have a 6.4% higher risk of mortality.[7] This makes it all the more vital that the number of people with diabetes being admitted to hospital remains as low as possible. In theory, adapted pre-hospital care implemented by EMTs and paramedics* could reduce conveyance and hospitalization rates and improve the service user experience and health outcomes, while associated care costs may simultaneously be reduced.

The aim of this study was to assess variables contributing to hospital conveyance for people with diabetes and the interactions between them. We also sought to generate hypotheses to inform research into approaches to reducing hospital conveyance and admission for people with diabetes.

2 | METHODS

In order to elucidate predictive and protective factors in diabetes-related hospital conveyance, a national retrospective

*In the UK Paramedics are qualified to degree level whereas emergency medical technicians have basic clinical examination and paramedic assistance skills. Paramedics can offer a wider range of treatments than emergency medical technicians.

data set was utilized from Scotland. Data were extracted by the Scottish Ambulance Service (SAS) from the electronic patient report form (ePRF) and TerraPACE, which collate information taken at the time of the call in ambulance control centres with data from ePRFs. The sample was based on incidents in which the ambulance crew used the final code group 'diabetic'. Data were supplied for 5 years from 1 January 2013 until 31 December 2017 and covered the whole of Scotland including very remote rural areas. Caldicott approval was granted for this study.

During 2017, the SAS moved to a new clinical reporting system but most of the data collected were common across both systems. Blood glucose readings were gathered using the first measurement recorded by the crews. The range of treatments for hypoglycaemia included glucagon, glucose gel and glucose-rich food, but was reduced to a binary category (e.g. applied/not applied) due to inconsistent labelling in the data set. Fewer treatment options are available in cases of hyperglycaemia and these are more complex to apply but include intake of fluids or intravenous 0.9% sodium chloride to help with dehydration according to Joint Royal Colleges Ambulance Liaison Committee 2019 guidance.

We examined primary diagnosis, whether care was provided, when, where, by whom and whether the person was conveyed to hospital. The variables were chosen on the basis that the data set was restricted to these factors. All analyses were carried out using R version 3.5.1 developed originally by Robert Gentleman and Ross Ihaka in the Statistics Department of the University of Auckland, New Zealand. A multiple logistic regression model was used to identify risk factors associated with hospital conveyance following ambulance attendance for people with diabetes. The variables in the model included age and gender, deprivation rank, whether treatment was administered, first blood glucose measurement, paramedic attendance and day of the week. Deprivation rank septiles were built on the Scottish Index of Multiple Deprivation.[17]

Multiple logistic regression analysis was used to compare adjusted models stratified by: (1) first blood glucose measurement (< 4, 4–11 or > 11 mmol/l); (2) treatment administered (yes/no); and (3) paramedic attendance (yes/no).

Odds ratios (OR) with corresponding 95% confidence intervals (CIs) were computed. Differences with $P \leq 0.05$ were considered statistically significant. The 'N-1' chi-squared test was used to calculate P -values for comparison of percentages.

It can be argued that where a response is linear it is best to include it as linear to avoid power loss and artificial boundaries. This is particularly relevant to age and deprivation. We checked whether the response to these variables was linear using the Box–Tidwell method for testing non-linearity.[18] Deprivation was linear, whereas age was not ($P < 0.0001$). We therefore incorporated deprivation as a linear term into the model and presented the OR for deprivation as per 1000-rank increase by multiplying the coefficient by 1000 before exponentiating. We also incorporated both the linear and quadratic functions for age into the model. The cubed term for age was also explored; however, it represented a very small increment in fit and so was not included in the final model. The two ORs for age and age^2 were interpreted together.

The significance of two-way interactions between the several explanatory variables in their effects on unscheduled hospital conveyance was evaluated. Hypotheses were developed by diabetes specialists initially and then by researchers after initial exploration of the data set. After descriptive analysis had taken place, these were refined. Interactions between the following were also considered: glucose and paramedic attendance; gender and paramedic attendance; deprivation and paramedic attendance; and administered treatment and paramedic attendance.

3 | RESULTS

A wide range of factors are associated with the risk of hospital admission and conveyance for people with diabetes. These are summarized in Table S1 [S1–S10]. All known factors contributing to conveyance and admission could not be incorporated into the multiple regression because many of these variables were not recorded in the ambulance service records. The sample contained 30 999 diabetes-related attendances. Most of the hospitals to which people were conveyed were district general hospitals, with a few tertiary units.

The demographic characteristics of the sample can be seen in Table 1. Hypoglycaemia accounted for 54.9% of cases compared with 32.1% with hyperglycaemia. However, 81.3% of people with hyperglycaemia were conveyed to hospital compared with 37.7% of people with hypoglycaemia ($P \leq 0.0001$) (Table 2). Hyperglycaemia is therefore associated with a higher proportion of people being conveyed to hospital compared with hypoglycaemia (49.8% vs. 39.3%, $P \leq 0.0001$). Overall, where no treatment was administered, 41.8% of people were left at home and 58.2% conveyed to hospital, compared with 52.7% and 47.3% where treatment was administered ($P \leq 0.0001$).

Figure 1 shows the age group with the highest rate of conveyance was ≤ 20 years closely followed by those aged ≥ 80 years. The lowest conveyance rate was for men aged 40–60 years at 45.7% ($P \leq 0.0001$). The quadratic OR for age shows a step change of 0.0005 in the odds of conveyance as age increases; however, because those aged under 20 years had high odds of conveyance, the linear OR for age shows an incremental decrease for conveyance of 0.047 (Table 2).

A greater proportion of people in deprived communities were conveyed to hospital following ambulance attendance. In the lowest deprivation rank septile (i.e. the most deprived

TABLE 1 Predictors of hospital conveyance

Risk factors	Level	Conveyance to hospital		
		No	Yes	No/Yes Combined
Gender	Male	8577 (49.7)	8695 (50.3)	17 272 (55.7)
	Female	6141 (44.7)	7586 (55.3)	13 727 (44.3)
Age (years)	≤ 20	542 (32.3)	1136 (67.7)	1678 (5.4)
	20–40	2904 (44.9)	3560 (55.1)	6464 (20.9)
	40–60	4821 (54.3)	4063 (45.7)	8884 (28.7)
	60–80	4733 (48.2)	5087 (51.8)	9820 (31.7)
	> 80	1718 (41.4)	2435 (58.6)	4153 (13.4)
Deprivation rank	0–1000	3371 (43.9)	4315 (56.1)	7686 (24.8)
	1001-2000	2700 (45.0)	3297 (55.0)	5997 (19.4)
	2001-3000	2449 (48.0)	2656 (52.0)	5105 (16.5)
	3001-4000	1943 (48.4)	2075 (51.6)	4018 (13.0)
	4001-5000	1709 (50.1)	1702 (49.9)	3411 (11.0)
	5001-6000	1380 (51.7)	1288 (48.3)	2668 (8.6)
	6001-7000	1166 (55.2)	948 (44.8)	2114 (6.8)
First blood glucose measurement (mmol/l)	4–11	2261 (56.0)	1775 (44.0)	4036 (13.0)
	≤ 4	10 599 (62.3)	6404 (37.7)	17 003 (54.9)
	> 11	1858 (18.7)	8102 (81.3)	9960 (32.1)
Treatment administered	No	6188 (41.8)	8622 (58.2)	14 810 (47.8)
	Yes	8530 (52.7)	7659 (47.3)	16 189 (52.2)
Day	Monday	2066 (45.4)	2486 (54.6)	4552 (14.7)
	Tuesday	1933 (46.3)	2241 (53.7)	4174 (13.5)
	Wednesday	1971 (47.0)	2223 (53.0)	4194 (13.5)
	Thursday	2067 (48.6)	2189 (51.4)	4256 (13.7)
	Friday	2067 (48.7)	2177 (51.3)	4244 (13.7)
	Saturday	2287 (48.2)	2462 (51.8)	4749 (15.3)
	Sunday	2327 (48.2)	2503 (51.8)	4830 (15.6)
Hour	00:00–06:00	3062 (58.8)	2149 (41.2)	5211 (16.8)
	06:00–12:00	3090 (43.7)	3988 (56.3)	7078 (22.8)
	12:00–18:00	4155 (44.1)	5260 (55.9)	9415 (30.4)
	18:00–24:00	4411 (47.5)	4884 (52.5)	9295 (30.0)
Paramedic in attendance	No	1680 (40.5)	2466 (59.5)	4146 (13.3)
	Yes	13 038 (48.6)	13 815 (51.4)	26 853 (86.7)

Note: Values are given as *n* (%).

areas) 56.1% were conveyed to hospital compared with 44.8% of those in the highest deprivation rank septile (i.e. the least deprived areas) ($P \leq 0.001$) (Figure 2). The odds of conveyance also declined incrementally up to the highest septile (OR 0.95, $P \leq 0.001$) (Table 2).

Hyperglycaemia was associated with high odds of conveyance with an OR of 10.55 ($P \leq 0.001$) compared with 0.54 for those experiencing hypoglycaemia ($P < 0.001$) (Table 2).

Overall paramedic attendance was associated with a reduced conveyance rate from 59.5% to 51.4% ($P \leq 0.0001$) (Table 1). Paramedic attendance to females was associated with reduced odds of conveyance (OR 0.82, $P \leq 0.01$) (Table 2). Where treatment was administered the odds of conveyance increased (OR 1.96, $P \leq 0.001$).

3.1 | Interactions between risk factors

In cases of hyperglycaemia women were more likely to be conveyed to hospital following attendance (OR 1.61,

TABLE 2 Multiple logistic regression analysis of risk factors associated with hospital conveyance

Risk factor	Level	Multivariate odds ratio (95% CI)	*P*-value
Gender	Male		
	Female	1.26 (1.09, 1.46)	0.002
Age		0.953 (0.947, 0.959)	< 0.001
Age^2		1.0005 (1.0004, 1.0006)	< 0.001
Deprivation rank		0.95 (0.94, 0.96)	< 0.001
First blood glucose measurement	4–11 mmol/l		
	≤ 4 mmol/l	0.54 (0.43, 0.68)	< 0.001
	> 11 mmol/l	10.55 (8.19, 13.59)	< 0.001
Day	Monday		
	Tuesday	1.02 (0.93, 1.12)	0.71
	Wednesday	1.03 (0.94, 1.13)	0.57
	Thursday	0.96 (0.87, 1.05)	0.36
	Friday	0.94 (0.86, 1.03)	0.21
	Saturday	0.93 (0.85, 1.02)	0.12
	Sunday	0.91 (0.83, 0.99)	0.04
Hour	00:00–06:00		
	06:00–12:00	1.59 (1.47, 1.72)	< 0.001
	12:00–18:00	1.63 (1.51, 1.76)	< 0.001
	18:00–24:00	1.44 (1.33, 1.55)	< 0.001
Treatment administered	No		
	Yes	1.96 (1.63, 2.35)	< 0.001
Paramedic in attendance	No		
	Yes	0.88 (0.72, 1.08)	0.23
Treatment administered: Paramedic in attendance	Treatment administrated Yes: Paramedic in attendance Yes	0.85 (0.70, 1.03)	0.09
First blood glucose measurement: Paramedic in attendance	≤ 4 mmol/l: Paramedic in attendance Yes	1.08 (0.85, 1.37)	0.54
	> 11 mmol/l: Paramedic in attendance Yes	0.51 (0.39, 0.66)	< 0.001
Gender: Paramedic in attendance	Gender Female: Paramedic in attendance Yes	0.82 (0.70, 0.96)	0.01

Abbreviation: CI, confidence interval.

$P \leq 0.01$). (Table S2). Paramedic attendance in hyperglycaemic cases was associated with reduced odds of conveyance (OR 0.52, $P \leq 0.001$) (Table S2).

The association between paramedic attendance and conveyance, where blood glucose was within the normal range, was not statistically significant (OR 0.91, $P \leq 0.52$) (Table S3). Nor was the association between paramedic attendance and conveyance significant in cases of hypoglycaemia (OR 0.88, $P \leq 0.27$) (Table S4).

Where only EMTs were present, women were more likely to be conveyed to hospital (OR 1.27, $P \leq 0.001$) (Table S5). In these cases, the difference between conveyance rates for those with low (< 4 mmol/l) and high (> 11 mmol/l) glucose readings was also significant (OR 0.54, $P \leq 0.001$; OR 10.59, $P \leq 0.001$, respectively). Reduction in the odds of conveyance, for both men and women on Fridays and over the weekend was also more pronounced where only EMTs were present (Table S5).

In cases attended only by an EMT, lower levels of deprivation were associated with decreased odds of conveyance. The incremental decrease was greater here than in cases attended by a paramedic. Where only EMTs were present and treatment was administered, we found increased odds of conveyance (OR 1.97, $P \leq 0.001$).

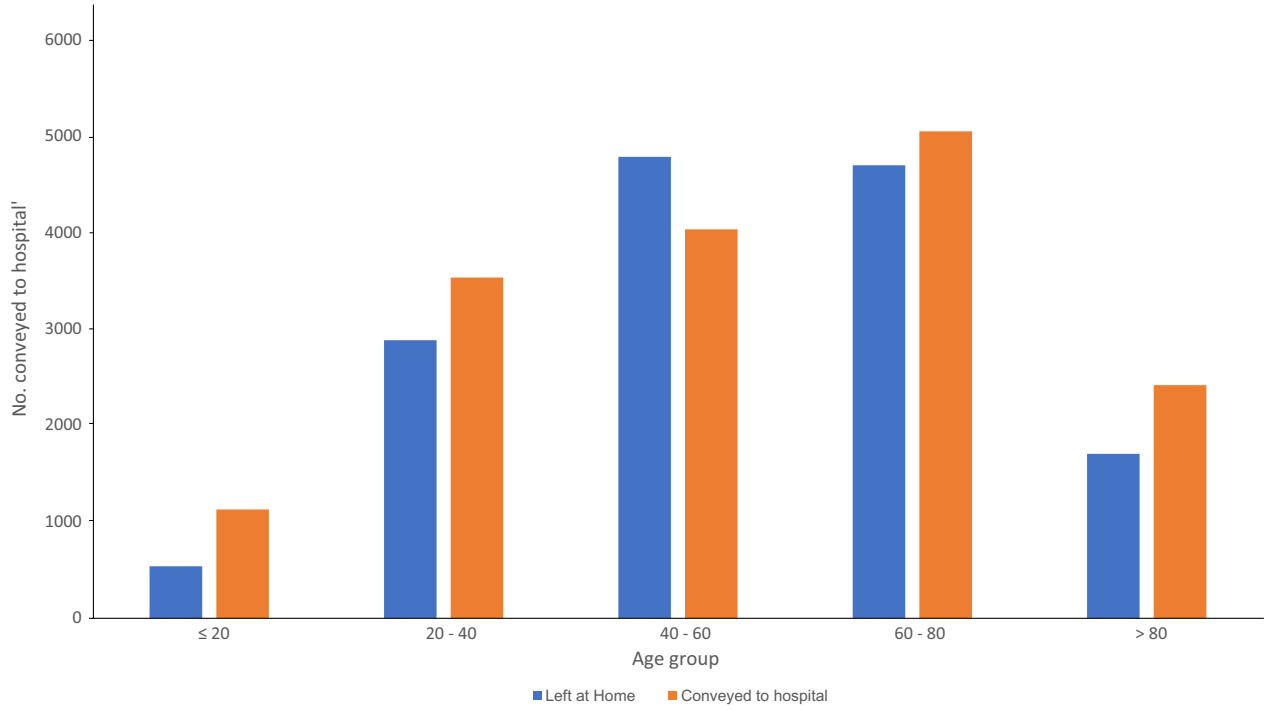

FIGURE 1 Age and conveyance for people with diabetes in Scotland: 2013–2017.

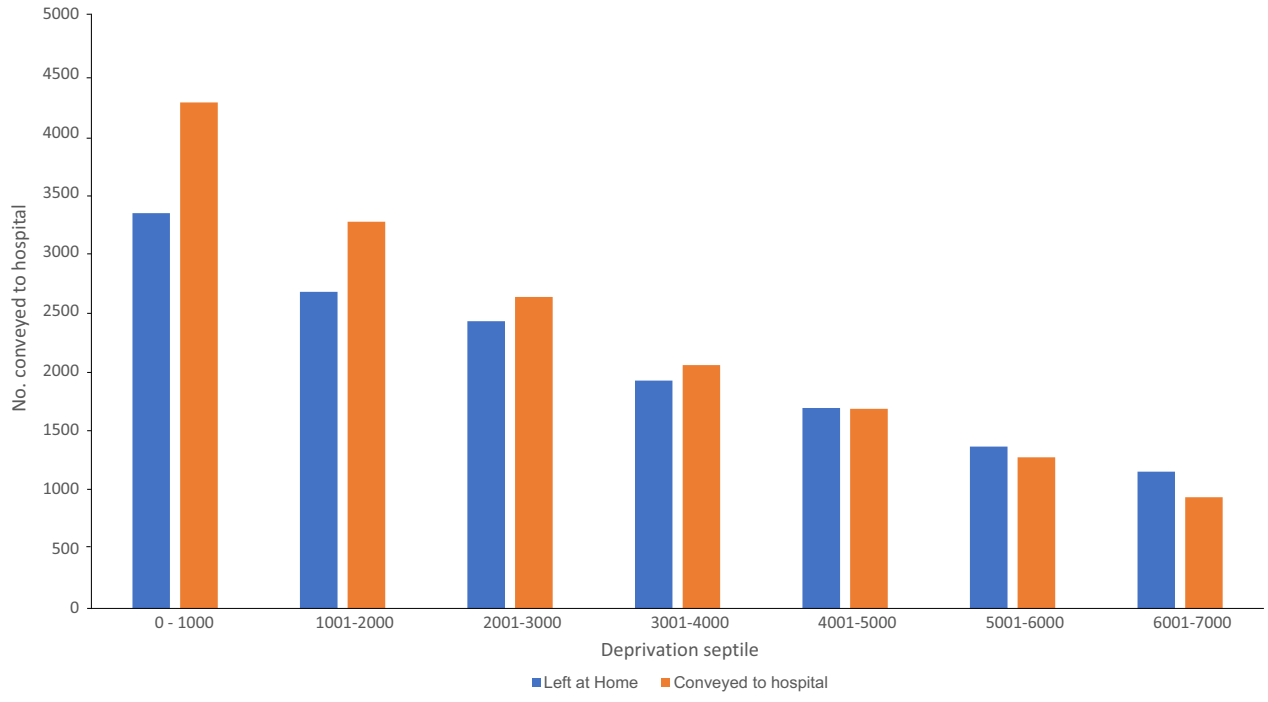

FIGURE 2 Deprivation and conveyance for people with diabetes in Scotland: 2013–2017.

The difference between odds of conveyance according to deprivation rank was reduced where paramedics were in attendance (OR 0.96, $P \leq 0.001$ compared with 0.92, $P \leq 0.001$) (Table S6). In addition, the difference between those with low and high glucose was less pronounced where paramedics were in attendance compared with cases attended only by EMTs (OR 0.58, $P \leq 0.001$; OR 5.38, $P \leq 0.001$ compared with OR 0.54 $P \leq 0.001$; OR 10.59, $P \leq 0.001$).

Overall, where treatment was administered, 47.3% of people were conveyed and 52.7% were not ($P \leq 0.0001$) (Table

2). In cases of hypoglycaemia, if treatment was administered at the scene then the likelihood of conveyance increased (OR 2.01, $P \leq 0.001$) by a similar margin to that in hyperglycaemic cases (OR 2.1, $P \leq 0.04$) (Table S2). Where results were based on subset analysis of cases in which treatment was administered, people with glucose levels < 4 mmol/l were much less likely to be conveyed to hospital than those with glucose levels > 11 mmol/l at first measurement (OR 0.59, $P \leq 0.001$ vs. OR 5.47, $P \leq 0.001$) (Table S6). In the subset of people who received treatment, paramedic attendance was associated with reduced odds of conveyance also (OR 0.74, $P \leq 0.001$).

Overall, where no treatment was administered at the site, 58.2% of people were conveyed to hospital and 41.8% were not ($P \leq 0.0001$) (Table 2). Subset analysis of these cases revealed that where treatment was not administered, women were more likely to be conveyed to hospital (OR 1.46, $P \leq 0.001$) (Table S7). Paramedic attendance to women was associated with reduced conveyance rates (OR 0.7, $P \leq 0.002$). Paramedic attendance, in cases where no treatment was administered, was also associated with reduced odds of conveyance (OR 0.75, $P \leq 0.001$). Subset analysis where no treatment was applied showed a similar divergence between hypoglycaemia and hyperglycaemia. Cases with blood glucose < 4 mmol/l were associated with reduced odds of conveyance (OR 0.55, $P \leq 0.001$); by contrast, cases with blood glucose > 11 mmol/l were associated with increased odds of conveyance (OR 5.71, $P \leq 0.001$).

4 | DISCUSSION

Paramedic attendance was associated with reduced conveyance to hospital (59.5% vs. 51.4%), although cases where only EMTs were present were less frequent (Table 1). Where treatment was administered, lack of paramedic attendance was associated with increased odds of conveyance (OR 1.97, $P \leq 0.001$). In addition, having a paramedic at the scene in cases of hyperglycaemia was associated with significantly reduced odds of conveyance (OR 0.52, $P \leq 0.001$). This suggests that paramedic attendance in cases of hyperglycaemia, and treatment at the scene generally, could potentially reduce conveyance rates. This may be because paramedics are equipped to apply a wider range of treatment options at the scene.

The data set does not provide information on the factors relevant in deciding whether a paramedic was in attendance in any given case. It is possible that cases without paramedics were milder; however, the fact that more people were conveyed if no paramedic was present indicates this was not the case.

The presence of a paramedic at the scene was associated with an increase in time spent with the person with diabetes. This means a wider range of pre-hospital interventions can be delivered.[19] Paramedics make up around 52% of emergency responders in the SAS and therefore the allocation of paramedics to diabetes complication cases appears to be prioritized by control centres already. The policy of SAS control centre staff is to allocate paramedics in urgent cases according to guidance issued in 2017.[20] However, previous research has found no difference in the type or severity of conditions attended by paramedic or non-paramedic crews.[19] It is already an aim of the UK government to increase the numbers of paramedics, and in 2018 the Scottish government committed themselves to training 1000 more paramedics.[21]

Because of the nature of the data set it was difficult to determine whether high blood glucose levels were an indication of diabetes-related hyperglycaemia and if this was the main reason for conveyance. People with a high blood glucose levels will be ill for other reasons (e.g. infection). However, as all cases included in the data set had a primary diagnosis of diabetes and the average reading for cases with a blood glucose > 11 mmol/l was 25.5 mmol/l, it is reasonable to assume a high proportion of the cases involved diabetes-related hyperglycaemia.

The results suggest that in order to reduce hospital conveyance and admissions, paramedic attendance in emergency cases in which the person has a diabetes-related metabolic problem could be an effective strategy. Where glucose levels are abnormal, appropriate action should be taken and treatment provided at the scene. Additional training and protocols may be needed for EMTs and paramedics in cases of high blood glucose where treatment is likely to be more challenging. Point of care ketone measurement may be one way of improving outcomes in cases of hyperglycaemia, providing a means of ruling out ketoacidosis at the scene.[22] Continuous or flash glucose monitoring may also be an option to explore for remote observation of glucose levels so more people can be safely left at home.[10] Provision of guidance on self-management and contact details for diabetes specialists who can provide advice ('hear and treat') might also reduce the risks associated with leaving people at home.[11]

4.1 | Strengths and limitations

Utilization of a national database, the large sample size (30 999) and varied demographic area means that the findings are generalizable to other jurisdictions. In addition, analysis of interactions between variables enabled us to describe the relationship between different factors. This approach allowed us to tentatively suggest ways in which pre-hospital pathways might be adapted to achieve reductions in conveyance and avoidable admissions.

The use of septiles in categorizing deprivation ranks was a pragmatic approach to maintain power and granularity, although we are aware that quintiles or deciles are more common approaches. In many previous studies the relationship between deprivation and other variables has been examined by segmenting the population into septiles.[23]

We also used 20-year age bands in the demographic table and in Figure 1 as the conveyance rates for each 20-unit increase in age provides a readily interpretable result. However, in the regression analysis, it was necessary to use a more granular approach of linear and quadratic ORs. This provides more robust analysis because age bands assume that risk is constant within each band, which is a problematic assumption.

Data were stratified into cases of hypoglycaemia/hyperglycaemia and cases in which blood glucose was in the normal range (< 4, 4–11, > 11 mmol/l). These definitions were used in accordance with American Diabetes Association and World Health Organization definitions of hypoglycaemia/hyperglycaemia.[24,25] Although not all incidences of high/low blood glucose necessarily indicate that this was the sole reason for the ambulance callout, because each case was included in the data set had a primary diagnosis of diabetes, it is reasonable to assume that in the majority of cases this was a significant factor. In addition, in cases with blood glucose > 11 mmol/l, average blood glucose was 25.5 mmol/l, which indicates that hyperglycaemia was a significant contributory factor to conveyance in this subset of cases.

Additional information on diagnosis (i.e. whether high blood glucose was indicative of acute hyperglycaemia), context, type of treatment applied, admissions and other health outcomes are required to understand the mechanisms by which blood glucose levels, paramedic attendance and treatment at the scene influence hospital conveyance. In addition, more data are needed to quantify the divergence between conveyance rates and hospital admission rates.

Data could not be stratified according to whether people had t1 or type 2 diabetes, and assessment of practice relating to diabetes treatment in pre-hospital services was not possible. This meant that clinical decision-making processes could not be scrutinized properly. Neither could we determine how many hyperglycaemic cases were due to ketoacidosis or whether conveyance to hospital was appropriate in any given case.

The types of treatment applied were analysed as a binary category (yes/no). Findings therefore do not provide insight into what treatment was provided for what type of diabetes or presenting metabolic problem.

4.2 | Conclusions

Several risk factors for hospital conveyance are highlighted in this study that are currently underexplored in the literature. The complex role that paramedic attendance and treatment at the scene both play in interaction with blood glucose levels is elucidated. Hyperglycaemia is associated with a greater proportion of people being conveyed to hospital and conveyance in these cases appears to be more avoidable when dealt with by paramedics. More research is needed to develop 'see and treat' protocols and training for dealing with high blood glucose in pre-hospital care, and to examine what strategies are effective in reducing avoidable conveyance and/or admission rates for people with diabetes.

Gender and deprivation also appear to be important variables which indicate that broader social, political and economic strategies to reduce hospitalization rates will be vital. More research, and more comprehensive data sets, are needed to better understand the mechanisms involved and to explore the sociological issues and perspectives of relevant stakeholders.

COMPETING INTERESTS

None declared

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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