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RESEARCH REPORTS

IS RURALITY ASSOCIATED WITH HIGHER PROBABILITY OF CONVEYANCE TO HOSPITAL FOLLOWING DIABETES-RELATED AMBULANCE CALLOUTS? A RETROSPECTIVE OBSERVATIONAL STUDY

Benjamin M. Clubbs Coldron, LLM, PhD[1]; Aoife Watson, BSc, PhD[2]; Vivien E. Coates, BA, MPhil, PhD[3,2]; Sandra M. MacRury, MBChB, MD, FRCP*[4,1]

Author Affiliations: 1. Lifesciences Innovation Centre, University of Highlands and Islands, Inverness, UK; 2. School of Nursing, Ulster University, Derry, UK; 3. Western Health and Social Care Trust, Altnagelvin Area Hospital, Londonderry, UK; 4. Raigmore Hospital, Inverness, UK.

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**Corresponding Author:* EX67SM@uhi.ac.uk

ABSTRACT

Objectives: Understanding the factors that influence avoidable and unavoidable hospital conveyance, including rurality and distance from hospital, is important and will help to inform guidelines and develop policy for emergency services including paramedic and ambulance staff. This national study compared the impact of degree of rurality, and other factors on conveyance rates across rural and urban areas for diabetes-related metabolic problems.

Methods: Using a national retrospective five-year dataset from a national ambulance service, we conducted a univariate, bivariate, and multivariable analysis of factors influencing conveyance to hospital for people with diabetes-related metabolic complications. The analysis focused on rurality using a standardized classification, initial blood glucose level, type and complexity of treatment at the scene, day of the week or time of day, paramedic attendance, time spent at the scene, and the distance to the nearest hospital as potentially significant factors.

Results: Conveyance rates were highest for those experiencing hyperglycemia (82%), for those under 20 (69%) or over 80 years of age (64%), and for females (58%). Rates were lower for longer time spent at the scene, up to 40mins (p<0.001) and the longer the distance to hospital from the scene, up to 150km (p<0.001). Probability of conveyance was more likely with increasing age (p<0.001), with glucose levels in the normal or higher range (> 4mmol/L p<0.001 and > 11mmol/L, p<0.05), and less likely for males (p<0.05) and if there was a paramedic in attendance (p<0.001). There was no association of degree of rurality with probability of conveyance (p=0.6).

Conclusions: Assessment of database metrics suggests that rurality does not appear to be associated with increased probability of higher conveyance rates. The presence of a paramedic is associated with lower probability of conveyance. Conveyance to hospital following ambulance callouts for diabetes metabolic complications is related to predictable factors.

INTRODUCTION

There are various indications from the literature that rural communities present a number of challenges for pre-hospital care

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(Alanazy et al., 2019). In addition, there may be a higher instance of general acute health care needs arising in remote and rural contexts, (World Health Report, 2006). This means that achieving reductions in inappropriate hospitalization in rural communities presents issues and dilemmas that are relevant for health care systems all over the world (van de Mortel et al., 2017; Abel et al., 2018).

Although rurality means reduced accessibility to various healthcare and social services, high levels of community engagement and support can compensate for this in ways that are not yet fully understood. Thus, sensitivity to the types of rurality is vital, and taxonomies like the Scottish Urban Rural Classifications (URC) can be helpful in this regard (Urban rural classification, 2022). At present, whether rurality (if taken as a unified concept) is a significant factor impacting conveyance and hospitalization rates is unclear, although there is evidence indicating that avoidable admission rates are higher in rural settings (Chen et al., 2017; Ridge et al., 2021).

Reducing inappropriate hospitalization for people with diabetes is a policy priority internationally (Seringa et al., 2019), particularly for older adults with diabetes (Fismen et al., 2021). In remote settings, high quality diabetes care is very much dependent on accessibility, connectivity, and community engagement (Longman et al., 2013). However, various barriers to adequate diabetes care in rural communities have been demonstrated (Simmons et al., 2007). Research has found a lower uptake of diabetes self-management education in rural communities (Luo et al., 2022) and higher mortality rates in comparison to more urban areas (Callaghan et al., 2020). A lack of access to integrated care and knowledge of the individual requiring treatment could cause problems in pre-hospital care of patients with diabetes-related metabolic complications (Watson et al., 2021). In addition, the increased risk of leaving someone at home when they have little or no support network in the immediate vicinity, and where they are far from a hospital should an emergency arise, may result in an increased concern on the part of first responders and thus impact on the probability of conveyance (Allan & Sampson, 2013).

In people with type 1 diabetes < 50 years, around 22% of deaths are due to metabolic complications such as diabetic ketoacidosis or coma with around 79% of these deaths occurring out of hospital (O'Reilly et al., 2020). The factors influencing the ability of paramedics and ambulance technicians to treat diabetes-related metabolic complications such as hypoglycemia, hyperglycemia, or ketoacidosis effectively at the scene in rural settings has not been fully investigated but concerns have been raised about the lack of access to blood ketone meters by paramedics (van Woerden et al., 2021).

A study comparing rural and urban ambulance practices for people suffering trauma in the west of Scotland found that prehospital times were significantly longer for rural patients, included more air ambulance transfers, and are characterized by greater paramedic presence (McGuffie et al., 2005). Distinguishing these various push-and-pull factors is vital for a more informed policy response to the complexity of delivering high quality care in rural settings.

We have hypothesized that conveyance, a factor in hospitalization, is more likely in rural versus urban areas because the patient's condition may be more serious due to delay in response times and inaccessible services and also greater risks of leaving patients in isolated locations. We sought to investigate the factors influencing conveyance to hos-

pital by looking at national ambulance service data covering five, pre-pandemic years between 2013 and 2017. We analysed the relationship between conveyance rates, demographic data, initial blood glucose levels and relevant treatment, time at scene, distance from hospital and the degree of rurality based on the Scottish government URC (Urban rural classification, 2020).

METHODS

A national anonymised retrospective dataset from the TerraPACE electronic patient report system was provided by the Scottish ambulance service which collate information taken at eh time of the call in ambulance control centres. This was a subset of data that formed part of a larger project on unscheduled hospital admissions for diabetes. Data were extracted from the electronic patient report form (ePRF). The sample was based on incidents related to emergency callouts, NHS24 (Out of hours service) or community medical staff and in which the ambulance crew used the final code group 'diabetic'. These incidents covered a range of different medical emergencies, but the majority related to cases of hyper or hypoglycemia. Data were supplied for 5 years from 1 January 2013 until 31 December 2017 and covered remote rural areas to densely populated urban centres, country wide. Prior to data cleansing, there were 40,458 observations within the incident data set. From these, 3,525 observations were removed from the dataset - for example we identified 1,634 pairs of observations which had identical incident numbers but different time of arrival and where the first was not conveyed but the latter was. In these cases, we removed the 1,634 earlier observations and retained the later observations. These were labelled as repeat callers 'within 24 hours' which is shorthand for "conveyed not immediately but within 24 hours. A further 948 duplicates and triplicates were manually scrutinised to determine whether they were 'true' duplicates (i.e., all data points were identical) or whether they should be treated as repeat callouts within 24 hours.

Caldicott Guardian approval, which allows for the transfer of data between the national health service and other organizations, and relevant data sharing agreements were granted for this study.

During 2017, the ambulance service 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 ambulance paramedics and technicians. The range of treatments for hypoglycemia included glucose-rich food, glucose gels, parenteral glucagon, or intravenous glucose. These were coded in relation to the severity of symptoms being treated. Categories 0 to 3 dealt with treatments for hypoglycemia. No treatment was categorized as 0, food was category 1, Oral glucose (e.g., dextrose gel) was category 2 and intramuscular (IM) or intravenous (IV) Glucagon and Glucagen and IV glucose treatments were category 3. Categories 1 and 2 are 'simple' hypoglycemia treatments, and category 3 were considered 'complex' hypoglycemia treatments. Fewer treatment options are available in cases of hyperglycemia, and these are more complex to apply but include intake of fluids or intravenous 0.9% sodium chloride to treat dehydration as well as the provision of oxygen according to Joint Royal Colleges Ambulance Liaison Committee 2019 guidance (Brown et al., 2019). Neither intravenous fluids nor oxygen therapy were included as a category of hyperglycemic treatment as it is ambiguous as to whether they were being used for hyperglycemia or for some other reason. Therefore, in this category, only the relationship between glucose levels and conveyance was

examined and analysis was only conducted on treatment for hypoglycemia. In many cases there were multiple hypoglycemic treatments associated with a particular incident. Where we found multiple treatments for a particular hypoglycemia incident number, we selected the maximum treatment of those given, based on the above scale from 0 to 3.

The category of a conveyance associated with an incident which we labelled 'Conveyed within 24 hours' was identified by looking at duplicate incident numbers where all other data fields were the same, but the "resource arrived at scene time" diverged. In these cases, we assumed that the ambulance when first called out treated the patient at the scene and left but were subsequently called out a second time. Where the individual was then conveyed on the second call out, and that second call out was within 24 hours of the original arrival time, we categorized them as conveyed within 24 hours. The numbers of "within 24 hours" data were low, and we included the "within 24 hours" as "conveyed" and removed the duplicates from the analysis.

We examined primary diagnosis, what treatment 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 and on expert opinion of what was of interest to the study. All analyses were carried out using R version 4.0.3. We conducted univariate and bivariate analysis prior to multiple stepwise logistic regression analyses to assess risk factors associated with hospital conveyance.

The complexity of treatment for hypoglycemia was categorized in Table 1.

The Scottish URC classification utilized is shown in Table 2 (1 = Large urban area, 8 = remote rural area).

Multiple logistic regression analysis models were used to estimate the relationship between conveyance and rurality, first blood glucose measurement, hypoglycemia treatment category, age, gender, and paramedic attendance. Chi-Square tests were used to determine associations between distance, time at scene, paramedic attendance and conveyance. Differences with $p \leq 0.05$ were considered statistically significant.

Treatment	Complexity Rank
No treatment	0
Food	1
Oral glucose gel	2
IM or IV glucagon / IV glucose solution	3

Table 1. Categorization of complexity of treatment for hypoglycemia at the scene.

RESULTS

The summary in Table 2 is derived from a dataset consisting only those incidents which had information on all the characteristics identified above (36,933 incidents had complete data). Conveyance rates were highest for females, for those under 20 or over 80yrs, and for those experiencing hyperglycemia. Conveyance rates were also higher in these categories for repeat callers conveyed within 24 hours of the original call. Those in large urban areas were most likely to be repeat callers conveyed within 24 hours. Where paramedics were in attendance, there was a lower conveyance rate compared to cases where paramedics did not attend.

Univariate analysis indicated that people experiencing hyperglycemia (BG > 11mmol/L) had a conveyance rate of 82% (n=8,685) straight from the scene and 6% (n=608) conveyed

within 24 hours While 36% of those with hypoglycemia were conveyed following first attendance by an ambulance crew (*n*=6,155) and 4% (*n*=606) were conveyed within 24 hours. A total of 45% of those with glucose in the normal range were conveyed following first attendance (*n*=1,975) and 3% (*n*=136) were conveyed within 24 hours (Table 2).

Of the 36,933 conveyances, the breakdown by rurality as per the URC 2020 can be seen in Table 2. While the percentage of people conveyed was higher than that for those not conveyed in all categories, there was no clearly defined pattern in the data to suggest that in remote rural and very remote rural areas (i.e. categories 7 and 8) there was a higher percentage of conveyance compared to the large urban or other urban areas (categories 1 and 2). Initial analysis indicated that, the probability of conveyance to hospital was not

Characteristics	Participants	Not Conveyed	Conveyed Immediately	Conveyed Within 24 Hours
Gender				
Female	16,350 (44%)	6,052 (37%)	9,507 (58%)	791 (5%)
Male	20,204 (55%)	8,720 (43%)	10,642 (52%)	842 (4%)
NA	379 (1%)	82 (22%)	295 (78%)	2 (0.01%)
Age (years)				
<20	2,100 (6%)	509 (24%)	1,455 (69%)	136 (6%)
(20-40]	7,180 (19%)	2,641 (37%)	4,152 (58%)	387 (5%)
(40-60]	9,976 (27%)	4,592 (46%)	4,970 (50%)	414 (0.04%)
(60-80]	11,132 (30%)	4,425 (40%)	6,261 (56%)	446 (4%)
>80	4,493 (12%)	1,422 (32%)	2,885 (64%)	186 (4%)
NA	2,052 (6%)	1,265 (62%)	721 (35%)	66 (3%)
First Blood Glucose (mmol/L)				
≤ 4	17,190 (47%)	10,405 (60%)	6,155 (36%)	630 (4%)
4-11	4,426 (12%)	2,315 (52%)	1,975 (45%)	136 (3%)
> 11	10,626 (29%)	1,333 (13%)	8,685 (82%)	608 (6%)
NA	4,691 (13%)	801 (17%)	3,629 (77%)	261 (6%)
Treatment Category for Hypoglycemia				
No Treatment (0)	4	4 (100%)	0 (0%)	0 (0%)
Oral Food/Glucose (1 & 2)	6,200 (16%)	3,222 (52%)	2,675 (43%)	303 (5%)
Glucago IM/IV or IV Glucose (3)	7,252 (19%)	4,298 (59%)	2,628 (36%)	326 (5%)
NAP	23,481 (63%)	-	-	-
Rural/Urban Classification				
1 Large Urban Areas	12,822 (35%)	5,366 (42%)	6,679 (52%)	777 (6%)
2 Other Urban Areas	14,511 (39%)	5,572 (38%)	8,300 (57%)	639 (5%)
3 Accessible Small Towns	2,770 (8%)	1,162 (42%)	1,515 (55%)	93 (3%)
4 Remote Small Towns	895 (2%)	384 (43%)	502 (56%)	9 (1%)
5 Very Small Towns	533 (1%)	133 (25%)	400 (75%)	0 (0%)
6 Accessible Rural Areas	2,852 (8%)	1,249 (44%)	1,526 (53%)	77 (3%)
7 Remote Rural Areas	806 (2%)	328 (41%)	467 (58%)	11 (1%)
8 Very Remote Rural Areas	870 (2%)	391 (45%)	475 (54%)	4 (0.5%)
NA	874 (2%)	269 (31%)	580 (66%)	25 (3%)
Paramedic Attendance				
No	4,146 (11%)	1,680 (41%)	2,466 (59%)	-
Yes	26,853 (73%)	13,038 (49%)	13,815 (51%)	-
NA	5,934 (16%)	-	-	-

Table 2. Characteristics in relation to conveyance to hospital.
NA = Not Available; NAP = Not Applicable

significantly higher in rural compared with urban areas, (p=0.07) although there was a decreasing probability of conveyancing as the index increased.

Conveyance to hospital was highest when staff spent beween 10-30 mins at the scene (68-75%) and least likely when staff spent more than 40 minutes at the scene, (29-37%), p<0.0001 (Table 3).

Time	< 10min	10-20min	20-30min	30-40min	40-50min	50-60min	1hr+
Total Number	4,983*	7,726	7,570	6,678	5,705	3,970	0
% Conveyed	45	75	68	51	37	29	-
% Not Conveyed	55	25	32	49	63	71	-

Table 3. Time at scene and percentage of indivdiuals conveyed to hospital.
** Missing data 301*

Data was only available for 40% (n=14,827) of incidents for distance between scene and hospital, with the greatest number of recordings for incidents that were < 20km from hospital. There was an inverse linear relationship between the number of people conveyed and distance form hospital, p< 0.0001 (Table 4).

Distance	< 20km	20-40km	40-60km	60-80km	80-100km	100-150km	150km+
Total Number	10,435	2,904	726	310	98	126	228
% Conveyed	60	44	43	32	29	16	3
% Not Conveyed	40	56	57	68	71	84	97

Table 4. Distance to hospital and percentage of indivdiuals conveyed.

There was no difference in number of callouts with a paramedic in attendance across distance from hospital and difference in conveyance rates when a paramedic was present was not related to distance. p>0.05 (Table 5).

Distance	< 20km	20-40km	40-60km	60-80km	80-100km	100-150km	150km+
Total Number	10,435	2,904	726	310	98	126	228
Paramedic							
% Conveyed	47	34	34	24	18	13	3
% Not Conveyed	33	47	49	58	54	71	84
No Paramedic							
% Conveyed	10	8	7	6	10	2	0
% Not Conveyed	5	7	6	8	15	10	11
Not Recorded							
Not Recorded	5	4	4	4	3	4	2

Table 5. Distance to hospital and conveyance percentage by paramedic attendance.

Multiple regression analysis indicated that probability of conveyance was significantly more likely the higher a person's age p<0.001 and for blood glucose levels > 4mmol/L (p<0.001) or > 11mmol/L, (p<0.05). Conveyance was also less likely if a paramedic was in attendance, p<0.001, the higher the category of hypoglycemic treatment administered,

$p<0.001$ or if the patient was male, $p<0.01$. There was no association of conveyance with URC in the model, $p=0.6$ (Supplementary Table 1).

DISCUSSION

Our analysis has shown that the greatest number of callouts were associated with hypoglycemia although the highest percentage of people conveyed to hospital were those with hyperglycemia. Individuals with non-hypoglycemic blood levels were significantly more likely to be conveyed to hospital. This would include individuals with conditions such as ketoacidosis usually associated with type 1 diabetes and reflected in the high rate of conveyance for individuals < 20 years, although this was not specifically recorded. Conditions such as hyperosmolar hyperglycemia state in older individuals may have accounted for some cases with initial high blood glucose levels but the high rate of conveyance of older individuals, particularly over 80 years suggests the presence of associated medical conditions such as diabetes-related chronic complications or infections as the main reason for conveyance rather than a diabetes-related metabolic problem (Lin et al., 2016). Interestingly, our results suggest that those receiving more complex treatment for hypoglycemia were less likely to be conveyed. It could be speculated that in general, individuals whose episode of hypoglycemia was the sole medical issue were treated successfully at the scene. Although current treatment of diabetes was not recorded, previous research suggests that admission for hypoglycemia is associated with use of oral hypoglycemic agents in type 2 diabetes and with more complex treatment of diabetes (Sinclair et al., 2023), meaning some elderly individuals may have had protracted hypoglycemia associated with medication and thus more likely to require hospital transfer.

While there was a greater number of male participants, reflecting the higher prevalence of diabetes in males, (Kautsky-Willer et al., 2023) females were more likely to be conveyed to hospital in keeping with the more general population age demographic (United Nations, 2022).

Paramedics were present in most callouts, however, the absence of a paramedic in attendance at the scene was associated with an overall higher conveyance rate. There was no effect of distance from hospital on these conveyance rates whether a paramedic was present or not. Previous research suggests that in terms of non-conveyance of elderly people to hospital, role-related factors such as emergency staff educational background may be important, with paramedic staff less frequently conveying patients to hospital (Oosterwold et al., 2018).

We also examined time at scene to assess the relationship with conveyance, and it appeared that transfer to hospital was less likely when staff spent more than 40 mins at the scene. This may reflect implementation of a 'see and 'treat' approach in these instances and/or more time spent on ensuring other forms of support were in place to allow for non-conveyance to hospital (Oosterwold et al., 2018). In addition, although not specifically related to the diabetes context, research has demonstrated that ambulance crews tend to spend more time with frail patients over the age of 50 years and they are also less likely to be conveyed to hospital (Charlton et al., 2022).

It is not known if call backs were secondary to incidents where initial conveyance had been considered unnecessary by ambulance staff, refusal by patients, or if there had been deterioration or recurrence of the original problem. Callbacks within 24 hours were

slightly more common in urban areas as compared to rural areas and compare with callback figures cited in other countries (Ebben et al., 2017). The slight increase in conveyance numbers in more urban areas after repeat calls may be a result of greater accessibility and that ambulance staff are less likely to take the risks of non-conveyance in locations where the distance to hospital is shorter.

Data was not available regarding subsequent hospital admission following conveyance and further research would be useful to understand if rurality impacts this.

We hypothesized that rurality would be associated with greater probability of conveyance to hospital, and while the greater the distance from hospital the less conveyance occurred, it is important to recognise the low numbers of data recordings for distance between scene and hospital and the increasingly lower numbers of callout the greater the distance. Rurality in terms of the URC was not associated with an increased chance of conveyance.

Individuals may be more reluctant to travel to hospital in more rural areas for several reasons meaning that everything possible is done to stabilize them at the scene (van Vuuren et al., 2021). However, it is possible we were not observing statistical significance due to the lower number of incidents occurring in the more rural categories with consequent reduced statistical power. This points to a question of whether the uneven distribution of data amongst the different rurality categories warrants a different classification such as an aggregation of the current classes. There is almost an inherent barrier in studying rurality because rural areas are invariably less populated so gathering enough data to conduct robust statistical analysis comparing rural and urban settings is difficult (McGrail et al., 2005). Of course, the small effect size may also indicate that rurality is not a significant causative factor and is merely incidental to other factors such as deprivation associated with more urban areas (Nishino et al., 2015). In addition, the complexity of the concept of rurality and the multitude of sub-factors that constitute it make it a contradictory and difficult parameter to measure in terms of its impact on the quality of health care (Hart et al., 2005). In future studies it may be more productive to split rurality into more granular factors such as distance to hospital, accessibility of primary/social care, community support, and population density.

Although rurality does not appear to have a relationship with conveyance rates, there is evidence in the literature that context specific initiatives to reduce unscheduled care admissions might be very effective in rural areas (Spleen et al., 2014). For example, although not specifically to do with conveyance, the Community Paramedicine program, posting trained paramedics in rural communities to serve patients who frequently use the emergency department, was shown to reduce Emergency Department and inpatient stays, it resulted in less intensive care utilization, improved health outcomes, and reduced healthcare expenditure (Bennett et al., 2018). Because rurality contains various push and pull factors in terms of likelihood of conveyance, it seems likely that whatever the location or nature of the callout, paramedic attendance could reduce conveyance to hospital as sufficient and effective treatment can be provided at the scene. This indicates that if we want to safely impact the conveyance rate in rural ambulance call outs, ambulance services could assign more experienced paramedics to these cases if possible. How paramedics are assigned and whether they are more likely to attend more rural callouts is not something we can establish in the data but would be an interesting question for further study.

In some rural locations, those who call an ambulance may be collected using an air ambulance helicopter resulting in different practices and approaches to treatment and conveyance decisions at the scene (Neagle et al., 2019). Greater resources dedicated to patients in extremely rural areas may mitigate some of the factors that contribute to worse outcomes.

Future studies are necessary and should address rurality assessment and definition as well as transport times for emergency services in this context. Furthermore, the development or adaption of an existing emergency service decision-making framework with ongoing evaluation could help with understanding and analysis of the more nuanced environmental and contextual factors that contribute to conveyance and hospitalization in general (Lauder & Penney, 2023) and would provide important insights into avoidable or unavoidable hospital conveyance in rural areas.

LIMITATIONS

The research outcomes in this study that relate to conveyance are based on analysis of metrics within a database and it is likely that other contextual and social factors influence conveyance in individual circumstances. Further exploration of these factors would help to explain the contribution of the variables we have identified to be associated with conveyance and rurality. While conveyance is linked to hospitalization, our dataset did not include information on subsequent hospital admission following conveyance. Also, the results within this study are specific to the definition of rurality and context of emergency medical services in Scotland and may not be directly comparable with rurality contexts, service provision, and related metrics of other nations.

CONCLUSIONS

Conveyance to hospital for metabolic-related diabetes complications is associated with predictable factors such as youth and older age, hyperglycemia more than hypoglycemia, and lack of attendance of a paramedic. Based on this dataset analysis of linear elements, it appears that degree of rurality does not appear to be associated with higher rates of conveyance compared with urban areas. More prospective research deploying a pragmatic mix of methodologies is required to elucidate the way rurality (and its various constituent factors) and more complex real-time circumstantial or contextual decision-making related to patients and paramedic staff might be associated with or impact operational and administrative decision-making and pre-hospital service provision and patient outcomes in rural communities.

Coefficient	Estimate	Std. Error	z-value	p
(Intercept)	-0.6043201	0.1097609	-5.506	< 0.001
Urban Rural Classificaition	-0.0052800	0.0101586	-0.520	0.6
Age Yrs.	0.0151089	0.0009555	15.812	<0.001
Gender Male	-0.1031095	0.0371677	-2.774	<0.01
BG 4-11mmol/L	0.4277217	0.0745370	5.738	<0.001
BG > 11mmol/L	0.5851149	0.2495422	2.345	<0.05
Category Hypoglycemia Treatment	-0.1076280	0.0221097	-4.868	<0.001
Paramedic Present	-0.1771318	0.0518364	-3.417	<0.001

Supplementary Table 1. Multiple regression analysis of factors associated with probability of conveyance.

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