Project Title

Development and Validation of Predictors of Inpatient Hypoglycaemia Using Data from More Than 25,000 Admissions

Project Lead and Members

Project lead: Dr Ester Yeoh

Project members: Lin Yi; Dr Ooi Say Tat; Dr Allen Liu

Organisation(s) Involved

Khoo Teck Puat Hospital

Healthcare Family Group(s) Involved in this Project

Medical; Allied Health

Applicable Specialty or Discipline

Endocrinology, General Medicine, Epidemiology

Project Period

Start date: 5 Jan 2022

Completed date: 2 Sep 2022

Aims

To identify independent risk factors associated with incidence of inpatient hypoglycaemia and develop a predictive tool for the inpatient hypoglycaemia among patients with DM.

Background

See poster appended/ below

Methods

See poster appended/ below

Results

See poster appended/ below

Lessons Learnt

1. Data quality and data management are important. Careful attention needs to be paid, as the data chosen have to be consistent and representative of clinical practice. While managing varieties of data including administrative and clinical data, one needs to have a clear strategy of handling missing data and aggregating clinical data following the study objectives guided by clinical practice.
2. Variables selection and further variable engineering are critical. Literature review and a Directed Acyclic Graph (DAG) would help with the processes of variables selection. Understanding of how variables were selected and transformed would improve model's interpretability.
3. In addition to model's accuracy, a more interpretable model would be preferred to be integrated into the existing clinical workflows and decision-making processes. Although our current project has not been implemented yet, it lays an important groundwork for future development and deployment.

Conclusion

See poster appended/ below

Additional Information

Singapore Health & Biomedical Congress (SHBC) 2022: SHBC Best Poster Award (Clinical Research) (Posters category) – (Gold Award)

Project Category

Applied/ Translational Research

Quantitative Research

Keywords

Hypoglycaemia, Prediction Models, Inpatient Diabetes, Diabetes Mellitus

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Development and Validation of Predictors of Inpatient Hypoglycaemia Using Data from More Than 25,000 Admissions

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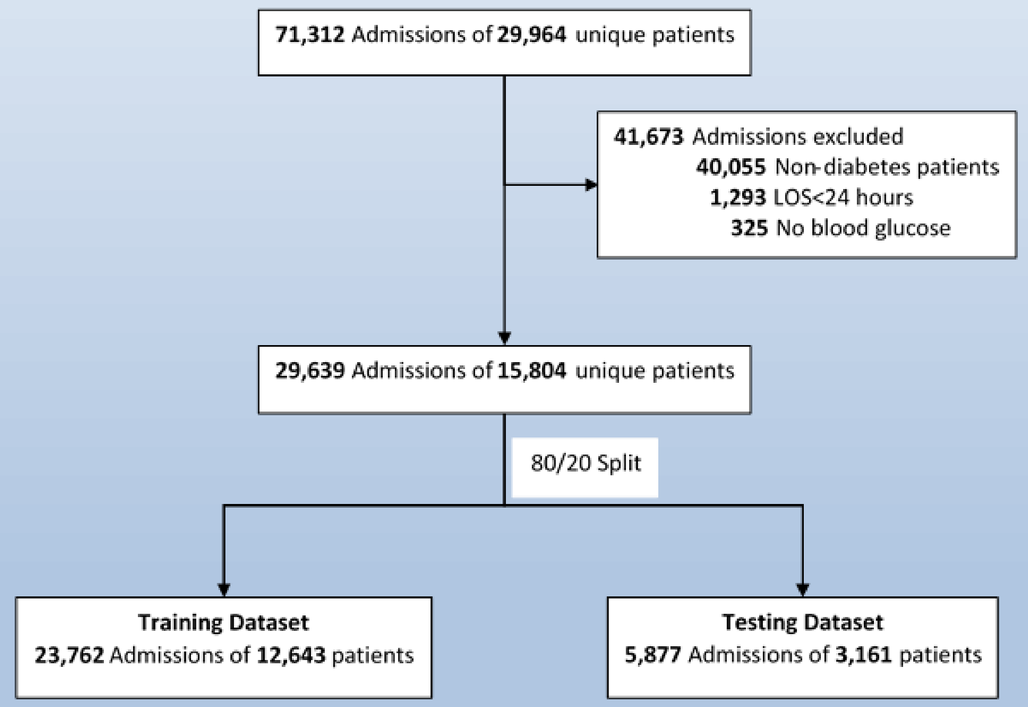
Background

Hypoglycaemia, a common clinical problem encountered under inpatient settings, increases length of stay and is associated with significant morbidity and mortality. A strategy to reduce inpatient hypoglycaemia is to analyse historical clinical data to develop prediction tools to determine individualised risk of inpatient hypoglycaemia.

Methods

Data from inpatients with diabetes mellitus (DM) from January 2020 to December 2021 were analysed. Those with any hypoglycaemia events [laboratory or capillary blood glucose (BG)<4 mmol/L] during hospitalisation, excluding day 1 of admission or at Emergency Department, was considered an outcome. Patients' demographics, vital signs, oral intake, administered medications and medical history were collected from Electronic Medical Records for variable selection and model building.

Figure 1: Flowchart of Study Population Selection*



*: All inpatients admitted in KTPH between Jan 2020 and Dec 2021 were selected. Identification of diabetic population is based on 1) all historical primary and secondary ICD codes before the index admission episodes (inclusive of E10, E11, E13, E14, and O24); 2) all clinical documents from diabetes notes in Diabetes Centre.
The study population was randomly split into Training (80%) and Testing (20%) Datasets at patient's level.

Results

Data from 15,804 DM inpatients who had 29,639 admissions were randomly split into the training dataset (23,762 admissions of 12,643 patients) and the test dataset (5,877 admissions of 3,161 patients), as shown in Figure 1. From the training dataset, predictive factors included in the logistic regression model were age, weight, diastolic blood pressure, pulse rate, temperature, estimated glomerular filtration rate, prior hypoglycaemia within 6 months of admission, albumin, white blood cell count, inpatient oral intake (starch and desserts), diabetes medication list (oral and insulin with its dosages) and steroid use, which are detailed in Table 1.

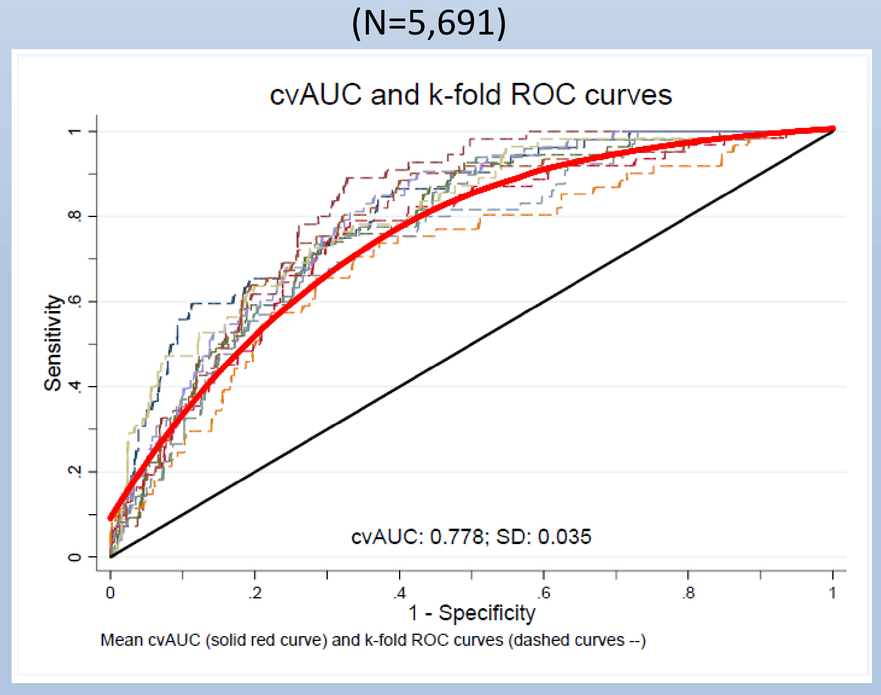
Table 1: Most Significant Predictors from the Logistic Regression Model*

Final Logistic Regression Model Fitted on Training dataset (N=22,926)					
	Coefficient	Z score	95% CI		P-value
Sulfonylureas	0.841	15.4	0.734	0.948	<0.001
Transformed eGFR	10.171	14	8.747	11.595	<0.001
Transformed Albumin	4.706	12.67	3.978	5.434	<0.001
Hypoglycaemia history within 6 months prior to the admission	0.727	11.13	0.599	0.855	<0.001
Transformed Weight	15.465	10.43	12.558	18.373	<0.001
Short-acting human	-0.473	-7.61	-0.594	-0.351	<0.001
Tramadol	0.377	6.63	0.265	0.488	<0.001
Dessert intake (daily average)	-0.259	-5.69	-0.348	-0.170	<0.001
Starch intake (daily average)	-0.200	-5.49	-0.272	-0.129	<0.001
Transformed Pulse rate	4.838	5.25	3.033	6.642	<0.001
Transformed Temperature (daily average)	7.084	4.9	4.252	9.916	<0.001
Transformed Mixed-acting human doses (average daily total dose)	3.153	4.88	1.888	4.419	<0.001
Transformed Short-acting human doses (average daily total dose)	3.182	4.86	1.899	4.465	<0.001
Transformed WBC	2.684	4.79	1.587	3.781	<0.001
Transformed Diastolic BP (daily average)	4.120	4.03	2.114	6.125	<0.001
Metformin	0.245	3.79	0.119	0.372	<0.001
Transformed Mixed-acting analog doses (average daily total dose)	3.071	3.62	1.410	4.732	<0.001
Transformed Intermediate-acting human doses (average daily total dose)	1.769	3.59	0.803	2.735	<0.001
Mixed-acting analog	0.542	3.29	0.219	0.865	0.001
Long-acting analog	0.350	3.27	0.140	0.560	0.001
Mixed-acting human	0.508	3.13	0.189	0.826	0.002
Hydrocortisone	0.237	2.69	0.064	0.410	0.007
Transformed Long-acting analog dose (average daily total dose)	1.170	2.46	0.239	2.100	0.014
Intermediate-acting human	0.197	2.14	0.017	0.378	0.032
I.V. insulin	0.169	1.91	-0.004	0.342	0.056
Transformed Rapid-acting analog dose (average daily total dose)	1.201	1.73	-0.158	2.560	0.083
Transformed Age	-5.368	-1.63	-11.830	1.093	0.103
Rapid-acting analog	0.255	1.63	-0.051	0.561	0.103

*: AUC on training dataset: 0.795 (95% CI: 0.786, 0.804)

Applying the selected logistic regression model to test dataset, this achieved AUC of 0.78 (10-fold cross-validation, corrected 95% CI: 0.76, 0.80).

Figure 2: Performance of selected Logistic Regression model on the **Test** dataset (N=5,691)



Discussion & Conclusion

Logistic regression models using selected predictive factors are useful in predicting risk and lowering the occurrence of inpatient hypoglycaemia. This provides the groundwork for more advanced machine learning algorithms to reduce inpatient hypoglycaemia further.