

Review Article

A scoping review of the prevalence, risk factors, impact, and prediction tools of inpatient hypoglycaemia in selected Asian regions

Andrew Gerald Hua Kiong Tan^{1,2}, Ernieda Md Hatah¹, Adyani Md Redzuan^{1*}

¹Centre for Quality Management of Medicine, Faculty of Pharmacy, Universiti Kebangsaan Malaysia, Kuala Lumpur, ²Training Management Division, Ministry of Health Malaysia, Putrajaya, Malaysia

*For correspondence: Email: adyani@ukm.edu.my; Orcid: 0000-0002-8125-8462

Sent for review: 22 August 2025

Revised accepted: 11 January 2026

Abstract

Purpose: This scoping review mapped evidence on the prevalence, risk factors, clinical impacts, and prediction models of inpatient hypoglycaemia in Eastern, Southern, and Southeastern Asia.

Methods: The indexing engines searched include MEDLINE, Web of Science, Scopus, ProQuest, and Google Scholar, covering publications from the inception of each database. Ninety-four studies were included and synthesized in accordance with the PRISMA-ScR guidelines.

Results: Outputs from the regions of interest were uneven, with Eastern Asia contributing the most ($n = 66$). Prevalence varied widely (up to 57.9 %), particularly among insulin-treated and critically ill patients. Risk factors identified included age, insulin use, and diabetes duration, alongside novel factors such as surgery grade, rural residence, functional status, and specific biomarkers (e.g., low-density lipoprotein-cholesterol, C-peptide), and certain medications. Hypoglycaemia was linked to higher mortality, prolonged hospitalization, cognitive decline, and other major complications. Five clinical prediction models, all from China, were identified; however, none covered type 1 diabetes or underwent external validation. Inpatient hypoglycaemia is linked to adverse outcomes yet remains under-researched in Southern and Southeastern Asia.

Conclusion: These findings highlight the need for region-specific data, validated predictive tools, and targeted preventive measures to mitigate its clinical impact.

Keywords: Asia, Hypoglycaemia, Inpatients, Prevalence, Risk factors

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited.

Tropical Journal of Pharmaceutical Research is indexed by Scopus, Chemical Abstracts, Embase, Index Copernicus, EBSCO, African Index Medicus, JournalSeek, Directory of Open Access Journals (DOAJ), African Journal Online, Bioline International, Open-J-Gate and Pharmacy Abstracts

INTRODUCTION

Diabetes Mellitus (DM), a chronic metabolic illness, is a leading cause of death from noncommunicable disease worldwide and a major contributor to mortality in Asia [1,2]. Hospitalization rates are significantly higher among individuals with DM, where one in four hospitalized adults was reported to have DM [3]. Inpatient hyperglycaemia frequently complicates

care and negatively impacts outcomes [4]. Overzealous management of hyperglycaemia can increase hypoglycaemia risk [5], an event linked to higher mortality, prolonged stays, and cognitive decline [6].

The American Diabetes Association defines hypoglycaemia as a random blood glucose level below 70 mg/dL (3.9 mmol/L), categorized into three levels: Level 1 (54 - 70 mg/dL (3.0 - 3.8 mmol/L)), Level 2 (< 54 mg/dL (< 3.0 mmol/L))

and Level 3, which denotes severe cognitive impairment requiring external assistance for recovery, regardless of blood glucose level [7]. Severe hypoglycaemia is known to result in consequences like cardiac arrhythmia, convulsions, and even death. Inpatient hypoglycaemia refers to episodes occurring during hospitalization, distinguished from primary hypoglycaemia leading to admission [8].

The prevalence of inpatient hypoglycaemia varies significantly depending on patient demographics (critical vs. non-critical care), the definition of hypoglycaemia used, and the method of data collection [9,10]. In the United Kingdom, it was reported to be 18.4 % [11], with various studies exploring its prevalence, risk factors, and predictive models globally. However, recent reviews reveal a significant gap in Asian data [6,9,10,12]. For example, a systematic review on inpatient hypoglycaemia risk factors included only one Asian study (Taiwan) focusing on primary hypoglycaemia [10]. Likewise, a 2019 review on its impact and prevention lacked Asian representation [6]. In their study, Zhang *et al* identified only three Chinese studies in their review of prediction models [12]. Additionally, a few studies included in these reviews were unrelated to inpatient hypoglycaemia.

Given the ethnic and cultural diversity within Asia [13], findings from single regions may not be broadly applicable. Moreover, the variability across existing hypoglycaemia prediction models suggests that differences in study design, demographics, and data quality impact generalisability [12]. Addressing these gaps is crucial for developing hypoglycaemia prevention strategies tailored to Asian populations.

Given this context, a scoping review has been conducted to examine studies on inpatient hypoglycaemia in Eastern, Southern, and Southeastern Asia. Their underrepresentation may have resulted from strict inclusion criteria in earlier systematic reviews and publication biases, especially in low- to middle-income countries. Hence, this review addressed two key questions, viz., what are the prevalence, risk factors, and impact of inpatient hypoglycaemia among individuals with diabetes in these Asian regions and what are the characteristics - population and performance metrics - of prediction models developed and validated in these settings?

By synthesizing existing literature, this review aimed to clarify knowledge, highlight research gaps, and support guideline development. The findings may also guide the validation and wider application of predictive tools in clinical practice.

METHODS

This scoping review was conducted following the original framework by Arksey & O'Malley [14] and subsequent refinements by Levac *et al* [15]. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses – Extension for Scoping Reviews (PRISMA-ScR) for reporting was followed [16]. The review protocol was registered with the Open Science Framework (OSF) and is available at <https://osf.io/cs38z/> (DOI 10.17605/OSF.IO/CS38Z). Ethics approval was not required for this review.

Eligibility criteria

Selection criteria were developed to address the research questions. Studies were eligible if they included any study design on patients with DM, evaluated inpatient hypoglycaemia as an independent or dependent variable, were published in English or Malay and used data from Southern, Eastern, or Southeastern Asia.

Studies were excluded if they involved paediatric populations, diabetes other than type 1 or type 2 diabetes, hypoglycaemia as the primary cause of hospitalization, studies not evaluating hypoglycaemic events or reporting none, or investigations focused solely on specific/direct causes of hypoglycaemia (e.g., human or institutional error).

Search strategy

Three major electronic databases, including MEDLINE, Scopus, and Web of Science, were searched. These were considered sufficient for a robust evidence base in health-related topics [17]. To enhance comprehensiveness and reduce publication bias, grey literature, e.g., conference papers, reports, and thesis were searched via Google Scholar and ProQuest [18]. Furthermore, studies regardless of whether inpatient hypoglycaemia was investigated as a primary or secondary outcome were also included.

Searches were conducted between August 28 and 31, 2024, covering publications from each database's inception. Keywords and Boolean operators included: "diabetes" AND "inpatient OR hospitalized OR hospitalization" AND "hypoglycemia" AND ("prevalence" OR "incidence" OR "risk factor" OR "predictor" OR "tool" OR "model" OR "impact" OR effect). Country and language filters were applied as needed. The list of countries from Eastern, Southern, and Southeastern Asia was adapted

from the United Nations Statistics Division, as shown in Table 1 [19].

Study selection and data extraction process

All search results were compiled in EndNote v20.6 (Clarivate Analytics, Pennsylvania, USA) to remove duplicates. The records were then uploaded to Rayyan (Doha, Qatar: Qatar Computing Research Institute, Hamad Bin Khalifa University) for additional de-duplication and screening. The titles, abstracts and full-text reviews were conducted by two reviewers, TAGHK and MRA, to finalize the study selection, in addition to screening the reference lists of included articles for eligible studies. Any discrepancies were resolved through discussion or, when necessary, consultation with another reviewer, MHE.

Next, TAGHK and MRA collaboratively developed a data-charting form to define extraction variables. Both reviewers independently extracted and cross-checked data, iteratively refining the form. Variables included publication details, study design, year, country, sample size, population, blood glucose monitoring methods, and definitions of hypoglycaemia. Outcome variables included prevalence/incidence, risk factors, hypoglycaemia outcomes, prediction models, performance metrics, and conclusions.

Data synthesis

A narrative synthesis analysis was used to extract data, focusing on themes aligned with the research questions. Analysis began with country distribution, study designs, and population types. The definitions and prevalence/incidence of inpatient hypoglycaemia were summarized. Where prevalence was not reported, it was

calculated manually and the risk factors and impacts were explored. For predictive studies, the model characteristics and performance metrics were compiled.

RESULTS

Study selection

The initial search yielded 3,303 records. After removing 121 duplicates and screening titles and abstracts, 94 articles were included in the final review (Figure 1). This final set was derived after excluding 75 articles during the full-text review and adding seven additional studies identified through reference screening. Of the included articles, 90 were original research; the remainder comprised a letter to the editor, a meeting abstract, a review, and a thesis. Publications spanned from 2010 to 2024, with the majority (n = 79) published in the last decade

Figure 2 illustrates the geographical distribution of included studies. Eastern Asia contributed the most (n = 66), led by China (n = 37), followed by Japan (n = 24) and Korea (n = 5). Southern Asia contributed 16 articles - 13 from India and 3 from Iran. Southeastern Asia was least represented, with 12 studies: four each from Thailand and Singapore, two from Indonesia, and once each from Malaysia and the Philippines. Notably, six countries (Brunei Darussalam, Cambodia, Laos, Myanmar, Timor-Leste, and Vietnam) had no representation.

Regarding study characteristics, 69 were observational, of which 34 were cohort studies [20-53]. Five studies developed prediction models, each using distinct patient cohorts [21,25,28,29,54]. Twenty-two studies focused on critically ill populations [20,23-26,32,34,35,38,41,42,47,50,52,55-62].

Table 1: List of countries included by geographical region, adapted from the United Nations Statistics Division [19]

Eastern Asia	Southern Asia	South-eastern Asia
China	Afghanistan	Brunei Darussalam
Hong Kong Special Administrative Region	Bangladesh	Cambodia
Macao Special Administrative Region	Bhutan	Indonesia
Democratic People's Republic of Korea	India	Laos
Japan	Iran	Malaysia
Mongolia	Maldives	Myanmar
Republic of Korea	Nepal	Philippines
	Pakistan	Singapore
	Sri Lanka	Thailand
		Timor-Leste
		Vietnam

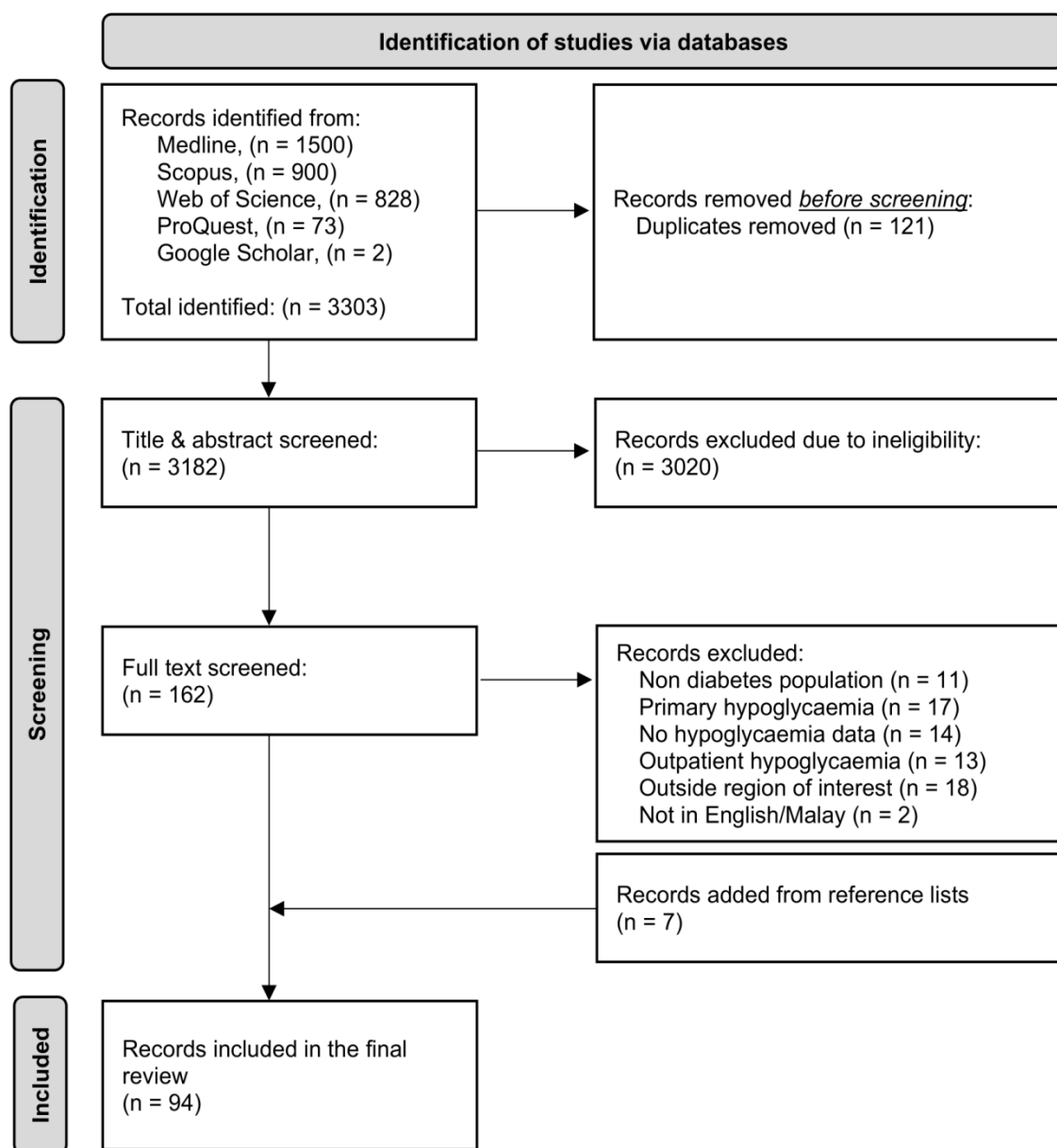


Figure 1: Flow diagram of the screening process according to PRISMA-ScR guidelines

Prevalence of inpatient hypoglycaemia

Hypoglycaemia definitions varied across studies: < 3.9 mmol/L (n = 56), < 4.0 mmol/L (n = 15), other thresholds (n = 19), and unspecified (n = 4). Most relied on point-of-care (POC) capillary glucose testing. Only 13 studies from China and Japan employed continuous glucose monitoring (CGM) [27,31,39,43,44,63-70]. Some CGM studies reported hypoglycaemia as the proportion of time spent below threshold, ranging from 1 – 1.6 % to 0.04 – 0.32 % [63,67], the latter using a stricter < 2.8 mmol/L threshold. One review of artificial pancreas systems reported minimal hypoglycaemia [68]. By contrast, POC-

based studies reported higher prevalence rates, ranging between 0.3 and 5.4 % [32,71-76].

Prevalence was most commonly reported as the proportion of patients experiencing at least one hypoglycaemic episode (n = 70). Where this was not stated, it was calculated manually when possible. Reported prevalence ranged from 0 % in certain subgroups to 57.9 % in the overall population, with rates as high as 74.5 % among patients receiving basal-bolus insulin therapy [61,77]. The distribution of prevalence rates across studies was: < 10 % (n = 30), 10 – 19.9 % (n = 18), 20 – 29.9 % (n = 12), 30 – 39.9 % (n = 3), 40 – 49.9 % (n = 4), and > 50 % (n = 3).

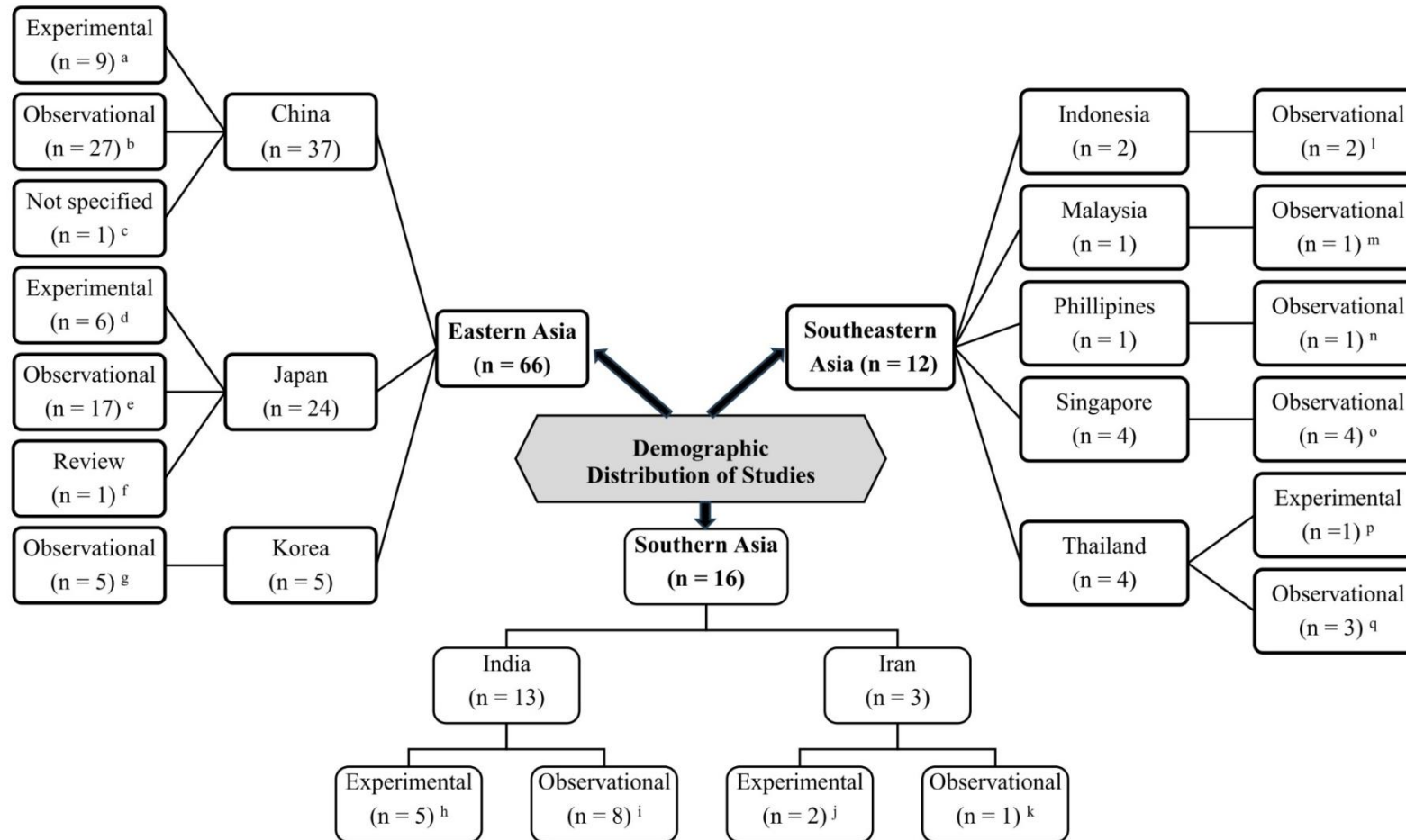


Figure 2: Distribution of studies from Southern, Eastern, and Southeastern Asia. a. [67,78-85]; b [20-31,50-52,54,55,62,69,73,74,77,86-90]; c [91]; d [63,70,71,92-94]; e [34-44,57,60,64-66,95]; f [68]; g[45-47,61,96]; h [56,58,59,97,98]; i [32,72, 99-104]; j [105,106]; k [107]; l [33,108]; m [109]; n [48]; o [49,76,110,111]; p [112]; q [53,75,113]

Twelve studies reported lower rates ($\leq 25\%$) in mixed populations (with and without diabetes), compared to diabetes-only cohorts (up to 57.9 %) [32,35,38,39,52,55,60,61,81,86,89,90]. Among the 22 studies on critically ill patients, prevalence reached as high as 25.6 % [20,23-26,32,34,35,38,41,42,47,50,52,55-62]. Although these studies often included mixed populations, many provided subgroup analyses from which data among people with DM could be extracted. Of 23 studies exclusively involving insulin-exposed patients, the highest reported prevalence was 57.9 % [25,54,56-59,65,77,79,81,82,84,85,91,92,94-98,104,105,112]. Six of these reported lower rates ($< 15\%$) [59,81,82,96,104,112], particularly in studies examining long-acting basal insulin [81,96,112] or insulin infusions [59,82]. In contrast, studies not limited to insulin-treated patients generally observed lower prevalence.

Risk factors

Nineteen observational studies (primarily cohort designs) investigated risk factors for inpatient hypoglycaemia. These were conducted in Japan ($n = 7$), China ($n = 6$), India ($n = 3$), Indonesia ($n = 1$), Korea ($n = 1$), and the Philippines ($n = 1$). Most defined hypoglycaemia as < 3.9 mmol/L or < 4.0 mmol/L; two applied a stricter threshold of < 3.4 mmol/L [57, 103]. Key risk factors are summarized in Table 2.

Three additional studies warrant mention for their specific focus. Takeishi *et al* found that pre- and post-breakfast glucose levels predicted nocturnal hypoglycaemia [43]. A Chinese cross-sectional study identified diabetic nephropathy, age, diabetes duration, body weight, autonomic neuropathy, lower education, poor self-management, and limited diabetes knowledge as

risk factors for Level 2 hypoglycaemia (< 3.0 mmol/L) [87]. In Malaysia, severe hypoglycaemia (< 2.2 mmol/L) was reportedly associated with age, opioid use, and stroke [109].

Impact of inpatient hypoglycaemia

Twenty-one studies reported adverse outcomes linked to inpatient hypoglycaemia. Fourteen found increased mortality risk, especially among critically ill patients [20,22-24,26,35,41,42,45,47,50,55,60,62,74].

Prolonged hospital stay was another frequent consequence, reported in several studies [22,33,46,90,111,114], with one linking hypoglycaemia with a prolonged intensive care unit stay [24]. A multi-country study found mortality was significantly higher (28.4 vs. 16.5 %, $P = 0.03$) in patients with > 1 hypoglycaemic episode [60].

Additional complications included major organ dysfunction (cardiac, renal, hepatic), bacteraemia, disseminated intravascular coagulation, poorer HbA1c improvements and postoperative complications [22,46,47,62]. Additionally, two studies linked inpatient hypoglycaemia with major adverse cardiovascular events [24,74].

From a neurological perspective, Ebadi *et al* reported lower Mini-Mental State Examination (MMSE) scores in Iranian patients with Type 1 or Type 2 diabetes following hypoglycaemia [107].

Assessments were performed after stabilization (72 – 96 hours post-event), revealing a linear relationship between hypoglycaemia frequency and cognitive decline.

Table 2: Risk factors for inpatient hypoglycaemia

Demographic characteristic	Laboratory parameters	Others
Age [21,24,46,48]	Low C-peptide [25,74]	Nothing by mouth [21,48,100]
Low body mass index [21,24,25,46,74]	Low fasting blood glucose [25,54]	Poor oral intake [33,100]
Female [46]	Low fasting insulin [54]	Tube feeding [48]
Poor functional status [103]	Low serum albumin [37]	Geriatric nutrition risk index [37]
Rural residence [21]	Low LDL-cholesterol [74]	Insulin use [21,33,48,57,74,101]
Diabetes duration [21,44,48,74,101]	Mean blood glucose [44,64,65]	Sulfonylurea use [33,101]
Hypoglycaemia history [33]	Glucose variability [21,31,42,44,64,65]	Intensive insulin treatment time [54]
Type 1 diabetes [46]	HbA _{1c} [60]	Fluoroquinolone Use [100]
Chronic kidney disease [48,100]		Beta Blocker Use [100]
Chronic liver disease [100]		General Anaesthesia Use [21]
Cardiovascular disease [48]		Liver Failure [57]
Heart failure [48]		Operation Time [25]
		Infection [100, 103]
		Surgery Grade [21]

Clinical prediction tools

Only five studies developed prediction models, all from China [21, 25, 28, 29, 54]. Three were previously included in a systematic review [12]; the remaining two introduced novel angles: one focused on predicting postoperative hypoglycaemia [25], and the other on patients receiving enteral nutrition with concurrent insulin pump therapy [28].

Details of model features and performance metrics are presented in Table 3. All models were designed for patients with type 2 diabetes mellitus (T2DM); with four tailored to specific subpopulations, and one applicable to general T2DM inpatients [29]. Study designs also varied, with one cross-sectional study [54] while others were cohort studies. Prediction horizons varied, with two models designed for perioperative prediction. Despite the existence of national guidelines [115], hypoglycaemia definitions lacked uniformity, with some using a threshold of < 3.9 mmol/L while others used < 4.0 mmol/L.

Most models employed logistic regression; only one study used machine learning (XGBoost). All evaluated discrimination using the area under the curve (AUC), while two reported the Youden index [25] and accuracy [29]. However, model calibration was only reported in three studies [21, 25, 54]. Internal validation was conducted in all but one study [25]. Sample sizes were small (< 500) in most cases, with only two studies exceeding this threshold [21,29]. Notably, the smaller studies also lacked power calculations.

DISCUSSION

The increasing volume of research on inpatient hypoglycaemia over the past decade underscores the prior lack of attention before 2010, as the search yielded zero articles before that year. However, notable gaps remain, particularly in Southern and, even more markedly, Southeastern Asia. The finding that prediction model studies were exclusively from China further exposes regional disparities in research output.

The broad range of hypoglycaemia prevalence reported can be attributed to heterogeneity in study populations, designs, definitions, glucose monitoring methods, and treatment protocols, as previously suggested [9]. Compared to point-of-care (POC) testing, continuous glucose monitoring (CGM) records glucose more frequently (every 1–15 minutes depending on the device) [116]. While this enhances sensitivity, it also inflates the number of measurements, which can paradoxically reduce the reported proportion of hypoglycaemic events. Additionally, studies

using artificial pancreas systems reported very low hypoglycaemia rates due to the system's capacity to pre-emptively suspend insulin [117]. Although direct comparisons are difficult, prevalence in the Asian studies that were reviewed was comparable to/exceeded previous global estimates (0.5 - 32.8 %) [9], reinforcing the need for a more focused regional effort.

Risk factors varied substantially across studies due to differing designs and aims. Nonetheless, some commonly reported factors across regions included age, low body mass index, diabetes duration, insulin use, glycaemic variability, and nutritional deficits, aligning with previous global reviews [6,9,10]. However, certain risk factors identified in other reviews, such as ethnicity, hyponatraemia, C-reactive protein, and admission type, were not examined in the included studies [6]. Interestingly, whereas “high body weight” and “being a male” were flagged in previous reviews, findings from this review highlighted low body weight and female sex as risk factors [46]. Similarly, Pratiwi *et al* [10] also identified conditions such as cerebrovascular disease, liver cirrhosis, malignancy, and elevated alkaline phosphatase, none of which appeared in the current review.

Conversely, this review identified several novel risk factors absent from previous literature. These included surgery grade, functional status, rural residence, specific biomarkers (e.g., low-density lipoprotein-cholesterol, C-peptide, insulin), glucose variability, and certain medications (e.g., fluoroquinolones, beta-blockers, general anaesthesia). Such variation suggests that risk profiles may not be universally generalisable, highlighting the need for population-specific data and local validation before clinical application.

Mortality and increased length of hospital stay were the most frequently reported adverse outcomes, echoing prior reviews [6, 9, 10]. Notably, some studies found that inpatient hypoglycaemia was associated with increased mid- to long-term mortality (up to one-year post-discharge) [22,41,45,47], a finding previously underreported. This review also documented a broader range of hypoglycaemia-related morbidities and complications than prior work. However, some important consequences, such as seizures and falls, were not captured in the included studies, though reported elsewhere [118]. The impact of inpatient hypoglycaemia on economic and psychological outcomes also remains unclear in the studied regions, despite being observed in general hypoglycaemic study [119].

The five prediction models, all from China, are limited. Most used static variables via logistic regression, which, while practical, misses the dynamic nature of hypoglycaemia risk. However, the model, which includes 40 predictors and was developed using machine learning, is only feasible for settings with integrated electronic records. A critical omission across all models is their exclusive focus on T2DM; the distinct pathophysiology of Type 1 diabetes raises significant concerns about their applicability [120], as the suitability and safety of these models for this population have not been established.

The most significant limitation is the complete lack of external validation. Internal validation is insufficient, as performance degrades in new populations, leaving the generalisability of their findings unknown [121]. This statistical fragility is compounded by methodological flaws, such as univariable pre-selection, which increases overfitting risk and compromises external validity [122]. Future research must pivot from this approach. There is a clear need to develop parsimonious models using robust methods, such as penalised regression, to create tools that are genuinely generalisable, practical, and easily calibrated across diverse clinical settings.

Table 3: Clinical prediction tools compiled from studies in China

Reference	Population type	Variable inputs	Hypoglycaemia definition	Prediction horizon	Model algorithm	Validation method	Model performance
Han <i>et al</i> , [21]	1,410 (T2DM ≥ 18 years old undergoing elective surgery) -Excluded: <i>insulin used in the operating room</i>	(1) Diabetes Duration (2) Body Mass Index (3) Blood Glucose Standard Deviation (4) Preoperative hypoglycaemic regimen	<4.0 mmol/L	Perioperative period	Multiple Logistic Regression analysis	Bootstrapping	AUC: 0.715 ($P < 0.001$) Hosmer-Lemeshow test: ($P = 0.765$)
Hu <i>et al</i> , [54]	257 (adult T2DM on intensive insulin treatment during hospitalization)	(1) Total treatment time (2) Fasting blood glucose (3) Fasting insulin	<4.0 mmol/L	Hospital stay	Multiple Logistic Regression analysis	Bootstrapping	AUC: 0.664 ($P < 0.001$) Hosmer-Lemeshow test: ($P = 0.3662$)
Liu <i>et al</i> , [25]	440 (T2DM ≥ 18 years old undergoing elective surgery with postoperative insulin use) -Excluded: <i>enteral/parenteral nutrition, liver/kidney dysfunction, neurological deficit</i>	(1) operation time (2) preoperative C-peptide <500pmol/L (3) Body Mass Index (4) preoperative FBG	<3.9 mmol/L	Postoperative period	Multiple Logistic Regression analysis	NIL	AUC: 0.745 ($P < 0.05$) Youden index: 0.367 (sensitivity = 0.455 and specificity = 0.912) Hosmer-Lemeshow test: ($P = 0.606$)
Wu <i>et al</i> , [28]	122 (T2DM patients receiving enteral nutrition on insulin pump therapy during hospitalization) -Excluded: <i>gastrointestinal disorder/surgery, critically ill, hypoglycaemia history before insulin administration</i>	(1) Time to reach glycaemic targets (2) Average glycemia (3) Coronary heart disease (4) Hormone therapy	<3.9 mmol/L	Hospital stay	Multiple Logistic Regression analysis	Split-sample	<u>Development</u> (n = 91) AUC: 0.872 ($P < 0.05$) <u>Validation</u> (n = 31) AUC: 0.839 ($P < 0.05$)
Yang <i>et al</i> , [29]	29,843 (all T2DM ≥ 18 years old)	<u>Top 4 variables</u> (1) History of presenting illness (2) Chief complaint (3) Insulin (4) Family History Total of 40 variables	<3.9 mmol/L	Hospital stay	XGBoost	5-fold cross-validation and sample balancing with Adaptive Synthetic Sampling (ADASYN) technique	AUC: 0.822 ($P < 0.05$) Accuracy: 0.934 ($P < 0.05$)

Strengths and limitations

This scoping review is the first known study to comprehensively explore the significance of inpatient hypoglycaemia within Asia in T2DM patients. Synthesizing the types of studies conducted and their outcomes and also uncovering additional insights that contribute to the existing body of knowledge. Additionally, this review highlights the substantial heterogeneity in study designs, methodologies, and findings, which poses challenges for direct comparisons.

Notably, key research gaps that present opportunities for future investigations have identified. Many countries within the regions studied were underrepresented, limiting the generalizability of findings across Asia. Variability in study designs led to inconsistencies in reported risk factors and impacts of inpatient hypoglycaemia. Moreover, available prediction tools remain scarce and lack broad applicability, highlighting the need for further model development and validation in diverse populations.

Despite the rigorous methods applied, several limitations should be acknowledged. Firstly, studies from Central and Western Asia were excluded to maintain a manageable scope. This decision was supported by the selected regions sharing close geographical and ancestral ties due to historical migration patterns [123, 124], and by epidemiological data indicating that Central and Western Asia have distinct profiles, including higher DM-related mortality and disability rates [125].

Secondly, the restriction to English and Malay-language publications may have limited the comprehensiveness of the review. Additionally, the potential exclusion of relevant grey literature cannot be overlooked, as the search was limited to Google Scholar and ProQuest. While the value of region-specific databases is recognized, these were not included due to language limitations, indexing inconsistencies, and possible overlapping content with Google Scholar. Future reviews may benefit from their inclusion to enhance regional representation.

Lastly, as is inherent to scoping reviews, the heterogeneity of included studies precluded a formal quality appraisal and comparative analysis. Future systematic reviews with rigorous quality assessments may help clarify the strength of evidence in this area.

Implications for research

This review identifies significant gaps and opportunities in the study of inpatient hypoglycaemia in patients with DM across parts of Asia. While prevalence rates are comparable

to, and sometimes exceed, global estimates, research remains unevenly distributed, with a need for broader regional representation. Risk factors and outcomes, including some population-specific variables, warrant further investigation.

Significantly, prediction model development has been limited to China, with no external validation or adaptation for Type 1 diabetes observed. Future research should prioritise validating and refining these tools across diverse settings, alongside exploring novel predictors tailored to local contexts. Strengthening the evidence base will be critical in informing clinical guidelines, improving risk stratification, and enhancing patient outcomes.

CONCLUSION

Inpatient hypoglycaemia is a clinically significant but under-recognised issue in many regions of Asia, with serious implications for morbidity, mortality, and healthcare utilisation. This review provides the first comprehensive synthesis of existing evidence on its prevalence, risk factors, outcomes, and predictive tools in Eastern, Southern, and Southeastern Asia. While prevalence rates are high, the research landscape is unevenly distributed, with critical evidence gaps in Southern and Southeastern Asia. By mapping the current landscape and highlighting these gaps, particularly in methodological limitations and the lack of validation of existing prediction models, the review lays a crucial foundation for context-specific research. Moving forward, enhanced awareness, the development of robust and generalisable predictive models, and policy-driven action are essential to advancing the safety and quality of care for diabetic patients across Asia.

DECLARATIONS

Acknowledgements/Funding

This research received no funding.

Conflict of interest

The authors declare no conflict of interest.

Author Contributions

This is an original work of the authors. All authors read and approved the manuscript for publication. The authors' contributions were as follows: TAGHK contributed to the conceptualisation and design of the study,

developed the methodology and data-charting form, conducted article screenings and data extraction, performed formal analysis and investigation, drafted the original manuscript and performed subsequent revisions. The MHE provided validation and consensus where doubt arose, supervision, and critically reviewed the manuscript. MRA contributed to the conceptualisation and design of the study, developed the methodology and data-charting form, conducted article screenings, provided supervision, and reviewed the manuscript. She is also the guarantor.

REFERENCES

1. World Health Organization. Noncommunicable diseases 2022 (cited 2024 May 2). Available from: <https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases#:~:text=Cardiovascular%20diseases%20account%20for%20most,disease%20deaths%20caused%20by%20diabetes>.
2. Yang JJ, Yu D, Wen W, Saito E, Rahman S, Shu X-O, Chen Y, Gupta PC, Gu D, Tsugane S, et al. Association of Diabetes With All-Cause and Cause-Specific Mortality in Asia. *JAMA Netw Open* 2019; 2(4): e192696.
3. Eccles-Smith J, Puri G, Hinton N, Cutmore C, Porter K, Dermedoglou A, Donovan P. Access to inpatient diabetes resources: hospital characteristics from the inaugural Queensland Inpatient Diabetes Survey. *Intern Med J* 2022; 52(11): 1950-1956.
4. Barmanray RD, Cheuk N, Furlanos S, Greenberg PB, Colman PG, Worth LJ. In-hospital hyperglycemia but not diabetes mellitus alone is associated with increased in-hospital mortality in community-acquired pneumonia (CAP): a systematic review and meta-analysis of observational studies prior to COVID-19. *BMJ Open Diabetes Res Care* 2022; 10(4): e002880.
5. Dhatariya K, Corsino L, Umpierrez GE. Management of Diabetes and Hyperglycemia in Hospitalized Patients. *Endotext* 2020.
6. Ruan Y, Tan GD, Lumb A, Rea RD. Importance of inpatient hypoglycaemia: impact, prediction and prevention. *Diabet Med* 2019; 36(4): 434-443.
7. American Diabetes Association. Diabetes Care in the Hospital: Standards of Medical Care in Diabetes. *Diabetes Care* 2020; 43(Supplement_1): S193-S202.
8. Gómez-Huelgas R, Guijarro-Merino R, Zapatero A, Barba R, Guijarro-Contreras A, Tinahones F, Bernal-López R. The frequency and impact of hypoglycemia among hospitalized patients with diabetes: A population-based study. *J Diabetes Complications* 2015; 29(8): 1050-1055.
9. Eiland L, Goldner W, Drincic A, Desouza C. Inpatient hypoglycemia: a challenge that must be addressed. *Current Diabetes Reports* 2014; 14(1): 445.
10. Pratiwi C, Mokoagow MI, Kshanti IAM, Soewondo P. The risk factors of inpatient hypoglycemia: A systematic review. *Heliyon* 2020; 6(5): e03913.
11. NHS Digital. National Diabetes Inpatient Audit (NaDIA) - 2017 - NHS Digital Leeds: NHS Digital; 2018 [cited 2024 May 8]. Available from: <https://digital.nhs.uk/data-and-information/publications/statistical/national-diabetes-inpatient-audit/national-diabetes-inpatient-audit-nadia-2017>.
12. Zhang L, Yang L, Zhou Z. Data-based modeling for hypoglycemia prediction: Importance, trends, and implications for clinical practice. *Front Public Health* 2023; 11: 1044059.
13. Parreñas RS, Kim JK. Multicultural East Asia: An Introduction. *J Ethn Migr Stud* 2011; 37(10): 1555-1561.
14. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol* 2005; 8(1): 19-32.
15. Levac D, Colquhoun H, O'Brien KK, Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implement Sci* 2010; 5(1): 69.
16. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med* 2018; 169(7): 467-473.
17. Gusenbauer M, Haddaway NR. Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed, and 26 other resources. *Res Synth Methods* 2020; 11(2).
18. Paez A. Gray literature: An important resource in systematic reviews - PubMed. *J Evid Based Med* 2017; 10(3): 233-240.
19. United Nations Statistics Division. Standard country or area codes for statistical use (M49) 2024 [cited 2024 April 4]. Available from: <https://unstats.un.org/unsd/methodology/m49/>.
20. Guo YJ, Zhou Y, Zhang SY, Wei Q, Huang Y, Xia WQ, Wang SH. Optimal target range for blood glucose in hyperglycaemic patients in a neurocritical care unit. *Diab Vasc Dis Res* 2014; 11(5): 352-358.
21. Han H, Lai J, Yan C, Li X, Hu S, He Y, Li H. Development and validation of a prediction model of perioperative hypoglycemia risk in patients with type 2 diabetes undergoing elective surgery. *BMC Surg* 2022; 22(1): 1-8.
22. He J, Zhang Y, Cheng X, Tian Y, Hao P, Li T, Xiao Y, Peng L, Feng Y, Deng H, et al. Association of

- Postoperative Hypoglycemia With Mortality After Elective Craniotomy. *Neurosurgery* 2024; 95(3): 682-691.
23. Li DB, Hua Q, Guo JC, Li HW, Chen H, Zhao SM. Admission Glucose Level and In-hospital Outcomes in Diabetic and Non-diabetic Patients with ST-elevation Acute Myocardial Infarction. *Intern Med* 2011; 50(21): 2471-2475.
 24. Li X, Hou X, Zhang H, Qian X, Feng X, Shi N, Sun H, Feng W, Zhao W, Li G, et al. Effect of early hypoglycaemia on hospitalization outcomes in patients undergoing coronary artery bypass grafting. *Diabetes Res Clin Pract* 2022; 186.
 25. Liu ZX, Dai J, He XD, Li JX, Zhang HX, Ji C. Identification of Risk Factors and Development of a Predictive Model for Postoperative Hypoglycemia among Diabetic Patients during the Perioperative Period. *Int J Endocrinol* 2023; 2023: 8.
 26. Lou R, Jiang L, Wang M, Zhu B, Jiang Q, Wang P. Association Between Glycemic Gap and Mortality in Critically Ill Patients with Diabetes. *J Intensive Care Med* 2023; 38(1): 42-50.
 27. Wei W, Zhao S, Fu SL, Yi L, Mao H, Tan Q, Xu P, Yang GL. The Association of Hypoglycemia Assessed by Continuous Glucose Monitoring With Cardiovascular Outcomes and Mortality in Patients With Type 2 Diabetes. *Front Endocrinol (Lausanne)* 2019; 10: 9.
 28. Wu J, Wu J, Zhou Y, Lu X, Zhao W, Xu F. Nomogram for Predicting Hypoglycemia in Type 2 Diabetes Mellitus Patients Treated with Insulin Pump During Enteral Nutrition. *Diabetes Metab Syndr Obes* 2024; 17: 2147-2154.
 29. Yang H, Li J, Liu S, Yang X, Liu J. Predicting Risk of Hypoglycemia in Patients with Type 2 Diabetes by Electronic Health Record-Based Machine Learning: Development and Validation. *JMIR Med Inform* 2022; 10(6): 12.
 30. Yuan J, Liu T, Zhang X, Si Y, Ye Y, Zhao C, Wang Q, Shen X. Intensive Versus Conventional Glycemic Control in Patients with Diabetes During Enteral Nutrition After Gastrectomy. *J Gastrointest Surg* 2015; 19(8): 1553-1558.
 31. Yuan S-J, Shen J. Increased Preoperative Glucose Variability Is Associated with Adverse Perioperative Outcomes Following Orthopedic Surgery in Patients with Type 2 Diabetes Mellitus. *Curr Med Sci* 2020; 40(3): 523-529.
 32. Sundarsingh V, Poddar B, Saran S, Jena SK, Azim A, Gurjar M, Singh RK, Baronia AK. Glucometrics in the first week of critical illness and its association with mortality. *Med Intensiva* 2023; 47(6): 326-337.
 33. Pratiwi C, Rumende M, Kshanti IAM, Soewondo P. Risk Factors for Inpatient Hypoglycemia in a Tertiary Care Hospital in Indonesia. *J ASEAN Fed Endocr Soc* 2022; 37(2).
 34. Fujishima S, o S, Saitoh D, Kushimoto S, Ogura H, Abe T, Shiraishi A, Mayumi T, Sasaki J, Kotani J, et al. Incidence and Impact of Dysglycemia in Patients with Sepsis Under Moderate Glycemic Control. *Shock* 2021; 56(4): 507-513.
 35. Furukawa M, Kinoshita K, Yamaguchi J, Hori S, Sakurai A. Sepsis patients with complication of hypoglycemia and hypoalbuminemia are an early and easy identification of high mortality risk. *Intern Emerg Med* 2019; 14(4): 539-548.
 36. Hajime M, Okada Y, Mori H, Uemura F, Sonoda S, Tanaka K, Kurozumi A, Narisawa M, Torimoto K, Tanaka Y. Hypoglycemia in blood glucose level in type 2 diabetic Japanese patients by continuous glucose monitoring. *Diabetol Metab Syndr* 2019; 11(1).
 37. Kimura Y, Kimura N, Akazawa M. Increased nutrition-related risk as an independent predictor of the incidence of hypoglycemia in the hospitalized older individuals with type 2 diabetes: a single-center cohort study. *Diabetol Int* 2021; 12(4): 420-429.
 38. Kushimoto S, Abe T, Ogura H, Shiraishi A, Saitoh D, Fujishima S, Mayumi T, Hifumi T, Shiino Y, Nakada T, et al. Impact of blood glucose abnormalities on outcomes and disease severity in patients with severe sepsis: An analysis from a multicenter, prospective survey of severe sepsis. *PLoS One* 2020; 15(3): 15.
 39. Naraba H, Goto T, Shirakawa T, Sonoo T, Kanda N, Nakano H, Takahashi Y, Hashimoto H, Nakamura K. Time in blood glucose range 70 to 180 mg/dL and survival rate in critically ill patients: A retrospective cohort study. *PLoS One* 2021; 16(5): e0252158.
 40. Oba T, Nagao M, Kobayashi S, Yamaguchi Y, Nagamine T, Tanimura-Inagaki K, Fukuda I, Sugihara H. Perioperative glycemic status is linked to postoperative complications in non-intensive care unit patients with type-2 diabetes: a retrospective study. *Ther Adv Endocrinol Metab* 2022; 13: 14.
 41. Shirakabe A, Hata N, Kobayashi N, Okazaki H, Matsushita M, Shibata Y, Nishigoori S, Uchiyama S, Kiuchi K, Okajima F, et al. Decreased blood glucose at admission has a prognostic impact in patients with severely decompensated acute heart failure complicated with diabetes mellitus. *Heart Vessels* 2018; 33(9): 1008-1021.
 42. Takeishi S, Mori A, Hachiya H, Yumura T, Ito S, Shibuya T, Hayashi S, Fushimi N, Ohashi N, Kawai H. Hypoglycemia and glycemic variability are associated with mortality in non-intensive care unit hospitalized infectious disease patients with diabetes mellitus. *J Diabetes Investig* 2016; 7(3): 429-435.
 43. Takeishi S, Mori A, Kawai M, Yoshida Y, Hachiya H, Yumura T, Ito S, Shibuya T, Fushimi N, Ohashi N, et al. Major Increases between Pre- and Post-breakfast Glucose Levels May Predict Nocturnal

- Hypoglycemia in Type 2 Diabetes. *Intern Med* 2016; 55(20): 2933-2938.
44. Torimoto K, Okada Y, Hajime M, Tanaka K, Tanaka Y. Risk Factors of Hypoglycemia in Patients with Type 2 Diabetes Mellitus: A Study Based on Continuous Glucose Monitoring. *Diabetes Technol Ther* 2018; 20(9): 603-612.
 45. Lee SA, Cho SJ, Jeong MH, Kim YJ, Kim CJ, Cho MC, Kim HS, Ahn Y, Koh G, Lee JM, et al. Hypoglycemia at admission in patients with acute myocardial infarction predicts a higher 30-day mortality in patients with poorly controlled type 2 diabetes than in well-controlled patients. *Diabetes Care* 2014; 37(8): 2366-2373.
 46. Lee J, Kim TM, Kim H, Lee S-H, Cho JH, Lee H, Yim HW, Yoon K-H, Kim H-S. Differences in Clinical Outcomes between Patients with and without Hypoglycemia during Hospitalization: A Retrospective Study Using Real-World Evidence. *Diabetes Metab J* 2020; 44(4).
 47. Park S, Kim D-G, Suh GY, Kang JG, Ju Y-S, Lee Y-J, Park JY, Lee SW, Jung K-S. Mild hypoglycemia is independently associated with increased risk of mortality in patients with sepsis: a 3-year retrospective observational study. *Crit Care* 2012; 16(5): R189.
 48. Duyongco-Tiu MV, Lagula-Bilocura I. The incidence of in-hospital hypoglycemia and its associated risk factors among adult filipino patients with diabetes mellitus in Chong Hua Hospital. *Philipp J Intern Med* 2017; 55(4).
 49. Lim SF, Jong M, Chew DEK, Lee JYC. Impact of Timing Between Insulin Administration and Meal Consumption on Glycemic Fluctuation and Outcomes in Hospitalized Patients With Type 2 Diabetes. *J Pharm Pract* 2020; 33(4): 449-456.
 50. Chao HY, Liu PH, Lin SC, Chen CK, Chen JC, Chan YL, Wu CC, Blaney GN, Liu ZY, Wu CJ, et al. Association of in-hospital mortality and dysglycemia in septic patients. *PLoS One* 2017; 12(1).
 51. Leung CH, Liu CP. Diabetic status and the relationship of blood glucose to mortality in adults with carbapenem-resistant *Acinetobacter baumannii* complex bacteremia. *J Microbiol Immunol Infect* 2019; 52(4): 654-662.
 52. Wang CH, Chang WT, Huang CH, Tsai MS, Chou E, Yu PH, Wu YW, Chen WJ. Associations between intra-arrest blood glucose level and outcomes of adult in-hospital cardiac arrest: A 10-year retrospective cohort study. *Resuscitation* 2020; 146: 103-110.
 53. Ratanasuwan T, Ratanasuwan W. The effectiveness of management protocol for acute diabetic complications in a Thai hospital. *J Med Assoc Thai* 2012; 95(10): 1278-1284.
 54. Hu X, Xu W, Lin S, Zhang C, Ling C, Chen M. Development and Validation of a Hypoglycemia Risk Model for Intensive Insulin Therapy in Patients with Type 2 Diabetes. *J Diabetes Res* 2020; 2020.
 55. Ma HM, Yu G, Wang ZW, Zhou PR, Lv WT. Association between dysglycemia and mortality by diabetes status and risk factors of dysglycemia in critically ill patients: a retrospective study. *Acta Diabetol* 2022; 59(4): 461-470.
 56. Verma V, Kotwal N, Upreti V, Nakra M, Singh Y, Shankar KA, Nachankar A, Kumar K. Liraglutide as an Alternative to Insulin for Glycemic Control in Intensive Care Unit: A Randomized, Open-label, Clinical Study. *Indian J Crit Care Med* 2017; 21(9): 568-572.
 57. Okawa M, Kunitomo F, Kanamoto M, Narahara H, Hinohara H, Tobe M, Yanagisawa A, Saito S. Effect of different blood glucose target levels on the incidence of hypoglycemia during insulin therapy in the intensive care unit. *J Diabetes* 2013; 5(1): 51-56.
 58. Mohod V, Ganeriwal V, Bhange J. Comparison of intensive insulin therapy and conventional glucose management in patients undergoing coronary artery bypass grafting. *J Anaesthesiol Clin Pharmacol* 2019; 35(4): 493-497.
 59. Chawla M, Malve H, Shah H, Shinde S, Bhoraskar A. Safety of intravenous insulin aspart compared to regular human insulin in patients undergoing ICU monitoring post cardiac surgery: An Indian experience. *J Diabetes Metab Disord* 2015; 14(1): 5.
 60. Egi M, Krinsley JS, Maurer P, Amin DN, Kanazawa T, Gh, i S, Morita K, Bailey M, Bellomo R. Pre-morbid glycemic control modifies the interaction between acute hypoglycemia and mortality. *Intensive Care Med* 2016; 42(4): 562-571.
 61. Yoo HJ, Suh EE, Shim J. Effectiveness of blood glucose control protocol for open heart surgery patients. *J Adv Nurs* 2021; 77(1): 275-285.
 62. Liu D, Fan Y, Zhuang Y, Peng H, Gao C, Chen Y. Association of Blood Glucose Variability with Sepsis-Related Disseminated Intravascular Coagulation Morbidity and Mortality. *J Inflamm Res* 2022; 15: 6505-6516.
 63. Tanaka S, Suzuki K, Aoki C, Niitani M, Kato K, Tomotsune T, Aso Y. Add-on treatment with teneligliptin ameliorates glucose fluctuations and improves glycemic control index in Japanese patients with type 2 diabetes on insulin therapy. *Diabetes Technol Ther* 2014; 16(12): 840-845.
 64. Saisho Y, Tanaka C, Tanaka K, Roberts R, Abe T, Tanaka M, Meguro S, Irie J, Kawai T, Itoh H. Relationships among different glycemic variability indices obtained by continuous glucose monitoring. *Prim Care Diabetes* 2015; 9(4): 290-296.
 65. Uemura F, Okada Y, Torimoto K, Tanaka Y. Relation between Hypoglycemia and Glycemic Variability in Type 2 Diabetes Patients with Insulin Therapy: A Study Based on Continuous Glucose

- Monitoring. *Diabetes Technol Ther* 2018; 20(2): 140-146.
66. Morimoto A, Nishimura R, Tsujino D, Taki K, Tajima N, Utsunomiya K. Relationship among A1C, hypoglycemia, and hyperglycemia in Japanese with type 2 diabetes-results from continuous glucose monitoring data. *Diabetes Technol Ther* 2011; 13(6): 667-670.
 67. Gu W, Liu Y, Chen Y, Deng W, Ran X, Chen L, Zhu D, Yang J, Shin J, Lee SW, et al. Multicentre randomized controlled trial with sensor-augmented pump vs multiple daily injections in hospitalized patients with type 2 diabetes in China: Time to reach target glucose. *Diabetes Metab* 2017; 43(4): 359-363.
 68. Hanazaki K, Tanioka N, Munekage M, Uemura S, Maeda H. Closed-loop artificial endocrine pancreas from Japan. *Artif Organs* 2021; 45(9): 958-967.
 69. Zhang Y, Zhao Z, Wang S, Zhu W, Jiang Y, Sun S, Chen C, Wang K, Mu L, Cao J, et al. Intensive insulin therapy combined with metformin is associated with reduction in both glucose variability and nocturnal hypoglycaemia in patients with type 2 diabetes. *Diabetes Metab Res Rev* 2017; 33(7).
 70. Okajima F, Nakamura Y, Yamaguchi Y, Shuto Y, Kato K, Sugihara H, Emoto N. Basal-Bolus Insulin Therapy with Gla-300 During Hospitalization Reduces Nocturnal Hypoglycemia in Patients with Type 2 Diabetes Mellitus: A Randomized Controlled Study. *Diabetes Ther* 2018; 9(3): 1049-1059.
 71. Tanaka N, Hiura Y. Effects of rapid-acting insulin analogues insulin glulisine and insulin aspart on postprandial glycemic excursion with single bout of exercise in patients with type 2 diabetes. *Endocr J* 2015; 62(5): 411-416.
 72. Valgardson JD, Merino M, Redgrave J, Hudson JI, Hudson MS. Effectiveness of inpatient insulin order sets using human insulins in noncritically ill patients in a rural hospital. *Endocr Pract* 2015; 21(7): 794-806.
 73. Yang CM, Ma YL, Kang J, Jia Z, Wang YY, Ma HY, Wang J. Time and department distribution of hypoglycemia occurrences in hospitalized diabetic patients. *Int J Nurs Stud* 2015; 2(3): 263-267.
 74. Wang SH, Shao W, Jiang QH, Zheng XL, Shen QB, Lin XY, Zhang QQ, Zhang LL, Shi XL, Wang WG, et al. Risk Factors for Glycemic Control in Hospitalized Patients with Type 2 Diabetes Receiving Continuous Subcutaneous Insulin Infusion Therapy. *Diabetes Ther* 2023; 14(1): 167-178.
 75. Sriphrapadang C, Mongkolrattanakul P, Tanasanitkul H, Reutrakul S. Improving inpatient glycemic control by diabetes education program in internal medicine residents. *Diabetes Metab Syndr* 2019; 13(4): 2647-2652.
 76. Swee DS, Ang LC, Heng WM, Lee DXY, Xin X, Kumaran S, Wong KS, Bee YM, Goh SY, Teh MM. Inpatient glucose management programme in the Asian healthcare setting. *Int J Clin Pract* 2017; 71(8).
 77. Gao JL, Xiong QY, Miao J, Zhang Y, Xia LB, Lu MQ, Zhang BH, Chen YP, Zhang AS, Yu C, et al. Analysis of alternatives for insulinizing patients to achieve glycemic control and avoid accompanying risks of hypoglycemia. *Biomed Rep* 2015; 3(3): 284-288.
 78. Cao SG, Ren JA, Shen B, Chen D, Zhou YB, Li JS. Intensive Versus Conventional Insulin Therapy in Type 2 Diabetes Patients Undergoing D2 Gastrectomy for Gastric Cancer: A Randomized Controlled Trial. *World J Surg* 2011; 35(1): 85-92.
 79. Huang QX, Lou FC, Wang P, Liu Q, Wang K, Zhang L, Zhu L, Yu S, Xu H, Wang Q, et al. Basal insulin therapy strategy is superior to premixed insulin therapy in the perioperative period blood glucose management. *Chin Med J* 2013; 126(21): 4030-4036.
 80. Ke T, Cheng G, Tan L, Zhou X, Miao Y, Du S, Wang J, Pan Y, Bi J, Zhao L, et al. Efficacy and safety of a combination of miglitol, metformin and insulin aspart in the treatment of type 2 diabetes. *Trop J Pharm Res* 2021; 20(10): 2171-2177.
 81. Li XW, Du T, Li WG, Zhang T, Liu HY, Xiong YF. Efficacy and Safety of Weight-based Insulin Glargine Dose Titration Regimen Compared With Glucose Level- and Current Dose-based Regimens in Hospitalized Patients With Type 2 Diabetes: A Randomized, Controlled Study. *Clin Ther* 2014; 36(9): 1269-1275.
 82. Li R. Comparison and analysis of the efficacy of different routes of insulin administration in the treatment of diabetic ketoacidosis. *Acta Med Mediterr* 2019; 35(3): 1651-1655.
 83. Song J, Pan X, Chen Y, Ding Y, Li X. Evaluation of the effectiveness regarding the participation of pharmacists in perioperative blood glucose management via the iGMS: a pilot RCT. *Diabetol Metab Syndr* 2023; 15(1).
 84. Zhang X, Zhang T, Xiang G, Wang W, Li Y, Du T, Zhao Y, Mosha SS, Li W. Comparison of weight-based insulin titration (WIT) and glucose-based insulin titration using basal-bolus algorithm in hospitalized patients with type 2 diabetes: a multicenter, randomized, clinical study. *BMJ Open Diabetes Res Care* 2020; 8(1).
 85. Zhang X, Yan D, Du T, Zhao Y, Zhang J, Zhang T, Lin M, Li Y, Li W. Efficacy and safety of basal-bolus insulin at 1:1.5 ratio compared to 1:1 ratio using a weight-based initiation and titration (WIT2) algorithm in hospitalized patients with type 2 Diabetes: a multicenter, randomized, clinical study. *Diabetol Metab Syndr* 2023; 15(1).

86. Hao S, Zhang N, Fish AF, Yuan X, Liu L, Li F, Fang Z, Lou Q. Inpatient glycemic management in internal medicine: an observational multicenter study in Nanjing, China. *Curr Med Res Opin* 2017; 33(8): 1371-1377.
87. Li M, Zhao M, Yan H, Guo H, Shi B. Clinical characteristics and influencing factors of hypoglycemia in hospitalized patients with type 2 diabetes mellitus: A cross-sectional study. *Nurs Open* 2023; 10(10): 6827-6835.
88. Lin JY, Zhang JY, Liang B, Lin JK, Wang N, Lin JL, Huang HB. Comparison of in-patient glucose team based management with conventional blood glucose management- a retrospective study from China. *Diabetol Metab Syndr* 2024; 16(1): 10.
89. Lin SD, Tu ST, Lin MJ, Jhang YL, Hsieh MC. A workable model for the management of hyperglycemia in non-critically ill patients in an asian population. *Postgrad Med* 2015; 127(8): 796-800.
90. Sheen YJ, Huang CC, Huang SC, Lin CH, Lee IT, Sheu WHH. Electronic dashboard-based remote glycemic management program reduces length of stay and readmission rate among hospitalized adults. *J Diabetes Investig* 2021; 12(9): 1697-1707.
91. Bi Y, Yan JH, Tang WL, Yang J, Weng JP. Prevalence of hypoglycemia identified by intensive bedside glucose monitoring among hospitalized patients with diabetes mellitus. *J Diabetes* 2013; 5(3): 300-301.
92. Fushimi N, Shibuya T, Yoshida Y, Ito S, Hachiya H, Mori A. Dulaglutide-combined basal plus correction insulin therapy contributes to ideal glycemic control in non-critical hospitalized patients. *J Diabetes Investig* 2020; 11(1): 125-131.
93. Kawaguchi Y, Sawa J, Hamai C, Kumeda Y. Differential Effect of Hypoalbuminemia on Hypoglycemia on Type 2 Diabetes Patients Treated with Insulin Glargine 300 U/ml and Insulin Degludec. *Diabetes Ther* 2019; 10(4): 1535-1541.
94. Suzuki J, Yamakawa T, Oba M, Nagakura J, Shigematsu E, Tamura H, Takahashi K, Okamoto Y, Sakamoto R, Shinoda M, et al. Efficacy and safety of insulin degludec U100 and insulin glargine U100 in combination with meal-time bolus insulin in hospitalized patients with type 2 diabetes: An open-label, randomized controlled study. *Endocr J* 2019; 66(11): 971-982.
95. Cho KY, Nakagaki O, Miyoshi H, Akikawa K, Astumi T. Evaluation of thrice-daily injections of insulin Lispro Mix 50/50 versus basal-bolus therapy in perioperative patients with type 2 diabetes. *Diabetol Int* 2014; 5(2): 117-121.
96. Lim Y, Ohn JH, Jeong J, Ryu J, Kim SW, Cho JH, Park HS, Kim HW, Lee J, Kim ES, et al. Effect of the Concomitant Use of Subcutaneous Basal Insulin and Intravenous Insulin Infusion in the Treatment of Severe Hyperglycemic Patients. *Endocrinol Metab* 2022; 37(3): 444-454.
97. Kuchay MS, Mathew A, Mishra M, Surendran P, Kaur P, Wasir JS, Gill HK, Jain R, Gagneja S, Kohli C, et al. Efficacy and safety of degludec U100 versus glargine U300 for the early postoperative management of patients with type 2 diabetes mellitus undergoing coronary artery bypass graft surgery: A non-inferiority randomized trial. *Diabet Med* 2023; 40(1): 9.
98. Mitra A, Ray S, Jayan S. Effect of basal insulin therapy with glargine U300 versus basal-bolus insulin therapy in hospitalized patients with type 2 diabetes. Real-world study from India. *Clin Diabetol* 2021; 10(2): 180-187.
99. Kant R, Yadav P, Pratti M, Barnwal S. Hypoglycemia: Elucidating its circadian propensity and recovery time based on clinical parameters. *Caspian Journal of Internal Medicine* 2022; 13(1): 29-37.
100. Krishnamoorthy S, Pandurangan V, Varadan S, Gopalan S, Sudagar Singh RB. Clinical Characteristics and Hospitalisation Outcomes of Hypoglycaemia in Hospitalised Patients With Type 2 Diabetes Mellitus. *Scr Med (Brno)* 2024; 55(3): 287-296.
101. Kuragayala SD, Nayak S, Khatib K. Hypoglycemia in hospitalized patients: A sleeping monster. *Muller J Med Sci Res* 2024; 15(1): 5-11.
102. Lakshmi B, Prabhakar U, Sireesha N. A Study on Identifying the Causes of Hypoglycemia and to Implement a Process to Prevent Hypoglycemia Events in Diabetic Patients in a Tertiary Care Hospital, Hyderabad. *IJSHR* 2022; 7(2): 79-83.
103. Mary George K, Mathew B. Study of Hypoglycaemia in Elderly Subjects with Diabetes Mellitus. India: Rajiv Gandhi University of Health Sciences (India); 2011.
104. Vikas PV, Chandrakumar A, Dilip C, Suriyaprakash TNK, Thomas L, Surendran R. Incidence and risk factors of hypoglycemia among Type 2 diabetic patients in a South Indian hospital. *Diabetes Metab Syndr* 2016; 10(2): S22-S25.
105. Houshyar J, Bahrami A, Aliasgarzadeh A. Effectiveness of Insulin Glargine on Recovery of Patients with Diabetic Ketoacidosis: A Randomized Controlled Trial. *J Clin Diagn Res* 2015; 9(5): OC1-OC5.
106. Farsaei S, Karimzadeh I, Elyasi S, Hatamkhani S, Khalili H. Glycemic control in the infectious diseases ward; role of clinical pharmacist interventions. *J Infect Dev Ctries* 2014; 8(4): 480-489.
107. Ebadi SA, Darvish P, Fard AJ, Lima BS, Ahangar OG. Hypoglycemia and cognitive function in diabetic patients. *Diabetes Metab Syndr* 2018; 12(6): 893-896.

108. Hartuti S, Nasution A, Syafril S. The effect of drug-related problems on blood glucose level in the treatment of patients with type 2 diabetes mellitus. *Open Access Maced J Med Sci* 2019; 7(11): 1798-1802.
109. Huri HZ, Aziz MIA, Vethakkan SR, Widodo RT. Factors associated with hypoglycemia episodes in hospitalized type 2 diabetes mellitus patients in a tertiary health facility in Malaysia. *Trop J Pharm Res* 2016; 15(6): 1313-1320.
110. Kao SL, Chen Y, Ning Y, Tan M, Salloway M, Khoo EYH, Tai ES, Tan CS. Evaluating the effectiveness of a multi-faceted inpatient diabetes management program among hospitalised patients with diabetes mellitus. *Clin Diabetes Endocrinol* 2020; 6(1).
111. Ong KY, Kwan YH, Tay HC, Tan DSY, Chang JY. Prevalence of dysglycaemic events among inpatients with diabetes mellitus: A Singaporean perspective. *Singapore Med J* 2015; 56(7): 393-400.
112. Thammakosol K, Sriphrapradang C. Effectiveness and safety of early insulin glargine administration in combination with continuous intravenous insulin infusion in the management of diabetic ketoacidosis: A randomized controlled trial. *Diabetes Obes Metab* 2023; 25(3): 815-822.
113. Anthanont P, Khawcharoenporn T, Tharavanij T. Incidences and outcomes of hyperglycemic crises: A 5-year study in a tertiary care center in Thailand. *J Med Assoc Thai* 2012; 95(8): 995-1002.
114. Lin J, Zhang J, Liang B, Lin J, Wang N, Lin J, Huang H. Comparison of in-patient glucose team-based management with conventional blood glucose management- a retrospective study from China. *Diabetol Metab Syndr* 2024; 16(1): 1-10.
115. Zhu D. Guideline for the prevention and treatment of type 2 diabetes mellitus in China (2020 edition). *Chin J Diabetes Mellitus* 2021; 13(04): 315-409.
116. Galindo RJ, Umpierrez GE, Rushakoff RJ, Basu A, Lohnes S, Nichols JH, Spanakis EK, Espinoza J, Palermo NE, Awadje DG, et al. Continuous Glucose Monitors and Automated Insulin Dosing Systems in the Hospital Consensus Guideline. *J Diabetes Sci Technol* 2020; 14(6): 1035-1064.
117. Moon SJ, Jung I, Park C-Y. Current Advances of Artificial Pancreas Systems: A Comprehensive Review of the Clinical Evidence. *Diabetes Metab J* 2021; 45(6): 813-839.
118. Korytkowski MT. Hypoglycemia in patients with non-critical illness in the hospital setting. *Diabetic Hypoglycemia* 2013; 6(2): 3-8.
119. Fidler C, Elmelund Christensen T, Gillard S. Hypoglycemia: an overview of fear of hypoglycemia, quality-of-life, and impact on costs. *J Med Econ* 2011; 14(5): 646-655.
120. Sameer A, Banday M, Nissar S. Pathophysiology of diabetes: An overview. *Avicenna J Med* 2020; 10(4): 174.
121. Grant SW, Collins GS, Nashef SAM. Statistical Primer: developing and validating a risk prediction model†. *Eur J Cardiothorac Surg* 2018; 54(2): 203-208.
122. Dyer BP. Variable selection for causal inference, prediction, and descriptive research: a narrative review of recommendations. *Eur Heart J Open* 2025; 5(3): oeaf070.
123. Lipson M, Cheronet O, Mallick S, Rohland N, Oxenham M, Pietrusewsky M, Pryce TO, Willis A, Matsumura H, Buckley H, et al. Ancient genomes document multiple waves of migration in Southeast Asian prehistory. *Science* 2018; 361(6397): 92-95.
124. Tirtosudarmo R. *Migration, Ethnicity and Conflict in Southeast Asia*: Springer Singapore; 2018. 179-196 p.
125. Li X, Han F, Liu N, Feng X, Sun X, Chi Y, Hou N, Liu Y. Changing trends of the diseases burden attributable to high BMI in Asia from 1990 to 2019: results from the global burden of disease study 2019. *BMJ Open* 2023; 13(10): e075437.