Postprint of a Scoping Review of Early Warning Assessment Tools for Cardiovascular Disease Risk

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Abstract

Background Cardiovascular disease constitutes a major cause of global mortality, characterized by insidious onset, complex and variable clinical manifestations, and poor prognosis. Early identification and proactive intervention in potentially critically ill patients are crucial for improving outcomes. Objective To conduct a scoping review of domestic and international research on early warning assessment tools for cardiovascular disease risk, summarize and analyze their assessment components and application status, and provide a reference for selecting early warning assessment tools for cardiovascular patients in China. Methods Guided by the scoping review methodological framework, we systematically searched CNKI, Wanfang Data Knowledge Service Platform, VIP, Chinese Biomedical Literature Database, PubMed, Web of Science, Cochrane Library, Embase, CINAHL, and Scopus databases from inception to May 2023. Two researchers independently screened literature and extracted data, analyzing assessment content, study populations, validation methods, reliability and validity, and predictive performance. Results Sixteen articles were included, comprising 7 on tool development and validation and 9 on tool localization/application, encompassing 20 early warning assessment tools for cardiovascular disease risk. Analysis revealed that each tool contained 3-17 assessment items, with the most frequently occurring being age, systolic blood pressure, respiratory rate, oxygen saturation, heart rate, comorbidities, level of consciousness, and gender. Reliability and validity testing in 2 articles demonstrated good psychometric properties, while other studies lacked such evaluation. Ten articles reported area under the curve (AUC) values ranging from 0.550 to 0.926. Conclusion Early warning assessment tools for cardiovascular disease risk exhibit considerable diversity, yet quality deficiencies persist, and disease-specific tools are lacking. Future research should further validate the reliability and validity of existing tools and develop localized, psychometrically sound early warning assessment tools tailored to cardiovascular specialties and

disease characteristics.

Full Text

Early Warning Assessment Tools for Cardiovascular Disease Risk: a Scoping Review

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Abstract

Background: Cardiovascular disease (CVD) is a major cause of human mortality worldwide, characterized by its insidious onset, intricate and variable course, and poor prognosis. Early identification and active intervention of potentially critically ill patients is essential to improve their prognosis. **Objective:** To conduct a scoping review of the research on early warning assessment tools for cardiovascular disease risk at home and abroad, summarize and analyze their assessment content and application, ultimately providing reference for the selection of appropriate early warning tools for cardiovascular disease patients in China. **Methods:** CNKI, Wanfang Data Knowledge Service Platform, VIP, China Biomedical Literature Database, PubMed, Web of Science, Cochrane Library, Embase, CINAHL, and Scopus were systematically searched from inception to May 2023. Two investigators independently screened literature and extracted data, analyzed in terms of assessment content, study subjects, validation method, reliability and validity, and predictive efficacy. **Results:** A total of 16 papers were included, comprising 7 papers on the development and validation of assessment tools and 9 papers on the localized application of these tools, involving 20 early warning assessment tools for cardiovascular disease risk. The results of the analysis showed that each assessment tool contained 3 to 17 assessment items, with the most frequently mentioned items of age, systolic blood pressure, respiratory rate, oxygen saturation, heart rate, comorbidities, level of consciousness, and gender. The results of the reliability and validity tests for 2 papers indicated robust reliability and validity, while all other studies lacked reliability and validity evaluations. Ten papers reported the area under the curve (AUC), with values ranging from 0.550 to 0.9269. **Conclusion:** Diverse early

warning assessment tools for cardiovascular disease risk are available, however, their overall quality remains to be improved and there is a lack of specific assessment tools. In the future, it is imperative to conduct further validations of the reliability and validity of the existing tools, and develop localized early warning assessment tools specialized for cardiovascular diseases considering the unique characteristics of the disease, which exhibit robust reliability and validity.

Keywords: Cardiovascular diseases; Early warning; Risk assessment; Tools; Scoping review; Nursing

Introduction

Cardiovascular disease has become a major public health problem threatening human life and health globally. In China, the number of people living with cardiovascular disease exceeds 330 million, with over 4 million deaths annually, making it the leading cause of death among urban and rural residents[1]. Due to its insidious onset, long latency period, and complex and variable condition, cardiovascular disease is difficult to cure completely after onset[2–3]. Moreover, patients with cardiovascular disease often suffer irreversible organic damage due to untimely treatment, seriously threatening their lives and increasing the medical economic burden[4–6]. Studies have shown that signs of vital sign changes can appear minutes or even hours before serious deterioration[7–9]. Therefore, early detection of critical changes in patients with cardiovascular disease is key to improving rescue success rates and reducing mortality[10]. Early warning assessment tools are quantitative scoring systems constructed based on patient vital signs and other indicators, which have proven effective in identifying potential risks and predicting disease severity[11]. However, there is considerable heterogeneity in the assessment content, applicable populations, and clinical predictive efficacy of early warning assessment tools both domestically and internationally, and the appropriate early warning assessment tools for cardiovascular disease patients remain unclear. Based on this, this study systematically reviewed relevant literature in this field both domestically and internationally following the scoping review framework developed by Arksey et al.[12], comparing the assessment content, applicable populations, reliability and validity, and predictive efficacy of different tools, aiming to provide reference for the selection of early warning assessment tools for cardiovascular disease patients in China.

Methods

Research Questions The specific research questions of this study include: (1) What early warning assessment tools are currently applied to cardiovascular disease patients both domestically and internationally? (2) What assessment content do these early warning assessment tools mainly involve? (3) What are the reliability, validity, and predictive efficacy of each assessment tool when

applied to cardiovascular disease patients, and have internal and external validation been conducted?

Inclusion and Exclusion Criteria Based on the "PCC" principle[13], the inclusion criteria were determined as follows: (1) Population (P): cardiovascular disease patients aged $ $18 years; (2) Concept (C): original research involving assessment content and predictive efficacy for early warning of disease risk in cardiovascular disease patients; (3) Context (C): occurrence of adverse cardiovascular disease outcome events. Exclusion criteria: (1) non-Chinese or non-English literature; (2) inability to obtain full text; (3) conference abstracts; (4) duplicate publications.

Search Strategy We systematically searched CNKI, Wanfang Data Knowledge Service Platform, VIP, China Biomedical Literature Database, PubMed, Web of Science, Cochrane Library, Embase, CINAHL, and Scopus databases from inception to May 2023. A combination of subject headings and free-text terms was used, and references of included literature were further searched. Preliminary searches were conducted in CNKI and PubMed databases before formal searching, and the search strategy was revised accordingly. Taking PubMed as an example, the English search strategy was: ("cardiovascular disease" [MeSH Terms] OR "CVD" *[Title/Abstract] OR " cardiac disease*" [Title/Abstract] OR "CHD" *[Title/Abstract] OR " circulation system diseases*" [Title/Abstract]) AND ("early warning" [MeSH Terms] OR "risk assessment" [MeSH Terms] OR "prediction rule" *[Title/Abstract] OR " prediction model*" [Title/Abstract] OR "prognosis model" *[Title/Abstract] OR " evaluation tool*" [Title/Abstract]). Taking CNKI as an example, the Chinese search strategy was: (SU= '心血管疾病' + '心脏疾病' + '循环系统疾病') AND (SU= '病情变化' + '早期预警' + '早期预警评分' + '风险评估' + '风险预测') AND (SU= '评估工具' + '工具' + '量表').

Literature Screening and Data Extraction Retrieved literature was imported into EndNote X9 software to remove duplicates. Two trained investigators independently conducted initial screening by reading titles and abstracts according to inclusion and exclusion criteria, followed by full-text review for secondary screening. Any disagreements during the screening process were resolved through discussion with a third investigator. Information from included literature was independently extracted by two investigators, including first author, publication year, country, research method, assessment content, study subjects, study endpoints, risk score presentation format, cutoff values, validation methods, reliability and validity, and predictive efficacy indicators.

Results

Literature Screening Results The initial search yielded 5,123 articles. After removing duplicates, literature that did not match the research content and purpose, literature without full text or conference abstracts, and non-

Chinese/non-English literature, 16 articles[14–29] were finally included. The literature screening process is shown in Figure 1 [Figure 1: see original paper].

Application of Early Warning Assessment Tools The 16 included articles involved 20 assessment tools applied to cardiovascular disease patients. Seven early warning assessment tools were identified as developed in China[15,17–19,21,24–25], with only two studies[15,21] conducting reliability and validity testing in cardiovascular disease populations. Four studies[16,22–23,26] introduced assessment tools from different countries but did not conduct reliability and validity testing. Three studies[23,26,28] collected prospective data for external validation, while four studies[15,19–20,25] used retrospective cohort data for internal validation, all of which were single-center studies. Among them, the study by Hagemen et al.[20] both developed a new assessment tool and validated other scoring systems. Additionally, the main study endpoints for the application of these assessment tools were death due to cardiovascular disease[14–16,20,22–23,26,29], cardiac arrest[16,25,29], and unplanned readmission[16,22,26]. The study populations included in the research were heterogeneous, comprising patients with ST-segment elevation myocardial infarction[22,29], cardiovascular disease patients over 40 years old[26,28], and post-cardiac surgery patients readmitted to ICU[14], with most focusing on adult hospitalized cardiovascular disease patients.

Assessment Content of Early Warning Tools The early warning assessment tools for cardiovascular disease risk included in this study contained 3 to 17 assessment items. The common method for selecting assessment items was to use the Modified Early Warning Score (MEWS) as a reference and screen relevant sensitive indicators through literature review or Logistic regression analysis. Multiple studies among the 16 articles involved laboratory data and focused on family history, vital signs, physical condition, disease-related factors, and lifestyle factors, making the content complex and difficult to manage. Two studies[15,21] had simple and manageable assessment content, focusing on subtle changes in vital signs to measure cardiovascular disease severity. The most frequently occurring assessment items across the tools were age, systolic blood pressure, respiratory rate, oxygen saturation, heart rate, comorbidities, level of consciousness, and gender.

Reliability and Validity of Early Warning Tools Among the 16 included articles, two studies[15,21] reported reliability and validity testing results indicating good reliability and validity, while all other studies lacked reliability and validity evaluation. The predictive validity of assessment tools was mostly reported using the area under the receiver operating characteristic curve (AUC) along with sensitivity and specificity, with a few studies reporting Hosmer-Lemeshow goodness-of-fit test and positive or negative predictive values. The reported AUC values for assessment tools ranged from 0.550 to 0.9269. The seven domestically developed assessment tools[15,17–19,21,24–25] mostly used in-

ternal validation methods, with AUC values all above 0.7, indicating acceptable predictive validity. For the five tools reported sequentially, AUC values were 0.550, 0.725, 0.653, 0.685, and 0.794, with sensitivities of 0.223, 0.567, 0.500, 0.400, and 0.800, and specificities of 0.948, 0.812, 0.779, 0.935, and 0.734. For the three tools reported sequentially, AUC values were 0.8341, 0.7007, and 0.706. For the three models reported sequentially, AUC values were 0.9269, 0.9220, and 0.9246, with sensitivities of 0.8048, 0.8195, and 0.8501, and specificities of 0.9014, 0.8951, and 0.8695.

Discussion

Development Methods Need Improvement This study found that the construction methods for early warning assessment tools were not unified. Among them, two studies[15],[21] improved upon the Modified Early Warning Scale (MEWS) through literature review, group discussion, and expert consultation, but the screening of assessment indicators was not rigorous enough. In contrast, the study by Li et al.[17] constructed an early warning model based on big data combined with artificial intelligence analysis technology, which, compared with traditional construction methods, helps to quickly mine effective assessment indicators and improve prediction accuracy and efficiency[30–31]. Therefore, the development methods for cardiovascular disease risk early warning assessment tools need further improvement. It is recommended that future research screen early warning assessment indicators based on big data and combine them with the Delphi method to improve the indicator system, thereby promoting the decision-making process for selecting effective assessment content and enhancing the scientific nature and interpretability of research.

Content Should be Specialized and Timely This study summarized the relevant assessment content for cardiovascular disease risk early warning, including age, gender, systolic blood pressure, respiratory rate, oxygen saturation, heart rate, level of consciousness, arrhythmia, chest pain, antihypertensive medication use, total cholesterol, high-density lipoprotein, etc., which can be preliminarily divided into basic indicators including vital signs and consciousness level[32], and specialized indicators including cardiovascular disease characteristics and laboratory data. The risk assessment tools in multiple studies[20],[26–27] covered family history, total cholesterol, high-density lipoprotein, BMI, antihypertensive medication use, etc. Although these had high prediction accuracy, the numerous indicators could not be obtained quickly and directly in clinical practice, limiting the timeliness of assessment. In contrast, the cardiovascular disease early warning assessment scale constructed by Yu et al.[15] included both basic indicators (systolic blood pressure, heart rate, respiration, oxygen saturation, body temperature, consciousness) and specialized indicators (arrhythmia, pain score, age), demonstrating specialization and timeliness. The specialization and timeliness of assessment content are key characteristics of cardiovascular disease risk early warning assessment tools, which can help nurses objectively assess the severity of patients' conditions, improve early identification capabil-

ities, and provide reliable basis for clinical nursing decision-making. Therefore, future research should fully consider the characteristics of cardiovascular disease and clinical application timeliness when screening early warning assessment content, and construct cardiovascular disease risk early warning assessment tools that combine both specialization and timeliness.

Effectiveness Evaluation Needs to be Comprehensive This study found that two studies[21],[28] did not conduct predictive efficacy evaluation; these studies only designed early warning systems without clinical testing and application. Although the AUC values of domestically developed assessment tools[15],[17–19],[21],[24–25] were above 0.7, there were large differences between internal and external validation AUC values, and their predictive performance needs further evaluation. While AUC is a key indicator for evaluating the discriminative performance of early warning assessment tools, calibration performance indicators are also needed to evaluate clinical practical application effectiveness[33], yet most studies did not report these. Although most cardiovascular disease risk early warning assessment tools included in this study have evaluated their predictive efficacy, they lack reliability and validity testing. Additionally, this study showed that the initial study populations for 12 assessment tools were not cardiovascular disease patients. Due to the heterogeneity of patient populations, this may lead to poor performance of external validation or assessment tools in clinical practice[34]. Therefore, when developing cardiovascular disease early warning assessment tools, in addition to focusing on predictive efficacy, it is necessary to verify their reliability and validity to ensure the generalizability of the tools. Furthermore, most assessment tools were only single-center studies with small sample sizes, which also affected the effectiveness and stability of the tools. In summary, the reliability and validity of current cardiovascular disease early warning assessment tools still need to be explored. Subsequent research should develop localized, highly sensitive early warning assessment tools based on the characteristics of Chinese cardiovascular disease patients, and focus on conducting multi-center, prospective external validation studies based on existing early warning assessment tools to fully demonstrate their broad applicability.

Conclusion

This study summarizes the relevant content of cardiovascular disease risk early warning assessment tools to provide reference for clinical selection of cardiovascular disease early warning assessment tools. Due to the inclusion of only Chinese and English literature, there are still limitations in the demonstration of assessment content and effectiveness evaluation. Currently, there are diverse types of cardiovascular disease risk early warning assessment tools, but the development methods and warning content need further improvement, and there is a lack of specific assessment tools. Future research still needs to further verify the reliability and validity of existing tools and develop localized, reliable, and valid specific early warning assessment tools for cardiovascular disease risk

based on cardiovascular disease characteristics.

Author Contributions: Zuo Zhongqi and Wang Yu were responsible for conceptualization, design, writing, and revision of the manuscript; Jin Yan and Yu Man conducted feasibility analysis; Zhang Qingwei, Yuan Binbin, Shen Saiya, and Wang Fei were responsible for literature/data collection and organization; Zuo Zhongqi and Yu Man handled English revision, quality control, and final approval, and were accountable for the overall work and supervision.

Conflict of Interest: The authors declare no conflict of interest.

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Note: Figure translations are in progress. See original paper for figures.