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Artificial Intelligence for Diabetic Foot Screening Based on Digital Image Analysis: A Systematic Review

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Corresponding author:
Heri Kristianto

heri.kristianto@ub.ac.id

Author Affiliation:
Nursing Department, Faculty of Health Sciences, Brawijaya University.

Anggreni, NIK; Kristianto, H; Handayani, D; Yueniwati, Y; Irawan, PLT; Rosadi, R; Kapti, RE; Purnama, AD.

ADMINISTRATIVE INFORMATION

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Review Stage at time of this submission - Completed but not published.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 11 January 2025 and was last updated on 11 January 2025.

INTRODUCTION

Review question / Objective This systematic review aims to identify a study on the development of an AI model for diabetic foot screening using digital image analysis. To this end, the proposed systematic review will address the following question:
(1) What data sources and digital imagery features are most commonly used for diabetic foot detection by AI systems based on the synthesis of evidence from various studies?
(2) What are the most commonly used AI subtypes that have the best performance for diabetic foot screening through digital image analysis?

Rationale Although much research has been conducted on the use of AI and digital image processing in identifying complications of diabetic foot, few studies have been carried out in terms of systematic reviews on this topic. The research related to the systematic review doesn't discuss about the use of digital image processing specifically (1). In addition, there is still a gap in understanding the features or characteristics of digital image data sets that contribute to the detection of diabetic feet by AI systems as well as the type of AI and its accuracy.

Condition being studied Diabetic foot is one of the major complications observed in diabetic patients, associated with the development of foot ulcers and can lead to amputation (2) Measured audits show that more than 35% of the DM patient population is affected by diabetic ulcers, another 20% are affected by diabetic neuropathy, and 30% of patients are affected by both conditions (3) The management and prevention of diabetic foot complications relies heavily on their early detection (4,5). Early detection helps in the proper triage of patients or healthcare workers towards more measures that are effective yet conservative for

management of diabetic foot complications (6,7). One of the nursing interventions that can be explored in the assessment of the diabetic foot is non-invasive digital image processing technology and artificial intelligence (AI) (8,9). These algorithms learn to recognize complex hierarchy data at previously impossible speeds and from even the concepts devoid of any structuring (10,11). Enhancements in image processing and analysis reduce the need for manual scrutiny that may overlook small differences and variation (12,13). These adequacy allow AI to improve accuracy in convoluted cases and overcome human errors caused by exhausted and limited supervision (14,15).

METHODS

Search strategy A comprehensive literature search was conducted using 3 electronic databases: PubMed, ProQuest, and ScienceDirect, with specific string for each database.
Pubmed:
artificial intelligence AND image analysis AND diabetic foot screening OR diabetic foot prevention OR diabetic foot prediction
Proquest:
(artificial intelligence AND image analysis AND diabetic for screening OR diabetic foot prediction) AND (at.exact("Article") AND stype.exact("Scholarly Journals") AND la.exact("ENG") AND subt.exact("diabetes" NOT ("diabetic retinopathy" OR "kidneys" OR "genomes" OR "angiogenesis" OR "cancer")) AND pd(20181113-20231113))
Science direct:
artificial intelligence AND image analysis AND diabetic foot prevention OR diabetic foot prediction.

Participant or population Diabetes patient with or without diabetic foot complication

Intervention Diabetic foot assessment or screening using digital image analysis with artificial intelligence.

Comparator Other AI method or subtype, conventional screening using questionnaire or physical examination

Study designs to be included In this current systematic review, eligible studies specifically on primary research articles that developed or evaluated artificial intelligence-based methods for diabetic foot screening, utilized digital image processing techniques, and included quantitative performance metrics of the AI system. Both observational (case control and cohort) and interventional research are included in this review.

Eligibility criteria Studies were included if they met the following criteria: (i) original articles published between 2018-2023; (ii) were written in English. Studies were excluded if they were: (i) including review articles (such as systematic reviews, meta-analyses, and narrative reviews), conference abstracts or proceedings, study protocols, case reports or case series, and letters to editor, commentaries, or opinion pieces; (ii) sourced from books, encyclopedias, videos, or conference proceedings, (iii) not accessible as full-text; (iv) focused solely on general diabetic foot care without AI components, used AI for general diabetes management without specific foot screening components, or employed only traditional image processing without AI implementation; (v) not have clear description of the AI methodology used, failed to report performance metrics, or did not specify sample size or data collection methods.

Information sources A comprehensive literature search was conducted using 3 electronic databases: PubMed, ProQuest, and ScienceDirect

Main outcome(s) Applications of diagnostic performance of the proposed AI model accuracy, precision, sensitivity, F1-score, and specificity

Additional outcome(s) None

Data management Study selection was performed in two stages. The first involved independent screening of titles and abstracts of all unique records identified by the search against the eligibility criteria by both reviewers (NIS and HKS). Excluded were those studies which clearly did not meet the criteria. The full-text retrieval and independent assessment of the remaining potentially relevant studies were done in the second stage by the two reviewers. Reasoning for exclusion of studies during full-text phase was documented. Disagreements were resolved through discussion with a third reviewer (HKS). The selection process was documented using the PRISMA 2020 flow diagram. Data from the included studies were extracted and summarized using NVivo.

Quality assessment / Risk of bias analysis Reviewers (NIS and HKS) assessed each risk of bias for all studies included using the QUADAS-2 checklist as a quality evaluation method for diagnostic accuracy. Any disparities in scores were addressed through conversation. The risk of bias

and applicability were evaluated across four domains: (1) patient selection; (2) index test; (3) reference standard; and (4) flow and timing. Each domain received a rating of low, uncertain, or high risk. Unclear risk was evaluated using inadequate study data to reach a judgment. Not applicable (N/A) was used when the QUADAS domain was not applicable owing to the study methodology.

Strategy of data synthesis Data from the included studies were extracted and summarized independently by the first author (NIS) using NVivo. The coding scheme in NVivo was organized hierarchically, with parent nodes corresponding to major extraction categories and child nodes for specific data elements. In identifying and analyzing the content, the researcher performed systematic coding of information relevant to the research questions. The coding was organized into three main categories: introduction, data sources and digital imaging features, and artificial intelligence (AI) methodology. All coding results were then tabulated and organized in spreadsheet format using Microsoft Excel to facilitate comprehensive analysis of the reviewed studies.

Subgroup analysis Each main category (parent nodes) consists of child nodes as follows: (1) introduction: authors, publication year, and research objectives; (2) data sources and digital imaging features: the types of imaging used, number of respondents or samples, and data sources; (3) AI methodology: type of AI implemented, system architecture used, and system results or performance.

Sensitivity analysis Non sensitivity analysis was conducted in this study.

Language restriction English.

Country(ies) involved Indonesia.

Keywords
artificial intelligence; deep learning; diabetic foot; digital image analysis; machine learning.

Dissemination plans
Public publications.

Contributions of each author
Author 1 - Ni Kadek Indah Sunar Anggreni.
Concept and design; drafting of the manuscript; and acquisition, analysis, or interpretation of data
Email: nikadekindah@student.ub.ac.id
ORCID 0009-0003-0213-5689
Affiliation: Nursing Department, Faculty of Health Sciences, Brawijaya University
Author 2 - Heri Kristianto.
Concept and design; supervision; critical review of the manuscript for important intellectual content
Email: heri.kristianto@ub.ac.id
ORCID 0000-0002-9869-4519
Affiliation: Nursing Department, Faculty of Health Sciences, Brawijaya University
Author 3 - Dian Handayani.
Concept and design; supervision; critical review of the manuscript for important intellectual content
Email: handayani_dian@ub.ac.id
ORCID 0000-0001-9018-0233
Affiliation: Nutrition Department, Faculty of Health Sciences, Brawijaya University
Author 4 - Yuyun Yueniwati.
Concept and design; critical review of the manuscript for important intellectual content
Email: yuyun@ub.ac.id
ORCID 0000-0002-1395-5557
Affiliation: Radiology Department, Faculty of Medicine, Brawijaya University
Author 5 - Paulus Lucky Tirma Irawan.
Concept and design; critical review of the manuscript for important intellectual content
Email: paulus.lucky@machung.ac.id
ORCID 0000-0002-2907-6223
Affiliation: Informatics Engineering Department, Faculty of Technology and Design, Ma Chung University
Author 6 - Rulli Rosadi.
Concept and design; critical review of the manuscript for important intellectual content
Email: rulliendokrin@ub.ac.id
ORCID 0000-0003-4814-5842
Affiliation: Internal Medicine Department, Faculty of Medicine, Brawijaya University
Author 7 - Rinik Eko Kapti.
Concept and design; supervision; critical review of the manuscript for important intellectual content
Email: rinik.eko@ub.ac.id
ORCID 0000-0002-7016-0136
Affiliation: Nursing Department, Faculty of Health Sciences, Brawijaya University
Author 8 - Avief Destian Purnama.
Drafting of the manuscript; and acquisition, analysis, or interpretation of data
Email: Aviefdestian@ub.ac.id
ORCID 0009-0009-8292-455X
Affiliation: Nursing Department, Faculty of Health Sciences, Brawijaya University

Other relevant information
The citation style that used in this protocol is National Library of Medicine.

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