INPLASY

INPLASY202570076

doi: 10.37766/inplasy2025.7.0076

Received: 19 July 2025

Published: 19 July 2025

Systematic Review and Meta-analysis of AI-driven Applications for Screening Nasopharyngeal Carcinoma Using MRI

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ADMINISTRATIVE INFORMATION

Support - Hong Kong Research Grant Council, General Research Fund 2021/22 (Ref: 14104221).

Review Stage at time of this submission - Data analysis.

Conflicts of interest - None declared.

INPLASY registration number: INPLASY202570076

Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 19 July 2025 and was last updated on 19 July 2025.

INTRODUCTION

Review question / Objective Review questions: 1. What are the reported localization and discrimination performances of AI for nasopharyngeal carcinoma (NPC) identification and discrimination from non-NPC on MRI? 2. To what extent do screening-relevant clinical constraints, such as the adoption of suitable MRI protocol and characteristics of patient population, influence the performance of AI systems? 3. How applicable are existing AI studies to the screening of NPC on MRI?

Rationale Undifferentiated nasopharyngeal carcinoma (NPC) is highly prevalent among young to middle-aged men in Southeast Asia, particularly in regions around the South China Sea. It remains a leading cancer in men aged 20-49 in places like Hong Kong and Singapore. Early-stage NPC (stage I-II) is highly curable with intensity-modulated radiotherapy alone, yielding excellent 5-year recurrence-free survival rates. However, early NPC is usually asymptomatic and difficult to detect, resulting in over 70% of patients being diagnosed at advanced stages where treatment outcomes are significantly worse despite more intensive therapy. Recent advances in NPC screening using Epstein-Barr Virus (EBV)-related serological tests (antibodies and plasma DNA) have shown high sensitivity, especially for early-stage disease. For screen-positive individuals, a fast, non-contrast-enhanced MRI prior to endoscopy is recommended to prioritize suspicious cases and guide biopsy. MRI provides a more comprehensive view of the nasopharynx and detects more early NPCs than endoscopy alone. However, the high cost and required radiology expertise limit cost-effective MRI-based screening programs.

Artificial intelligence (AI) offers promise for cost-effective, automated MRI assessment by detecting and characterizing NPC lesions, facilitating screening particularly in high-risk individuals identified by EBV testing. Despite numerous AI studies for NPC management, few address AI's role in screening, which has unique challenges such as the predominance of NPC-negative

individuals and the need for non-contrast MRI protocols. AI models developed on arbitrary imaging protocols may not perform well under screening conditions due to domain shifts, a critical gap in current research.

Previous reviews have not focused on AI applications specifically for NPC screening or early detection. While there has been systematic reviews and meta-analysis that investigate the use of AI in management of NPC, none have been conducted in the context of screening despite its high feasibility and effectiveness of standard treatment to its early stage disease. Thus, this review aims to promote the translation of AI for screening NPC on MRI by answering the review questions listed.

Condition being studied Nasopharyngeal carcinoma (NPC) and benign lesions in the nasopharynx.

METHODS

Search strategy Three databases were searched: (i) PubMed, (ii) Embase, and (iii) Scopus. Search was conducted using the following inclusion keywords: MRI, NPC, screening, detection, segmentation, discrimination, radiomics, deep learning, artificial intelligence, machine learning, and neural network. The exact search term are provided below:

PubMed:
((("MRI"[Title/Abstract] OR "magnetic resonance imaging"[Title/Abstract] OR "MR"[Title/Abstract]) AND ("nasopharyngeal carcinoma"[Title/Abstract] OR "nasopharyngeal cancer"[Title/Abstract]) AND ("screening"[Title/Abstract] OR "detection"[Title/Abstract] OR "segmentation"[Title/Abstract] OR "discrimination"[Title/Abstract]) AND ("radiomics"[Title/Abstract] OR "deep learning"[Title/Abstract] OR "machine learning"[Title/Abstract] OR "artificial intelligence"[Title/Abstract] OR "neural network"[Title/Abstract])) NOT ("review"[Title] OR "commentary"[Title] OR "letter to the editor"[Title])

Scopus:
TITLE-ABS-KEY((MRI OR "magnetic resonance imaging" OR MR) AND ("nasopharyngeal carcinoma" OR "nasopharyngeal cancer") AND (screening OR detection OR segmentation OR discrimination) AND (radiomics OR "deep learning" OR "machine learning" OR "artificial intelligence" OR "neural network")) AND NOT TITLE(review OR commentary OR "letter to the editor")

Embase (Ovid based syntax):
(('mri' or 'magnetic resonance imaging' or 'MR') and ('nasopharyngeal carcinoma' or 'NPC' or 'nasopharyngeal cancer') and ('screening' or 'detection' or 'segmentation' or 'discrimination') and ('radiomics' or 'deep learning' or 'machine learning' or 'artificial intelligence' or 'neural network')).ab,hw,kf,kw,ot,ti not ('review' or 'commentary' or 'letter to the editor')).ti.

Participant or population Patients who are confirmed to have or are suspected to have NPC in the endemic region of NPC are concerned.

Intervention N/A.

Comparator N/A.

Study designs to be included Retrospective and Prospective cohort studies.

Eligibility criteria Detailed inclusion criteria:
1. The study proposed and evaluated an AI-driven algorithm utilizing either radiomics with conventional machine learning or deep learning;
2. The algorithm was designed to detect and/or characterize lesions in the nasopharynx;
3. The study investigated MRI data of patients with NPC;
4. The study population was from endemic region(s) of NPC.

and studies were excluded to ensure relevance to MRI screening setting based on:
1. The AI-driven algorithm required additional imaging inputs beyond MRI (e.g., CT). However, additional clinical record inputs collected prior to treatment were accepted;
2. The study focused on post-diagnosis steps, such as treatment planning, outcome prediction, or survival analysis.
We only include studies from endemic.

Information sources Electronic database and contact with authors.

Main outcome(s) 1. Pooled performance of AI for the localization of suspected nasopharynx lesion and discrimination of NPC with benign hyperplasia or normal nasopharynx on MRI.
2. Meta-analysis subgroup investigation that advice scan protocol and screening-related constraints for screening NPC on MRI.
3. Applicability investigation result of existing AI for screening NPC on MRI.
3. Applicability.

Data management Excel sheets.

Quality assessment / Risk of bias analysis The PRISMA guideline is followed, with signaling questions designed based on the CLAIM checklist and well-accepted standards for screening. Two reviewers will independently follow such guideline to rate each study for applicability and risk of bias concern evaluation.

Strategy of data synthesis Data were systematically extracted from the included articles in accordance with a predefined extraction guideline. This includes the single-group metrics for localization, such as intersection of union, Dice similarity coefficient, average surface distance; and bivariate diagnostic metrics.

Single-group metrics, such as segmentation accuracy measures, will be pooled and analyzed based on univariate restricted maximum likelihood model (REML) with random effect. Diagnostic test measure will be pooled and analyzed based on bivariate modeling including Hierachical Summary Receiver Operator Characteristics (HSROC). Heterogeneity of the pooled performance will be reviewed by I^2, Q and tau where appropriate.

Subgroup analysis Subgroup analysis is to be conducted on top of meta-analysis to investigate:
1. Performance of AI systems built from input MRI scanned with/without intravenous contrast.
2. Performance of AI systems built from single/multiple MRI sequences.
3. Performance of AI systems based on deep learning and conventional machine learning.

Sensitivity analysis Iterative Leave-one-out analysis will be performed to investigated if any included studies introduced statistically significant moderation.

Language restriction Limited to English studies.

Country(ies) involved This study is conducted in HKSAR, China.

Keywords Nasopharyngeal carcinoma; artificial intelligence; screening; MRI; intravenous contrast.

Dissemination plans Publication of results on peer-reviewed journals.

Contributions of each author
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