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Prevalence, awareness, treatment, and control of hypertension among high-altitude populations: a systematic review and meta-analysis

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ADMINISTRATIVE INFORMATION**Support** - West China School of Public Health and West China Fourth Hospital, Sichuan University.**Review Stage at time of this submission** - The review has not yet started.**Conflicts of interest** - None declared.**INPLASY registration number:** INPLASY202690102**Amendments** - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 23 September 2026 and was last updated on 23 September 2026.**INTRODUCTION**

Review question / Objective What are the pooled prevalence, awareness, treatment, and control rates of hypertension among adults living at high altitude ($\geq 1,500$ m), and how do these estimates vary by altitude, ethnicity, survey period, and sample source?

Rationale Hypertension is a major public health burden in high-altitude regions, where prevalence has been reported to exceed national averages, while awareness, treatment, and control rates remain consistently low. No systematic review has quantitatively synthesized the hypertension care cascade (prevalence, awareness, treatment, and control) in high-altitude populations; existing syntheses focused on prevalence alone or were restricted to single regions. A pooled estimate of the care cascade, together with an exploration of variation by altitude, ethnicity, and survey period, is needed to quantify the prevention and control gap

and to inform health policy for high-altitude populations.

Condition being studied Hypertension (essential/primary hypertension) among adults. The care cascade comprises prevalence, awareness, treatment, and control of hypertension.

METHODS

Search strategy Databases: PubMed, Europe PMC, Web of Science, Scopus, and the Chinese databases CNKI and Wanfang; preprint servers medRxiv and bioRxiv (via category browsing). Date range: 1 January 2010 to the date of the formal search (search date to be recorded). Language: English and Chinese. Search concepts: (hypertension OR "high blood pressure") AND (prevalence OR awareness OR treatment OR control OR "care cascade" OR "treatment cascade" OR epidemiology) AND (altitude OR "high altitude" OR plateau OR

highland* OR Tibetan OR Tibet OR Qinghai OR Xizang OR Himalaya* OR Andes OR Andean OR Peruvian OR Bolivian OR Ethiopian OR Pamir* OR Altiplano OR 高原 OR 高海拔 OR 藏族).

Example PubMed string:

("hypertension"[Mesh] OR hypertension[tiab] OR "high blood pressure"[tiab]) AND (prevalence[tiab] OR awareness[tiab] OR treatment[tiab] OR control[tiab] OR "care cascade"[tiab] OR epidemiology[tiab]) AND (altitude[tiab] OR "high altitude"[tiab] OR plateau[tiab] OR highland*[tiab] OR Tibet*[tiab] OR Qinghai[tiab] OR Xizang[tiab] OR Himalaya*[tiab] OR Andes[tiab] OR Andean[tiab] OR Peruvian[tiab] OR Bolivian[tiab] OR Ethiopian[tiab] OR Pamir*[tiab] OR Altiplano[tiab])

Citation tracking: forward and backward citation searching of all included studies.

Participant or population Inclusion: adults aged ≥ 18 years residing at high altitude (residential altitude $\geq 1,500$ m). The primary analysis will be restricted to studies conducted at $\geq 2,500$ m; studies at 1,500–2,499 m will be included in sensitivity analyses.

Exclusion: pregnancy-related hypertension; children and adolescents; populations selected solely for chronic mountain sickness or high-altitude pulmonary edema (unless general population rates are also reported); clinic- or hospital-based inpatients (considered only in subgroup/sensitivity analyses).

Intervention Not an intervention review. The exposure/stratifying variables are: residential altitude (categories: 1,500–2,499; 2,500–3,499; 3,500–4,499; $\geq 4,500$ m), ethnicity (e.g., Tibetan, Han migrants, Andean, other), survey period (before 2020 vs 2020 or later), and sample source (community-based vs hospital-based).

Comparator Not applicable for the primary estimates (prevalence/awareness/treatment/control). Where available, low-altitude (altitude $< 1,500$ m) estimates from comparable national or regional surveys will be used as a reference in subgroup analyses and meta-regression.

Study designs to be included Cross-sectional studies (including repeated cross-sectional surveys) and baseline data of prospective cohort studies reporting prevalence and/or awareness, treatment, or control of hypertension. Conference abstracts will be considered only for sensitivity analyses; preprints will be considered only for sensitivity analyses.

Eligibility criteria Inclusion criteria: (1) cross-sectional studies (including repeated cross-sectional surveys) and baseline data of cohort studies; (2) adults aged ≥ 18 years residing at high altitude (residential altitude $\geq 1,500$ m; primary analysis restricted to $\geq 2,500$ m); (3) reporting the prevalence of hypertension and/or at least one of awareness, treatment, or control; (4) hypertension defined by measured blood pressure and/or self-reported diagnosis or use of antihypertensive medication; (5) sample size ≥ 300 (studies with ≥ 100 considered in sensitivity analyses); (6) published in English or Chinese between 2010 and the search date.

Exclusion criteria: (1) pregnancy-related hypertension; (2) children and adolescents; (3) populations selected solely for chronic mountain sickness or high-altitude pulmonary edema; (4) hospital inpatient or clinic-only samples (considered only in subgroup/sensitivity analyses); (5) conference abstracts without full text and preprints (sensitivity analyses only); (6) reviews, editorials, or commentaries without primary data; (7) studies conducted below 1,500 m or with unascertainable altitude.

Information sources PubMed, Europe PMC, Web of Science, Scopus, CNKI, and Wanfang Data; preprint servers medRxiv and bioRxiv (category browsing); forward and backward citation tracking of all included studies and relevant reviews. Publication period: 2010 to the date of the formal search. Languages: English and Chinese.

Main outcome(s) 1) Prevalence of hypertension (defined by measured blood pressure and/or self-reported diagnosis or use of antihypertensive medication, as defined by each study). 2) Awareness rate among hypertensive participants. 3) Treatment rate among hypertensive participants. 4) Control rate among hypertensive participants (the blood pressure threshold used for control will be recorded for each study; $< 140/90$ mmHg and $< 130/80$ mmHg thresholds will be documented and, if data permit, analysed separately).

Additional outcome(s) Sex-specific rates; proportion of stage 2 or higher hypertension; antihypertensive treatment patterns (where reported).

Data management Two reviewers will independently screen titles/abstracts and full texts, with disagreements resolved by a third reviewer; inter-rater agreement (kappa) will be reported. A piloted extraction form will record: first author and year; country/region; altitude (metres); survey

period; sampling method; sample size; age range and sex distribution; ethnicity; blood pressure measurement method (device, number of readings, position); definitions of hypertension, awareness, treatment, and control (including the control threshold); the numerator and denominator for each rate; and the study quality score. Data will be extracted in duplicate.

Quality assessment / Risk of bias analysis Risk of bias will be assessed using the AHRQ checklist for cross-sectional studies (11 items). Two reviewers will independently assess each study; disagreements will be resolved by consensus or a third reviewer. Studies will be classified as high, moderate, or low risk of bias, and risk of bias will be examined in subgroup and sensitivity analyses.

Strategy of data synthesis Proportion meta-analyses will be performed using random-effects models. Proportions will be transformed using the logit transformation. Pooled estimates with 95% confidence intervals will be reported, along with I^2 , τ^2 , and 95% prediction intervals. Where ≥ 10 studies are available, meta-regression will explore altitude (continuous) and survey year as covariates, and publication bias will be assessed using funnel plots and Egger's test. Analyses will be performed in R (meta/metafor packages) or Stata.

Subgroup analysis Subgroup analyses are planned by: altitude category; ethnicity; survey period (before 2020 vs 2020 or later); sample source (community vs hospital); and risk-of-bias level. Where data permit, control rates will be compared between studies using $<140/90$ mmHg and $<130/80$ mmHg thresholds, and prevalence will be reported by sex.

Sensitivity analysis Sensitivity analyses will include: (1) excluding studies at high risk of bias (AHRQ checklist); (2) excluding studies with a sample size <300 ; (3) excluding conference abstracts and preprints; (4) excluding hospital-based samples; (5) using broader altitude eligibility (including studies at 1,500–2,499 m); (6) leave-one-out analyses; and (7) where data permit, comparing pooled control rates between studies using $<140/90$ mmHg and $<130/80$ mmHg thresholds.

Language restriction English.

Country(ies) involved China.

Other relevant information This review has not been registered in any other registry. The review will be conducted and reported in accordance with

the PRISMA 2020 statement. At the time of this registration, the formal literature search, screening, and data extraction have not yet commenced; the formal search date will be recorded and reported. Any amendments to this protocol will be documented with a dated audit trail.

Keywords hypertension; high altitude; prevalence; awareness; treatment; control; care cascade; systematic review; meta-analysis; plateau.

Dissemination plans Publication in a peer-reviewed journal; presentation at relevant scientific conferences; summary of findings shared with collaborating high-altitude health institutions.

Contributions of each author

Author 1 - Yaxi Zhou - The author conceived the review, drafted the protocol, and will conduct the literature search, study screening, data extraction, quality assessment, and meta-analysis, and will write the manuscript.

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