Review Article

Prevalence, awareness, risk factors and control of hypertension in Nepal from 2000 to 2020: A systematic review and meta-analysis

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ABSTRACT

Objective: To analyse published literatures on prevalence, awareness, risk factors and control of hypertension in Nepal.

Methods: We used electronic databases to search relevant articles from January 2000 till October 2020. All relevant data from selected studies were extracted into a standardized form designed in Excel. Statistical analysis was conducted using Comprehensive Meta-Analysis Software (CMA) version 3. Proportions or Odds Ratio (OR) was used to estimate the outcome with 95% confidence interval (CI). The I-squared (I2) test was used for the assessment of heterogeneity.

Results: We identified a total of 3726 studies after comprehensive database searching. We performed qualitative and quantitative analysis of 40 studies. Pooling data showed 28.52% of patients with hypertension (CI: 26.40 – 30.75); 45.28% (CI: 38.89 – 51.83) aware of their high blood pressure; 31.66% (CI: 23.18 – 41.56) under treatment; 44.4% (CI: 36.17 – 53.04) had their blood pressure under optimum range. 27.4% (CI: 21.57 – 34.11) had pre-hypertensive range elevated blood pressure. 25.99% (CI: 21.81 – 30.65) of females and 34.25% (CI: 30.49 – 38.21) of male were hypertensive (p = 0.007).

The pooling of data showed smokers have 1.43 times (CI: 1.1429 – 1.7889); and alcohol users have 2.073 times (CI: 1.7154 – 2.5050) higher risk of having hypertension. Individuals with normal BMI have 53.15% (OR: 0.4685 CI: 0.3543 – 0.6195); with formal educated have 37.27% (OR: 0.6273, CI: 0.5485 – 0.7175); and with adequate exercise have 31.6% (OR: 0.6839, CI: 0.5203 – 0.8991) lower chance of having hypertension.

Conclusion: Our study shows the prevalence of hypertension in Nepal is high. However, awareness, treatment and subsequently control of high blood pressure are found to be alarmingly low. Hypertension was associated with male gender, smoking, alcohol use, high BMI, no education and inadequate exercise. It calls for more attention to address the burden of hypertension and associated risk factors in Nepal.

1. Introduction

Hypertension (HTN), which is also known as High Blood Pressure (HBP) is one of the leading preventable risk factors for premature cardiovascular diseases and mortality [1]. Persistent uncontrolled hypertension can cause complications like stroke, heart failure, atrial fibrillation, kidney failure, coronary artery diseases, peripheral vascular diseases, retinopathies and vascular dementia [2–4]. Factors such as
unhealthy diet (especially high salt consumption), alcohol and tobacco use, increasing trends of sedentary lifestyle and ageing are attributed to the development of hypertension [5,6].

Hypertension has become one of the major challenging public health concerns globally. It was estimated that more than one billion adults were living with it in 2015, most of them belonging to low and middle income countries [6–8]. Globally, hypertension has reportedly been responsible for 12.8% of all total annual deaths and 3.7% of total disability-adjusted life years (DALYs) [9]. Throughout the world, the high prevalence of hypertension has significantly contributed to present cardiovascular disease pandemic and it is estimated that 29% (i.e. 1.56 billion) of the world’s adult population will be having hypertension by 2025 [6]. The prevalence, awareness and risk factors of hypertension in Nepal has not been properly studied. As much of our health system is focused on battling against communicable diseases like tuberculosis, malaria, kala-azar and other tropical diseases, there is a lack of focus towards common non-communicable diseases which account for a bulk of health problems. Thus, we aimed to evaluate the prevalence, awareness, risk factor and control of hypertension in Nepal through our meta-analysis.

3.1. Protocol registration
The systematic review was registered in PROSPERO (CRD 42020212230) and was documented according to the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) guidelines [10].

3.2. Data sources and search strategy
We used electronic databases like Pubmed, Pubmed Central, Scopus and Google scholar to search relevant articles from January 2000 till October 2020 using the following MeSH terms and appropriate Boolean operators as: “hypertension” [MeSH] OR “high blood pressure” [Tab] OR “Hypertension” AND (“prevalence” OR “risk factor”) AND “Nepal” AND PUB YEAR >1999. The detailed search strategy is documented as Supplementary Appendix 1.

3.3. Eligibility criteria
The eligibility criteria for inclusion were: (1) Cross-sectional studies, prospective and retrospective cohort studies from January 2000 till October 2020; (2) Studies reporting prevalence, awareness, control or risk factors of hypertension in adults (18 years and above) living in Nepal; (3) Published articles. We excluded (1) studies involving older adults who were attending hospital or were hospitalized for chronic diseases; (2) Studies with outcomes like self-reported hypertension; (3) Case reports, case series, narrative reviews, letter to editors, abstracts and posters. For studies with the same dataset, we considered the most comprehensive and updated one.

3.4. Study selection
We filtered the studies using COVIDENCE. Two reviewers (SL, AB) independently screened the title and abstract based on the inclusion criteria. Discrepancies were resolved by consensus obtained from the third reviewer (MS).

3.5. Data collection process and data items/data extraction
All the data were extracted independently by four reviewers (PB, AB, MS, and SL) into a standardized form designed in Excel. All reviewers were involved in verifying the accuracy and completeness of other’s work. The characteristics extracted for each selected study include: first author, year of publication, age group of participants, prevalence of hypertension and prehypertension, population under antihypertensive medication, level of awareness, those with controlled blood pressure and associated risk factors.

3.6. Summary measures
Hypertension was defined as systolic blood pressure (SBP) of 140 mm Hg or more, and/or diastolic blood pressure (DBP) of 90 mm Hg or more, or taking antihypertensive medication (JNC VII). Prehypertension was defined as SBP of 120–139 mm Hg and/or DBP of 80–89 mm Hg. Hypertension control was defined as a hypertensive patient with SBP <140 mm Hg and DBP <90 mm Hg on antihypertensive medication [11].

3.7. Data synthesis
Statistical analysis was conducted using Comprehensive Meta-Analysis Software (CMA) version 3. Proportions or Odds Ratio (OR) was used to estimate the outcome with 95% confidence interval (CI). The I-squared ($I^2$) test was used for the assessment of heterogeneity (0%–40%–might not be important; 30% to 60%–may represent moderate heterogeneity; 50% to 90%–may represent substantial heterogeneity; 75% to 100%–considerable heterogeneity) [12]. Heterogeneity between studies was evaluated using a fixed/random-effects model. Forest plot was used to visualize the degree of variation between studies.

3.8. Risk of bias assessment based on the critical appraisal checklist
We performed the qualitative assessment of the individual study using the Joanna Briggs Institute (JBI) critical appraisal tool. This checklist consisted of 9-items that assessed the methodological quality of a study and determined the extent to which a study has addressed the possibility of bias in its design, conduct and analysis [13]. The bias assessment of 40 included studies are depicted in Table 1.

3.9. Subgroup analysis
Subgroup analyses were conducted based on gender.

3.10. Sensitivity analysis
Sensitivity analysis for prevalence of hypertension carried out by excluding studies with participants less than 500. For other outcomes, sensitivity analysis was done excluding individual study to evaluate its effect in the overall result.

4. Results
We identified a total of 3726 studies after comprehensive database searching. After removal of 365 duplicates, we screened the title and abstracts of 3361 studies. We excluded 3219 studies and assessed the full-text eligibility of 142 studies. A total of 102 studies were excluded with definite reasons and we performed qualitative analysis of 40 studies. Similarly, quantitative analysis of 40 studies were done (Fig. 1).

4.1. Qualitative analysis
The qualitative analysis of 40 included studies are depicted in Table 2. The detailed results of the qualitative synthesis are provided as Supplementary Appendix 2.
4.2. Quantitative analysis

Total 40 studies were included in quantitative synthesis.

4.2.1. Prevalence of hypertension

Using random effect model pooling data from 40 studies showed 28.52% patient with hypertension (Proportion: 0.2852; CI:
0.2640–0.3075; I²: 97.73) (Fig. 2). Sensitivity analysis done excluding individual studies and studies with sample size of less than 500; showed no significant changes (Supplementary Appendix 3; Figs. 1 and 2). Further analysis for prevalence of hypertension based on the timeframe and re-running analysis using random effect showed 26.92% hypertension between 2011 and 2015 (Proportion, 0.2692; CI, 0.2277–0.3152). Similarly, prevalence of hypertension was 31% for 2016–2020 (Proportion, 0.3100; CI, 0.2797–0.3421) (Supplementary Appendix 3; Figs. 3 and 4).

4.2.2. Awareness of hypertensive status
Total 12 studies showed hypertensive awareness status, pooling of data among those studies using random-effect model showed 45.28% of hypertensive patients only aware of the fact that they have high blood pressure (Proportion: 0.4528; CI: 0.3889–0.5183; I²: 95.27%) (Fig. 3). Sensitivity analysis excluding individual studies showed no significant differences (Supplementary Appendix 3; Fig. 5).

4.2.3. Hypertensive individuals under treatment
Seventeen studies reported treatment status among hypertensive patients. Among hypertensive individuals 31.66% were under some form of treatment for their hypertension (Proportion: 0.3166; CI: 0.2318–0.4156; I²: 99.09%) (Fig. 4). Sensitivity analysis performed excluding individual studies showed no significant differences (Supplementary Appendix 3; Fig. 6).

4.2.4. BP under control among patient under treatment
Twelve studies reported blood pressure status among hypertensive patients receiving their treatment. Among hypertensive individuals under some form of treatment, 44.4% have their blood pressure under optimum range (Proportion: 0.4444; CI: 0.3617–0.5304; I²: 94.8) (Fig. 5). Sensitivity analysis performed excluding individual studies showed no significant differences (Supplementary Appendix 3; Fig. 7).

4.2.5. Prevalence of pre-hypertension
Fourteen studies reported prevalence of pre-hypertension in their study population. Pooling data from all 14 studies showed 27.4% have pre-hypertensive range elevation in blood pressure (Proportion: 0.2740; CI: 0.2157–0.3411; I²: 98.65) (Fig. 6). Sensitivity analysis performed excluding individual studies showed no significant differences (Supplementary Appendix 3; Fig. 8).

4.2.6. Prevalence of hypertension based on gender
Twenty-six studies segregated the prevalence of hypertension among females and 27 studies among male. Pooling of data showed 25.99% of females were hypertensive (Proportion: 0.2599; CI: 0.2181–0.3065; I²: 98.59) while 34.25% of male were hypertensive (Proportion: 0.3425; CI: 0.3049–0.3821; I²: 97.21%) and difference was significant (p = 0.007) (Supplementary Appendix 3; Fig. 9).

4.2.7. Smoking and hypertension
Thirteen studies reported smoking status among hypertensive individuals. The pooling of data using random-effect model showed smokers have 1.43 times higher odds of having hypertension comparing with non-smokers (OR: 1.4299; CI: 1.1429–1.7889; I²: 75.82) (Fig. 7). Sensitivity analysis performed excluding individual studies showed no significant differences (Supplementary Appendix 3; Fig. 10).

4.2.8. Alcohol use and hypertension
Twelve studies reported alcohol use habits among hypertensive individuals. The pooling of data using random-effect model showed alcohol users have 2.073 times higher odds of having hypertension comparing with alcohol non-users (OR: 2.0729; CI: 1.7154–2.5050; I²: 63.56) (Fig. 8). Sensitivity analysis performed excluding individual studies showed no significant differences (Supplementary Appendix 3; Fig. 11).
Table 2
Qualitative table.

| Study          | Study type                      | Study Location                                    | Study date                  | Sample size | Age group                              | Response Rate | BP Instrumentation                                      | Measurement frequency | Total number of hypertension cases | Total number of pre-hypertension cases |
|----------------|---------------------------------|--------------------------------------------------|----------------------------|-------------|----------------------------------------|---------------|---------------------------------------------------------|------------------------|-------------------------------------|---------------------------------------|
| Karki [14], 2019 | Community based observational cross-sectional study | Ribidikot Rural Municipality and Tansen Municipality of Palpa district | May to July 2019.           | 372         | 20 and above                          |               | Manual Doctor’s aneroid sphygmomanometer and stethoscope | 3                      | 82/372 (22%)                        | –                                     |
| Manandhar [15], 2012 | Population based cross-sectional study, | 11 wards of Banepa municipally, wards number 1, 3, 5, 6, 7, and 10 | May 15 to June 15, 2009.   | 405         | Above 50 population                    |               | Manual Doctor’s aneroid sphygmomanometer and stethoscope | 2                      | 182/405 (44.9%)                    | –                                     |
| Kafle [16], 2018 | Community-based cross-sectional survey, | ward number eight of Suklagandaki municipality of Tanahu district | 1st November - December 30, 2017. | 568         | Above 18                              |               | Calibrated aneroid sphygmomanometer and stethoscope      | 2                      | 236/568 (41.5%)                    | –                                     |
| Maharjan [17], 2017 | Community cross sectional study, | 4 wards (wards not specified) Kirtipur Municipality | December 2015 to April 2016 | 580         | Age between 20 and 59 years            |               | Manual Doctor’s aneroid sphygmomanometer and stethoscope | 1                      | 215/580 (37%)                      | 130/580 (22.4%)                     |
| Khanal [18], 2018 | Community-based cross-sectional survey, | Lamjung-district-2014 | October-November 2014       | 388         | 40-80 years of age 88.9%              |               | Manual Doctor’s aneroid sphygmomanometer and stethoscope | 3                      | 182/345 (52.9%)                    | –                                     |
| Chautai [19], 2011 | Cross sectional study, | Dhulikhel district | Janawary to march 2011       | 527         | age ≥18 years                          |               | Manual mercury sphygmomanometer and stethoscope           | 1                      | 258/527 (49.4%)                    | 253/527 (48%)                      |
| Khanal [20], 2019 | Descriptive cross-sectional study, | Deurali Village of Nuwakot district | May to July 2019.           | 234         | age ≥18 years                          |               | Aneroid sphygmomanometer and stethoscope                  | 1                      | 20/234 (8.54%)                     | –                                     |
| Dhungana [21], 2018 | Cross sectional study, | Sitapaila Village Development Committee, Kathmandu | February 2014 to February 2015 | 347         | 18-70 years                           |               | Doctor’s Aneroid sphygmomanometer and stethoscope         | 2                      | 128/347 (37.4%)                    | –                                     |
| Dhungana [22], 2014 | Cross sectional study, | Tinkanya Village Development Committee, Sinduli | January and April 2014      | 406         | age 20-50 years                        |               | Doctor’s Aneroid sphygmomanometer and stethoscope         | 3                      | 49/406 (12.3%)                     | 13/406 (3.2%)                      |
| Shrestha S [23], 2016 | Cross sectional study, | Changunarayan Municipality | April and May 2015           | 240         | aged ≥18                              |               | Adult size aneroid sphygmomanometer and stethoscope       | 3                      | 49/240 (20.4%)                     | 85/240 (35.4%)                     |
| TANDSTAD [24], 2017 | Hospital based cross sectional study, | Kiritar health Center, Dolakha, Nepal | Oct to Nov 2016              | 260         | ≥18 years                             |               | Fully automated BP monitor                                | 2                      | 50/260 (19.2%)                     | –                                     |
| Shrestha D [25], 2016 | Cross sectional study, | Hansposa VDC, Sunsari, Nepal High hills areas of ramechhap, solukhumbu and dolakha district | Sep 25 to oct 25 2014       | 351         | ≥25 years                             |               | Aneroid sphygmomanometer                                  | 3                      | 130/351 (37%)                      | 42/351 (11.97%)                    |
| Lamal [26], 2012 | Cross sectional study, | Total 18 sites in 7 districts covering 5 provinces (excluding province 2 and 6) | May and June 2017            | 5968        | ≥18 years                             |               | Both digital (OMRON) and manual sphygmomanometers         | 3                      | 1456/5968 (24.4%)                  | –                                     |
| Mishra [27], 2019 | Cross sectional study, | Duwakot village of Bhaktapur District | Nov 2009                    | 641         | ≥35 years                             |               | Both digital (OMRON) and manual sphygmomanometers         | 3                      | 112/641 (17.5%)                    | –                                     |
| Adhikari [28], 2020 | Cross sectional study, | Nepal | May 2018                  | 15561       | ≥18 years                             |               | Both digital (OMRON) and manual sphygmomanometers         | 3                      | 4321/15561 (27.8%)                 | –                                     |
| Vaidya [29], 2012a | Population-based cross sectional study, | Nepal | Nov 2009                    | 641         | ≥35 years                             |               | Standard mercury sphygmomanometer                          | 2                      | 112/641 (17.5%)                    | –                                     |
| Study          | Study type                        | Study Location                          | Study date       | Sample size | Age group          | Response Rate | BP Instrumentation                          | Measurement frequency | Total number of hypertension cases | Total number of pre-hypertension cases |
|----------------|-----------------------------------|-----------------------------------------|------------------|-------------|--------------------|---------------|---------------------------------------------|------------------------|------------------------------------|---------------------------------------|
| Ghimire [30], 2018 | Secondary analysis of STEPS survey 2013 | Kathmandu valley                       | 2014             | 5530        | ≥18 years         | –             | Automated digital blood pressure monitor    | 1460/5530 (26.4%)     | 2605/5530 (47.1%)                  |                                       |
| Anil [31], 2018   | Cross sectional study             | Kathmandu valley                       | 2014             | 1460/5530   | –                  | 2605/5530 (47.1%) | Standardized calibrated mercury column type sphygmomanometer |                       |                                    |                                       |
| Chatnat [32], 2015 | Community based cross-sectional study | Rural community of Ramechap district    | NR               | 648         | ≥18 years         | –             | Standard mercury sphygmomanometer          | 133/648 (20.5%)       | 302/648 (46.6%)                   |                                       |
| Dhungana [33], 2016 | Community based cross-sectional study | Kathmandu                              | Jan-July 2015    | 587         | ≥18 years         | –             | Aneroid sphygmomanometer                    | 191/587 (32.5%)       |                                    |                                       |
| Shrestha [34], 2016 | Cross sectional study             | Seven urban municipalities              | 2001 to 2002     | 1012        | ≥40 years         | 85.7%         | Mercury sphygmomanometer                    | 230/1012 (22.7%)      |                                    |                                       |
| Vaidya [35], 2018  | Cross sectional study             | Dharan Municipality                    | Jun 2004 to Feb 2005 | 1000      | ≥35 years         | –             | Mercury sphygmomanometer                    | 227/1000 (22.7%)      |                                    |                                       |
| Koju [36], 2011   | Cross sectional study             | Dhalikhel municipality                  | 2007             | 796         | 18-88 (48.41 ± 17.38) | – | – | Mercury sphygmomanometer | 230/796 (28.9%)    | 42/230 (18.3%)                  |                                       |
| Sharma [37], 2011 | Cross sectional study             | Eastern region                         | 2007             | 14422       | 20-100 (41.4 ± 15.1) | – | – | – | 4894/14422 (33.9%) |                                    |                                    |
| Karka [38], 2011  | Cross sectional study             | Dharan Municipality                    | NR               | 119         | 25-86 (54.1 ± 10.5) | – | – | – | 42/119 (35.3%)   |                                    |                                    |
| Vaidya [39], 2012b | Cross sectional study             | Bhadrabas village area of Kathmandu valley | 2006           | 1218        | ≥21 (40.54 ± 16) | 84% | – | Mercury sphygmomanometer | 412/1218 (33.8%) |                                    |                                       |
| Koju [40], 2015   | Cross sectional study             | Nationwide                             | May-13           | 2100        | 18-65 (34.4 ± 12.6) | 99.6% | – | Digital sphygmomanometer | 317/2100 (15.1%) | 915/2100 (43.6%)               |                                       |
| Khanal [41], 2017 | Cross sectional study             | Birendranagar Municipality of Surkhet District | Jan to Dec 2016 | 1159       | ≥30 (47 ± 12.6) | – | – | Aneroid sphygmomanometer | 451/1159 (38.9%) |                                    |                                       |
| Sainju [42], 2018 | Cross sectional study             | Sindupalchowk District                  | 2016             | 1243        | ≥18 (48.73 ± 16.25) | – | – | – | 375/1243 (30.17%) | 137/1243 (11.02%) |                                    |
| Gyawali [43], 2018 | Cross sectional study             | Pokhara Metropolitan City               | 2016             | 2310        | 25-64 | – | Digital sphygmomanometer | 797/2310 (34.5%) |                                    |                                       |
| Gupta [44], 2019  | Secondary analysis of NDHS Survey | Entire Nepal                           | June 2016 to January 2017 | 13393 | Above or equal to 18 | – | – | – | 2827/13393(21.1%, 95% CI = 19.9% - 22.4%) | 137/1243 (11.02%) |                                    |
| Neupane [45], 2017 | Cross-sectional survey             | Lekhnath Municipality, Western Nepal Dhalikhel | 2013          | 2815        | 25-65 year old | 80% | – | Digital Sphygmomanometer | 398/1073 (27.7%) |                                    |                                       |
| Karmacharya [46], 2017 | Cross-sectional study             | Dhalikhel                              | November 2013 March-February 2015 | 1073 | Above 18 | – | Standard Digital Blood Pressure Machine | 298/1073 (27.78%) |                                    |                                       |
| Devkota [47], 2016 | Community cross-sectional study   | Municipalities of Kathmandu District    | January-July 2015 | 587  | 18-70 years | – | – | Aneroid Sphygmomanometer and stethoscope | 191/587 (32.5%) |                                    |                                       |
| Aryal [48], 2018   | Cross-sectional survey of high altitude | More than 2800 m from sea level in Mustang and Humla | June 2014-August 2014 | 521 | More than 30 years | 90% | – | Automatic blood pressure measuring device | 181/521 (34.74%) | 159/521 (30.52%) |                                    |
| Vaidya [49], 2013  | Community based cross-sectional study | Bhaktapur district of Kathmandu Valley | September to November 2011 | 777 | 25-59 years | 94.07% | – | Automated measurement | 168/777 (21%) |                                    |                                       |
| Pyakurel [50], 2018 | Cross-sectional study             | Eastern Nepal Sunsari and Morang       | July 2012 to July 2013 | 494 | 20-59 years | – | Standard technique | 166/494 (33.60%) | 205/494 (41.5%) |                                    |

(continued on next page)
### Table 2 (continued)

| Study | Study type | Study Location | Study Date | Sample size | Response Rate | Age group | BP Instrumentation | Measurement | Total number of hypertension cases | Total number of pre-hypertension cases | Sample Size | Age group | Education | Hypertension | Pre-hypertension |
|-------|-------------|----------------|------------|-------------|---------------|-----------|-------------------|-------------|----------------------------------|---------------------------------------|------------|-----------|------------|--------------|----------------|
| Sharma [51], 2013 | Community based survey | Dharan | September 2003-2005 | 3218 | More than 20 years | - | Standard sphygmomanometer | 1243/3218 | (38.6%) |
| Vaidya [52], 2014 | Population based cross-sectional analytical study | Dharan Municipality | September 2004-2005 | 1000 | More than 35 years | - | Standard mercury sphygmomanometer | 615/1935 (31.8%) | 752/1935 (38.86%) |
| Mehta [53], 2011 | Cross-sectional study | Sunsari District, Eastern Nepal | September 2006-2007 | 1270 | More than 30 years | - | Standard adult mercury sphygmomanometer | 752/1935 (38.86%) | 752/1935 (38.86%) |

#### 4.2.9. BMI and hypertension

Twelve studies reported BMI among hypertensive individuals. The pooling of data using random-effect model showed normal BMI has 53.15% lower odds of having hypertension (OR: 0.4685; CI: 0.3543–0.6195; $I^2 = 91.57$ (Fig. 9). Sensitivity analysis performed excluding individual studies showed no significant differences (Supplementary Appendix 3; Fig. 12).

#### 4.2.10. Education and hypertension

Twelve studies reported education status among hypertensive individuals. The pooling of data using random-effect model showed formal education has 37.27% lower odds of having hypertension (OR: 0.6273; CI: 0.5485–0.7175; $I^2 = 67.25$ (Fig. 10). Sensitivity analysis performed excluding individual studies showed no significant differences (Supplementary Appendix 3; Fig. 13).

#### 4.2.11. Exercise and hypertension

Eight studies reported exercise among hypertensive individuals. The pooling of data using random-effect model showed adequate exercise has 31.61% lower odds of having hypertension (OR: 0.6839; CI: 0.5203–0.8991; $I^2 = 83.82$ (Fig. 11). Sensitivity analysis performed excluding individual studies showed no significant differences (Supplementary Appendix 3; Fig. 14).

#### 4.2.12. Diet, stress, salt intake, residential set-up and hypertension

The pooling of data using random-effect model showed no differences among diet type and hypertension (OR: 0.7568; CI: 0.4022–1.4238; $I^2 = 71.16$ (Supplementary Appendix 3; Fig. 15 and 16). The pooling of data using random-effect model did not show a statistically significant association of stress with hypertension (OR: 2.6887; CI: 0.6840–10.5688; $I^2 = 93.21$) (Supplementary Appendix 3; Fig. 17 and 18). The pooling of data using random-effect model did not show a statistically significant association of salt intake and hypertension (OR: 1.200; CI: 0.7175–2.0991; $I^2 = 61.19$) (Supplementary Appendix 3; Fig. 19). The pooling of data using random-effect model did not show a statistically significant association of residential setup and hypertension (OR: 0.8991; CI: 0.7235–1.0927; $I^2 = 62.78$) (Supplementary Appendix 3; Fig. 20).

Pooling of data on diet, stress, salt intake and residential set-up did not show significant relation with hypertension in this analysis. This may be because of less number of studies reporting these outcomes.

### 5. Discussion

We analyzed 40 studies done in different parts of Nepal after thorough database searching. We found out that hypertension and pre-hypertension are major health problems in Nepal with a prevalence of 28.52% and 27.5% respectively. The results are alarming because 56.02% have a different spectrum of hypertension disorders. The prevalence of pre-hypertension in our study was lower than that reported by Huang et al. (35.4%) which analyzed studies from 2000 to 2018, however, the prevalence of hypertension appears to be similar [54]. The prevalence of hypertension and pre-hypertension in Nepal was similar to the overall prevalence among SAARC countries as reported by Neupane et al. [55] Nepal has the third-highest prevalence of hypertension among the SAARC countries behind Maldives (31.5%) and India (31.4%) [55]. However, the prevalence of hypertension was lower than the global prevalence of hypertension which stands at 40.8% [56].

Only 45.23% of patients with hypertension were aware that they have hypertension. This is lower than the overall awareness in South Asia and Africa where 64.9% and 50.6% were aware that they had hypertension on the diagnosis [56]. Only 31.66% were under some form of antihypertensive following their diagnosis which was lower than 57.8% in South Asia and 46.6% in Africa [56]. This may be attributed to lack of affordability, poor patient counseling regarding the necessity of adhering to treatment, inaccessible health services and increased costs during...
follow up with physicians. Although a national Multi-Sectoral Action Plan (2014–2020) for prevention of hypertension has been developed, there is still a lack of necessary awareness about this condition and poor compliance with the intake of medication [57]. WHO has emphasized on a core set of interventions addressed at primary care level that should be made accessible to all people based on their need and ability to pay as per the WHO Package of Essential Non-Communicable Disease that was implemented in Nepal in 2016 [58]. However, most of the primary care centers at Nepal are understaffed and have inadequate resources to tackle non-communicable diseases. Further, only 44.4% of patients had optimum control of blood pressure. The optimum control of blood pressure was better than in South Asia and Africa where blood pressure was controlled in 24% and 10.6% of the population.

Hypertension was found more in males compared to females in Nepal which was similar to the study done in 2018. Similarly, multiple studies have found hypertension to be more common in males compared to females [55, 56, 59]. We also found an increased risk of hypertension with smoking, drinking alcohol and obesity while higher education and exercise were associated with decreased risk of hypertension. A study in China found an increased risk for hypertension with habitual alcohol use, less physical activity and exercise which is concordant with our finding [59]. Our finding of an association of increased BMI with hypertension was similar to the study done by Neupane et al. which showed a significant association of obesity with hypertension throughout different SAARC countries [55]. We found no association of hypertension with stress, vegetarian diet and excess salt intake. This can be explained by the lack of relevant data about these variables in most of our included studies.

Our study has several strengths. Our meta-analysis is the first meta-analysis to provide comprehensive details about the prevalence, awareness and risk factors of hypertension in Nepal. Although a previous study done in 2018 reported the prevalence of hypertension and prehypertension in Nepal, it included 23 studies and also did not give an idea about the awareness levels and risk factors of hypertension in Nepal [54]. On the other hand, our meta-analysis includes 40 studies. Also, the findings of our study are significant because it highlights the lack of awareness in more than half of people with hypertension about their condition and that more than two-thirds of hypertensive patients do not take any medications. The following condition is worse than some of the least developed parts in the world including the countries in Africa. There is a real need on the side of the government to prioritize the diagnosis, management and prevention of hypertension throughout the country by focusing on modifiable risk factors. Greater awareness needs to be spread regarding the risks of smoking, regular use of alcohol, less physical activity and obesity. In line with the WHO’s package for non-communicable diseases, the primary care centers should be improved, and promotion of health through activities like tobacco cessation, regular physical activity for 30 min, decreased salt intake and a diet rich in vegetables and fruits.

**Fig. 2.** Prevalence of hypertension.
### Fig. 3. Meta-analysis pooling data on awareness status of hypertensive patients.

| Study name   | Event rate | Lower limit | Upper limit |
|--------------|------------|-------------|-------------|
| Neupane, 2017 | 0.485      | 0.432       | 0.499       |
| Karmacharya, 2017 | 0.436      | 0.381       | 0.493       |
| Devkota, 2016  | 0.618      | 0.647       | 0.684       |
| Shrestha, 2016  | 0.777      | 0.697       | 0.840       |
| Adhikari, 2020 | 0.499      | 0.484       | 0.514       |
| Kafle, 2018    | 0.157      | 0.116       | 0.209       |
| Meharjan, 2017 | 0.372      | 0.310       | 0.439       |
| Chataut, 2011  | 0.602      | 0.511       | 0.686       |
| Dhungana, 2018 | 0.425      | 0.340       | 0.515       |
| Kaju, 2010     | 0.313      | 0.256       | 0.376       |
| Vaidya, 2012   | 0.318      | 0.275       | 0.365       |
| Khanal, 2017   | 0.534      | 0.488       | 0.580       |
|               | 0.453      | 0.389       | 0.518       |

### Fig. 4. Meta-analysis pooling data on treatment status of hypertensive patients.

| Study name   | Event rate | Lower limit | Upper limit |
|--------------|------------|-------------|-------------|
| Neupane, 2017 | 0.307      | 0.276       | 0.339       |
| Karmacharya, 2017 | 0.352      | 0.281       | 0.388       |
| Devkota, 2016  | 0.788      | 0.705       | 0.863       |
| Sharma, 2013  | 0.510      | 0.482       | 0.538       |
| Shrestha D, 2016 | 0.215      | 0.153       | 0.294       |
| Mishra, 2019  | 0.376      | 0.352       | 0.402       |
| Adhikari, 2020 | 0.391      | 0.376       | 0.405       |
| Ghimire, 2018 | 0.247      | 0.201       | 0.299       |
| Dhungana, 2016 | 0.157      | 0.112       | 0.216       |
| Kafle, 2018   | 0.753      | 0.677       | 0.817       |
| Meharjan, 2017 | 0.755      | 0.683       | 0.815       |
| Khanal, 2019  | 0.081      | 0.052       | 0.124       |
| Dhungana, 2018 | 0.153      | 0.119       | 0.195       |
| Kaju, 2010    | 0.183      | 0.138       | 0.238       |
| Sharma, 2011 | 0.085      | 0.078       | 0.093       |
| Vaidya, 2012b | 0.235      | 0.197       | 0.279       |
| Khanal, 2017  | 0.290      | 0.250       | 0.334       |
|               | 0.317      | 0.232       | 0.416       |
Fig. 5. Meta-analysis pooling data on blood pressure under control among hypertensive patients receiving their treatment.

**BP under control among patients taking treatment**

| Study name         | Statistics for each study | Event rate | Lower limit | Upper limit |
|--------------------|---------------------------|------------|-------------|-------------|
| Neupane, 2017      |                           | 0.498      | 0.437       | 0.559       |
| Karmacharya, 2017  |                           | 0.354      | 0.266       | 0.452       |
| Devkota, 2016      |                           | 0.495      | 0.395       | 0.595       |
| Shama, 2013        |                           | 0.213      | 0.183       | 0.247       |
| Mishra, 2019       |                           | 0.547      | 0.506       | 0.589       |
| Adhikari, 2020     |                           | 0.527      | 0.503       | 0.550       |
| Dhungana, 2016     |                           | 0.500      | 0.328       | 0.672       |
| Kafle, 2018        |                           | 0.564      | 0.470       | 0.653       |
| Khanal, 2019       |                           | 0.579      | 0.356       | 0.774       |
| Dhungana, 2018     |                           | 0.491      | 0.360       | 0.623       |
| Vaidya, 2012b      |                           | 0.402      | 0.309       | 0.502       |
| Khanal, 2017       |                           | 0.282      | 0.212       | 0.365       |
|                   |                           | 0.444      | 0.362       | 0.530       |

Fig. 6. Meta-analysis pooling data prevalence of pre-hypertension.

**Pre-Hypertension**

| Study name         | Statistics for each study | Event rate | Lower limit | Upper limit |
|--------------------|---------------------------|------------|-------------|-------------|
| Aryal, 2018        |                           | 0.305      | 0.267       | 0.346       |
| Pyakurel, 2018     |                           | 0.415      | 0.372       | 0.459       |
| Mhita, 2011        |                           | 0.389      | 0.367       | 0.411       |
| Shrestha D, 2016   |                           | 0.120      | 0.090       | 0.158       |
| Lamfal, 2012       |                           | 0.153      | 0.127       | 0.184       |
| Anj, 2018          |                           | 0.471      | 0.458       | 0.484       |
| Chautal, 2015      |                           | 0.466      | 0.428       | 0.505       |
| Maharjan, 2017     |                           | 0.224      | 0.192       | 0.260       |
| Chautal, 2011      |                           | 0.480      | 0.438       | 0.523       |
| Dhungana, 2014     |                           | 0.022      | 0.019       | 0.054       |
| Shrestha S, 2016   |                           | 0.354      | 0.296       | 0.417       |
| Koju, 2010         |                           | 0.291      | 0.261       | 0.324       |
| Koju, 2015         |                           | 0.436      | 0.415       | 0.457       |
| Sanju, 2018        |                           | 0.110      | 0.094       | 0.129       |
|                   |                           | 0.274      | 0.216       | 0.341       |
should be done. Patients should be educated by health professionals about the necessity to be compliant with cost-effective medications and about the different cardiovascular risks of untreated hypertension. The alarming findings of our study and the necessary attention it will generate among the concerned authorities add to the significance of our study.

6. Limitations

Our study has several limitations too. Firstly, we included a wide variety of studies with different sample sizes ranging from low to high and people of different socio-demographic features and from various locations. These factors have contributed to significant heterogeneity.
among the included studies. We also add that studies did not use the current definition of American Heart Association classification of hypertension being all our study were based on prior definition, if had been used would have further increased the prevalence of Hypertension. Also, we could not reach firm association of hypertension with several key factors like added salt, stress and DASH diet because of lack of adequate data. Some of the included studies included males only which might have contributed to the increased association of male gender with hypertension. Nepalese community do have some belief towards traditional cultural belief so try not to begin medication in early may have affected the treatment and its compliance.

7. Conclusion

The prevalence of hypertension and pre-hypertension were found to be 28.52% and 27.5% respectively encompassing more than half of the population. Despite widespread prevalence, the awareness of patients regarding their condition and compliance with treatment were found to be alarmingly low. The optimum control of blood pressure was 44.4% following treatment. Hypertension was associated with male gender, smoking, drinking alcohol and increased BMI. Increased attention should be given by the government and concerned agencies to implement core strategies proposed by WHO to decrease the modifiable risk factors for hypertension.

Fig. 9. Meta-analysis pooling relation of BMI and hypertension.

Fig. 10. Meta-analysis pooling relation of education and hypertension.
Moderate/Adequate exercise Versus No/Inadequate exercise

| Study name | Odds ratio | Lower limit | Upper limit | Moderate/Adequate exercise | No/Inadequate exercise | Odds ratio and 95% CI |
|------------|------------|-------------|-------------|----------------------------|------------------------|-----------------------|
| Vaidya, 2014 | 0.870 | 0.626 | 1.208 | 80 / 347 | 113 / 441 | 0.392 | 0.233 | 0.638 |
| TANDSTAD, 2017 | 0.492 | 0.211 | 0.207 | 42 / 2 | 234 / 12 | 0.472 | 0.268 | 0.849 |
| Shrestha D, 2016 | 0.400 | 0.248 | 0.645 | 75 / 232 | 53 / 106 | 0.513 | 0.305 | 0.863 |
| Karki, 2019 | 0.751 | 0.400 | 1.409 | 25 / 136 | 24 / 104 | 1.071 | 0.981 | 1.170 |
| Shrestha S, 2016 | 0.708 | 0.545 | 0.919 | 687 / 2046 | 110 / 264 |
| Sharma, 2011 | 1.071 | 0.981 | 1.170 | 1333 / 3543 | 1898 / 5268 |
| Khanal, 2017 | 0.630 | 0.493 | 0.805 | 260 / 744 | 191 / 415 |
| Gyawali, 2019 | 0.708 | 0.545 | 0.919 | 687 / 2046 | 110 / 264 |

Fig. 11. Meta-analysis pooling relation of exercise and hypertension.

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Availability of data and materials
The datasets analyzed during the current study is available in supplementary appendix 2.

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Authors' contributions
DBS, PB, and YRS contributed to the concept and design, analysis, and interpretation of data. DBS, PB, AB, SI, MS, BJK, RKB and NP contributed to the literature search, data extraction, review and initial manuscript drafting.

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Declaration of competing interest
The authors declare that they have no competing interests.

Appendix A. Supplementary data
Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhip.2021.100119.

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