Hypertension in a rural community in Sri Lanka: prevalence, associated factors and its effect on the renal profile

Sameera Senanayake, Thilanga Ruwanpathirana, and Nalika Gunawardena

Introduction: Chronic kidney disease (CKD) in which the disease cannot be attributed to any known cause is named CKD of uncertain aetiology (CKDu). The main aims of this analysis were to estimate the prevalence of hypertension and to identify the associated factors in a rural community vulnerable to CKDu and to identify the effect of hypertension on the renal profile among this community.

Methods: We conducted a cross-sectional representative population survey in five study areas in Anuradhapura district, a rural district in Sri Lanka. Blood pressure, blood glucose, bioimpedance measurements and renal profile were measured using standard instruments and protocols.

Results: A total of 4803 participants (88.7%) took part in the study. The overall prevalence of hypertension in the study population was 26.3% (95% confidence interval 25.0–27.5). Among those who were previously diagnosed, only 17.3% had normal blood pressure. Increasing age, family history of hypertension, presence of diabetes mellitus, estimated glomerular filtration rate (eGFR) less than 60 ml/min per 1.73 m² and increasing BMI were independently associated with having hypertension. High prevalence of hypertension was observed among those who had eGFR less than 60 ml/min per 1.73 m². Hypertension was significantly associated with having eGFR less than 60 ml/min per 1.73 m² (adjusted odds ratio 2.931).

Conclusion: One in four individuals in the rural district of Anuradhapura is a hypertensive. Hypertension poses a significant burden to CKD even in populations affected by CKDu. Hence, public health initiatives should be implemented parallelly to control both CKDu and hypertension in these rural communities.

Keywords: chronic kidney disease of uncertain cause, hypertension, Sri Lanka

Abbreviations: ACR, albumin-Creatinine ratio; aOR, adjusted odds ratio; BP, blood pressure; CKD, chronic kidney disease; CKDu, chronic kidney disease of uncertain aetiology; eGFR, estimated glomerular filtration rate; NCDs, noncommunicable diseases; NCP, North Central Province

INTRODUCTION

The prevalence of hypertension, a major modifiable risk factor of noncommunicable diseases (NCDs), is increasing globally. It is projected to affect 29% or approximately 1.56 billion of the adult world's population by 2025 and this will be a 60% increase from the corresponding figure in the year 2000 [1]. World over, hypertension is responsible for around 45% deaths related to ischaemic heart disease and 51% deaths due to stroke [2]. Of the global attributable burden of hypertension, 80% is said to occur in low-income and middle-income countries [3]. However, less is known about the magnitude, distribution and determinants of hypertension in these parts of the world.

During the World Health Assembly in 2013, the countries set a target to reduce the prevalence of hypertension by a quarter of its 2010 level, by 2025 [4]. Furthermore, the 2030 Agenda for Sustainable Development targets to reduce premature mortality from NCDs by one-third by 2030 with a focus on universal health coverage, reaching all [5]. Thus, it is imperative that low-income and middle-income countries generate epidemiological evidence on magnitude, distribution and determinants of hypertension among the population groups that are likely to be more vulnerable for NCDs, which will enable them design and implement evidence-based targeted interventions [6].

Research confirm that the prevalence and the determinants of hypertension vary significantly according to the place or residence even within a country [7–9]. According to two studies done by Kibria et al. [6] in Bangladesh and Wang et al. [9] in China, a significant difference in the prevalence was noted between urban and rural populations.

Current burden of hypertension in Sri Lanka and its geographical distributions is poorly understood. This is in the context wherein a contrasting difference is observed in the socioeconomic context between urban and rural communities and many health-related indicators show urban rural disparities with rural populations showing...
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140 mmHg and/or

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Sri Lanka [16]. The study was conducted in three of

survey designed primarily to estimate the magnitude of

This was a community-based, cross-sectional household

Study design and study setting

MATERIALS AND METHODS

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relatively poorer outcomes [10]. Lack of recent population-based epidemiological studies, variations of definitions used to define hypertension and failing to present disaggregated estimates of geographical distributions are some of the reasons.

According to a national survey conducted in 2005 by Katulanda et al. [11], the prevalence of hypertension was 27.4% [95% confidence interval (95% CI) 26.1–28.7] among adults of more than 18 years of age (n = 4485). The study included both the ‘diagnosed hypertension’ (previously diagnosed at a government hospital or by a registered medical practitioner or if they were on antihypertensive treatment) and ‘undiagnosed hypertension’ [the average of two resting seated blood pressure (BP) readings, separated by 5 min were above or equal to 140/90 mmHg] in its estimation of hypertension prevalence. The prevalence of hypertension among urban and rural populations were 26.5% (95% CI 25.7–27.7) and 22.9% (95% CI 21.5–24.3), respectively, confirming the vulnerability of the rural populations. The latest source of evidence on prevalence of hypertension from a population-based survey in Sri Lanka is from the WHO’s STEPS survey conducted in 2015. It included a nationally representative sample of 5188 adults aged 18–69 years and reported a prevalence of raised BP of 26.1% (95% CI 24.4–27.7) accounted by those on medication for hypertension and those who had raised BP at the time of survey [the average of two resting seated BP readings, separated by 5 min were SBP > 140 mmHg and/or DBP > 90 mmHg] [12]. It does not present the disaggregated estimates for urban and rural populations.

Hypertension is a well known risk factor of chronic kidney disease (CKD) [13, 14]. Triggered by an exponential increase noted in the number of CKD cases in the rural populations of the North Central Province (NCP) in Sri Lanka in early 1990s, the rising burden of CKD in Sri Lanka has drawn the attention of national and international medical communities [15]. CKD in which the disease cannot be attributed to any known cause, such as hypertension, is named CKD of uncertain aetiology (CKDu) and the rise in CKD burden in rural populations of NCP is attributed to cases of CKDu. However, although all the attention is drawn to the ‘unknown’ CKD (CKDu), burden of CKD due to known causes such as hypertension is poorly understood in communities affected by CKDu.

In this milieu, the main aims of this analysis are to fill two knowledge gaps; first was to estimate the prevalence of hypertension and to identify the associated factors in a rural community in NCP vulnerable to CKDu and the second was to identify the effect of hypertension on the renal profile among this community. The evidence generated from this analysis will help to better understand the burden of hypertension and design targeted interventions in rural CKDu-affected communities in Sri Lanka.

MATERIALS AND METHODS

Study design and study setting

This was a community-based, cross-sectional household survey designed primarily to estimate the magnitude of impaired kidney function in the district of Anuradhapura, Sri Lanka [16]. The study was conducted in three of 23 Divisional Secretariat areas of the Anuradhapura district, from March to May 2017. Anuradhapura district is a rural agricultural district and the most CKDu affected district in Sri Lanka. Within the three Divisional Secretariat areas, five geographically demarcated settings comprising two to four villages located adjacent to each other were selected as the study areas. The basis for the geographical demarcation was to include approximately 1000 potentially eligible adult residents.

Study participants

All adults above the age of 18 years, whose main place of residence (defined as living in the setting for at least for 5 days of the week for the past 6 months) was in the study area, were invited to take part. Exclusion criteria were pregnancy and patients undergoing treatment for cancer.

Sample size and sampling technique

This study presents an analysis of data collected to determine the population prevalence of impaired kidney function in the Anuradhapura district. The required sample size was estimated as 1000 from each of the five study areas [17] with 5000 from all areas. We confirmed that this sample size also allows accurate estimation of the prevalence of hypertension with sufficient statistical power for comparisons between population subgroups. As indicated above, the study areas were selected to ensure an approximate 1000 potentially eligible adult residents from each of the five areas, and this was done using the official updated voter’s lists of local administrative officers. Using the voter’s lists as the base, all of the households in the defined study area were visited and all eligible adults were invited to take part. Study information was provided, and those granting informed written consent were recruited to the study. A team of 10 graduates from a University located in the district were trained to collect data.

Data collection

Upon recruitment, history related to previous diagnosis of hypertension and treatment were collected in the home using an interviewer-administered questionnaire by the trained interviewers. The medical and treatment records were photographed and were used to cross check the accuracy of the self-reported information at the stage of analysis. Information on other existing NCDs, sociodemographic and lifestyle characteristics were also collected using the interviewer-administered questionnaires. Upon completion of the questionnaire, study participants were provided with a container and an instruction sheet on collecting the early morning urine sample and were requested to visit the ‘clinic’ on the following day before work for the anthropometry measurements and biological sample collection. Revisits of the houses were done to recruit any eligible study participants who were not available in the house at the time of the first visit. The ‘clinics’ were set up within the study areas in locations that were acceptable and accessible to all the villagers and about 100 were invited to each clinic.

At the clinics, the trained data collectors performed the BP measurements.
All data collectors successfully completed training sessions on the use of the BP measurement protocol. The training included preparation of study participants for BP measurement, selection of an appropriate cuff size and standard BP measurement techniques. BP was measured using calibrated automated ‘Omron HEM-7270 Intelisense Electronic Blood Pressure Monitor’ (Omron Corp., Kyoto, Japan). Three measurements were done on each study unit in sitting position ensuring 5 min resting in between each measurement. Other than the BP measurements, samples of 5 ml of blood were drawn for measurements of serum creatinine and samples of overnight urine were collected for measurement of urine proteins. Capillary random plasma glucose was measured using a glucometer, height using stadiometer, bioimpedance outputs of body fat percentage, BMI and total body water percentage using a TANITA SC-240MA body composition analyser (Tanita Corp., Tokyo, Japan).

Serum creatinine and urine protein: creatinine ratio was tested in the laboratory of the Anuradhapura Teaching Hospital. Serum creatinine was measured using assays calibrated utilizing quality controls traceable to isotope dilution mass spectrometry (IDMS) standards. Estimated glomerular filtration rate (eGFR) value was calculated using the CKD-EPI equation, which needed the serum creatinine value, age, sex and race (black or other).

Institutional ethics committee approval was obtained from the Ethics Review Committee of the Faculty of Medicine, University of Colombo (EC-17-031). All the study units were informed regarding their clinical and laboratory findings. Those who require medical referral were referred to the Anuradhapura Teaching Hospital for appropriate care.

**Data analysis**

In estimating the prevalence of hypertension, a study unit was classified as having ‘hypertension’, if he/she had any of the following criteria:

1. previously diagnosed of hypertension with evidence of medical records;
2. being on antihypertension drugs;
3. the average of two resting seated BP readings of SBP more than 140 mmHg and/or DBP at least 90 mmHg at the time of the survey.

Prevalence of hypertension was estimated for the total population and for subgroups of population disaggregated by age, sex and area.

The mean values of clinical and biochemical parameters, namely BMI, body fat percentage, eGFR value, urine albumin-creatinine ratio (ACR) and random blood glucose (RBS) of those classified as hypertension were compared with those without. Nonparametric tests were used, as all the above variables were nonnormally distributed indicating a skewed distribution.

Mean SBP and DBP were calculated dividing the cumulative SBP and DBP by the total number of study units. Distribution of the mean SBP and mean DBP of the total study population and men and women by sociodemographic, lifestyle and biological characteristics, presence of diabetes and renal function were evaluated for significant differences.

Furthermore, the study units previously diagnosed as hypertensive individuals and who were identified as having hypertension at the survey were categorized into five groups in line with the American Heart Association guidelines [18].

1. Normal: Less than 120/80 mmHg
2. Elevated: Systolic between 120 and 129 mmHg and diastolic less than 80 mmHg
3. Stage 1: Systolic between 130 and 139 mm Hg or diastolic between 80 and 89 mmHg
4. Stage 2: Systolic at least 140 mmHg or diastolic at least 90 mmHg
5. Hypertensive crisis: Systolic over 180 mmHg and/or diastolic over 120 mmHg

Association of sociodemographic, lifestyle and biological characteristics and presence of diabetes with hypertension were identified by conducting bivariate as well as multiple logistic regression analyses. In classifying a study unit as a diabetic, he/she was considered a diabetic if he/she either self-reported being a diabetic (with evidence of medical records) or being on treatment for diabetes or capillary random plasma glucose more than 200 mg/dl at the time of survey.

To assess the independent association between renal effect and hypertension, two separate logistic regression models were developed, keeping eGFR level (eGFR less than 60 ml/min/1.73 m² and eGFR more than or equal to 60 ml/min per 1.73 m²) and urine ACR (less than or equal to 30 mg/g and ACR more than or equal to 30 mg/g) as dependent variables. The other factors controlled in the models were age, sex, number of years of education, current smoking status, current alcohol consumption status, daily water intake, body fat percentage, body water percentage, BMI, diabetes mellitus, family history of CKD, use of agrochemicals and ever occupied in farming.

A *P* value of less than 0.05 was considered statistically significant.

**RESULTS**

**Characteristics of the study participants**

The total study included 4803 participants with an overall response rate of 88.7%. Nearly half of the study participants were in the age category of 31–50 years. Of the study population, majority were women (68.2%). Nearly 50% of the participants (46.6%) were engaged in full-time farming and 28.7% in part-time farming.

**Prevalence of hypertension in the population**

The overall prevalence of hypertension in the study population was 26.3% (95% CI 25.0 – 27.5) (*n* = 1262). Of those classified as having hypertension, 58.0% (*n* = 733) were previously diagnosed with evidence of medical records or were on antihypertension drugs, while 41.9% (*n* = 529) were not, but found to have average BPs of SBP more than 140 mmHg and/ or DBP more than 90 mmHg > 140/90 at the time of the survey (Table 1). There was no significant difference in the prevalence of hypertension between men 27.9% (95% CI 25.7 – 30.2) and...
women 25.4% (95% CI 23.9–26.9) ($P = 0.065$). In both sexes, the prevalence of hypertension significantly increased with increasing age ($P < 0.05$).

Evaluating the treatment history of the 733 who had records of previously been diagnosed with hypertension, 396 (54.0%) were found not to be on any medications in spite of having been prescribed drugs. A total of 167 (22.8%) were on one drug, 99 (13.7%) were on two drugs and 71 (9.7%) were on more than two drugs, at the time of survey.

Table 2 describes the mean values of clinical and biochemical parameters according to the hypertension status. BMI, body fat percentage, eGFR value, urine ACR and RBS values were significantly ($P < 0.001$) higher in those who had hypertension.

**Distribution of SBP and DBP according to different characteristics**

The mean SBP and the mean DBP in the study sample were 121.2 (SD $\pm$ 15.5) and 74.4 (SD $\pm$ 13.2), respectively (Table 3). Both mean SBP and DBP were significantly ($P < 0.05$) higher in men than in women. In both men and women, the lowest SBP was observed in the youngest age category (age 18–30 years), while the highest was among the oldest age category (age more than 70 years). Those who were not occupied in farming recorded the lowest SBP and DBP and this was seen in both men and women. As expected, the participants who had a family history of hypertension had the highest SBP and DBP. Interestingly, consumption of alcohol and smoking were not significantly associated with both SBP and DBP in both sexes. Among those who had records of previously been diagnosed with hypertension, those who were not on any antihypertensive drugs recorded the highest mean SBP and DBP between both sexes. Study participants who had either diabetes mellitus or eGFR less than 60 ml/min per 1.7 m$^2$ had significantly higher SBP and DBP than those who did not.

Distribution of the study units previously diagnosed as hypertensive individuals and who were identified as having hypertension at the survey according to the American Heart Association guidelines is presented in Table 4. Among those who were previously diagnosed, only 17.3% had normal BP. The category that reflects the poorest BP control, the 'hypertensive crisis', recorded 2.1% of those who were previously diagnosed as well as 3.6% of those who were identified as having hypertension at the survey.

**Factors associated with hypertension**

Multiple logistic regression analysis was performed to evaluate the factors independently associated with hypertension (Table 5). Increasing age (adjusted odds ratio (aOR) 1.068), family history of hypertension (aOR 1.736), presence of diabetes mellitus (aOR 2.594), eGFR less than 60 ml/min per 1.7 m$^2$ (aOR 2.772) and increasing BMI (aOR 1.051) were found to be significantly associated with having hypertension. Being a female (aOR 0.598) and increase in body water percentage (aOR 0.957) were significant protective factors of having hypertension.

| TABLE 2. Comparison of clinical and biochemical parameters according to the hypertension status |
|---------------------------------------------|---------------------------------------------|---------------------------------------------|
| Clinical and biochemical parameters         | Hypertensive Mean (SD)                      | Nonhypertensive Mean (SD)                   |
|---------------------------------------------|---------------------------------------------|---------------------------------------------|
| BMI (kg/m²)                                 | 24.3 (5.2)                                  | 22.8 (4.6)                                  |
| Body fat percentage                         | 31.0 (9.3)                                  | 28.7 (9.4)                                  |
| Body water percentage                       | 49.5 (5.9)                                  | 50.0 (5.3)                                  |
| eGFR (60 ml/min per 1.7 m²)                 | 71.4 (27.9)                                  | 93.3 (23.6)                                  |
| Urine albumin-creatinine ratio (mg/g)       | 78.2 (325.4)                                 | 24.5 (209.0)                                 |
| Random blood glucose value (mg/dl)          | 139.8 (62.1)                                 | 118.3 (42.7)                                 |

* Mann–Whitney U test.
TABLE 3. Mean SBP and DBP and sociodemographic characteristics in all adults, men and women

| Age categories | Male (N = 1529) | Female (N = 3274) |
|----------------|-----------------|------------------|
| 18–30          |                 |                  |
| 31–50          |                 |                  |
| 51–70          |                 |                  |
| > 70           |                 |                  |
| Number of years of education in schools and in higher education institutes |                 |                  |
| No schooling   |                 |                  |
| < 10           |                 |                  |
| ≥ 10           |                 |                  |
| Ever occupied in farming |                 |                  |
| No             |                 |                  |
| Part-time farming |               |                  |
| Full-time farming |              |                  |
| Family history of hypertension |                 |                  |
| Present         |                 |                  |
| Absent          |                 |                  |
| Current use of alcohol |             |                  |
| Present         |                 |                  |
| Absent          |                 |                  |
| Current smoking |                 |                  |
| Present         |                 |                  |
| Absent          |                 |                  |
| Daily water intake |              |                  |
| Less than 3 l  |                 |                  |
| ≥ 3 l           |                 |                  |
| Number of antihypertensive drugs* (N = 733) |                 |                  |
| Not on drugs    |                 |                  |
| One drug        |                 |                  |
| Two drugs       |                 |                  |
| More than two drugs |             |                  |
| Diabetes mellitus |               |                  |
| Present         |                 |                  |
| Absent          |                 |                  |
| eGFR level <60  |                 |                  |
| ≥60             |                 |                  |

**TABLE 4. Distribution of the study units identified as having hypertension according to the American Heart Association guidelines**

| American Heart Association category | Previously diagnosed as having hypertension no. (%) | Identified as having hypertension at the survey no. (%) |
|------------------------------------|---------------------------------------------------|------------------------------------------------------|
| Normal                             | 127 (17.3)                                        | 0 (0.0)                                              |
| Elevated                           | 102 (13.9)                                        | 0 (0.0)                                              |
| Stage – 1                          | 193 (26.3)                                        | 0 (0.0)                                              |
| Stage – 2                          | 296 (40.4)                                        | 510 (96.4)                                           |
| Hypertensive crisis                | 15 (2.1)                                          | 19 (3.6)                                             |
| Total                              | 733 (100.0)                                       | 529 (100.0)                                          |

Independent effect of hypertension on the renal profile

High prevalence of hypertension was observed among those who had eGFR less than 60 ml/min/1.73 m² (61.7% (95% CI 57.8–65.6)) compared with those who had more than or equal to 60 ml/min per 1.7 m² (21.1% (95% CI 19.8–22.3)). Furthermore, the prevalence of hypertension among those who had the urine ACR more than 30 mg/g (49.1%; 95% CI 44.4–53.7) was significantly higher than those who had ACR less than 30 mg/g (23.9%; 95% CI 22.6–25.2).
To assess the independent association between renal effect and hypertension, multiple logistic regression analysis was performed. Two separate logistic regression models were run, keeping eGFR level (eGFR less than 60 ml/min per 1.7 m$^2$ and eGFR more than or equal to 60 ml/min/1.7 m$^2$) and urine ACR (ACR less than or equal to 30 mg/g and ACR more than 30 mg/g). The other factors controlled in the models were age, sex, number of years of education, current smoking status, current alcohol consumption status, daily water intake, body fat percentage, body water percentage, BMI, diabetes mellitus, family history of CKD, use of agrochemicals and ever occupied in farming. The results indicate that hypertension is significantly associated with having eGFR less than 60 ml/min per 1.7 m$^2$ (aOR 2.931) and ACR more than 30 mg/g (aOR 2.168) (Table 6).

**DISCUSSION**

This study was done to assess the burden of hypertension and its effect on the renal profile in a rural CKDu-affected community in Sri Lanka. To the best of the authors’ knowledge, this is the first in-depth analysis of the burden of hypertension in a rural community severely affected by CKDu.

The overall prevalence of hypertension in the study population was 26.3% (95% CI 25.0–27.5). There was no

| Covariates                        | Bivariate analysis | Multivariate analysis |
|-----------------------------------|--------------------|-----------------------|
|                                   | OR                 | 95% CI                | Sig. | aOR   | 95% CI   | Sig.  |
| Age in years                      | 1.073              | 1.067                 | 1.079| 0.001 | 1.068 | 1.060 | 1.076 | <0.001 |
| Sex                               |                    |                       |      |       |        |       |       |       |
| Male                              | 0.879              | 0.767                 | 1.008| 0.065 | 1.058 | 0.835 | 1.338 | 0.645 |
| Female                            |                    |                       |      |       |        |       |       |       |
| Number of years of education      | 0.905              | 0.887                 | 0.922| 0.001 | 0.996 | 0.980 | 1.011 | 0.580 |
| Ever occupied in farming          |                    |                       |      |       |        |       |       |       |
| No                                | 2.565              | 2.119                 | 3.102| 0.001 | 1.577 | 0.835 | 1.338 | 0.645 |
| Part-time farming                 | 3.332              | 2.726                 | 4.073| 0.001 | 1.211 | 0.868 | 1.447 | 0.381 |
| Family history of hypertension    |                    |                       |      |       |        |       |       |       |
| Present                           | 1.605              | 1.404                 | 1.835| 0.001 | 1.736 | 1.472 | 2.046 | <0.001 |
| Absent                            | 1                  |                       |      |       |        |       |       |       |
| Current use of alcohol            |                    |                       |      |       |        |       |       |       |
| Present                           | 0.820              | 0.687                 | 0.977| 0.027 | 0.834 | 0.63  | 1.105 | 0.206 |
| Absent                            | 1                  |                       |      |       |        |       |       |       |
| Current smoking                   |                    |                       |      |       |        |       |       |       |
| Present                           | 0.969              | 0.770                 | 1.218| 0.778 | 1.024 | 0.746 | 1.405 | 0.884 |
| Absent                            | 1                  |                       |      |       |        |       |       |       |
| Daily water intake                |                    |                       |      |       |        |       |       |       |
| Less than 3 l                     | 1.055              | 0.883                 | 1.114| 0.939 | 1.082 | 0.917 | 1.277 | 0.352 |
| ≥ 3 l                             | 1.055              | 0.883                 | 1.114| 0.939 | 1.082 | 0.917 | 1.277 | 0.352 |
| Diabetes mellitus                 |                    |                       |      |       |        |       |       |       |
| Present                           | 5.029              | 4.128                 | 6.127| 0.001 | 2.594 | 2.051 | 3.281 | <0.001 |
| Absent                            | 1                  |                       |      |       |        |       |       |       |
| eGFR level                         |                    |                       |      |       |        |       |       |       |
| < 60                              | 6.074              | 5.069                 | 7.276| 0.001 | 2.772 | 2.203 | 3.49  | <0.001 |
| ≥ 60                              | 1.065              | 1.050                 | 1.080| 0.001 | 1.051 | 1.021 | 1.083 | 0.001 |
| Body fat percentage               | 1.027              | 1.020                 | 1.034| 0.001 | 1.014 | 0.991 | 1.038 | 0.247 |
| Body water percentage             | 0.983              | 0.971                 | 0.994| 0.004 | 0.957 | 0.931 | 0.983 | 0.001 |

aOR, adjusted odds ratio; CI, confidence interval; eGFR, estimated glomerular filtration rate.

### TABLE 6. Independent effect of hypertension on the renal profile among study participants

| Renal parameter (dependent variable in the multiple logistic regression model) | Hypertension status (as an independent variable) | Adjusted OR of being a hypertensive (95% CI) |
|-------------------------------------------------------------------------------|-----------------------------------------------|------------------------------------------|
| eGFR level < 60                                                              | Hypertensive                                  | 2.931 | 2.321 | 3.698 | <0.001 |
|                                                                     | Nonhypertensive                               | 1                                             |
| Urine albumin-creatinine ratio > 30 mg/g                                    | Hypertensive                                  | 2.168 | 1.711 | 2.748 | <0.001 |
|                                                                     | Nonhypertensive                               | 1                                             |

aOR, adjusted odds ratio; CI, confidence interval; eGFR, estimated glomerular filtration rate.
significant difference in the prevalence of hypertension between men 27.9% (95% CI 25.7–30.2) and women 25.4% (95% CI 23.9–26.9). The current study defined ‘hypertension’ as previously diagnosed with evidence of medical records or being on antihypertensive drugs or the average of two resting seated BP readings of SBP more than 140 mmHg and/or DBP at least 90 mmHg at the time of the survey. This was in keeping with the two national surveys conducted in Sri Lanka, STEPS survey (2015) [12] and the study by Katulanda et al. [11], which allowed comparisons across the studies. Katulanda et al. [11] reported a prevalence of hypertension of 22.9% (95% CI 21.5–24.3) among a rural community, with a similar age and sex distribution to the present study, which was significantly lower than the prevalence of hypertension among the rural population of the present study. The data of the study by Katulanda et al. [11] were collected in 2005 and this significant increase of prevalence can be attributed to the time lapse. However, possibilities of higher vulnerability of the CKDu-affected communities included in the present study to hypertension need to be further explored. Although more recent, the STEPs survey in 2015 did not stratify the prevalence according to the rural and urban areas, precluding direct comparison with the results of the present study. Comparable prevalence of hypertension in rural parts of other regional countries was evident in the literature. According to a study done in rural communities in India [19], the prevalence was found to be 27.0% (95% CI 26.3–27.7).

In the present study, 11.0% (n = 529) were found to have average BPs of SBP more than 140 mmHg and/or DBP more than 90 mmHg and were classified as hypertensive at the time of the survey. Furthermore, 3.6% among them were in hypertensive crisis (>180/120 mmHg) at the time of detection. The problem of undiagnosed hypertensive patients was evident in Argentina (35.9%) [20], India (22.2%) [21] and China (15.5%) [22], indicating that it is a public health problem that needs greater attention.

Among those who were already diagnosed as having hypertension, 23.2% were on two or more antihypertension medications. This value is slightly lower than a multicountry study done by Jafar et al. [23], which included Sri Lanka, where 31% of the already diagnosed hypertensive patients were on two or more drugs. Evidence indicate that it takes two to three antihypertensive drugs to achieve optimal BP control [24]. In United States, the use of multiple classes of antihypertensive drugs increased from 37% in 2001 to 48% in 2009. Furthermore, the overall hypertension control rate increased from 29 to 47% during the same time period [25].

The American College of Cardiology and the American Heart Association (ACC/AHA) latest guidelines recommended target BP levels below 130/80 mmHg, irrespective of the comorbid conditions or age [26]. In the current study, among those who were previously diagnosed, 68.8% had their BP more than 130/80 mmHg. The fact that those with an existing diagnosis of hypertension showed poor BP control, together with the fact that the proportion of diagnosed hypertensive patients taking two or more drugs was comparatively low in the study population, could indicate lack of effective titration of number of antihypertensive medications among this rural community, which could have been contributed to the poor BP control.

Poor control of BP among those who are already diagnosed in rural communities is a common finding evidence indicating that poor compliance is the main reason for unsatisfactory BP control [27]. Two studies done in two resource-poor settings in Nigeria and Pakistan found that the compliance could be as low as 32–48% [28,29]. Poor knowledge of the importance of the compliance [30] and lack of affordability of drugs due to high out-of-pocket expenditure [31] were found to be associated with poor compliance.

Multiple logistic regression analysis revealed increasing age, male sex, family history of hypertension, presence of diabetes mellitus, eGFR less than 60 ml/min per 1.7 m² and increasing BMI to be significantly associated with having hypertension. Old age and increased BMI are consistently been found to be associated with increased risk of hypertension [32,33]. Evidence concerning the sex has been inconsistent in the literature. According to a meta-analysis by Neupane et al. [33], male sex was a significant risk factor of hypertension [odds ratio (OR) 1.19; 95% CI 1.02–1.37] [32] and similar finding was found in couple of other studies as well [34,35]. However, contrasting results have been evident in couple of studies done in several Asian countries [6,36,37].

Although there is lack of evidence regarding the population attributable risk of hypertension on CKD [38], hypertension is an established risk factor of CKD [39]. In our study, the prevalence of hypertension was significantly higher among those who had eGFR less than 60 ml/min per 1.7 m² (61.7%), and those who had ACR more than 30 mg/g (49.1%). However, interestingly, both these proportions are much low when compared with the current literature from other countries. According to the United States Renal Data System (2013), prevalence of hypertension among those who has eGFR less than 60 ml/min per 1.7 m² is around 84% and among those who had ACR more than 30 mg/g is around 69% [40].

CKDu in Anuradhapura is characterized by eGFR less than 60 ml/min per 1.7 m² and/or ACR more than 30 mg/g, with no known risk factors of CKD, such as hypertension and diabetes. Thus, comparatively low proportions of those with hypertension among those with poor renal profile could reflect the situation of CKDu in the study area.

Our study had couple of limitations. Although longitudinal measurement of BP is needed to confirm the diagnosis of hypertension, those with the average of two high resting BP readings at the time of the survey were considered as having hypertension. Similarly, blood glucose measurements and eGFR values were also measured only once, thus misclassification is a possibility.

In conclusion, one in four individuals in the rural district of Anuradhapura is a hypertensive.

Poor BP control and treatment compliance among majority of those who had been previously diagnosed as hypertension is a great concern. Couple of modifiable risk factors were identified during the study and targeted primary preventive interventions are recommended. Poor renal profiles in the absence of any known causes of CKD confirmed the vulnerability of the study population to CKDu.
REFERENCES

1. Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J. Global burden of hypertension: analysis of worldwide data. Lancet 2005; 365:217–223.

2. World Health Organization. Causes of death 2008: data sources and methods. Geneva: World Health Organization; 2011. https://www.who.int/healthinfo/global_burden_disease/cod_2008_sources_methods.pdf. [Accessed 25 November 2018]

3. Lawes CM, Vander Hoorn S, Rodgers A. Global burden of blood-pressure-related disease, 2001. Lancet 2008; 371:1513–1518.

4. World Health Organization. About 9 voluntary global targets: global monitoring framework for NCDs. Geneva: World Health Organization, 2017. https://www.who.int/mnh/ncd-tools-definition-targets/en/. [Accessed 20 December 2018]

5. United Nations. Sustainable Development Goal 3 - ensure healthy lives and promote well-being for all at all ages. United Nations; 2018. https://sustainabledevelopment.un.org/SDG3/

6. Kibria GM, Swasey K, Das Gupta R, Choudhury A, Nayeej S, Sharmeen A, et al. Differences in prevalence and determinants of hypertension according to rural-urban place of residence among adults in Bangladesh. J Biostat Sci 2018;1:1–13. [Epub ahead of print]

7. Harshfield E, Choudhury R, Harhay MN, Bergeust H, Harhay MO. Association of hypertension and hyperglycaemia with socioeconomic contexts in resource-poor settings: the Bangladesh Demographic and Health Survey. Int J Epidemiol 2015; 44:1625–1636.

8. Rahman MM, Gilmour S, Akter S, Abe SK, Saito E, Shibuya K. Prevalence and control of hypertension in Bangladesh: a multilevel analysis of a nationwide population-based survey. J Hypertens 2015; 33:465–472.

9. Wang Q, Xu L, Sun L, Li J, Qin W, Ding G, et al. Rural-urban difference in blood pressure measurement frequency among elderly with hypertension: a cross-sectional study in Shandong, China. J Health Popul Nutr 2018; 37:25.

10. Lab SI. Sustainable development goals. Sri Lanka Sri Lanka2018. www.un.org/sustainabledevelopment/en. [Accessed 20 December 2018]

11. Katulanda P, Ranasinghe D, Constantine GR, Rezvi Sh, Matthews DR. The prevalence, predictors and associations of hypertension in Sri Lanka: a cross-sectional population based national survey. Clin Exp Hypertens 2014; 36:484–491.

12. World Health Organization. Non-communicable Disease Risk Factor Survey. Sri Lanka, 2015. http://www.who.int/chp/steps/STEPS-report-2015-Sri Lanka.pdf. [Accessed 15 December 2018]

13. Horowitz B, Mekulun D, Zager P. Epidemiology of hypertension in CKD. Adv Chronic Kidney Dis 2015; 22:86–95.

14. Mihajlov R, Stoeva D, Pencheva B, Bogusheva E, Russeva A, Gencheva-Angelova I.Albuminuria and glomerular filtration in patients with essential hypertension. Clin Lab 2015; 61:677–685.

15. Senanayake Chronic kidney disease in Sri Lanka: a glimpse into lives of the affected. J Coll Comm Phys Sri Lanka 2018; 24:54–65.

16. Epidemiology Unit of Sri Lanka. Prevalence and risk factors for CKDs in the district of Anuradhapura. Sri Lanka. Epidemiology Unit of Sri Lanka; 2018

17. Abramson J, Abramson Z. Research methods in community medicine: surveys, epidemiological research, programme evaluation, clinical trials. Chichester, UK: John Wiley & Sons, 2011.

18. American College of Cardiology. New ACC/AHA high blood pressure guidelines lower definition of Hypertension American College of Cardiology. 2017. http://www.acc.org/latest-in-cardiology/articles/2017/11/08/11/47/mon-5pm-bp-guideline-aha-2017. [Accessed 2 January 2019]

19. Singh M, Kotwal A, Mittal C, Babu SR, Bhatti S, Ram CVS. Prevalence and correlates of hypertension in a rural-southern population of Southen India. J Hum Hypertens 2017; 32:66–74.

20. Mills KT, Dolan J, Bazzano LA, Chen J, He J, Krousel-Wood M, et al. Comprehensive approach for hypertension control in low-income populations: rationale and study design for the hypertension control program in Argentina. Am J Med Sci 2014; 348:139–145.

21. Joshi SR, Saboo B, Vadivala M, Dami SI, Mithal A, Kaul U, et al. Prevalence of diagnosed and undiagnosed diabetes and hypertension in India: results from the Screening India’s Twin Epidemic (SITE) study. Diabetes Technol Ther 2012; 14:8–15.

22. Gonzalez-Villalpando C, Stern MP, Hoffner SM, Villalpando MEG, Gaskill S, Martinez DR. Prevalence of hypertension in a Mexican population according to the sixth report of the joint national committee on prevention, evaluation, and treatment of high blood pressure. J Cardiovasc Risk 1999; 6:177–181.

23. Jafar TH, Gandhi M, Jehan I, Naheed A, de Silva HA, Shahab H, et al. Determinants of uncontrolled hypertension in rural communities in South Asia-Bangladesh, Pakistan, and Sri Lanka. Am J Hypertens 2018; 31:1205–1214.

24. Cushman W, Ford C, Cutler J, Margolis K, Davis B, Grimm R, et al. ALLHAT Collaborative Research Group: success and predictors of blood pressure control in diverse North American settings: the Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial (ALLHAT). J Clin Hypertens 2002; 4:395–404.

25. Sarganas G, Knopf H, Grams D, Neuhäuser HK. Trends in antihypertensive medication use and blood pressure control among adults with hypertension in Germany. Am J Hypertens 2015; 29:104–113.

26. Aleyadeh W, Hutt-Centeno E, Ahmed HM, Shah NP. Hypertension guidelines: treat patients, not numbers. Cleveland Clin J Med 2019; 86:47–56.

27. Seedat Y. Why is control of hypertension in sub-Saharan Africa poor? Cardiovasc J Afr 2015; 26:193–195.

28. Tutum V, Etikis U. Impact of patients’ knowledge, attitudes and practices on hypertension with antihypertensive drugs in a resource poor setting in Nigeria. J TAF Prev Med Bull 2010; 9:87–92.

29. Ahmed N, Abdul Khalig M, Shah SH, Anwar W. Compliance to antihypertensive drugs, salt restriction, exercise and control of systemic hypertension in hypertensive patients at Abbottabad. J Ayub Med Coll Abbotsabad 2006; 16:66–69.

30. Akoko BM, Fon PN, Ngui RC, Ngui KB. Knowledge of hypertension and compliance with therapy among hypertensive patients in the Bamenda Health District of Cameroon: a cross-sectional study. Cardiol Ther 2017; 6:53–67.

31. Steenbrook R. Closing the affordability gap for drugs in low-income countries. N Engl J Med 2007; 357:1996–1999.

32. Neupane D, McLachlan CS, Sharma R, Gyawali B, Khanal V, Mishra SR, et al. Prevalence of hypertension in member countries of South Asian Association for Regional Cooperation (SAARC): systematic review and meta-analysis. Medicine 2014; 93:474.

33. Singh RB, Suh IL, Singh VP, Chaithiraphan S, Laohavorn P, Sy RG, et al. Hypertension and stroke in Asia: prevalence, control and strategies in developing countries for prevention. J Hum Hypertens 2000; 14:749–763.

34. Maziak W, Rastam S, Mzyek F, Ward KD, Eisenberg T, Keil U. Cardiovascular health among adults in Syria: a model from developing countries. Ann Epidemiol 2007; 17:715–720.

35. Baynouna LM, Revel AD, Nagelkerke NJ, Jaber TM, Omar AO, Ahmed MM, et al. High prevalence of the cardiovascular risk factors in Al-Ain. United Arab Emirates. An emerging healthcare priority. Saudi Med J 2008; 29:1173–1178.

36. Al-Nozha MM, Abdullah M, Arafah MR, Khalil MZ, Khan NB, Al-Mazrou YY, et al. Hypertension in Saudi Arabia. Saudi Med J 2007; 28:77–81.

37. Shah SM, Luby S, Rahbar M, Khan AW, McCormick JB. Hypertension and its determinants among adults in high mountain villages of the Northern Areas of Pakistan. J Hum Hypertens 2001; 15:107–112.

38. Jamerson KA, Townsend RR. The attributable burden of hypertension: focus on CKD. Adv Chronic Kidney Dis 2011; 18:6–10.

39. Moghimi Lankarani M, Assari S. Diabetes, hypertension, obesity, and long-term risk of renal disease mortality: racial and socioeconomic differences. J Diabetes Investig 2017; 8:590–599.

40. Collins AJ, Foley RN, Herzog C, Chavers B, Gilbertson D, Ishani A, et al. US Renal Data System 2012 annual data report. Am J Kidney Dis 2013; 61:A7, e1-476.