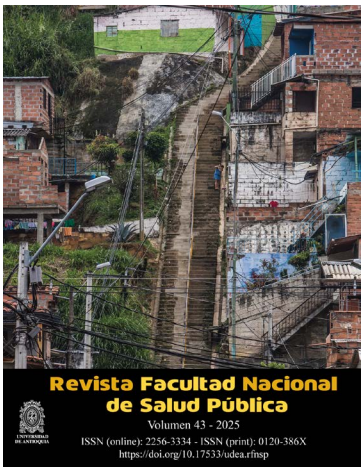

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Study protocol for a survey on the epidemiology of hypertension in Tetouan, Morocco, using a stratified cluster sampling method*

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Abstract

Objective: To present the design and methodological framework of a protocol for a population-based cross-sectional survey aimed at assessing the prevalence, knowledge, treatment, and control of hypertension in Tetouan, Morocco.
Methods: A cross-sectional design was adopted. The study used a multistage stratified cluster sampling process, which required special attention to minimize potential biases and ensure efficient data collection.
Results: The article provides a detailed description of each phase of the survey process, beginning with initial planning, continuing with the sampling stages and physical measurements taken, and concluding with the statistical methods for data analysis. The methodology of the study was designed to provide reliable and current data on the epidemiology of hypertension in the region.
Conclusion: This research contributes valuable information for those planning or conducting similar population-based surveys.

---------*Keywords:* population-based survey, epidemiology, hypertension, stratified cluster sampling.

* This study is part of the research project entitled "Prevalence and Risk Factors of Elevated Blood Pressure and Hypertension in the Urban Area of the Province of Tetouan, Morocco", approved by the experts of the Research Committee of the Faculty of Medicine of Tangier – Abdelmalek Essaâdi University (Tetouan, Morocco). The study was conducted between November 2024 and January 2025.

Protocolo de estudio para una encuesta sobre la epidemiología de la hipertensión en Tetuán, Marruecos, empleando el método de muestreo por conglomerados estratificados

Resumen

Objectivo: Este artículo presenta el diseño y el marco metodológico de un protocolo de una encuesta transversal de base poblacional, destinada a evaluar la prevalencia, el conocimiento, el tratamiento y el control de la hipertensión en Tetuán, Marruecos.
Métodos: Se adoptó un diseño transversal. El estudio utilizó un proceso de muestreo por conglomerados estratificado multi etapas, que requirió especial atención para minimizar posibles sesgos y garantizar una recolección de datos eficiente.
Resultados: El artículo proporciona una descripción detallada de cada fase del proceso de la encuesta, comenzando con la planificación inicial, pasando por las etapas de muestreo y las mediciones físicas realizadas, y concluye con los métodos estadísticos para el análisis de datos. La metodología del estudio se diseñó para proporcionar datos fiables y actuales sobre la epidemiología de la hipertensión en la región.
Conclusión: Esta investigación contribuye con información valiosa para quienes planifican o realizan encuestas poblacionales similares.

----------*Palabras clave:* encuesta poblacional, epidemiología, hipertensión, muestreo por conglomerados estratificado.

Protocolo de estudo para uma enquete sobre a epidemiologia da hipertensão em Tetuão, Marrocos, empregando o método de amostragem por conglomerados estratificados

Resumo

Objetivo: apresentar o desenho e o quadro metodológico de um protocolo de uma enquete transversal de base populacional, destinada a avaliar a prevalência, o conhecimento, o tratamento e o controle da hipertensão em Tetuão, Marrocos.
Método: Adotou-se um desenho transversal. O estudo utilizou um processo de amostragem por conglomerados estratificado multietapas, que demandou atenção especial para minimizar possíveis distorções e garantir uma coleta de dados eficiente.
Resultados: O artigo proporciona uma descrição detalhada de cada fase do processo da enquete, começando pela planificação inicial, passando pelas etapas de amostragem e as medições físicas realizadas, e conclui com os métodos estatísticos para a análise de dados. A metodologia do estudo foi desenhada para proporcionar dados fiáveis e atuais sobre a epidemiologia da hipertensão na região.
Conclusões: Esta pesquisa contribui com informação valiosa para aqueles que planificam ou realizam enquetes populacionais semelhantes. .

----------*Palavras-chave:* enquete populacional, epidemiologia, hipertensão, amostragem por conglomerados estratificados

Introduction

Hypertension is a primary contributing factor to the increasing incidence of cardiovascular diseases and premature mortality worldwide [1].

Evidence from large cohort studies consistently demonstrates that hypertension is a major leading risk factor for a range of serious health conditions involving heart failure, stroke, coronary heart disease, chronic kidney disease, atrial fibrillation, valvular heart diseases, aortic syndromes, and dementia [2-7].

Throughout midlife and advancing age, there exists no evidence of a defined blood pressure threshold for overall vascular-related vascular mortality risk [1,8].

The statistical independent and linear association linking the risk of cardiovascular diseases and blood pressure indicates that each difference of 20 mmHg in usual systolic blood pressure (or an equivalent difference of 10 mmHg in usual diastolic blood pressure) among individuals aged 40–69 years is linked to more than a twofold increase in the mortality rate from stroke, ischemic heart disease, and other vascular causes [1,8]. Moreover, meta-analyses have demonstrated that there exists a continuing association with risk all across the usual blood pressure normal range, confirming that even at lower levels—specifically down to a minimum 115 mmHg for systolic blood pressure and 75 mmHg for diastolic blood pressure—the proportionate difference in cardiovascular disease mortality risk remains consistent throughout different age groups [8,9].

Comparative analysis of blood pressure-related cardiovascular disease mortality between individuals aged 40–69 and those aged 80–89 indicates that the proportional differences are nearly twice as great in the younger group, although absolute 12-month risk differences increase with age [8]. At ages 35–57 years, systolic blood pressure had a strong relationship with stroke and ischemic heart disease risks than diastolic blood pressure in all blood pressure deciles. The relative risks associated with systolic and diastolic blood pressure were, respectively, 3.7 and 2.8 for ischemic heart disease, and 8.2 and 4.4 for stroke, when comparing the highest and lowest deciles [10].

In addition to its burden on public health, hypertension has a substantial economic cost to societies around the globe. The entire cost of high blood pressure includes direct treatment costs such as medications, medical supplies, hospital stays, etc., as well as indirect economic losses due to presenteeism, illness-related absenteeism, and early mortality [11]. In 2020, the global estimation of hypertension total costs ranged from the lowest cost of 204,676,723.54 international dollars (Int$) in Jamaica to the highest cost of 316,000,000,000.00 Int$ in USA [11]. Moreover, the average total costs per person for all countries were 630.14 Int$, with direct costs amounting to 1,497.36 Int$, and indirect costs to 282.34 Int$ [11]. Hence underscoring the significant financial toll of hypertension to people, healthcare institutions, and society at large.

In 2021, reports from the World Health Organization (WHO) indicated that the highest prevalence of hypertension was in Africa at 27 %, while the lowest prevalence was in the Americas at 18 % [12]. The same data estimates that approximately 1.28 billion adults worldwide, aged between 30 and 79, suffer from hypertension, with the majority, constituting two-thirds, located in low- and middle-income nations. Furthermore, 46 % of individuals are unaware of their hypertension status, with only 42 % receiving diagnosis and treatment, of which a mere 21 % achieve control over the condition [12].

Variations in high blood pressure prevalence and in hypertension awareness, treatment, and control rates are determined by risk factors that vary between those that are either modifiable or not. Obesity, physical inactivity, poor diet, alcohol consumption, sodium intake, and low potassium intake are deemed to clarify some of the regional differences in high blood pressure prevalence worldwide [1].

Data from a study analyzing hypertension trends from 1990 to 2019 across 200 countries [13] revealed significant disparities in awareness, treatment, and control rates. In 2019, 49 % (95 % CI: 46 %–52 %) of males along with 59 % (95 % CI: 55 %–62 %) of females worldwide stated having been diagnosed with hypertension, with 38 % (95 % CI: 35 %–41 %) of males in addition to 47 % (95 % CI: 43 %–51 %) of females receiving treatment. The control rate for adults with hypertension was 18 % (95 % CI: 16 %–21 %) for males and 23 % (95 % CI: 20 %–27 %) for females. In 2019, Canada, South Korea, and Iceland registered the highest rates of hypertension treatment (over 70 %) and control (over 50 %) [13], while Indonesia, Nepal, and numerous countries in Oceania and sub-Saharan Africa reported treatment rates lower than 25 %. Likewise, certain countries in south and central Asia, Eastern Europe, and North Africa had control rates below 10 % [13]. In South Korea, factors such as younger age (< 65 years), male gender, lower education levels, unhealthy behaviours, and better health conditions were associated with higher rates of unawareness and untreated hypertension [14]. Conversely, in North Africa, barriers to hypertension control included abdominal obesity, high cholesterol levels, overweight or obesity, and smoking [15].

There is a scarcity of hypertension-related data in Morocco. The most recent nationally reported data goes as far back as 2017, derived from the National Survey on Common Risk Factors for Non-Communicable Diseases 2017–2018 [16], using the methodology and protocol approved by the WHO for measuring common risk

factors for non-communicable diseases, also known as STEPS [17]. The prevalence of hypertension was determined at 33.6 %, with 46.3 % being the rate of individuals who were previously diagnosed as hypertensive prior to the survey and under antihypertensive treatment, and 15.6 % were those who still had high blood pressure despite taking treatment [16].

A national multicenter cross-sectional study [18] has determined the prevalence and clinical profile of hypertension in Morocco. The recruitment of participants in the study was limited to patients who had consulted primary care physicians, therefore uncovering the rest of the general population and missing data related to this large category of population. Likewise, Belayachi et al. [19] and Essayagh et al. [20] have described the epidemiological profile of hypertensive patients, with a particular emphasis on the uncontrolled spectrum of high blood pressure among hypertensive patients who had attended primary healthcare centers. Both studies did not investigate newly detected hypertensive subjects, and still, the study sample was confined to primary care centers, thus lacking details on the real prevalence of hypertension in the general population who were, for any reason, not having accessible healthcare services, especially those residing in rural areas.

The importance of collecting data on hypertension lies in depicting the disease's burden and providing information about its characteristics within the community. Maintaining up-to-date epidemiological data on hypertension is crucial for assessing trends over time, monitoring progress in reducing hypertension rates through community and individual-based interventions, implementing effective population-based health policies, and developing evidence-based clinical recommendations for the improvement of hypertension awareness, treatment, and control on regional and global levels [21].

This article therefore presents the design and methodological framework of a population-based, cross-sectional survey protocol intended to assess the prevalence, awareness, treatment, and control of hypertension in Tetouan, Morocco. Developed in response to persistent gaps in regional surveillance data, this protocol provides a rigorous, transparent, and contextually adapted foundation for future data collection.

At the time of writing, the analysis of study results has not yet been finalized; therefore, this manuscript focuses exclusively on the survey's conceptualization, sampling strategy, field procedures, and planned analytical approach.

Methods

This section details the methodological framework employed in the present study protocole. It encompasses the study design and setting, sampling strategy and sample size determination, data collection procedures, measurement methods and instruments, data management and statistical analysis, as well as ethical considerations.

Study design

A population-based cross-sectional survey was conducted between November 2024 and January 2025 on a representative sample of adults, randomly selected from the general population of the province of Tetouan, Morocco. A stratified multistage cluster sampling method was applied to ensure the random selection of the study participants.

Data were collected by trained investigators through face-to-face interviews, using printed questionnaires and conducting physical measurements. A biostatistician supervised data storing process and analyses.

The protocol represents the primary output of the study: a rigorously designed methodological framework for hypertension surveillance in Tetouan, Morocco. It was developed in strict accordance with established international guidelines [17,22-25] and best epidemiological practices [26-31], offering a replicable template for similar settings.

The following sections detail the implementation of these principles as adapted to the local context.

Setting

Tetouan is a Moroccan province located in the northwestern tip of the country (see Figure 1.a). It comprises two municipalities in the urban area, one of which alone contains eleven administrative annexes (urban communes). In the rural area, Tetouan consists of two rural circles (administrative divisions of the province within rural areas), which comprises eight *caïdats* (rural districts); encompassing twenty rural communes [32] (see Figure 1.b-c).

To provide clarity on how the sampling design is structured, it is important to note the general administrative divisions of a province in Morocco. In urban areas, a Moroccan province consists of one or more municipalities, which are further divided into urban circles (urban districts). These urban circles are then divided into administrative annexes. In rural areas, a province is divided into rural circles, each consisting of one or more *caïdats* (rural districts), which are further divided into rural communes [32].

According to the latest available data from the general population and housing census 2014 [32], the province of Tetouan has 573,784 residents and includes 126,969 households. Tetouan's population is approximately equally divided between men and women, with nearly 101 males for every 100 females [32]. Although

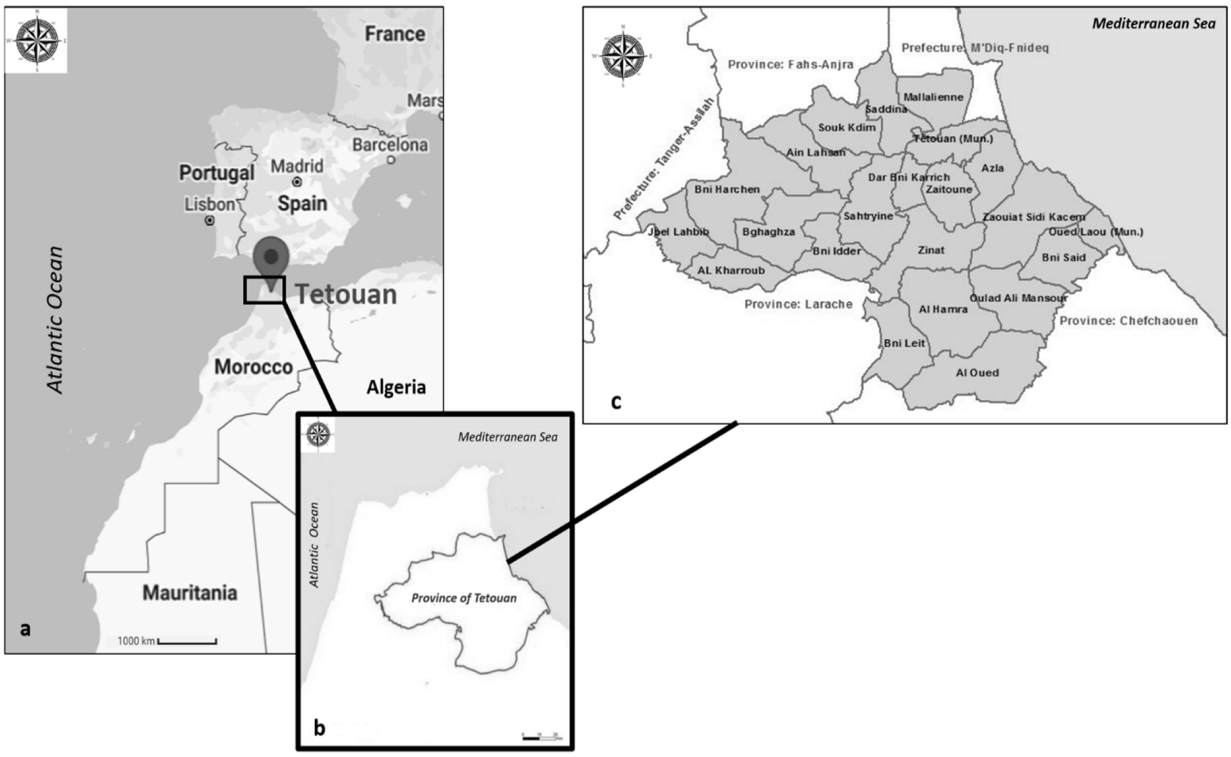

Figure 1. Maps of the geographical presentation of the province of Tetouan and its administrative division. ***a.*** Geographical location of Tetouan, Morocco [33]. ***b.*** Tetouan's territorial position in northern Morocco. ***c.*** The Administrative divisions of the province of Tetouan including both urban and rural areas [34].

the province of Tetouan consists mostly of rural communes (20 rural communes versus two urban communes), the majority of its population resides in urban areas, with 72.7 % living in cities compared to 27.3 % in rural areas [32].

Sample size

The sample size was calculated using Cochrane's single proportion formula [17]:

$$n = \frac{Z^2 \times p \times (1-p)}{e^2},$$

where Z is 1.96 (the probability value associated with a 95 % confidence interval), p is 29.30 % (the estimate of high blood pressure prevalence in the Moroccan population [16]), and e is 5 % (the acceptable margin of error).

For adjustments, a suitable design effect and anticipated response rate were considered. According to the WHO's STEPwise approach to surveillance, a design effect of 1.50 is recommended for sampling designs considerably more complex and structured than simple random sampling to improve the precision of survey results [17]. In addition, an anticipated response rate of 80 % [17] was incorporated into these adjustments. Consequently, a minimum of 606 participants is needed for the study sample.

Participants

The study included individuals who had lived in the province of Tetouan for at least six months, were 18 years of age or older at the time of the interviews and appeared to be in good health.

Subjects experiencing white coat hypertension, patients under drug-induced hypertension, pregnant women, individuals with cognitive, mental, or physical disabilities, those with language barriers, or anyone unable to provide accurate information during interviews and physical examinations were excluded from the study.

Sampling

The study sample was selected using a stratified multistage cluster sampling method, a commonly recommended sampling design for large, dispersed populations.

Making data collection more efficient in terms of logistics, time, and costs [26,27].

Stratified multistage cluster sampling is carried out in multiple steps. As the naming suggests, this method allows for a combination of cluster and stratified sampling, ensuring that all units of the larger population are adequately represented [26,27]. The population is stratified into different strata according to a key criteria, each stratum is divided into clusters, which are further subdivided at each stage, eventually leading to the selection of households or individuals in the final stage [26,27].

Moreover, unlike single-stage probability sampling, which requires a sampling frame for the entire studied population, stratified multistage cluster sampling only requires sampling frames for the ultimate stage, usually consisting of the final selected subgroups of households or individuals [26,28]. This approach makes it easier to provide information, as smaller clusters are more manageable compared to the entire population.

In the present research, available data from the 2014 general population and housing census in Morocco [32], along with information about the province's administrative divisions [34], provided the required basis for conducting the sampling method.

The study sampling process consisted of four stages. First, the province was stratified into urban and rural strata to ensure the representation of both populations in the final sampled subgroups. In the first stage, each stratum was divided into clusters based on the administrative divisions of the province—circles in urban areas and *caïdats* in rural areas. The Probability Proportional to Size method was then used to select the primary sampling units, three circles and three *caïdats*. Because clusters (circles and *caïdats*) vary significantly in size, Probability Proportional to Size method was applied to give each unit, whether large or small, an equal probability of inclusion in the sample [29].

In the second stage, the Simple Random Sampling method [30] was applied to select the secondary sampling units, one administrative annex within each circle previously chosen at the first stage in the urban areas. Similarly, one rural commune was selected within each *caïdat* previously chosen in the rural areas.

In the third stage, selecting households required a list of households within the secondary sampling units. Since access to local government housing registers was not available, the Electricity Department was contacted. This department supplied reliable source of lists comprising households within the selected areas and could help to identify households occupied by permanent residents based on the tariff structure, as well as uninhabited homes—a significant number of houses in Tetouan belong to Moroccan migrants living abroad [35], or houses owned by the same individuals. This information allowed for to compile a new list of households eligible for the third stage of sampling. Using simple random sampling method, a specified number of households was selected from each secondary sampling unit.

In the fourth stage, one subject per one household was selected to minimize environmental and hereditary factors as potential confounders. If there was more than one individual living in the same household and who met the inclusion criteria for selection, a simple random sampling method was used to select one subject among them. Individuals who refused to participate were counted as non-responders. If the target sample size of individuals in a grouping could not be achieved for various reasons, additional eligible subjects were selected using the same approach from the nearest eligible selected households until the required size was met.

Figure 2 summarizes the four stages of the sampling design using stratified multistage cluster sampling method employed in the study.

Data collection

The study investigators included three nurses and three trained interviewers, who were divided into three teams, each consisting of one nurse and one interviewer. All investigators completed a structured competency-based training [36-38] program led by the senior researcher. This program covered essential fieldwork skills, including household designation, participant recruitment, and standardized questionnaire administration. The training emphasized hands-on skill mastery, with particular focus on the correct use of measurement devices (e.g., automatic electronic oscillometric blood pressure monitors, mercury sphygmomanometers, body composition analyzers), and performance of anthropometric measurements.

To ensure uniform competency, the training incorporated didactic instruction on the study goal, hands-on practice through supervised simulations of interviews and performing measurements, formative assessment by real-time feedback from the senior researcher, summative evaluation involving final competency checks to verify proficiency, and self-reflection where investigators reviewed their performance to identify areas for improvement. Only after demonstrating consistent competence in all tasks, the investigators were approved for data collection.

The competency-based training approach aligns with WHO emphasis on competency demonstration through direct observation in field research training [39-41].

To promote acceptance and participation in the study, information strategies are planned, taking into account the cultural specificities and beliefs of the target population. Informative brochures, written in an accessible language—primarily in the local Arabic dialect—are provided to potential participants and include essential

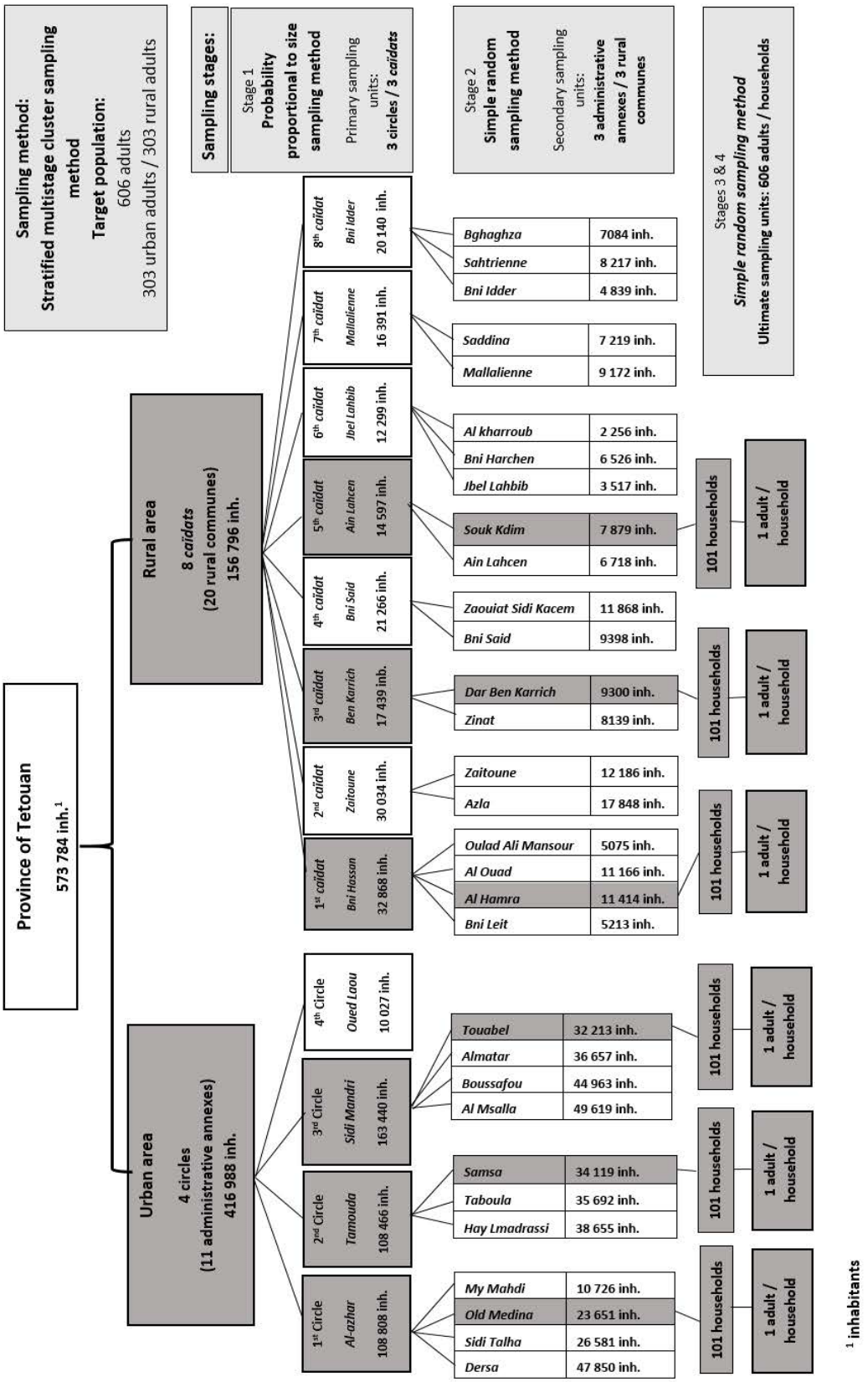

Figure 2. Sampling design based on stratified multistage cluster sampling method. Data presented in the figure is sourced from the 2014 General Population and Housing Census in Morocco [32].

* Shaded boxes indicate that the stratum, cluster, household o participant was selected.

information about the study: objectives, procedures, safety considerations, potential benefits of participation, and participants' rights. Verbal explanations are offered individually to participants with limited literacy or those seeking further clarification. An informed consent form, also written in a comprehensible language, outlines the voluntary nature of participation, the right to withdraw at any time, and the confidentiality of collected data.

Sociocultural norms are respected by training the survey investigators to adopt an approach considering the local context; for example, female investigators are assigned to interact with female participants to facilitate communication and avoid discomfort or reluctance related to gender norms.

Finally, a participatory and empathetic approach is adopted during interviews, fostering a respectful and reassuring environment, with a compassionate attitude aimed at building trust. Investigators are trained to engage in active, nonjudgmental listening, and to adjust their communication to align with each participant's level of understanding, ensuring respectful and effective interaction.

If the selected participant consented, a face-to-face interview was conducted either immediately or at a scheduled time in their residence.

Measurements

This subsection describes the tools and procedures used to collect data on the study variables. It includes information on the structured questionnaire administered to participants, the protocol followed for blood pressure measurement, and the methods used for obtaining anthropometric data. Standardized techniques and validated instruments were employed to ensure the accuracy and reliability of the measurements.

Questionnaire

The questionnaire aimed to investigate information on demographic and socio-economic characteristics, personal medical history of cardiovascular diseases and kidney disease, and/ or their risk factors, as well as family history of hypertension or any heart-related complications.

The official Arabic short version of the International Physical Activity Questionnaire (IPAQ) [42] was used to evaluate the physical activity profile of the recruited participants. Sleep apnea was assessed using the Arabic version of the STOP-Bang questionnaire (SBQ) [43]. These instruments were selected for their established psychometric properties, cultural adaptation, and applicability in Arabic-speaking populations [42,43].

Dietary intake data were compiled using the Dietary Quality Score (DQS) [44], which is a quick and valid tool that also correlates with cardiovascular risk factors.

Other health-risk behaviours, such as smoking and alcohol consumption, were also addressed during the interview. After completing the questionnaire, the participant proceeded to clinical and anthropometric measurements.

Blood pressure measurement

Blood pressure was measured using OMRON® M2 Basic, model HEM-7121J-E (OMRON® Corporation, Shiokoji Horikawa, Shimogyo-ku, Kyoto 600-8530, Japan) automatic upper arm blood pressure monitor device. According to guidelines [25], the measurement was made in a seated position, using an arm cuff of appropriate size, following at least five minutes of rest. At first, several measurements were taken in both arms. The last two readings were considered on the participant's upper arm which marked a consistently higher reading (the difference between two arms should not be > 20 mmHg for systolic blood pressure or > 10 mmHg for diastolic blood pressure), measurements were taken within a one to two minutes interval.

It was ensured that the participant had not consumed hot beverages such as coffee or tea, smoked cigarettes, or engaged in intense physical activity within the 30 minutes prior to the measurements [45]. If any of these conditions were present, the measurement was delayed by 30 minutes.

Finally, the last two measured values were averaged to confirm whether hypertension was present or not. Hypertension was identified based on WHO guidelines [12], which consider it to be present in any of the following situations: a systolic blood pressure of 140 mmHg or higher, a diastolic blood pressure of 90 mmHg or higher, or if the person was taking medication for hypertension at the time of the study.

The OMRON® M2 Basic (HEM-7121J-E) automatic upper arm device was selected blood pressure measurement due to its clinical validation [46], operational simplicity, and ability to reduce observer variability, making it particularly suitable for large-scale community surveys [47].

While automatic devices may exhibit minor discrepancies compared to manual mercury sphygmomanometers, a subsample of participants (6 %) underwent concurrent measurements using both the OMRON® device and a mercury sphygmomanometer. A linear regression adjustment was subsequently applied to the automatic readings, thereby improving data reliability and comparability. Furthermore, this dual approach aligns with established methodological recommendations [48,49].

Anthropometric measurements

Following the standardized protocols [50,51], the anthropometric measurements comprised body weight (kg), height (cm), waist and hip circumferences (cm), body fat (percentage), and visceral fat (visceral fat index, unitless).

While standing upright, wearing light clothing, and barefoot, body weight and body composition were assessed, utilizing an Omron® Body Composition Monitor, model HBF-222T-EBK (OMRON® Corporation, Shiokoji Horikawa, Shimogyo-ku, Kyoto 600-8530, Japan). This device was selected based on its validated performance in population-based health studies [52], portability, and the technology's ease of use in non-clinical settings [53].

Although bioelectrical impedance analysis is sensitive to variables such as hydration status [54], all measurements were conducted following recommended use considerations and best practices to reduce potential variability and ensure measurement reliability [55].

Height was measured using a stature meter (height measuring scale), model WS045 (Narang Medical Limited, India) with a 0.10 cm resolution. Hip circumference (at the level of the hipbones) and waist circumference (at the level of the umbilicus and at the end of exhalation breathing) were measured using a MyoTape®, model MT05 (AccuFitness, 70 E. 55th Ave, Unit A, Denver, CO 80216, USA) with a 0.10 cm resolution.

Data Storage and Statistical Analysis

Each day, at the end of data collection, data is entered into a password-protected database, shared with the biostatistician who ensures the verification of data entry, controls for abnormal values or missing data, addresses any issues if detected, and corrects them accordingly.

The Statistical Package for the Social Sciences (SPSS®, IBM Corp., Armonk, NY, USA, Version 27.0) [56] is used for statistical analyses.

The study population is statistically described by performing descriptive statistics such as mean, median, mode, standard deviations, frequencies, and percentages.

Upon the complete entry of data into SPSS® and the completion of necessary verifications, the study population is categorized into subgroups according to normal and high blood pressure values, hypertension awareness, hypertension treatment, and hypertension control variations.

The weighted prevalence of hypertension and its subgroups are calculated with their corresponding 95 % CIs.

To estimate the weighted prevalence, the method suggested by Eaton and Kessler [31,57] is adopted, using a weighted average of stratum-specific prevalences. In the stratified multistage cluster sampling design, the overall weighted prevalence of hypertension in Tetouan is computed as the weighted average of *tertiary sampling unit*-specific prevalences.

Each tertiary sampling unit (TSU) *i*, defined as a random selected geographic cluster, consisted of 101 households. Within each household, one eligible individual was randomly selected (Figure 2). For each TSU *i*, the *unit-specific prevalence* is estimated, and a *weight* is computed based on the proportion of the total population that the TSU *i* represents considering the th TSU's probability of selection.

The *overall weighted prevalence* is then calculated as:

$$\hat{P} = \sum_{i=1}^{L} w_i \cdot \hat{p}_i,$$

where:

$\widehat{P}$ is the overall estimated prevalence.

L is the total number of selected TSUs.

W_i is the weight for the i^{th} TSU, which corresponds to the proportion of the total population considering the i^{th} TSU's probability of selection. These weights are assumed to be fixed quantities and sum to one.

$\widehat{Pi}$ is the estimated prevalence in the i^{th} TSU.

The assessment of significant differences in blood pressure between geographical areas (urban/rural) and other socio-demographic factors' subgroups are conducted using either the independent t-test or Mann-Whitney test, according to whether the distribution of the quantitative variables is normal or not.

Multiple binary logistic regressions are performed to assess factors associated with hypertension. The identified associated factors are then evaluated using multivariate analysis to determine predictors of hypertension. Similar analyses are used to identify predictors of treated and controlled hypertension.

Results are considered statistically significant when the two-tailed *p*-value is less than 0.05.

Ethical Considerations

Upon the protocol's approval by the Hospital-University Ethics Committee of Tangier in March 6, 2024, the ethics committee has also verified that the informed consent process is appropriate and will be acquired from all participants. The research adheres to the ethical standards of the Declaration of Helsinki [58].

The study protocol was managed and presented in conformity with the reporting guideline of observational and qualitative study protocols [59].

The study is described to all willing participants. Every participant has the option to withdraw from the survey at any time. Each participant must provide infor-

med consent prior to interviewing and data collection. The statutory guardians fill out the informed consent forms on behalf of the illiterate respondents. The collected data are completely anonymized.

The study protocol emphasizes that blood pressure measurements conducted during a single-visit epidemiological field study serve as an initial screening tool to identify participants with suspected hypertension. A confirmed diagnosis requires further clinical evaluation, including standardized repeated measurements in a healthcare setting. Accordingly, participants who meet threshold values for hypertension are advised to consult their physician or health center for additional assessment and diagnostic verification, aligning with standard hypertension diagnostic protocols [22-23].

Discussion

This protocol was developed in response to persistent methodological and data gaps in hypertension surveillance in Morocco, particularly at the regional level. Although hypertension is a major global risk factor for cardiovascular disease [1,2,8], available data in Morocco are limited and primarily derived from facility-based studies, which lack population-level representativeness. The most recent nationally representative survey was the 2017–2018 national survey on common risk factors for non-communicable diseases [16], which does not provide sufficient subnational resolution for targeted public health planning in underrepresented areas such as Tetouan.

To address these gaps, this study employs a stratified multistage cluster sampling design [26] with probability proportional to size [29]. This method ensures balanced representation of urban and rural populations and avoids selection bias associated with small administrative units. PPS is particularly suitable for resource-limited settings, as it uses aggregated census data rather than complete individual-level sampling frames. The final random selection of one participant per household reduces intracluster correlation and potential confounding.

In contrast, facility-based studies in Morocco rely on convenience sampling and systematically exclude undiagnosed individuals [18-20]. The Ontario Hypertension Survey protocol [60] used a two-stage cluster design based on landline listings, which today presents coverage bias and lacked stratification by urban-rural status. The China Hypertension Survey protocol [61], though methodologically strong, demanded substantial national infrastructure and resources. The protocol proposed here achieves comparable rigor at a regional scale through cost-effective adaptations, such as using utility data in place of housing registries, making it replicable in similar resource-limited settings.

Compared to the WHO STEPwise approach [17], this protocol incorporates additional refinements, including stratification aligned with local administrative structures and explicit weighting procedures to adjust for complex sampling stages. These elements enhance the validity and precision of prevalence estimates, underemphasized in in many field applications of the STEPwise framework.

This study is subject to several limitations. First, the cross-sectional design precludes any causal inference between associated factors and hypertension outcomes. Second, the use of self-reported data for lifestyle factors such as physical activity, dietary habits, smoking, and alcohol intake may introduce recall or social desirability bias, potentially under- or overestimating the association with hypertension. Third, blood pressure measurements were taken during a single home-based visit, which may not capture individuals with white coat or masked hypertension. These limitations may lead to slight under- or overestimation of true prevalence and should be considered when interpreting results.

In conclusion, the present protocol contributes to the literature by offering a methodologically sound, context-sensitive, and scalable approach for population-based surveys in structurally constrained settings. Bridging the gap between large-scale national surveys and narrowly focused facility-based studies, it provides a pragmatic yet statistically robust design for estimating hypertension prevalence, awareness, treatment, and control. Furthermore, by documenting operational solutions, it establishes a replicable framework for researchers working in resource-limited environments.

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Conflict of Interest Statement

All the authors of the present manuscript have no conflicts of interest to declare for this study.

Disclaimer

The article presented is the responsibility of the authors and does not reflect the position of any institution involved.

Authors' Contribution Statement

Safae El Haddaoui: contribution to the conception and design of the work, drafting the work, final approval of the version to be published, and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved
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