

## Persistent Gaps in the Hypertension Care Cascade: Prevalence and Inequality among Older Adults in Mexico

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### Abstract

Hypertension represents the most important modifiable contributor to cardiovascular morbidity and mortality worldwide. Persistent failures in identifying, treating, and controlling elevated blood pressure reflect missed opportunities to reduce avoidable deaths. This study sought to quantify the prevalence of long-term undiagnosed, untreated, and uncontrolled hypertension among older adults in Mexico, to examine their socioeconomic distribution, and to estimate the likelihood of transitioning from these states to diagnosis, treatment, and sustained control over a five-year period. We used longitudinal data from Mexican adults aged 50 years and older participating in two survey waves (2009 and 2014) of the WHO Study on Global AGEing and Adult Health (SAGE). Hypertension was defined using objectively measured blood pressure, while information on prior diagnosis and treatment was obtained through self-report. We calculated five-year prevalence and transition probabilities and assessed socioeconomic inequality using concentration indices derived from a household wealth index. Multivariable probit models were applied to identify population groups facing the greatest obstacles to effective hypertension care. Among respondents with complete information (N = 945), more than three-fifths met the criteria for hypertension. A substantial proportion experienced persistent gaps in care: over one-third of those initially unaware of their condition remained undiagnosed after five years; more than 40% of untreated individuals continued without pharmacological management; and nearly two-thirds of those with uncontrolled blood pressure at baseline failed to achieve lasting control. While hypertension prevalence was higher among individuals in higher wealth groups, deficiencies in diagnosis, treatment, and control were disproportionately concentrated among socioeconomically disadvantaged populations. Persistent unmet need was more common among men, individuals not living with a partner, rural residents, those lacking health insurance coverage, and individuals with overweight. These results underscore significant weaknesses in Mexico's hypertension care continuum. Improvements are needed not only in early detection and initiation of treatment but also in maintaining long-term blood pressure control. To reduce socioeconomic disparities and strengthen cardiovascular disease prevention, policies and interventions should prioritize sustained hypertension care for men, single adults, uninsured populations, and those with overweight.

**Keywords:** Hypertension, Cardiovascular, LMICs, Adult health

### Introduction

Hypertension is recognized as the leading global risk factor for cardiovascular diseases (CVDs) [1]. Despite

the availability of effective interventions, large gaps persist in identifying, treating, and controlling high blood pressure across populations [2–7], reflecting widespread shortcomings in preventing CVD-related premature deaths [8]. These challenges are particularly acute in middle-income countries, where rising hypertension prevalence [9, 10], ageing populations, and overburdened health systems struggling with a dual disease burden exacerbate the impact of inadequate detection and management of hypertension [5, 11–13].

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Patterns of hypertension differ across socioeconomic groups. In high-income countries, lower socioeconomic status is consistently associated with higher hypertension prevalence [14]. In contrast, findings from low- and middle-income countries (LMICs) are more heterogeneous, potentially reflecting shifts in the socioeconomic distribution of hypertension as nations progress through the epidemiological transition [2, 15–17]. Regardless, there is strong evidence that disadvantaged groups in LMICs experience poorer access to hypertension care [5, 18], leaving them at higher risk of adverse health outcomes from prolonged uncontrolled blood pressure. Understanding which populations face these barriers is essential for designing equitable screening and treatment programs.

Mexico illustrates these challenges vividly. The country has the world's highest prevalence of overweight [19], and non-communicable diseases (NCDs) account for approximately 80% of deaths [20]. In 2016, 25.5% of adults aged 18 years and older were estimated to have hypertension, with prevalence rising sharply with age, reaching nearly 50% among those aged 60 and older [21, 22]. Among hypertensive adults, 40% were estimated to be unaware of their condition, 21% were not receiving treatment, and 55% did not achieve adequate blood pressure control [21].

Most evidence on hypertension care comes from cross-sectional studies, which provide a snapshot of diagnosis, treatment, and control but fail to capture long-term persistence. The duration of exposure to uncontrolled hypertension is strongly linked to the risk of severe cardiovascular outcomes [23], highlighting the need to quantify how many individuals remain undiagnosed, untreated, or uncontrolled over extended periods. Cross-sectional data also cannot track movement between states—such as transitioning from undiagnosed to diagnosed or from controlled to uncontrolled—information critical for evaluating treatment adherence and system performance.

Longitudinal studies, by following individuals over time, allow for a more complete understanding of hypertension management. They can identify the proportion of adults who remain in adverse hypertension states and measure transitions toward improved care. The current study uses this approach to examine Mexicans aged 50 years and older, estimating the prevalence and socioeconomic distribution of hypertension that persisted as undiagnosed, untreated, or uncontrolled for at least five years. Additionally, we quantify transition rates to

diagnosis, treatment, and control, and identify sociodemographic characteristics associated with prolonged gaps in hypertension care, with the goal of guiding more targeted and equitable interventions.

## Materials and Methods

### *Sample*

We utilized longitudinal data from Mexico's participation in the World Health Organization's (WHO) Study on Global AGEing and adult health (SAGE) [6]. The analysis targeted individuals aged 50 and older. Up to 2021, Mexico stood alone among the six SAGE nations in releasing its longitudinal dataset to the public.

Wave 1 (carried out between November 2009 and January 2010) was constructed from the 2003 WHO World Health Survey (WHS) in Mexico, which we designate as Wave 0. The design incorporated 96 strata spanning all 32 states and three urbanicity tiers (rural, urban, and metropolitan) [6]. National representativeness in Wave 0 was secured via cluster random sampling, using Basic Geo-Statistical Areas as primary sampling units (PSUs), with a total of 40,000 households drawn randomly [24]. To form the Wave 1 sample, 211 PSUs were chosen through probability selection from the 797 originally used in Wave 0 [25]. For selected rural and urban PSUs, every person from Wave 0 who would reach age 50 or older by 2003 was targeted. In metropolitan PSUs, 90% of such individuals were randomly retained. A further systematic selection added 1000 younger adults (aged 18–49 in Wave 0) from across the chosen PSUs.

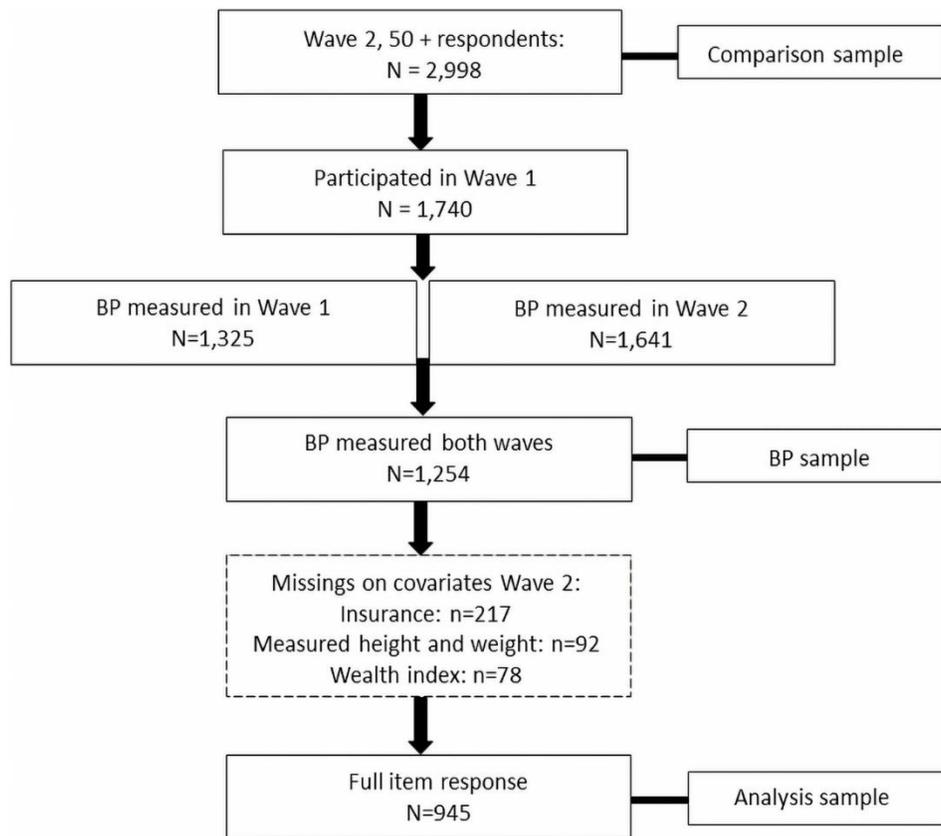
The overall response rate in Wave 1 stood at 53%, with notably lower participation among those aged 50–59 (42%) versus the 18–49 group (58%). This was mainly linked to constrained fieldwork timelines that limited follow-up attempts on initial non-respondents [6], compounded by substantial attrition over the six- to seven-year interval since Wave 0 [6]. Details on the profile of non-participants remain unavailable.

Wave 2 occurred from July to October 2014. Its target population covered all prior Wave 1 respondents, supplemented by any household members who had reached age 50 by 2014 but were not part of earlier waves [6]. Household and individual response rates in this wave were high, at 83% and 81%, respectively.

After applying weights, the SAGE dataset was structured to reflect the national population aged 50+ at each survey point. Our analytic sample was confined to this age group and required participation in both Waves 1 and 2. To

enlarge the longitudinal panel, we incorporated all respondents aged 50+ in Wave 2 with prior Wave 1 data (meaning a subset were slightly below 50 during Wave

1). We then removed cases lacking complete hypertension measures, followed by exclusion of those with incomplete Wave 2 covariates (**Figure 1**).



**Figure 1.** Flow of study participants

Notes: BP measured refers to participants for whom blood pressure was recorded and information on hypertension diagnosis and treatment was collected, enabling determination of their hypertension status.

### *Hypertension*

Blood pressure (BP) was recorded during home visits using the Boso Medistar Wrist Blood Pressure Monitor, Model S [26]. For each participant, three readings were taken, ensuring at least one minute between successive measurements. Participants were asked whether they had ever been told by a healthcare professional that they had high blood pressure (hypertension). Those who answered affirmatively were further asked if they had used any medications or other treatments for hypertension in the past two weeks or over the last 12 months.

Hypertension (HTN) was defined based on either measured BP or self-reported diagnosis. Participants were classified as hypertensive if the average of the last two BP readings showed a systolic BP of 140 mm Hg or

higher, a diastolic BP of 90 mm Hg or higher, or if they reported a prior diagnosis of high blood pressure [13, 27]. Among those identified as hypertensive, three additional categories were established: diagnosed (HTN Diagnosed) for individuals reporting a prior diagnosis, treated (HTN Treated) for those reporting current use of medication or other treatment, and controlled (HTN Controlled) for participants whose measured systolic BP was below 140 mm Hg and diastolic BP below 90 mm Hg.

Participants who did not meet these criteria, whether or not they were classified as hypertensive, were categorized as undiagnosed, untreated, or uncontrolled, using parallel definitions (**Table 1**).

**Table 1.** Classification of hypertension states

Category	Definition
<b>All Hypertension (HTN)</b>	Blood pressure reading of systolic $\geq 140$ mm Hg or diastolic $\geq 90$ mm Hg, or the person reports having ever been told by a health professional that they have high blood pressure.
<b>Diagnosed HTN</b>	Meets the criteria for hypertension and reports having ever been told by a health professional that they have high blood pressure.
<b>Undiagnosed HTN</b>	Meets the criteria for hypertension and reports never having been told by a health professional that they have high blood pressure.
<b>Treated HTN</b>	Meets the criteria for hypertension and reports currently taking medication or other treatment for high blood pressure within the past 2 weeks.
<b>Untreated HTN</b>	Meets the criteria for hypertension and reports not taking any medication or other treatment for high blood pressure within the past 2 weeks.
<b>Controlled HTN</b>	Meets the criteria for hypertension and has current blood pressure readings of systolic $< 140$ mm Hg and diastolic $< 90$ mm Hg.
<b>Uncontrolled HTN</b>	Meets the criteria for hypertension and has current blood pressure readings of systolic $\geq 140$ mm Hg or diastolic $\geq 90$ mm Hg.

Although hypertension is generally considered a chronic condition when diagnosed clinically, we chose not to carry forward a participant's hypertension classification from Wave 1 into Wave 2 automatically. The rationale was that standard clinical diagnoses rely on blood pressure (BP) readings taken across several visits, which our dataset lacked. An isolated BP measurement of  $\geq 140/90$  mm Hg might simply reflect a transient elevation rather than true hypertension. Consequently, we determined hypertension status separately for each wave, relying exclusively on the BP values and self-reported diagnostic history collected during that particular wave. This method helped prevent any potential inaccuracies from Wave 1 from affecting the Wave 2 categorizations.

#### *Wealth index*

To explore socioeconomic disparities related to the prevalence, diagnosis, treatment, and management of hypertension, we constructed a wealth index to serve as an indicator of socioeconomic position. The index corresponded to the primary principal component derived from a principal component analysis that encompassed participants' reported ownership of durable household goods and financial assets, together with housing features such as construction materials, sanitation systems, and sources of water [28].

#### *Covariates*

We explored links between ongoing undiagnosed, untreated, or poorly controlled hypertension and a range of sociodemographic and behavioral factors that could reasonably affect either the likelihood of developing hypertension or the ability to obtain relevant healthcare

services. Specifically, we assessed relationships with gender and age, known to elevate hypertension risk, alongside living arrangement (cohabiting or not), place of residence (rural versus urban), wealth (via the index), and possession of health insurance, all of which might influence healthcare access [29, 30]. Furthermore, we investigated connections with smoking habits, alcohol use, and Body Mass Index (BMI), factors potentially tied to heightened hypertension risk [29, 31, 32]. BMI values were derived from professional measurements of height and weight obtained during the interview visit. Individuals were grouped into normal weight (BMI  $< 25.0$ ), overweight (25.0–29.9), or obese ( $\geq 30.0$ ) categories [33]. Given the small number of participants with BMI under 20.0 ( $n = 19$ ), these cases were merged into the normal weight group.

#### *Statistical analyses*

We analyzed changes in hypertension status among participants aged 50 years and older in 2014 by estimating the proportion classified as hypertensive in each wave and in both waves combined. Additionally, we calculated the prevalence of untreated, undiagnosed, and uncontrolled hypertension, independent of whether participants met the criteria for hypertension. Transitions between different hypertension states from Wave 1 to Wave 2 were summarized using transition matrices, supported by visual illustrations. We also assessed how prior diagnosis or treatment status in Wave 1 influenced the likelihood of uncontrolled hypertension in Wave 2.

To evaluate socioeconomic disparities, we computed the concentration index for each hypertension state. This index, defined as the scaled covariance between a binary indicator of the state and participants' wealth rank,

reflects the distribution of hypertension across socioeconomic groups [34]. Positive values indicate that the condition is more concentrated among wealthier participants, whereas negative values indicate a concentration among poorer individuals.

We applied probit regression models to examine factors associated with persistent untreated, undiagnosed, and uncontrolled hypertension over the five-year period. From these models, we derived average marginal effects to quantify the impact of each covariate on the probability of remaining in a given hypertension state. Additional probit models focused on transitions from undiagnosed to diagnosed, untreated to treated, and uncontrolled to controlled hypertension. Each transition model was restricted to the relevant baseline subgroup, for example, participants undiagnosed in Wave 1 for the diagnosis transition analysis.

Sampling weights were not applied because they were not available at the cohort level. To assess the representativeness of the analytic cohort, we compared its sociodemographic characteristics with those of the full Wave 2 cross-sectional sample, which included weights representative of the national population aged 50 years and older in 2014. All analyses accounted for the survey's stratified and clustered design. Analyses were conducted using STATA version 16.0.

## Results and Discussion

### Sample description

In Wave 2 of the study (2014), 2,998 participants were aged 50 years and older. Of these, 1,740 individuals (58%) had also participated in Wave 1, forming a longitudinal cohort (**Figure. 1**). Among this group, 1,254 participants (72%) had valid blood pressure measurements recorded in both waves. Complete data across all variables required for the analyses were available for 945 respondents (54%), who constitute the primary analytic sample for this study. Comparable analyses conducted on the broader group with BP data from both waves yielded similar prevalence and transition estimates.

**Table 2** provides a summary of key characteristics for the analytic cohort, alongside weighted statistics for all Wave 2 participants aged 50 and above, which reflect the national population distribution [26]. The analytic sample tended to be older on average by approximately eight years, because younger participants were included in Wave 2 but had not participated in Wave 1. Differences in blood pressure and hypertension prevalence largely correspond to this age gap. The analytic cohort also included a higher proportion of rural residents, a greater share with health insurance coverage, and a higher prevalence of alcohol abstinence compared with the full weighted Wave 2 sample

**Table 2.** Participant characteristics, adults aged 50+ years, 2014 (Wave 2)

Characteristic	Analysis Sample (Observed in Waves 1 and 2) N = 945	Comparison Sample (Observed in Wave 2 only) N = 2,998
<b>Continuous variables</b>	Mean (SD)	Mean (SD)
Age (years)	70.7 (8.0)	62.5 (9.3)
Systolic blood pressure (mmHg)	141.8 (23.2)	138.8 (22.0)
Diastolic blood pressure (mmHg)	76.6 (11.0)	78.9 (11.0)
<b>Categorical variables</b>	No. (%)	No. (%)
<b>Hypertension diagnosis</b>		
Yes	609 (64.4)	1,675 (55.9)
No	336 (35.6)	1,323 (44.1)
<b>Gender</b>		
Female	523 (55.3)	1,613 (53.8)
Male	422 (44.7)	1,385 (46.2)
<b>Living with a partner</b>		
Yes	625 (66.1)	2,105 (70.2)
No	320 (33.9)	893 (29.8)
<b>Residence area</b>		
Urban	645 (68.3)	2,356 (78.6)
Rural	300 (31.8)	642 (21.4)

<b>Has health insurance</b>		
<b>Yes</b>	845 (89.4)	2,508 (83.7)
<b>No</b>	100 (10.6)	490 (16.3)
<b>Current smoker</b>		
<b>Yes</b>	104 (11.0)	375 (12.5)
<b>No</b>	841 (89.0)	2,623 (87.5)
<b>Consumes alcohol</b>		
<b>Yes</b>	438 (46.3)	1,844 (61.5)
<b>No</b>	507 (53.7)	1,154 (38.5)
<b>Body Mass Index (BMI) category</b>		
<b>Normal weight</b>	270 (28.6)	670 (23.2)
<b>Overweight</b>	397 (42.0)	1,236 (41.2)
<b>Obese</b>	278 (29.4)	1,065 (35.5)

Notes: The primary analysis focused on participants who had complete data and were followed in both waves. For comparison purposes, the full Wave 2 sample was used, applying survey weights to approximate the national distribution of adults aged 50 years and older in 2014.

*Hypertension: prevalence, diagnosis, treatment, and control*

**Table 3** presents the proportion of participants classified as hypertensive, alongside the percentages of those whose condition was undiagnosed, untreated, or uncontrolled, separately for each wave and across both waves. In the first wave, approximately 62% of participants (95% CI: 58.9–65.9) were identified as having hypertension. Five years later, this figure slightly increased to 64% (95% CI: 61.0–67.7) in Wave 2, a difference that was not statistically significant ( $P = 0.364$ ).

Just over half of the participants (51.1%; 95% CI: 47.5–54.7) met the criteria for hypertension in both waves.

This lower proportion compared with individual wave estimates reflects transitions in BP status over time: 107 participants shifted from hypertensive in Wave 1 to normotensive in Wave 2 (**Table 4**). Such changes can occur due to variability in single BP measurements taken outside a clinical setting, which may temporarily exceed diagnostic thresholds in one wave but fall below them in another. Additionally, inconsistencies in self-reported diagnoses—such as reporting a prior hypertension diagnosis in Wave 1 but denying it in Wave 2—can introduce apparent transitions, representing potential measurement errors in either wave.

**Table 3.** Hypertension prevalence and rates of untreated, undiagnosed, and uncontrolled hypertension

Hypertension Category	Persistent Across Both Waves		Wave 1		Wave 2	
	N,	(%) [95% CI]	N.	(%) [95% CI]	N.	(%) [95% CI]
<b>Total Hypertension (HTN)</b>	483	(51.1) [47.5–54.7]	590	(62.4) [58.9–65.9]	609	(64.4) [61.0–67.7]
<b>Untreated HTN</b>	145	(15.3) [13.2–17.8]	340	(36.0) [32.8–39.3]	256	(27.1) [24.4–30.0]
<b>Uncontrolled HTN</b>	328	(34.7) [31.7–37.9]	526	(55.7) [52.1–59.2]	460	(48.7) [45.4–52.0]
<b>Undiagnosed HTN</b>	107	(11.3) [9.5–13.4]	286	(30.3) [27.2–33.5]	210	(22.2) [19.7–24.9]

**Table 4.** Changes in hypertension status between waves

A. HTN Diagnosed	Wave 2			
	Wave 1	No HTN	HTN Diagnosed	HTN Undiagnosed
		No. (%)	No. (%)	No. (%)
		[95% CI]	[95% CI]	[95% CI]
<b>HTN Undiagnosed</b>		85 (29.7)	94 (32.9)	107 (37.4)

	[24.3, 35.7]	[27.8, 38.3]	[32.7, 42.4]
<b>No HTN</b>	229 (64.5)	48 (13.5)	78 (22.0)
	[59.9, 68.8]	[10.4, 17.4]	[18.3, 26.1]
<b>HTN Diagnosed</b>	22 (7.2)	257 (84.5)	25 (8.3)
	[4.9, 0.6]	[80.2, 88.1]	[5.6, 11.9]
<b>B. HTN Treated</b>	<b>Wave 2</b>		
<b>Wave 1</b>	No HTN	HTN Treated	HTN Untreated
	No. (%)	No. (%)	No. (%)
	[95% CI]	[95% CI]	[95% CI]
<b>HTN Untreated</b>	89 (26.2)	106 (31.2)	145 (42.7)
	[21.5, 31.5]	[26.6, 36.2]	[37.9, 47.5]
<b>No HTN</b>	229 (64.5)	41 (11.6)	85 (23.9)
	[59.9–69.8]	[8.6, 15.4]	[20.2, 28.2]
<b>HTN Treated</b>	18 (7.2)	206 (82.4)	26 (10.4)
	[4.9, 10.6]	[77.3, 86.6]	[7.3, 14.6]
<b>C. HTN Control</b>	<b>Wave 2</b>		
<b>Wave 1</b>	No HTN	HTN Controlled	HTN Uncontrolled
	No. (%)	No. (%)	No. (%)
	[95% CI]	[95% CI]	[95% CI]
<b>HTN Uncontrolled</b>	101 (19.2)	97 (18.4)	328 (62.4)
	[15.6, 23.4]	[15.3, 22.0]	[57.8, 66.7]
	[59.9, 68.8]	[4.7, 9.7]	[24.7, 33.2]
<b>No HTN</b>	229 (64.5)	24 (6.8)	102 (28.7)
	[59.9, 68.8]	[4.7, 9.7]	[24.7, 33.2]
<b>HTN Controlled</b>	6 (9.4)	28 (43.8)	30 (46.9)
	[4.4, 19.0]	[31.3, 57.0]	[33.7, 60.5]

Notes: In each cell of the table, the first value represents the number of participants, the second indicates the row percentage, and the 95% confidence interval for the row percentage is shown in parentheses.

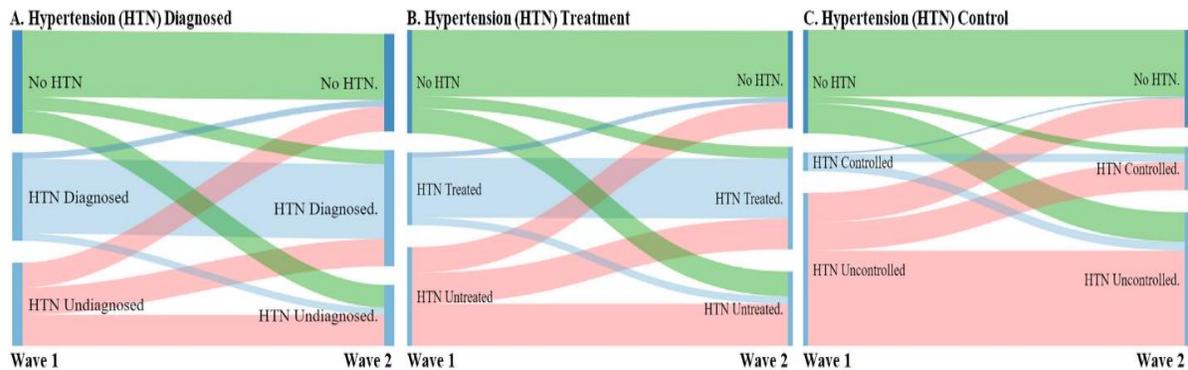
In Wave 1, an estimated 30.3% of participants (95% CI: 27.2–33.5) had hypertension that was undiagnosed, 36.0% (95% CI: 32.8–39.3) were untreated, and 55.7% (95% CI: 52.1–59.2) were uncontrolled. By Wave 2, these prevalences had decreased to 22.2% (95% CI: 19.7–24.9) for undiagnosed hypertension, 27.1% (95% CI: 24.4–30.0) for untreated, and 48.7% (95% CI: 45.4–52.0) for uncontrolled hypertension. The reductions in the proportions of undiagnosed, untreated, and uncontrolled hypertension between the two waves were statistically significant (all  $P = 0.000$ ). Over the five-year period, 11.3% of participants (95% CI: 9.5–13.4) remained undiagnosed, 15.3% (95% CI: 13.2–17.8) remained untreated, and 34.7% (95% CI: 31.7–37.9) continued to have uncontrolled hypertension.

#### *Transitions between hypertension states*

**Figure 2 and Table 4** present the movement of participants between hypertension states across the two waves. Considering hypertension and diagnosis status,

among the 355 individuals (229 + 48 + 78) without hypertension in Wave 1, 13.5% (95% CI: 10.4–17.4) had developed hypertension and received a diagnosis by Wave 2. A higher proportion, 22% (95% CI: 18.3–26.1), developed hypertension but remained undiagnosed, indicating that more than three-fifths ( $62\% = 22 / (13.5 + 22)$ ) of newly hypertensive individuals were not aware of their condition.

Among the 286 participants (85 + 94 + 107) who were hypertensive but undiagnosed in Wave 1, 37.4% (95% CI: 32.7–42.4) remained undiagnosed five years later, 32.9% (95% CI: 27.8–38.3) were newly diagnosed, and 29.7% (95% CI: 24.3–35.7) were reclassified as not having hypertension based on measured blood pressure and self-reported diagnosis in Wave 2. A small subset, 8.3% (95% CI: 5.6–11.9) of the 304 participants (22 + 257 + 25) who had been diagnosed and hypertensive in Wave 1, showed blood pressure above the hypertension threshold in Wave 2 but reported inconsistently that they had never been diagnosed.



**Figure 2.** Hypertension state transitions

Notes: The figure in the top panels provide a visual summary of the transition data presented in the matrix below. Each panel includes 945 participants.

Panel B focuses on treatment changes. Among participants without a hypertension classification in Wave 1, 11.6% (95% CI: 8.6–15.4) were receiving treatment for hypertension by Wave 2, while 23.9% (95% CI: 20.2–28.2) developed hypertension but remained untreated. Treatment showed high persistence: 82.4% (95% CI: 77.3–86.6) of participants who were on treatment in Wave 1 continued treatment five years later. A small proportion (10.4%; 95% CI: 7.3–14.6) of initially treated participants were no longer receiving treatment in Wave 2, although they remained hypertensive. Additionally, 7.2% (95% CI: 4.9–10.6) of those treated in Wave 1 were classified as normotensive in Wave 2, reflecting inconsistencies in self-reporting compared with previous treatment data. Of the participants initially untreated, 42.7% (95% CI: 37.9–47.5) remained untreated, and 31.2% (95% CI: 26.6–36.2) had initiated treatment by Wave 2.

Panel C describes blood pressure control outcomes. Among participants without hypertension at Wave 1, 28.7% (95% CI: 24.7–33.2) were classified as having uncontrolled hypertension five years later. Nearly half (46.9%; 95% CI: 33.7–60.5) of the 64 participants who

had controlled hypertension in Wave 1 transitioned to uncontrolled status. For those who were uncontrolled in Wave 1 ( $n = 526$ ), 62.4% (95% CI: 57.8–66.7) remained uncontrolled in Wave 2, while 18.4% (95% CI: 15.3–22.0) achieved control. Participants who were diagnosed in Wave 1 were more than twice as likely to achieve blood pressure control compared with those undiagnosed. A similar pattern was observed for those initially treated versus untreated.

#### *Wealth-related inequality*

**Table 5** reports concentration indices for wealth-related disparities in hypertension indicators. Positive values for overall hypertension indicate that wealthier participants were slightly more likely to be classified as hypertensive in each wave and across both waves, although confidence intervals included zero, indicating no significant inequality. The indices for undiagnosed, untreated, and uncontrolled hypertension were all negative, suggesting higher prevalence among poorer participants; however, the confidence intervals again included zero, so these differences were not statistically significant.

**Table 5.** Concentration indices for hypertension, untreated, undiagnosed, and uncontrolled hypertension

Category	Wave 1 Concentration Index [95% CI]	Wave 2 Concentration Index [95% CI]	Both Waves Concentration Index [95% CI]
All hypertension (HTN)	0.007 [-0.06, 0.08]	0.026 [-0.04, 0.09]	0.028 [-0.04, 0.10]
Undiagnosed HTN	-0.039 [-0.11, 0.02]	-0.026 [-0.09, 0.03]	-0.007 [-0.05, 0.04]
Untreated HTN	-0.068 [-0.14, 0.00]	-0.039 [-0.11, 0.03]	-0.050 [-0.10, 0.00]
Uncontrolled HTN	-0.029 [-0.10, 0.04]	-0.029 [-0.10, 0.04]	-0.047 [-0.11, 0.02]

#### *Multivariable analysis*

**Table 6** examines how different personal and lifestyle factors relate to ongoing issues with hypertension—whether it goes undiagnosed, untreated, or uncontrolled—across both survey waves. Men were generally at higher risk: they were 10 percentage points more likely to remain unaware of their condition, more likely to forgo treatment (by 9 points), and slightly more likely to have uncontrolled blood pressure (3 points), though the latter effect was not statistically strong. Single participants had a modestly higher chance (4 points) of remaining undiagnosed than those living with a partner. Rural residents tended to experience persistent hypertension across all three categories, but only the 9-point higher likelihood of uncontrolled hypertension

reached statistical significance. Lack of health insurance increased the probability of remaining undiagnosed by 4 points. Overweight individuals faced greater challenges, with a 5-point higher chance of staying untreated and a 13-point higher chance of having uncontrolled blood pressure.

Alcohol consumption appeared to have a protective effect: drinkers were somewhat less likely to stay undiagnosed (3 points) or untreated (4 points). Additional analysis of improvements over time showed that men were generally less likely to move from undiagnosed to diagnosed, untreated to treated, or uncontrolled to controlled, whereas smokers were more likely to get diagnosed if previously undiagnosed.

**Table 6.** The average marginal effects of various demographic, health, and lifestyle factors on the likelihood of persistent hypertension in its undiagnosed, untreated, and uncontrolled forms.

Characteristic	Undiagnosed Hypertension in Both Waves Marginal Effect [95% CI] (p-value)	Untreated Hypertension in Both Waves Marginal Effect [95% CI] (p-value)	Uncontrolled Hypertension in Both Waves Marginal Effect [95% CI] (p-value)
<b>All respondents (N = 945)</b>			
<b>Sex</b>			
Female	Reference	Reference	Reference
Male	0.10 [0.06, 0.15] (0.000)	0.09 [0.03, 0.14] (0.002)	0.03 [-0.04, 0.11] (0.366)
Age (years)	-0.00 [-0.00, 0.00] (0.900)	0.00 [-0.00, 0.00] (0.068)	0.01 [0.01, 0.01] (0.001)
<b>Cohabiting status</b>			
Yes	Reference	Reference	Reference
No	0.04 [0.01, 0.07] (0.007)	0.05 [-0.00, 0.07] (0.061)	0.06 [-0.01, 0.12] (0.107)
<b>Living area</b>			
Urban	Reference	Reference	Reference
Rural	0.02 [-0.00, 0.05] (0.083)	0.03 [-0.01, 0.07] (0.178)	0.09 [0.02, 0.16] (0.013)
<b>Health insurance</b>			
Has health insurance	Reference	Reference	Reference
No health insurance	0.04 [0.01, 0.08] (0.046)	0.05 [-0.00, 0.10] (0.103)	0.07 [-0.03, 0.16] (0.171)
<b>Wealth status</b>			
Tercile 1 (lowest)	Reference	Reference	Reference
Tercile 2	-0.01 [-0.04, 0.03] (0.710)	-0.02 [-0.06, 0.03] (0.431)	-0.03 [-0.11, 0.04] (0.411)
Tercile 3 (highest)	0.02 [-0.02, 0.05] (0.334)	-0.02 [-0.01, 0.03] (0.480)	-0.01 [-0.09, 0.07] (0.766)
<b>Body weight</b>			
Normal weight	Reference	Reference	Reference
Overweight	0.02 [-0.01, 0.05] (0.284)	0.05 [0.01, 0.10] (0.023)	0.13 [0.05, 0.20] (0.001)
Obese	-0.00 [-0.04, 0.04] (0.872)	0.04 [-0.01, 0.08] (0.134)	0.16 [0.08, 0.25] (0.000)
<b>Smoking status</b>			
Non-smoker	Reference	Reference	Reference
Smoker	0.00 [-0.04, 0.04] (0.931)	0.02 [-0.04, 0.08] (0.480)	0.07 [-0.03, 0.17] (0.182)
<b>Alcohol consumption</b>			
No	Reference	Reference	Reference
Yes	-0.03 [-0.06, -0.01] (0.017)	-0.04 [-0.08, -0.00] (0.048)	-0.04 [-0.11, 0.03] (0.250)

Note: Probit estimates of marginal effects were calculated as averages across the respective samples.

This study provides one of the first longitudinal analyses of hypertension diagnosis, treatment, and control [35, 36] in a middle-income country. Using data from Mexicans aged 50 years and older collected in two waves of the WHO Study on Global AGEing and Adult Health (SAGE) in 2009 and 2014, we observed a high prevalence of hypertension (64%). Over five years, the proportions of undiagnosed, untreated, and uncontrolled hypertension decreased to 22%, 27%, and 49%, respectively. Nevertheless, more than one-third of participants who were undiagnosed at baseline remained so after five years; over 40% of those untreated continued without therapy, and more than 60% of individuals with uncontrolled hypertension failed to achieve BP control. Persistent uncontrolled hypertension was far more common than successful BP control, suggesting considerable population-level health losses given that prolonged exposure to elevated BP significantly increases cardiovascular risk [37]. These results indicate ongoing challenges in detecting and managing hypertension and highlight gaps in patient adherence. While findings are specific to Mexico, they may encourage similar longitudinal evaluations in other settings.

Two other longitudinal studies offer useful comparisons. A study in Ghana identified predictors of hypertension diagnosis, such as urban residence and health insurance, though it did not track transitions between hypertension states [36]. A multi-country preprint including Mexico employed a design similar to ours [35]. Their observed rates of transitioning from undiagnosed to diagnosed and untreated to treated were roughly 30%, comparable to our study, but we report a threefold higher rate for treatment continuity. Differences in cohort composition likely explain this discrepancy: Mauer *et al.*'s cohort included participants aged 40–49, and the study waves spanned longer periods (first wave in 2005; second wave from 2009–2012), potentially lowering measured treatment persistence.

Our methodology allowed participants to be reclassified from hypertensive to normotensive between waves, a phenomenon that was relatively frequent. Such changes do not imply a cure but can reflect measurement error—either a false-positive BP reading at Wave 1 or inconsistent self-reported diagnosis. These errors could inflate cross-sectional estimates of undiagnosed, untreated, and uncontrolled hypertension but do not

reduce the importance of addressing gaps in hypertension care.

When comparing BP control by baseline diagnosis status, participants diagnosed at baseline were more than twice as likely to achieve control after five years, supporting the value of screening programs. Similarly, those treated at baseline were more than twice as likely to reach BP control compared with untreated participants, highlighting the importance of effective management. Antihypertensive therapy is highly cost-effective [38], and lifestyle interventions are also beneficial when successfully implemented. Treatment continuity was high, with over 80% of those on therapy at baseline remaining on treatment at follow-up. Overall, these findings suggest that the primary challenge lies in initiating diagnosis and treatment, while sustaining adherence, though secondary, remains important. Globally, treatment discontinuation is a concern, with approximately half of patients stopping antihypertensive medication within a year [38–40]. The persistence of uncontrolled hypertension underscores the need for regular follow-up of patients who have not achieved BP control [41].

In our sample, hypertension prevalence was slightly higher among wealthier individuals, a finding that contributes to mixed evidence from Latin America. While some studies report higher BP among lower-SES groups, most evidence from LMICs suggests a positive association between SES and chronic conditions, including hypertension [42, 43]. In low-income regions of Mexico, SES measures have shown inverse relationships with elevated BP [44]. Although participants with lower wealth tended to have slightly higher rates of persistent undiagnosed, untreated, and uncontrolled hypertension, differences were not statistically significant. Prior research shows that health system performance in LMICs is often poor: fewer than half of hypertensive individuals are diagnosed, only a third receive medication, and just 10% achieve BP control [45]. Lower household wealth increases the likelihood of being lost to care before achieving control [45]. In our cohort, wealthier participants' higher hypertension prevalence but lower undiagnosed, untreated, and uncontrolled rates suggests that diagnosis is more accessible among higher-SES individuals.

Regarding lifestyle and sociodemographic factors, alcohol consumers were less likely to remain undiagnosed, though the small number of drinkers limits

interpretation. Persistent undiagnosed, untreated, and uncontrolled hypertension was more common among men, individuals living alone, rural residents, the uninsured, and those who were overweight. These groups appear particularly vulnerable to shortcomings in hypertension screening, treatment, and adherence. Cross-sectional studies have similarly linked health insurance, education, marital status, and urban residence to lower rates of undiagnosed, untreated, and uncontrolled hypertension [17, 18, 46]. Evidence also indicates that enrollment in Mexico's Seguro Popular program improved access to care, including hypertension diagnosis and treatment [47, 48]. Consistently, we found that uninsured participants were more likely to experience persistent undiagnosed, untreated, and uncontrolled hypertension, although the association reached statistical significance only for undiagnosed hypertension. Finally, women were more likely than men to receive diagnosis, treatment, and achieve BP control, indicating gender differences in hypertension management.

#### *Limitations*

This study only included individuals who participated in both Wave 1 and Wave 2. Because Wave 1 had a low response rate and some participants dropped out between waves, the resulting cohort may not fully represent Mexicans aged 50 and above at the time of Wave 2 (2014). When compared with the Wave 2 cross-sectional sample, which is weighted to reflect the population aged 50+, our cohort was older and exhibited higher rates of hypertension, more rural residents, and greater health insurance coverage. Conversely, cohort members were less likely to cohabit or consume alcohol. These differences should be considered when interpreting our results, as they may not directly generalize to the broader population in 2014, although they are likely more representative of an older demographic. Furthermore, selective attrition might have skewed the cohort with respect to unobserved traits linked to hypertension and its management.

Individuals identified with elevated blood pressure at Wave 1 were notified and advised to consult a healthcare provider. Consequently, the prevalence of persistent undiagnosed, untreated, and uncontrolled hypertension in our cohort may be lower than in the general population, making the high levels we observed especially noteworthy.

A key limitation of this study, shared by most research on hypertension awareness and control, is that blood pressure was assessed on only one occasion per wave. Although multiple measurements were taken at that time, hypertension is typically diagnosed using readings from at least two separate occasions. This could have resulted in an inflated number of false-positive diagnoses. Therefore, the actual prevalence of undiagnosed hypertension at each wave—distinct from persistent undiagnosed hypertension across waves—may be lower than our estimates. The longitudinal design, however, allowed us to identify such measurement errors, an advantage over cross-sectional studies. In our analysis, 30% ( $n = 85$ ) of participants classified as undiagnosed hypertensive in Wave 1 were considered non-hypertensive in Wave 2. Similar reclassifications occurred for untreated and uncontrolled hypertension, at rates of 26% ( $n = 89$ ) and 19% ( $n = 101$ ), respectively. These figures suggest that cross-sectional estimates of hypertension may overstate prevalence due to false positives [49]. Nonetheless, because our focus was on persistent gaps over a five-year period, these classification issues are less problematic from a longitudinal perspective.

The study period spanned 2009–2014. Since then, the Mexican Institute of Social Security (IMSS) has shifted toward a more preventive approach [50] and launched several integrated care programs [51, 52]. These policy changes may have enhanced hypertension screening and management, potentially addressing some of the deficiencies highlighted by our findings.

#### *Policy implications*

The persistence of undiagnosed, untreated, and uncontrolled hypertension in older Mexicans underscores an urgent need for targeted health interventions. Integrating routine blood pressure checks into visits for other medical concerns could increase detection rates and enable earlier intervention. Our findings suggest that such efforts should focus on populations at higher risk, including men, individuals living alone, rural residents, those without health insurance, and individuals with overweight. The frequent transition from controlled to uncontrolled hypertension also points to the value of strategies that reinforce treatment adherence and continuity of care. Moreover, the association between persistent undiagnosed hypertension and lack of insurance indicates that expanding effective primary care coverage, or simply improving awareness of existing

entitlements, may help close gaps in hypertension management.

### Conclusion

This study reveals that many older adults in Mexico with hypertension remain undiagnosed, untreated, or poorly controlled over a period of at least five years, and that these states are not static but subject to change. The results highlight substantial opportunities to improve the detection, long-term management, and control of hypertension. To reduce premature mortality and promote equity in hypertension care, interventions should prioritize men, people living alone, rural residents, the uninsured, and those with overweight, emphasizing both diagnosis and sustained adherence to treatment.

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