

Hypertension care cascade in Chile: a serial cross-sectional study from national health surveys 2003-2010-2017.

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Abstract

Background: Data on trends in hypertension prevalence and indicators of attainment at each step of the care cascade are required in Chile. **Aim :** To quantify trends (2003-2017) in prevalence and in the proportion of individuals with hypertension attaining each step of the care cascade (awareness, treatment and control) among adults aged ≥ 17 years, and to assess the impact of lowering the blood pressure (BP) threshold on these indicators.

Methods: We used data from three Chilean national health surveys (ENS 2003; 2010; 2017). Mean systolic (SBP) and diastolic (DBP) levels, hypertension prevalence (BP \geq 140/90 mmHg or use of antihypertensive treatment), and levels of awareness, treatment and control were assessed in each year. Logistic regression on pooled data was used to assess trends in hypertension prevalence and in its care cascade; linear regression was used to assess trends in SBP and DBP. We compared levels of hypertension prevalence using two sources to ascertain use of antihypertensive treatment (ATC codes from a detailed medicine inventory and self-reported use). The 2017 ACC/AHA guidelines were used to re-define hypertension using lower thresholds (BP \geq 130/80 mmHg or use of treatment).

Results : Hypertension prevalence was 34.0%, 32.0% and 30.8% in 2003, 2010 and 2017, respectively. Mean SBP and DBP decreased over the 15-year period, except for SBP among females on treatment. Adopting the 2017 ACC/AHA guidelines would increase hypertension prevalence by 17% and 55% in absolute and relative terms, respectively. Levels of treated- and controlled-hypertension were significantly higher in 2017 than in 2003 (65% vs 41% for treatment; 34% vs 14% for control), while levels of awareness were stable (66% vs 59%). Gender disparities were evident, with higher awareness, treatment and control levels among females in 2003, 2010 and 2017.

Conclusions: The introduction of universal access to care for hypertension in Chile in 2005 accounted partly for the rise in levels of treated- and controlled-hypertension since 2003. Lowering the BP threshold would substantially increase the financial public health challenge of further improving levels of attainment at each step of the care cascade. Innovative and collaborative strategies are needed to improve the management of hypertension, especially among males.

Introduction

Hypertension continues to be one of the most important health challenges, being a major risk factor of cardiovascular disease (CVD) morbidity and mortality worldwide. More than 80% of the burden of disease attributable to high blood pressure (BP) in 2015 (Systolic Blood Pressure (SBP) \geq 115 mmHg) occurs in low- and middle-income countries (LMICs), reflecting the relatively recent sharp increase in prevalence, and the lower levels of attainment at each step of the hypertension care cascade, compared with high-income countries (HICs) [1]. High BP (SBP \geq 115 mmHg) is one of the major risks for the burden of disease attributable to risk factors in Chile, according to the years of life adjusted for disability and premature death [2]. Chile, a country of 18.7 million inhabitants with 11.4% aged \geq 64y and 37.4% living in the Metropolitan region (Santiago), has currently one of the most prosperous economies in Latin America (GDP per capita of 24,500 USD, ranked as a HIC since 2012) but at the same time has a very low level of health expenditure (7.8% of GDP). Furthermore, this economic prosperity has not been shared equally across all segments of the population, creating a unique profile for hypertension prevalence and its care cascade (i.e. the proportion of persons with hypertension at various stages of the management continuum that starts with screening and ends with control).

Chile has a very strong and efficient high coverage public-health care system bringing success in indicators of maternal and infant health. Sustained efforts have been made to provide care to the hypertensive population since the 1980s [3] through its Mixed Healthcare system (public and private), with 85% of the population using public-health insurance and services in 2015 [4]. Since the 1980s, two major health system interventions were introduced to improve the management of hypertension. First, in 2002, the former hypertension disease specific programme in primary public care was transformed into an integrated risk-stratified based model: the "Cardiovascular Health Program" and second, in 2005, a law was passed (Garantías Explícitas en Salud [GES]) which warranted timely access and financial coverage (e.g. medicines free-of-charge) to all insured Chileans (public and private) for the most prevalent chronic diseases, including hypertension [5]. These efforts are aligned with the current health goals for 2010 to 2020 of increasing the level of controlled hypertension (BP<140/90 mmHg) in relative terms by 50% [6].

While hypertension prevalence (defined as BP \geq 140/90 mmHg or use of antihypertensive treatment) across 90 countries remained stable between 2000 and 2010 at around 30%, key hypertension care cascade indicators - awareness, treatment and control – increased slightly from 41% to 47%; 32% to 37%; and 34% to 37% respectively [1]. Despite the availability of highly effective antihypertensive treatments, the majority of hypertensives on treatment do not therefore achieve BP control [1]. Hypertension prevalence, and levels of uncontrolled hypertension, would be even higher if a stricter definition of hypertension based on a lower BP threshold is adopted. According to the 2017 American College of Cardiology/American Heart Association guidelines (2017 ACC/AHA) [7], the commonly used (seventh Joint National Committee [JNC] 7) [8] threshold for high BP (BP \geq 140/90 mmHg) should be lowered to BP \geq 130/80 mmHg: this represents a more aggressive approach to decrease the risk of CVD events occurring at lower BP levels [7].

Even though attainment of care cascade indicators for various diseases have been recently described for LMICs [9] and HICs [10], there is scarce evidence of recent trends in the hypertension care cascade from countries such as Chile that have experienced fast epidemiologic transitions. As far as we know, no studies to date in the Latin American and Caribbean region (LAC) have quantified these trends using nationally representative, measured BP data the implications of lowering the BP threshold in line with the 2017 ACC/AHA guidelines (albeit using an indicator of high BP rather than hypertension) [11, 12]. Using data from three nationally representative Chilean health examination surveys covering a 15-year period (2003; 2010; 2017), the aims of the present study were to: 1) quantify trends in hypertension prevalence and in attainment at each step of its care cascade (including an assessment of gender disparities); and 2) quantify the impact of lowering the BP threshold on these indicators.

Methods

Aim, design and setting of the study

Participants in the cross-sectional Chilean National Health Surveys (ENS) 2003, 2010 and 2017 were selected using a stratified multistage probability sample of non-institutionalized adults from urban and rural areas. The minimum age of recruitment was 17 years in 2003; this was lowered to 15 in 2010 and 2017. One participant was randomly selected per household using a Kish grid.

Ethics approval and consent to participate

The study protocol and ethical consent forms were approved by the ethics committee of the Pontificia Universidad Católica de Chile (PUC) and the Chilean Ministry of Health (approval number for ENS2003,2010 and 2017: XXX; 09-113; 16-019, respectively). Persons selected for inclusion provided informed and signed consent before participation.

Data collection

Data collection procedures were generally similar across the three surveys. In the first home visit, a lay interviewer applied health questionnaires face-to-face, including the following questions regarding hypertension awareness: “Have you ever been told by a doctor, nurse or health care provider that you have high blood pressure?” and hypertension treatment (regardless of awareness) “Are you currently carrying or doing any program or treatment indicated by a health professional to keep your blood pressure under control?”. Participants reporting that they were on treatment were asked about type of treatment (response options: *medications, treatment without medication, or both*). During the second visit, a trained nurse measured BP and recorded the medications participants were currently using (prescribed or not) via a detailed inventory. Medications were classified using the anatomical therapeutic chemical (ATC) classification system [13]. Sitting BP was measured after a five-minute rest using an upper arm monitor (Omron, Healthcare Co Ltd, Kyoto, Japan, models HEM713C, HEM742 and HEM7200 in 2003, 2010 and 2017, respectively) with appropriately sized arm cuffs, with a two-minute pause between readings. Two BP readings were taken in 2003 while three readings were taken in 2010 and 2017. To ensure like-for-like comparisons, we used the average of the first- and second-readings in each year.

Definitions of hypertension and the care cascade

Estimates of hypertension prevalence vary by choice of high BP cutpoints [7]. We compared two different definitions of hypertension. First, we identified participants with hypertension based on the seventh report of the JNC on prevention, detection, evaluation and treatment of high blood pressure: SBP/DBP \geq 140/90 mmHg or current use of antihypertensive treatment (hereafter

referred to as the JNC 7 guideline) [8]. Second, we identified participants with hypertension based on the 2017 ACC/AHA recommendations: SBP/DBP $\geq 130/80$ mmHg or current use of antihypertensive treatment (hereafter referred to as the 2017 ACC/AHA guideline) [7].

We focused on three steps of the hypertension care cascade: awareness, treatment, and control. Among those classed as hypertensive, we defined: (1) awareness as the report of prior diagnosis of high BP by a healthcare professional; (2) treatment (in our main analyses) as the current use of antihypertensive medication as identified in the medicine inventory (ATC codes: C02, C03, C07, C08, C09); and (3) control according to the JNC 7 (BP < 140/90 mmHg) and the 2017 ACC/AHA (BP < 130/80 mmHg) guidelines.

Statistical analysis

Analyses were restricted to adults aged 17 years or over to ensure comparability across the three surveys. First, we summarised the sociodemographic profile (age; gender; educational level; place of residence) and estimated average SBP/DBP levels in each survey amongst all participants with valid BP and medicine data. Second, amongst those classed as hypertensive (JNC 7 guideline), we calculated the levels of awareness, treatment and control. Third, pooling data across years, we used age-adjusted logistic regression to estimate the gender-specific trends in hypertension (JNC 7 guideline). Among those classed as hypertensive, we used age-adjusted logistic regression to calculate gender-specific trends in awareness, treatment, and control. In each analysis survey year and age were entered into the models as a three-category independent variable and as a single continuous variable, respectively. Results were summarised using Odds Ratios (ORs) with accompanying 95% confidence intervals (95% CI). Pairwise comparisons were used to evaluate change over time (i.e. 2010 vs 2003; 2017 vs 2003; and 2017 vs 2010). Age-adjusted linear regression models were used to test for significant trends in mean SBP and DBP (regardless of treatment and separately by treatment status).

Fourth, we quantified the difference in hypertension prevalence and in levels of awareness, treatment and control between the current (JNC 7) and new (2017 ACC/AHA) guidelines. For each survey year, participants were classified into one of four mutually exclusive groups. According to the JNC 7 guideline, these groups were defined as follows: normotensive (<140/90 mmHg); treated and controlled (<140/90 mmHg); treated, but uncontrolled ($\geq 140/90$ mmHg); and untreated and uncontrolled ($\geq 140/90$ mmHg). The corresponding classification using the 2017 ACC/AHA guideline was as follows: normotensive (<130/80 mmHg); treated and controlled (<130/80 mmHg); treated, but uncontrolled ($\geq 130/80$ mmHg), and untreated and uncontrolled ($\geq 130/80$ mmHg). Applying the 2017 Chilean census data to the ENS 2017, we estimated the number of additional adults who would be eligible for antihypertensive treatment based on the 2017 ACC/AHA guideline [14].

In our main analysis, ascertaining use of antihypertensive treatment through ATC codes may slightly overestimate prevalence as some medicines can be used for other conditions without the co-existence of hypertension. To determine the robustness of our ascertainment of antihypertensive treatment we alternatively estimated hypertension prevalence based on the JNC 7 guideline using self-reported treatment and compared the difference between the two sets of estimates.

Analyses were based on complete-cases and were weighted accounting for differences in selection probability (e.g. selection of one person per household) and non-response rates. P-values < 0.05 were classed as statistically significant (two-tailed). All analyses were conducted in Stata V14.0 (StataCorp LP, College Station, Texas, U.S.) adjusting for the complex survey design.

Results

Sample characteristics

Table 1 shows the sample sizes, response rates, sociodemographic profile, and average levels of BP in each survey year amongst the 13,605 participants aged 17 years and over with valid BP and medicine data. Characteristics were similar across the three surveys, with the exception of an increase over time in the proportion of participants in the highest educational group (>12 years of formal education). Response rates for the total sample were 63%, 75% and 67% in 2003, 2010 and 2017 respectively.

Table 1 here

Hypertension and its care cascade

Based on the (current) JNC 7 guideline (SBP/DBP \geq 140/90 mmHg or current use of antihypertensive treatment), **Figure 1** shows the levels of hypertension and levels of attainment at each care cascade step (awareness, treatment, and control) across the three surveys. For brevity, we report here on the change between the first- and last-surveys (i.e. 2003 and 2017). Among all adults, hypertension prevalence decreased slightly from 34.0% (95% CI: 31.6-36.4%) to 30.8% (95% CI: 28.7-32.9%). Hypertension prevalence decreased among males from 37.1% (95% CI: 33.5-40.9%) to 31.2% (95% CI: 28.1-34.5%) and decreased among females from 31.0% (95% CI: 28.0-34.1%) to 30.3% (95% CI: 27.6-33.1%).

Among those classed as hypertensive, attainment at each cascade step mainly showed improvement. First, levels of awareness among males increased from 45.6% (95% CI: 39.9-51.4%) to 58.1% (95% CI: 52.2-63.8%); levels were higher among females but remained stable at around 73%. Second, levels of treatment among males increased from 24.3% (95% CI: 19.9-29.3%) to 56.7% (95% CI: 50.9-62.4%) and increased among females from 54.9% (95% CI: 49.5-60.1%) to 73.5% (95% CI: 68.4-78.0%). Third, levels of controlled hypertension among males increased from 6.3% (95% CI: 3.8-10.3%) to 28.2% (95% CI: 23.0-33.9%) and increased among females from 19.9% (95% CI: 15.9-24.7%) to 39.7% (95% CI: 34.7-45.0%).

Figure 1 here

Age-adjusted trends in hypertension and its cascade of care

Figure 2 shows the age-adjusted trends in hypertension and in attainment at each cascade step by gender based on logistic regression models. Among males the odds of hypertension decreased significantly between 2003 and 2010 (OR: 0.63; 95% CI: 0.48-0.83) and between 2010 and 2017 (OR: 0.77; 95% CI: 0.59-1.00). The odds of hypertension decreased for females between 2010 and 2017 (OR: 0.73; 95% CI: 0.57-0.92).

Amongst those classed as hypertensive, the odds of awareness did not change significantly over time, except among males, where the odds of awareness increased from 2003 to 2010 (OR: 1.45; 95% CI: 1.02-2.06). Compared with 2003, the odds of treatment and control were significantly higher in 2010 and in 2017 for both genders.

Age-adjusted trends in SBP and DBP

Average levels of age-adjusted SBP and DBP among all adults (i.e. regardless of treatment) decreased significantly over the 15-year period for both genders (see **Additional file 1** Table S1). For example, mean SBP decreased by 4.4 mmHg (95% CI: 2.9-6.0 mmHg) and by 5.8 mmHg (95% CI: 4.3-7.4 mmHg) between 2003 and 2017 among males and females, respectively.

Additional analyses stratified by treatment status showed that mean BP levels decreased significantly among all groups, with the exception of no significant change in mean SBP among females using antihypertensive treatment (see **Additional file 1**. Table S1).

Figure 2 here

Hypertension prevalence based on lower BP thresholds

Based on the ENS 2017 data, **Figure 3** shows the difference in hypertension prevalence and in the proportion of adults attaining each step of the care cascade based on the new (2017 ACC/AHA) and current (JNC 7) guidelines. Overall, hypertension prevalence in 2017 would be about 17% percentage points higher in absolute terms if the BP threshold was lowered to <130/80 mmHg (2017 ACC/AHA: 47.6%, 95% CI: 45.2-50.0%; JNC 7: 30.7%, 95% CI: 28.7-32.9%); a relative increase of around 55%. Based on the 2017 census, we estimate that an additional 2.3 million adults aged 17 years or over would therefore be classed as hypertensive and so be eligible for antihypertensive treatment. We estimate that the proportion of adults in the population with uncontrolled and untreated hypertension in 2017 using the 2017 ACC/AHA guideline would be about 17% percentage points higher (2017 ACC/AHA: 27.5%; 95% CI: 25.4-29.8%; JNC 7: 10.7%; 95% CI: 9.4-12.2%); whilst the proportion of adults with treated, but uncontrolled hypertension would be about 4.4% percentage points higher (2017 ACC/AHA: 14.0%; 95% CI: 12.6-15.5%; JNC 7: 9.6%; 95% CI: 8.5-10.8%).

Figure 3 here

Sensitivity analysis

Our sensitivity analysis showed similar levels of hypertension (based on the JNC 7 definition), whether using ATC-codes from the detailed nurse-administered medicine inventory or self-reported (SR) data to ascertain use of antihypertensive treatment. The absolute difference in the two sets of estimates (ATC vs SR) was 0.1%, 3.0% and 1.2% in 2003, 2010 and 2017 respectively (see **Additional file 2**. Figure S1).

Discussion

Data on current trends in hypertension prevalence and changes over time in the levels of attainment at each step of its care cascade (i.e. awareness, treatment and control) are required in the LAC region. Our analysis of Chilean health examination survey data indicates that around three-in-ten adults aged 17 years and over had hypertension, with the prevalence from 2003 to 2017 showing a small but significant decline (from 37% to 31% for males; from 31% to 30% for females). Mean SBP and DBP levels also decreased at the population level over the 15-year period. Adopting the 2017 ACC/AHA hypertension guideline would increase prevalence by about 55% in relative terms, resulting in an additional 2.3 million adults being eligible for antihypertensive treatment. Using self-reported data rather than ATC codes to ascertain use of antihypertensive treatment had little impact on the prevalence estimates.

Average BP levels fell steadily worldwide between 1975 and 2015 [15]. Some uncertainty exists about the drivers of the worldwide trends in average BP and hypertension prevalence, particularly as the reductions in BP levels have been accompanied by increases in a number of the leading risk factors for high BP, including high body mass index (BMI) and diabetes [16]. Our results also showed decreases in average BP levels regardless of treatment status (with the exception of no significant change in mean SBP among females on treatment), while evidence from other studies analysing Chilean data over the same time period shows that levels of obesity have increased, whilst levels of physical inactivity were unchanged [17]. The decrease in BP can be explained at least partially by the increased detection of high BP by health care professionals (awareness) and by the subsequent wider uptake of antihypertensive treatments [15]. Evidence consistently shows that higher levels of hypertension are associated with lower levels of income and formal education [18, 19]. Therefore, some of the BP decline in Chile could be attributed to the decrease in absolute poverty from 29% to 9% and the increase in the average length of time spent in formal education from 10 to 11 years between 2009 and 2017 [20]. The decline in hypertension prevalence in Chile was similar to that observed in other HICs, potentially driven by the decrease in risk factors which buffered the expected increase due to the rises in obesity and diabetes. For instance, salt intake [21] and exposure to dietary trans fatty acids and smoking decreased over time [17, 22]. Stop signs were introduced in 2012 on packaged foods “high in” energy, sodium, sugars, and saturated fats, which is contributing to a healthier food industry reformulation [23]. Despite the progress over the 15-year period, the prevalence of hypertension (defined as $BP \geq 140/90$ mmHg or use of antihypertensive treatment) is currently slightly higher in Chile compared to that found in HICs [10].

According to our results, current levels of attainment at each step of the hypertension care cascade are higher in Chile compared to most LMICs [9], while compared to HICs [10], levels of awareness, treatment and control were lower, higher and similar respectively. We found that levels of treated and controlled hypertension significantly increased from 2003 to 2017, while levels of awareness increased only among males between 2003 and 2010. In agreement with global trends, our analyses showed that the proportions of adults reaching each stage of the care cascade were similar to those reported in other HICs and were higher than those in LMICs between 2000 and 2010 [1, 9]. Several explanations have been put forward for the global improvement in levels of hypertension awareness, treatment and control, including increases in BP screening at the primary care and community levels, securing better treatment availability, reducing treatment costs, improving treatment adherence and preventing clinical inertia [24]. The GES was launched in Chile in 2005 with a wide marketing strategy and helped to disseminate evidence-based guidelines with simplified recommendations nationwide. In 2014, the law was enforced with an additional regulation called FOFAR, which, for the publicly insured, warranted medicines free-of-charge for hypertension, diabetes and dyslipidaemia. Although we cannot directly assess the impact of these programmes with the ENS data, we can speculate that they have had at least some positive impact through the improvements in treatment and control levels presented here.

Our analyses show no significant difference in hypertension prevalence by gender. However, levels of attainment at each cascade step were higher among females. These gender disparities were also reported among LMICs [9] and HICs [1, 10]. However, the gender gap was wider in Chile than in other HICs. For example, current levels of controlled hypertension were 41% and 26% higher in relative terms among females in Chile (according to our results) and in HICs, respectively [1]. Potentially these gender disparities

arise from higher levels of health care services utilisation among females and lower long-term adherence to antihypertensive treatment among males [25]. Although gender disparities exist, the trends show some evidence of faster improvements among males. Our analyses show that the Chilean 2010-2020 health goal of increasing the level of controlled hypertension by 50% in relative terms has been achieved among males, but is only at the halfway point among females since the relative increases from 2010 to 2017 were 97% and 24% for males and females respectively [6].

Using the 2017 data we found that implementing the 2017 ACC/AHA guideline – i.e. lowering the BP threshold from 140/90 mmHg to 130/80 mmHg - would result in 2.3 million more Chilean adults being classed as hypertensive and so be eligible for antihypertensive treatment. This is in addition to the 1.5 million hypertensive adults currently untreated according to the current (JNC 7) guideline. The relative increase of about 55% in hypertension prevalence as a result of adopting the 2017 ACC/AHA guideline seems to be higher in Chile than those estimated (using similar methods) in the United States (27%), China (45%) and Spain (42%) [11, 12], but lower than in Peru (130%) [26]. The definitions in the Peruvian study were based on high BP alone, however, and so is not strictly comparable with our findings. This new scenario would be a massive challenge for Chile, requiring significant increases in public health expenditure, especially for health-care services and medicines. Implementing the new guideline would potentially increase the absolute number of hypertensives who are aware and on treatment over time. There is a growing debate about the merits of lowering the BP threshold, including concerns about the expected costs of implementation [27].

One strength of our study is the use of nationally representative health examination survey data, in contrast to the Prospective Urban Rural Epidemiology (PURE) study which covers only a few cities [28], and our use of objective measures which overcome the limitations of self-report data. However, our study has a number of limitations. First, to ensure comparability across the three surveys, we used the average of the first and second BP readings. Compared to using the average of the second- and third-readings, our approach could have slightly (<1%) overestimated hypertension prevalence and underestimated levels of controlled hypertension [29]. Second, according to the JNC 7 and 2017 ACC/AHA guidelines, the diagnosis of hypertension should be made at follow-up visits.[7, 8] Evaluation of BP during a single visit (as done in the ENS surveys) may overestimate the true prevalence as raised BP is not necessarily persistent. According to analyses of Chilean data, a small but statistically significant reduction in hypertension prevalence (1%) was found when BP measurement was repeated in a follow-up visit [30]. Moreover, the impact of the 'white coat effect' (i.e. transient increase in BP produced by the presence of a healthcare professional) or of 'masked hypertension' (i.e. nonelevated BP in clinical but elevated in ambulatory monitoring) on levels of hypertension could not be estimated in our study.

Third, recall bias could also have impacted on our estimated levels of awareness and treatment. Ascertaining use of antihypertensive treatment based on ATC codes from the medicine inventory could have produced a slight overestimation of prevalence since some medicines can be used for other conditions without the co-existence of hypertension. However, our sensitivity analysis showed that the magnitude of bias was small: suggesting minor recall bias (versus self-reported use) or low use of antihypertensive treatments for conditions other than hypertension. Fourth, although the same BP monitor was used in each survey, use of different models may have weakened comparability to some extent. Finally, as in other nationally representative health examination surveys, levels of response to the Chilean health survey have decreased over time. However, the current levels of response are comparable to those achieved by other national health examination surveys [31].

In conclusion, mean levels of BP in the untreated and treated populations have declined in Chile during the last 15 years (with the exception of no significant change in mean SBP among females on treatment), while levels of treatment and control among adults with hypertension have increased. The introduction of Universal Access to care for hypertension in 2005 may have accounted at least partly for the rise in levels of treatment and control since 2003. Regardless of the hypertension definition, innovative and collaborative strategies are needed to improve levels of attainment at each step of the hypertension care cascade, including the promotion of screening and access to care, together with interventions to increase treatment coverage and its adherence, especially among males and high CVD risk populations.

Abbreviations

ACC: American College of Cardiology; **AHA:** American Heart Association; **ATC:** anatomical therapeutic chemical; **BP:** Blood pressure; **CVD:** cardiovascular disease; **DBP:** diastolic blood pressure; **ENS:** Chilean health survey; **GES:** Garantías Explícitas en Salud; **HICs:** high-income countries; **JNC 7:** Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment

of High Blood Pressure; **LAC**: Latin America and Caribbean region; **LMICs**: low-middle income countries; **PURE**: Prospective Urban Rural Epidemiology study; **SBP**: systolic blood pressure;

Declarations

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analysed during the current study are available in the Chilean Ministry of Health webpage: Departamento de Epidemiología, Ministerio de Salud de Chile, Encuesta Nacional de Salud, 2016-2017 at <http://epi.minsal.cl/bases-de-datos/>

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

APS made the statistical analysis and wrote part of the article, SS, JSM and MR contributed to the design of the study and writing of the research proposal, PM and CV revised the article for important intellectual content. All authors read and approved the final manuscript.

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Tables

Table 1. Sample size, response rate and sociodemographic characteristics by survey year. Chile ENS2003-2010-2017

		ENS2003		ENS2010		ENS2017	
		n*	% or mean (SE)	n*	% or mean (SE)	n*	% or mean (SE)
Total sample and response rate#		3614	63	5267	75	6074	67
Nurse visit sample and response rate		3448	95	4863	92	5379	89
Sample with valid BP and medicine data		3416		4820		5369	
Gender %	Male	1558	48.9	1919	48.4	1945	48.9
	Female	1858	51.1	2901	51.6	3424	51.1
Age %	17-34y	863	40.7	1361	35.5	1342	33.9
	35-44y	583	21.6	874	22.5	813	20.1
	45-54y	608	16	892	16.8	879	14.7
	55-64y	486	10.8	749	13	978	17.3
	65-74y	527	6.8	536	7.4	786	8
	75y+	349	4.2	408	4.7	571	5.9
Educational level %	Low (<8y)	1362	25.4	1277	19.1	1319	16.9
	Medium (8-12y)	1625	55.5	2531	55.5	2808	54.1
	High(>12y)	421	19.1	912	25.3	1195	29
Place of residence %	Urban	2798	86.4	4099	86.9	4513	89.2
	Rural	618	13.6	721	13.1	856	10.8
SBP mmHg		3416	127.8 (0.52)	4820	126.9 (0.48)	5369	124.9 (0.46)
DBP mmHg		3416	79.9 (0.34)	4820	76.6 (0.27)	5369	74.7 (0.25)

Figures

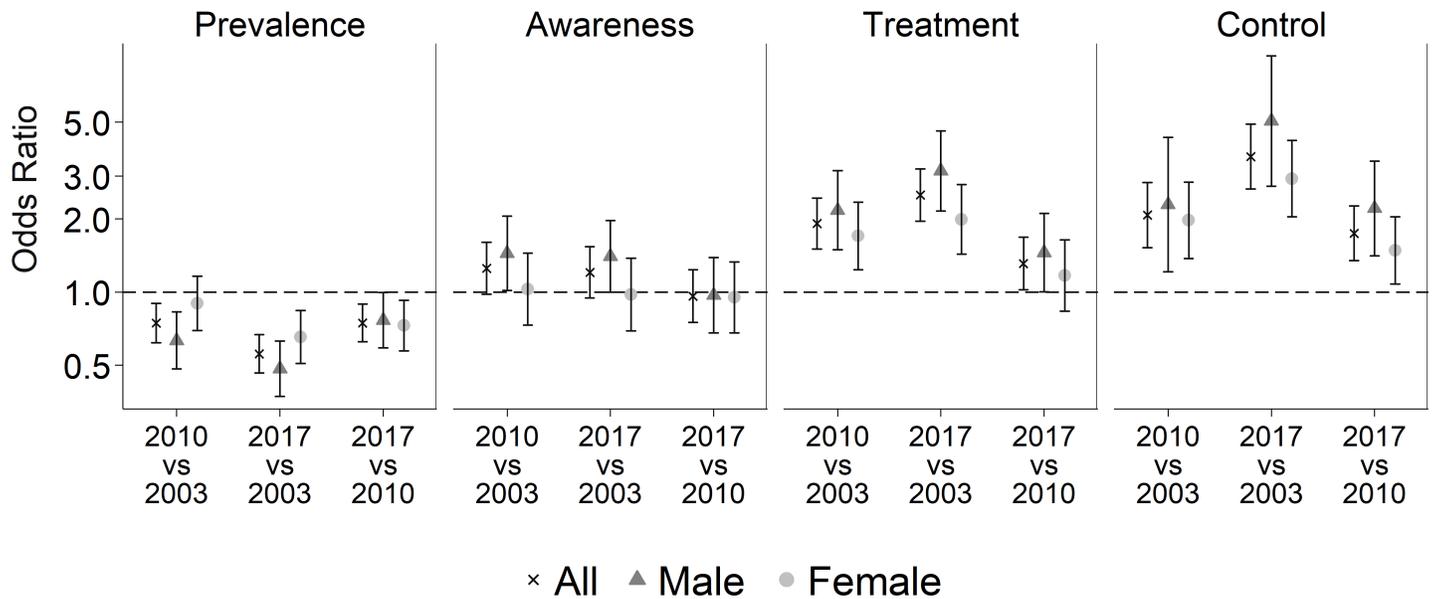


Figure 1

Hypertension prevalence, awareness, treatment and control by gender. Chile ENS2003-2010-2017 Legend to Figure 1: Definitions according to the JNC 7 guideline. Prevalence: SBP/DBP \geq 140/90 mmHg or current use of antihypertensive treatment; Awareness: prior diagnosis of high blood pressure; Treatment: current use of antihypertensive medication according to ATC codes; and Control: SBP/DBP < 140/90 mmHg. Levels of hypertension estimated among all adults. Levels of awareness, treatment and control estimated amongst those classed as hypertensive (see Additional file 2. Table S2 which shows the values of Figure 1).

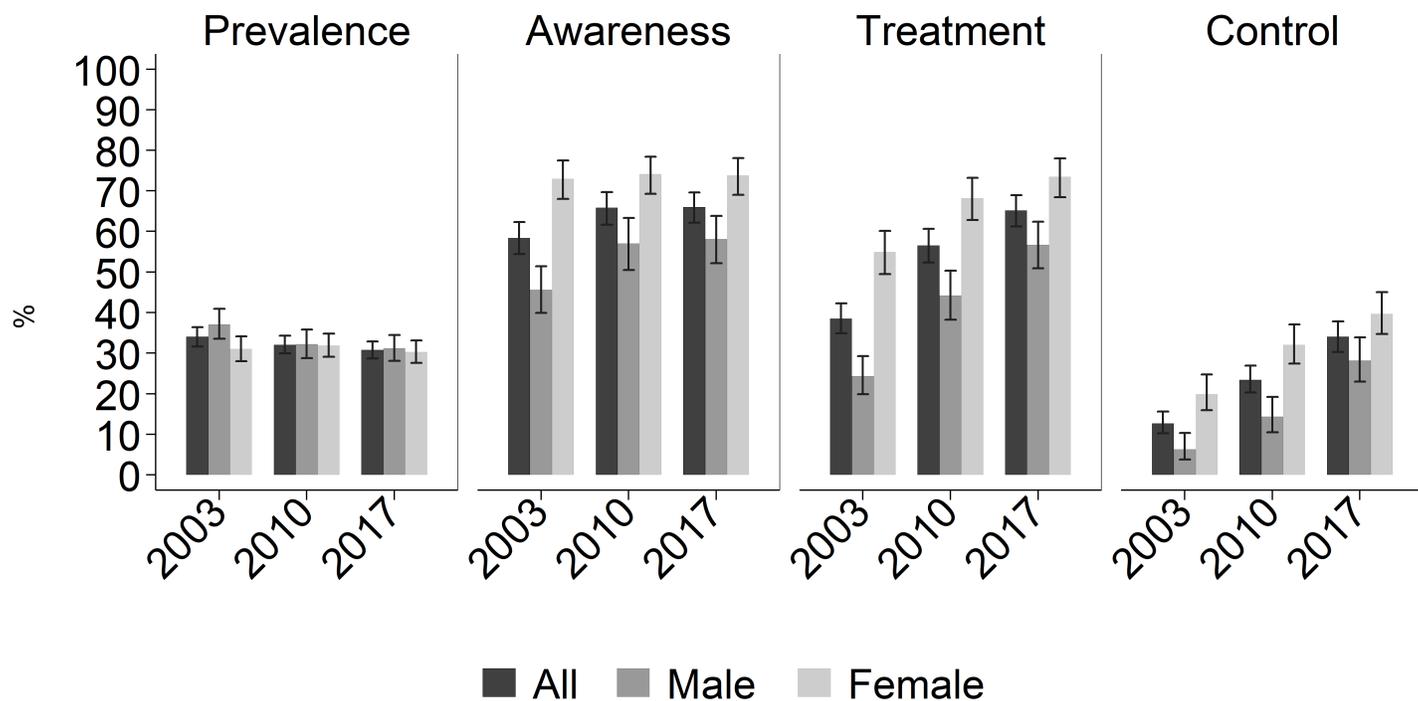


Figure 2

Trends for hypertension prevalence, awareness, treatment and control by gender. Chile ENS2003-2010-2017 Legend to Figure 2: *Odds ratios from age-adjusted logistic regression. Definitions according to the JNC 7 guideline. Prevalence: SBP/DBP \geq 140/90 mmHg or current use of antihypertensive treatment; Awareness: prior diagnosis of high blood pressure; Treatment: current use of antihypertensive medication according to ATC codes; and Control: SBP/DBP <140/90 mmHg. Odds of hypertension estimated among all adults. Odds of awareness, treatment and control estimated amongst those classed as hypertensive (see Additional file 2. Table S3 which shows the values of Figure 2).

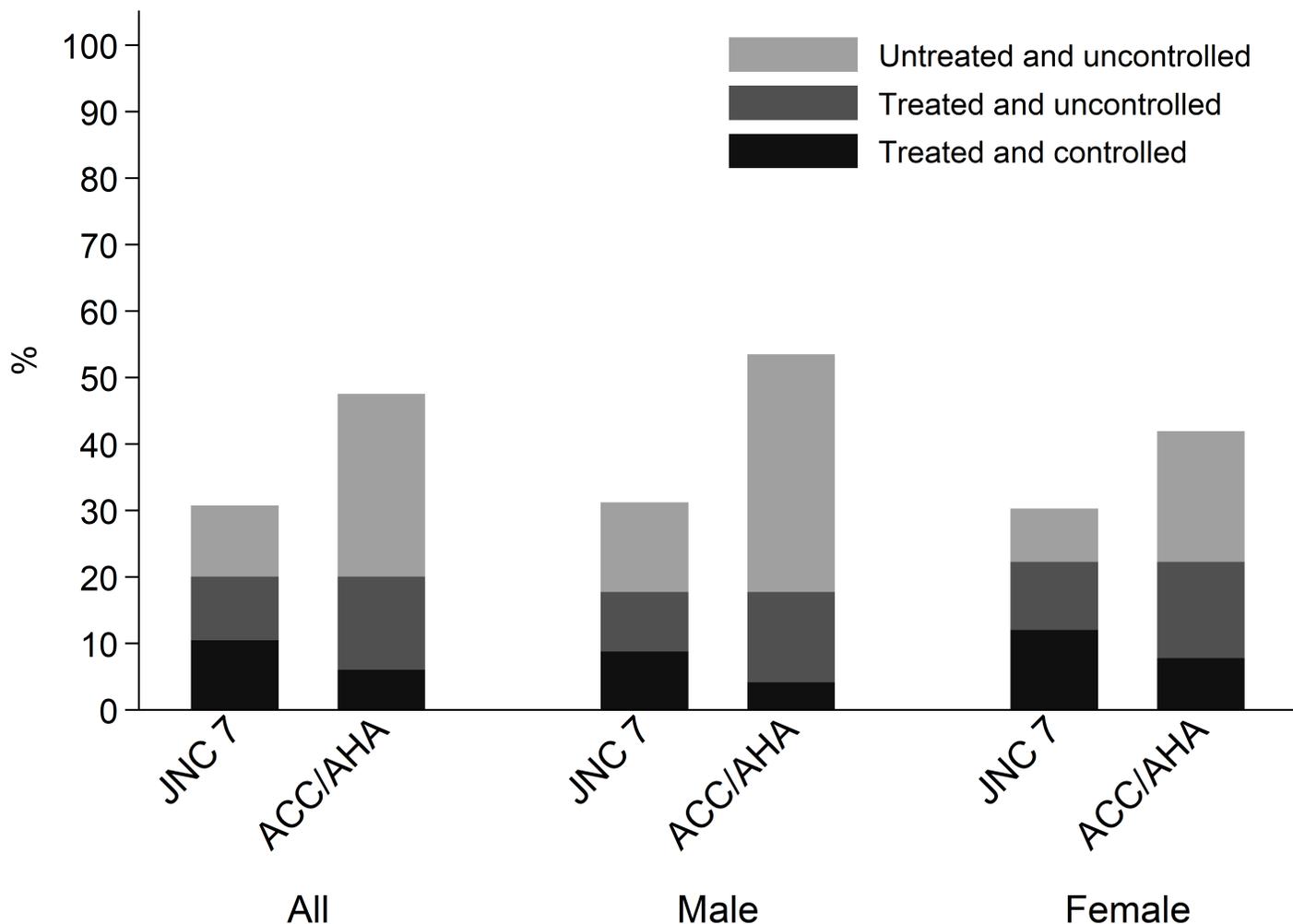


Figure 3

Prevalence, treatment and control of hypertension according to JNC 7 and 2017 ACC/AHA guidelines by gender. Chile ENS2017 Legend to Figure 3: JNC 7 groups defined as follows: normotensive (<140/90 mmHg); treated and controlled (<140/90 mmHg); treated and uncontrolled (\geq 140/90 mmHg); untreated and uncontrolled (\geq 140/90 mmHg). 2017 ACC/AHA groups defined as follows: normotensive (<130/80 mmHg); treated and controlled (<130/80 mmHg); treated and uncontrolled (\geq 130/80 mmHg); untreated and uncontrolled (\geq 130/80 mmHg). Use of antihypertensive treatment ascertained using ATC codes (see Additional file 2. Table S4 which shows the values of Figure 3).

Supplementary Files

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