UNIVERSIDADE FEDERAL DE MINAS GERAIS

Faculdade de Medicina

Programa de Pós-Graduação em Saúde Pública

Débora Moraes Coelho

CONTEXTO URBANO E HIPERTENSÃO ARTERIAL: abordagem multinível entre cidades da América Latina

Belo Horizonte

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Débora Moraes Coelho

CONTEXTO URBANO E HIPERTENSÃO ARTERIAL: abordagem multinível entre cidades da América Latina.

Tese apresentada ao Programa de Pós-Graduação em Saúde Pública da Faculdade de Medicina da Universidade Federal de Minas Gerais, como requisito parcial para obtenção do título de Doutor em Saúde Pública.

Orientadora: Profª. Dra. Waleska Teixeira Caiaffa

Coorientadora: Profª. Dra. Amanda Cristina de Souza Andrade

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ATA DE DEFESA DE TESE

Às **14:00** horas do dia **vinte e nove de fevereiro de 2024**, na plataforma *Zoom* , realizou-se a sessão pública para a defesa da **TESE** de **DÉBORA MORAES COELHO**, número de registro 2020658989, graduada no curso de ENFERMAGEM , como requisito parcial para a obtenção do grau de Doutor em SAÚDE PÚBLICA. A presidência da sessão coube à **professora Waleska Teixeira Caiaffa - Orientadora (UFMG).** Inicialmente, a presidente fez a apresentação da Comissão Examinadora assim constituída: **Profa. Waleska Teixeira Caiaffa - Orientadora (UFMG), Profa. Amanda Cristina de Souza Andrade- Coorientadora(Universidade Federal de Mato Grosso),Profa. Aline Dayrell Ferreira Sales (UFMG), Profa. Juliana Vaz de Melo Mambrini (Fiocruz- Minas), Profa. Natalia Caldeira Loss Vincens (University of Gothenburg, GU, Suécia)**. Em seguida, a candidata fez a apresentação do trabalho que constitui sua Tese de doutorado, intitulada: ***"CONTEXTO URBANO E HIPERTENSÃO ARTERIAL: ABORDAGEM MULTINÍVEL ENTRE CIDADES DA AMÉRICA LATINA"*.** Seguiu-se a arguição pelos examinadores e logo após, a Comissão reuniu-se, sem a presença da candidata e do público e decidiu considerar **APROVADA** a **TESE DE DOUTORADO**. O resultado final foi comunicado publicamente a candidata pela presidente da Comissão. Nada mais havendo a tratar, a presidente encerrou a sessão e lavrou a presente ata que, depois de lida, se aprovada, será assinada pela Comissão Examinadora.

Belo Horizonte, 29 de fevereiro de 2024.

Assinatura dos membros da banca examinadora:

Profa. Waleska Teixeira Caiaffa - Orientadora (UFMG)

Profa. Amanda Cristina de Souza Andrade - Coorientadora (Universidade Federal de Mato Grosso)

Profa. Aline Dayrell Ferreira Sales (UFMG)

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Profa. Natalia Caldeira Loss Vincens (University of Gothenburg, GU, Suécia)

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“É melhor tentar e falhar, que preocupar-se e ver a vida passar. É melhor tentar, ainda que em vão que sentar-se, fazendo nada até o final. Eu prefiro na chuva caminhar, que em dias frios em casa me esconder. Prefiro ser feliz embora louco, que em conformidade viver”. (Martin Luther King)

RESUMO

Introdução: Apesar do interesse global nos determinantes sociais da hipertensão arterial (HA), as pesquisas em áreas urbanas e regiões com alta prevalência de HA, como a América Latina, são limitadas e os resultados são inconsistentes. **Objetivos:** Investigar como a condição socioeconômica em nível individual e em nível de área está associada à HA em adultos de 230 cidades de oito países latino-americanos e, examinar se estas associações variam por sexo e entre países (Artigo 1), bem como analisar a associação das condições socioeconômicas individuais e contextuais com a HA, segundo o sexo, entre adultos mais velhos residentes em áreas urbanas no Brasil (Artigo 2). **Método:** Para contemplar o primeiro objetivo, foram analisados dados harmonizados de 109.184 adultos (57,8% mulheres), com idades entre 18 e 97 anos (média: 42,7±16,4), do projeto SALURBAL (Salud Urbana en America Latina). A HA foi autorreferida. A escolaridade em nível individual, de subcidades (unidades administrativas aninhadas dentro de cidades) e cidades foi usada como proxy para a condição socioeconômica. Foram utilizados modelos de regressão logística multinível de três níveis (indivíduos, subcidades e cidades), ajustados por idade, país e estratificados por sexo. Para contemplar o segundo objetivo foram analisados dados de 6.767 participantes residentes em áreas urbanas (54,4% mulheres), com 50 anos ou mais (média: 61,6±9,5), da linha de base (2015-2016) do Estudo Longitudinal da Saúde dos Idosos Brasileiros (ELSI-Brasil). A HA foi autorreferida. A medida de condição socioeconômica individual foi a escolaridade e a do contexto foi o Indicador Brasileiro de Privação (IBP), usado em nível de setor censitário. Modelos de regressão logística multinível de dois níveis (indivíduos e setores censitários), ajustados por idade e estratificados por sexo foram utilizados. **Resultados:** O artigo 1 mostrou que a escolaridade em nível individual foi inversamente associada a maiores chances de HA entre as mulheres (ensino universitário ou superior versus menos do que primário: odds ratio [OR] = 0,67, intervalo de confiança de 95% [IC] = 0,61-0,74), enquanto que para os homens foi positivamente associada (ensino universitário ou superior versus inferior ao primário: OR = 1,65, IC 95% = 1,47-1,86). Para ambos os sexos, residir em subcidades com maior nível de escolaridade foi associado a maiores chances de HA (OR por desvio-padrão [DP] = 1,07, IC 95% = 1,02-1,12; OR por DP = 1,11, IC 95% = 1,05-1,18 para mulheres e homens, respectivamente). Além disso, a associação da educação em nível de cidade e HA variou entre os países. No Peru, houve associação inversa (OR por DP = 0,79, IC 95% = 0,64-0,97; OR por DP = 0,77, IC 95% = 0,59-0,99 para mulheres e homens, respectivamente), enquanto nenhuma associação foi observada na Argentina, Brasil, Chile, Colômbia, México, El Salvador e Guatemala. Ainda, a associação inversa da educação individual com a HA tornou-se mais forte (nas mulheres) ou emergiu (nos homens) à medida que a educação da cidade ou subcidade aumentou. O artigo 2 mostrou que a prevalência da HA por escolaridade individual e por IBP em nível de setor censitário difere entre homens e mulheres. Em mulheres, quanto maior a escolaridade, menor a chance de HA (≥ 9 anos de estudo versus ≤ 4 anos de estudo: OR = 0,62, IC 95% = 0,52-0,74) e, residir em setores censitários com maior privação foi associado a maiores chances de HA (OR por DP = 1,04, IC 95% = 1,01–1,09). Em homens, nenhuma associação foi observada. **Conclusão:** O padrão social da HA difere por gênero e por contexto analisado. Nossos resultados sugerem que as políticas públicas destinadas a lidar com o ônus da HA em países da América Latina devem adotar estratégias sensíveis ao gênero e à abrangência do contexto onde esses indivíduos residem.

Palavras-chave: saúde urbana; hipertensão; posição socioeconômica; análise multinível; América Latina.

ABSTRACT

Introduction: Despite the global interest in the social determinants of arterial hypertension (AH), researches in urban areas and regions with a high prevalence of AH, such as Latin America, are limited and results are inconsistent. **Objectives:** To analyze how individual-level and area-level socioeconomic status are associated with AH in adults from 230 cities in eight Latin American countries and examine also examined the extent to which these associations vary by sex and across countries (Article 1), as well as to analyze the association between individual and contextual socioeconomic conditions with AH, according to sex, among older adults living in urban areas in Brazil (Article 2). **Methods:** To contemplate the first objective harmonized data were analyzed of 109,184 adults (57.8% women), aged between 18 and 97 years (mean: 42.7±16.4 years), from the SALURBAL project (Salud Urbana en America Latina). AH was self-reported. Individual-, sub-city- (administrative units nested within cities) and city-level education were used as proxies of socioeconomic status. Three-level multilevel logistic regression models were used (individuals, sub-cities, and cities), adjusted for age and country and stratified by sex. To contemplate the second objective, data from 6,767 participants living in urban areas (54.4% women), aged 50 or over (mean: 61.6±9.5 years), from the baseline (2015-2016) of the Brazilian Longitudinal Study of Aging (ELSI-Brazil) were analyzed. AH was self-reported. The measure of individual socioeconomic condition was the individual's education and the measure of the context was the Brazilian Deprivation Index (IBP, acronym in Portuguese), used at the census level. Two-level multilevel logistic regression models (individuals and census tracts), adjusted for age and stratified by sex were used. **Results:** Article 1 showed that education at the individual level was inversely associated with greater odds of AH among women (university education or higher versus lower than primary: odds ratio [OR] = 0.67, 95% confidence interval [CI] = 0.61-0.74), while for men it was positively associated (university education or higher versus lower than primary: OR = 1.65, 95% CI = 1.47-1.86). For both genders, living in sub-city areas with higher educational achievement was associated with higher odds of AH (OR per standard deviation [SD] = 1.07, 95% CI = 1.02-1.12; OR = 1.11 per SD, 95% CI = 1.05-1.18, for women and men, respectively). Furthermore, the association between city-level education and AH varied across countries. In Peru, there was an inverse association (OR for SD = 0.79, 95% CI = 0.64-0.97; OR for SD = 0.77, 95% CI = 0.59-0.99 for women and men, respectively), while no association was observed in Argentina, Brazil, Chile, Colombia, Mexico, El Salvador, and Guatemala. Furthermore, the inverse association of individual education with AH became stronger (in women) or emerged (in men) as city or sub-city education increased. Article 2 showed that the prevalence of AH by individual education and by IBP at the census tract level differs between men and women. In women, the higher the level of education, the lower the chance of AH (≥ 9 years versus ≤ 4 years of education: OR = 0.62, 95% CI = 0.52-0.74) and living in census tracts with greater deprivation was associated with greater odds of AH (OR per SD = 1.04, 95% CI = 1.01-1.09). In men, no association was observed. **Conclusions:** The social pattern of AH differs by gender and by analyzed context. Our results suggest that public policies aimed at dealing with the burden of AH in Latin American countries should adopt strategies that are sensitive to gender and the scope of the context in which these individuals reside.

Keywords: urban health, hypertension, socioeconomic position, multilevel analysis, Latin America.

LISTA DE ABREVIATURAS E SIGLAS

CI	Confidence interval
CIDACS	Centro de Integração de Dados e Conhecimentos para Saúde
DCNT	Doenças crônicas não transmissíveis
DP	Desvio Padrão
ELSI-Brasil	Estudo Longitudinal da Saúde dos Idosos Brasileiros
FIOCRUZ	Fundação Oswaldo Cruz
HA	Hipertensão arterial
IBGE	Instituto Brasileiro de Geografia e Estatística
IBP	Indicador Brasileiro de Privação
IC	Intervalo de Confiança
IDH	Índice de desenvolvimento humano
IMC	Índice de massa corporal
IQR	Interquartile ranges
LMICs	Low- and middle-income countries
mmHg	Milímetros o mercúrio
OPAS	Organização Pan-Americana da Saúde
OR	Odds Ratio
OSUBH	Observatório de Saúde Urbana de Belo Horizonte da
UFMG	Universidade Federal de Minas Gerais
PAD	Pressão arterial sistólica diastólica
PAS	Pressão arterial sistólica
PIB	Produto interno bruto
$PM_{2.5}$	Material particulado com diâmetro menor ou igual a 2,5 microns ou menos de diâmetro
ELSI-URBE:	A influência do ambiente físico e social na saúde de adultos brasileiros mais velhos: estudo de base populacional longitudinal multimétodos.
SALURBAL	Salud Urbana en America Latina/Urban Health in Latin America
SD	Standard deviation SES: Socioeconomic status

SUMÁRIO

1 APRESENTAÇÃO

Este volume consiste na apresentação da fundamentação teórica, objetivos, métodos e resultados da tese de doutorado da aluna Débora Moraes Coelho apresentada ao Programa de Pós-Graduação em Saúde Pública, da Faculdade de Medicina da Universidade Federal de Minas Gerais, como um dos requisitos para a obtenção do grau de Doutor em Saúde Pública.

Esta tese insere-se na linha de pesquisa em *Saúde Urbana* e é parte integrante de dois estudos maiores, intitulados projeto SALURBAL "Salud Urbana en America Latina" e ELSI-URBE "A influência do ambiente físico e social na saúde de adultos brasileiros mais velhos: estudo de base populacional longitudinal multimétodos". O projeto SALURBAL é uma colaboração internacional, desenvolvido por um grupo multidisciplinar de pesquisadores oriundos de onze instituições da América Latina e três dos Estados Unidos, que estuda como os ambientes urbanos e as políticas urbanas impactam a saúde dos moradores da cidade em toda a América Latina (DIEZ-ROUX et al., 2018). O ELSI-URBE é um projeto aninhado ao Estudo Longitudinal da Saúde dos Idosos Brasileiros (ELSI-Brasil), uma pesquisa longitudinal de base domiciliar, com amostra representativa de adultos com 50 anos ou mais, cujo objetivo é identificar os atributos do ambiente físico e social da vizinhança que influenciam a saúde e o bem-estar de adultos mais velhos ao longo do tempo.

O primeiro artigo, intitulado "*Gender differences in the association of individual and contextual socioeconomic status with hypertension in 230 Latin American cities from the SALURBAL study: a multilevel analysis*", foi publicado em agosto de 2023 no periódico *BMC Public Health*, classificação Qualis A1 na área de avaliação "Saúde Coletiva", de acordo com consulta realizada na plataforma Sucupira (classificação de periódicos quadriênio 2017-2020; disponível em: <https://sucupira.capes.gov.br/sucupira/public/consultas/coleta/veiculoPublicacaoQualis/listaConsultaGeralPeriodicos.jsf >).

Dando continuidade à investigação das características socioeconômicas individuais e contextuais com a hipertensão arterial em centros urbanos latino-americanos, o segundo artigo, intitulado "*Diferenças de gênero nos determinantes sociais da hipertensão arterial entre brasileiros mais velhos residentes em áreas urbanas: uma abordagem multinível do estudo ELSI-Brasil*", após avaliação da banca, será submetido ao periódico Journal of Urban Health.

Este volume de tese está apresentado no formato de artigo científico como previsto pelo regulamento do Programa de Pós-Graduação em Saúde Pública da Universidade Federal de Minas Gerais.

Esta tese contém:

1. *Introdução, referencial teórico e justificativa:* Apresentação da fundamentação teórica e justificativa para a realização da tese.

2. *Objetivos:* apresentação dos objetivos da tese, respondidos nos artigos científicos.

3. *Artigo original 1:* contém introdução, metodologia, resultados, discussão, referências bibliográficas, tabelas/figuras e material suplementar.

4. *Artigo original 2:* contém introdução, metodologia, resultados, discussão, referências bibliográficas, tabelas/figuras e material suplementar.

5. Considerações finais: conclusões da tese.

6. *Anexos:* Artigo de resultado 1 no formato publicado no periódico.

2 INTRODUÇÃO

A hipertensão arterial (HA), comumente conhecida como pressão arterial elevada, é um problema de saúde pública de grande impacto econômico e social por ser uma das principais causas para a carga global de doenças, especialmente para doenças cardiovasculares, e ser a mais importante causa evitável de morte e incapacidade no mundo (GBD, 2019). Na América Latina, estima-se que 17% das mortes e 8,2% dos anos de vida ajustados por incapacidade estejam relacionados à HA (IHME, 2021).

Enquanto a prevalência de HA padronizada por idade diminuiu em países de alta renda, um aumento crescente é observado em países de baixa e média renda (NCD-RisC, 2021), particularmente em áreas urbanas (LAMELAS et al., 2019; VILLARREAL-ZEGARRA; CARRILLO-LARCO; BERNABE-ORTIZ, 2021). Na América Latina, mais de um quarto das mulheres e quatro de cada dez homens (idade entre 30 e 79 anos) têm HA e, na maioria dos países da região, a prevalência da HA está aumentando (NCD-RisC, 2021). No Brasil, segundo a Pesquisa Nacional de Saúde (PNS), em 2019, 23,9% dos brasileiros com 18 anos ou mais relataram diagnóstico de HA, superior aos 21,3% observados em 2013, evidenciando o aumento dessa enfermidade (IBGE, 2020).

A literatura indica a inatividade física, o tabagismo, o consumo de álcool, as dietas não saudáveis, como fatores de risco modificáveis associados à HA, além de sexo e envelhecimento (MARQUES et al., 2020). Recentemente, a urbanização surgiu como um importante determinante da carga crescente de HA e de seus fatores de risco (SCHUTTE et al., 2021). Residentes em áreas urbanas têm maior acesso a alimentos processados, geralmente ricos em sódio, calorias e gordura, além de estilos de vida mais sedentários – resultado de transporte menos ativo e de trabalho fisicamente menos exigente associado ao viver urbano-, todos os quais podem contribuir para a relação entre a urbanização e a HA (ALLEN et al., 2017; STRINGHINI; BOVET, 2017; JIWANI et al., 2019).

Entre as populações urbanas, evidências de países de alta renda sugerem que a HA está associada à desvantagem socioeconômica do indivíduo (LENG et al., 2015; NAKAGOMI et al., 2022). Ainda que alguns estudos realizados em países da América Latina também relatam resultados semelhantes (BENTO; MAMBRINI; PEIXOTO, 2020; HESSEL; RODRÍGUEZ-LESMES; TORRES, 2020), as evidências são limitadas e apontam diferenças no padrão social da HA (WAGNER et al., 2016; TUMAS et al., 2021; KIRSCHBAUM et al., 2022).

Além da influência da condição socioeconômica individual, uma literatura substancial em países de alta renda aponta que a privação socioeconômica do contexto onde as pessoas

vivem, trabalham e envelhecem, também está associada à prevalência (MATHESON et al., 2010; KEITA et al., 2014; CASWELL, 2017) e incidência de HA (KEITA et al., 2014; CLAUDEL et al, 2018). Apesar dos fatores contextuais serem sugeridos como principais contribuintes para o aumento da HA em países de baixa e média renda (WHO, 2013), os estudos são escassos e apontam resultados heterogêneos por país no contexto latino-americano (WAGNER et al., 2016; BENTO; MAMBRINI; PEIXOTO, 2020; TUMAS et al., 2021).

Frente à ausência de evidências substanciais na América Latina, o objetivo desta tese foi analisar a associação entre as características socioeconômicas individuais e contextuais com a HA em adultos e idosos residentes em áreas urbanas latino-americanas.

3 REVISÃO DE LITERATURA

3.1 Hipertensão Arterial

3.1.1 Aspectos conceituais, prevalência e critérios diagnósticos da hipertensão arterial

A HA caracteriza-se como uma condição causada pela elevação persistente da pressão arterial sistólica (PAS) e/ou diastólica (PAD) (UNGER et al., 2020). Segundo a Organização Pan-Americana da Saúde (OPAS) e as diretrizes brasileiras de hipertensão são considerados portadores de HA indivíduos com PAS ≥140 mmHg e/ou PAD ≥ 90 mmHg (ou recebendo tratamento medicamentoso anti-hipertensivo) (BARROSO et al., 2020; HEALTH–AMERICAS, 2022).

Por se tratar de uma doença muitas vezes assintomática, a HA costuma progredir com alterações estruturais e/ou funcionais em órgãos-alvo, como coração, cérebro, rins e vasos, com evolução para graus variados de incapacidade ou para morte. Ainda, destaca-se globalmente como importante fator de risco associado a doenças crônicas não transmissíveis (DCNT), como doença arterial coronariana, acidente vascular cerebral, insuficiência cardíaca, doença pulmonar obstrutiva crônica, doença renal crônica, entre outras morbidades (BARROSO et al., 2020; UNGER et al., 2020).

Diante de sua relação com desfechos maléficos à saúde e sua alta prevalência, a HA está associada a uma demanda substancial de recursos financeiros, para os indivíduos e para o sistema de saúde, como gastos com medicamentos, exames laboratoriais, consultas clínicas, hospitalizações por complicações associadas à HA, absenteísmo e gastos com a previdência social. Soma-se ainda os custos indiretos, ou seja, aqueles relacionados à perda da produtividade e qualidade de vida, medida pelos anos vividos com incapacidades, e as mortes prematuras (MILLS; STEFANESCU; HE, 2020; JULIÃO; SOUZA; GUIMARÃES, 2021).

Nesse cenário, e visando diminuir a carga global de DCNT, ações de âmbito nacional e internacional têm sido realizadas na população. Algumas delas são: a) Plano de Ação Global para prevenção e controle das DCNT, com meta mundial de redução de 25% da mortalidade prematura por DCNT e de redução de 25% da prevalência de HA em pessoas ≥18 anos entre os anos de 2015 e 2025 (WHO, 2014); b) meta de redução da mortalidade prematura por DCNT em um terço até 2030, por meio de prevenção e tratamento, presente nos Objetivos do Desenvolvimento Sustentável na agenda de 2030 (UN, 2015).

Em consonância com o Plano de Ação Global, a América Latina (OPAS, 2015), bem como o Brasil (BRASIL, 2022), tem planos de prevenção e controle de DCNT que objetivam detectar e controlar as DCNT e seus fatores de risco modificáveis (tabagismo; alimentação inadequada; sedentarismo e consumo abusivo de bebidas alcoólicas). No Brasil, o plano enfatiza o papel da atenção primária à saúde para diagnóstico, prevenção e controle da HA, além da distribuição gratuita de medicamento para expansão do tratamento (MALTA; SILVA, 2013).

Mesmo com avanços nas políticas públicas de promoção e prevenção da HA, a prevalência permanece alta, crescente e com variações consideráveis entre países (20% a 40%) (NCD-RisC, 2021; LAMELAS et al., 2019). Por exemplo, dados recentes de pesquisas nacionais de saúde apontam que a prevalência de HA na população adulta no México foi de 25,5% (CAMPOS-NONATO et al., 2018) e no Chile 30,8% (PASSI-SOLAR et al., 2020). Na Argentina, um estudo transversal, realizado entre agosto de 2015 e março de 2016 em 25 cidades, revelou que 36,3% da população adulta apresentavam HA (DELUCCHI et al., 2017). No Peru, embora tenha sido identificado como um dos países com menor prevalência mundial de HA, um estudo recente reportou aumento da prevalência de HA padronizada por idade de 18,7% para 20,6% entre 2015 e 2018 usando uma amostra nacionalmente representativa (VILLARREAL-ZEGARRA; CARRILLO-LARCO; BERNABE-ORTIZ, 2021). Em todos os estudos, a HA foi definida como PA ≥ 140 mmHg/≥ 90 mmHg ou recebendo tratamento medicamentoso anti-hipertensivo e a prevalência foi maior entre os homens do que entre as mulheres.

No Brasil, a prevalência de HA para a população adulta, segundo os três diferentes critérios diagnósticos (autorreferida, medida por instrumento e medida por instrumento e/ou em de uso de medicação anti-hipertensiva) foi de, respectivamente, 21,4%, 22,8% e 32,3% (MALTA et al., 2018). A HA autorreferida foi mais elevada na região urbana e nas regiões Sudeste e Sul. As mulheres apresentaram prevalências mais elevadas pelo critério autorreferido e os homens, pelo critério medido por instrumento (MALTA et al., 2018).

As diferenças observadas na prevalência de HA segundo os critérios diagnósticos podem ser parcialmente explicadas pelo viés de vigilância. Por depender do conhecimento da doença pelo indivíduo, o critério autorreferido pode subestimar a prevalência de HA (MOREIRA; ALMEIDA; LUIZ, 2021) em regiões socioeconômicas mais vulneráveis, devido ao acesso diferencial aos serviços de saúde, especialmente à consulta médica (BARRAZA-LLORÉNS; PANOPOULOU; DIAZ, 2013; ALMEIDA et al., 2013) e entre os homens,

provavelmente por procurarem menos os serviços de saúde, o que leva a menos oportunidade de diagnósticos (ALMEIDA et al., 2013; LEVORATO et al., 2014).

Apesar das limitações dos dados autorreferidos, pesquisas atestam boa validade do autorrelato (MOREIRA; ALMEIDA; LUIZ, 2021). Além disso, questionários contendo medidas autorreferidas em inquéritos populacionais têm sido estratégicos e amplamente utilizados, especialmente em países de baixa e média renda, por serem mais baratos e fáceis de aplicar (SZWARCWALD et al., 2014; BRASIL, 2017). Por exemplo, o uso da pressão arterial medida em nível populacional requer padronização de técnicas de medição, consenso sobre critérios diagnósticos, qualidade dos equipamentos e treinamento da equipe de coleta, o que promove maior complexidade no planejamento da pesquisa e maior custo (BRASIL, 2014). Assim, estimar a HA autorreferida em nível populacional apresenta vantagens, como simplicidade de mensuração, facilidade de aplicação e baixo custo (BRASIL, 2017). Portanto, a utilização do critério autorreferido em estudos científicos pode contribuir para a discussão de suas limitações e seu potencial para o monitoramento e vigilância de doenças e fatores de risco em larga escala na população.

3.1.2 Fatores de risco para a hipertensão arterial

Fatores de risco cardiovasculares não modificáveis e modificáveis como idade, sexo, comportamentos de saúde (tabagismo, álcool, inatividade física e alimentação inadequada, como baixo consumo de frutas e hortaliças, alto teor de gordura e consumo de sal), índice de massa corporal e estresse têm sido tradicionalmente associados à HA. A literatura aponta, de forma consistente, uma relação direta entre idade e HA. Por exemplo, no Brasil, a prevalência de HA foi de 24,3% entre adultos e 60,9% entre os idosos (BRASIL, 2017). Um fato que pode explicar essa associação é que, com o envelhecimento, as artérias tendem a ficar mais rígidas, o que pode levar ao aumento da pressão arterial (WEBER et al., 2014).

Em relação ao sexo, a prevalência de HA foi maior em homens até os 50 anos, enquanto as mulheres apresentam prevalência igual ou até maior após essa idade (WILLIAMS et al., 2018; CAREY et al., 2018). Os padrões idade-sexo observados são provavelmente o resultado de uma interação complexa entre fatores relacionados ao sexo biológico (por exemplo, a influência dos hormônios sexuais no controle renal do sódio e/ou resistência vascular) e gênero (por exemplo, comportamento de buscar ajuda, consciência da HA e maior exposição ao estresse crônico em função da sobrecarga de papeis, emprego informal e violência) (KANDASAMY; ANAND, 2018; VEGA, 2019). De fato, o estresse, definido aqui como um

processo no qual as demandas ambientais excedem a capacidade adaptativa de um organismo podendo levar às alterações psicológicas e biológicas que colocam as pessoas em risco de doença (SPARRENBERGER et al., 2009), tem sido associado à HA (DIEZ-ROUX, 2018; CHAIX, 2010; SPARRENBERGER et al., 2009).

Se tratando da raça/cor como fator de risco para HA, percebe-se que já estão bem exploradas na literatura as diferenças existentes. A maior prevalência de HA foi observada na população não branca (BRASIL, 2014; CHOR, et al., 2015). Esse padrão pode ser explicado pela maior exposição ao estresse crônico devido à discriminação racial e desigualdades sociais vivenciadas por esse grupo (MENDES et al., 2018).

Partindo para os fatores de risco comportamentais e índice de massa corporal (IMC), uma revisão sistemática de 42 artigos, a maioria do tipo transversal (n=29), encontrou, de forma consistente em 100% dos estudos avaliados, apenas o índice de massa corporal como variável independente associada à HA. Em relação aos comportamentos de saúde, embora menos frequente que a variável anterior, foi descrita uma associação independente com a HA com o consumo de sal (50%), consumo de álcool (36,3%) e inatividade física (28,5%); tabagismo (18,7%) e a alimentação inadequada (18,2%) foram aqueles com relatos menos consistentes (MARQUES et al., 2020).

Além dos fatores de risco tradicionais, nas décadas recentes, alguns estudos têm mostrado fatores de risco ambientais, como espaço verde (ASTELL-BURT; FENG, 2020; SCHUTTE et al., 2021) e poluição (PRABHAKARAN et al., 2020; SCHUTTE et al., 2021) associados com o aumento da HA. Evidência recente revela que o incremento de um por cento na quantidade de copa de árvore foi associado a menores chances de HA incidente (ASTELL-BURT; FENG, 2020). Vários fatores podem explicar a relação do espaço verde com a HA. Por exemplo, o espaço verde reduz a exposição a estressores ambientais, como poluição do ar, calor e ruído, permite a atividade física e incentiva a interação e a coesão social (MARKEVYCH et al., 2017).

Quanto à poluição ambiental, Prabhakaran et al. (2020) referem que, para cada intervalo interquartil de aumento na exposição mensal ao $PM_{2.5}$, materiais particulados que abrange partículas de 0,1 até de 2,5 μm, a PAS e a PAD aumentaram em 1,8 mmHg e 1,1 mmHg, respectivamente. O $PM_{2.5}$ nos pulmões pode levar ao estresse oxidativo pulmonar e inflamação (BROOK et al., 2010). Além disso, os constituintes solúveis do ar poluído inalado podem atravessar a membrana alveolar, atingir a corrente sanguínea e, consequentemente, afetar o endotélio vascular, resultando em vasoconstrição e enrijecimento arterial (FURUYAMA et al., 2009).

Nesse sentido, a urbanização, processo caracterizado pelo movimento em massa de populações das zonas rurais para as urbanas e pelas consequentes mudanças físicas nas zonas urbanas, também está associada à HA (SCHUTTE et al., 2021).

3.2 Urbanização e Hipertensão Arterial

Na contemporaneidade, mais da metade da população mundial (55,0% em 2018) vive nas cidades e essa proporção pode se aproximar de 70% até 2050 (UNPD, 2018). A América Latina e o Caribe configuram-se como a segunda região mais urbanizada do mundo e estima-se que mais de 500 milhões de pessoas, ou 81% da população, vive em áreas urbanas (UNPD, 2018). No Brasil, em 2014, 85,1% da população brasileira já vivia em centros urbanos (IBGE, 2016).

A urbanização desempenha um importante papel na vida do indivíduo. Se, por um lado, o desenvolvimento econômico e global nas cidades pode representar oportunidades positivas, com maior disponibilidade e acesso a bens de consumo e serviços, por outro, gera um conjunto de privações e carências, como o desemprego/subemprego, a insuficiência de renda e a dificuldade de acesso a bens e serviços, refletindo em desigualdades sociais e pobreza (WHO, 2016; CAIAFFA et al., 2008).

Além disso, o viver urbano, associado à globalização, desenvolvimento econômico e industrialização, modulam a rápida transição no ambiente urbano, levando a uma transição nutricional, diminuição da atividade física, adoção de comportamentos mais sedentários, maior acesso ao tabaco, álcool e maior exposição a ambientes caracterizado por estresse, poluição (ar, água, luz e ruído) e menor quantidade de espaços verdes (ALLEN et al., 2017; STRINGHINI; BOVET, 2017; SCHUTTE et al., 2021).

Diante do contexto apresentado, o aumento dos fatores de risco, decorrentes da transformação do ambiente urbano, tem implicações nas condições de saúde das populações, principalmente na transição epidemiológica de doenças infecciosas para DCNT, que via de regra, ocorre inicialmente entre as populações mais ricas, para depois se concentrar, de forma desproporcional, nas populações desfavorecidas (RIVERA-ANDRADE; LUNA, 2014; SCHUTTE et al., 2021).

Vale mencionar que cidades latino-americanas, sobretudo as brasileiras, sofrem processos de urbanização acelerados e não planejados, enraizados historicamente em legados coloniais de exclusão sociopolítica que, em última instância, se manifesta cada vez mais em desigualdades sociais e espaciais (CAIAFFA et al., 2021). Além disso, essa região

experimentou um diferencial progresso social e econômico nas últimas décadas, exacerbando as marcadas desigualdades sociais e de saúde entre classes sociais e regiões geográficas (RIVERA-ANDRADE; LUNA, 2014; CAIAFFA et al., 2021).

3.3 Disparidades urbanas e hipertensão arterial

3.3.1 Condições socioeconômicas e hipertensão arterial

A condição socioeconômica reflete todas as situações, circunstâncias e aspectos que interferem na ordem social e nos recursos econômicos de um indivíduo, local ou região (ANTUNES, 2008). Está relacionada com um conjunto de variáveis subjetivas (como: aspectos econômicos, educativos, trabalhistas, sociais, culturais, entre outros) que qualificam um indivíduo ou um grupo na estrutura social e tem sido amplamente considerada para caracterizar resultados de desigualdades em saúde (ALVES et al., 2012; GALOBARDES et al., 2006; LYNCH; KAPLAN, 2000).

De fato, entre as condições de desigualdades urbanas, as condições socioeconômicas têm sido, repetidamente, associadas inversamente a HA e seus fatores de risco (ALVES et al., 2016; LE BRON et al., 2015; LENG et al., 2015; MURRAY et al., 2011; PUOLAKKA et al., 2017; TRUDEL et al., 2016), principalmente em países de alta renda (LENG et al., 2015; NAKAGOMI et al., 2022), com gradiente social da HA mais evidente entre mulheres, enquanto os homens revelaram associações menos consistentes (LENG et al., 2015). Em décadas recentes, a característica socioeconômica do contexto onde as pessoas vivem e trabalham também tem sido associada a HA e seus fatores de risco, mesmo após o ajuste para características individuais, como escolaridade e renda familiar (BENTO; MAMBRINI; PEIXOTO, 2020; WAGNER et al, 2016).

Corroborando com o que foi descrito no parágrafo anterior, evidências sugerem que muitos dos fatores de risco para HA são modulados de acordo com as condições socioeconômicas. Estudos apontam que residentes urbanos de grupos socioeconômicos baixos têm maior probabilidade de consumir dietas não saudáveis e de usar tabaco e álcool (HESSEL; RODRÍGUEZ-LESMES; TORRES, 2020; ALLEN et al., 2017), além de serem mais expostas ao estresse crônico, à poluição e ter menor acesso a espaços verdes (LORET, 2017; FERNÁNDEZ-ÁLVAREZ, 2017), fatores de risco para HA (SCHUTTE et al, 2021). Por exemplo, a poluição do ar é 17 vezes maior nas cidades de países de baixa e média renda em comparação às cidades da América do Norte e Europa (ANENBERG, 2019). Dentro das

cidades, a exposição à poluição do ar ocorre de forma diferencial, afetando desproporcionalmente os pobres residentes em áreas urbanas por viverem mais próximos de indústrias e atividades poluidoras do ar (BAUMGARTNER; BRAUER; EZZATI, 2020). Além disso, residir em um contexto com piores condições socioeconômicas está associado a maiores chances de obesidade (TUMAS et al., 2020; KEITA et al., 2014), marcadores inflamatórios (KEITA et al., 2014) e HA prevalente (KEITA et al., 2014; TUMAS et al., 2021) e incidente (KEITA et al., 2014; CLAUDEL et al, 2018).

As características socioeconômicas do contexto podem ser analisadas em diferentes escalas geográficas, como bairros, cidades, áreas administrativas maiores e são influenciadas por fatores proximais (escolaridade e trabalho) e por fatores distais (características do município, influências nacionais e mundiais), todos operando de forma interligada (CAIAFFA et al., 2008). Dessa forma, os mecanismos pelos quais as questões sociais e econômicas individuais e contextuais podem levar à HA são diversos e inclui efeitos sobre comportamentos de saúde e processos relacionados ao desgaste e estresse (DIEZ-ROUX, 2018; CHRISTINE et al., 2017; PARDO-CRESPO et al., 2013).

Em nível individual, o mecanismo comportamental postula que indivíduos expostos a privação socioeconômica estão mais propensos a adotarem comportamentos de risco relacionados à HA como dieta não saudável, inatividade física, consumo excessivo de álcool e tabagismo, além de utilizarem menos os cuidados de saúde preventivos (HAVRANEK et al., 2015). O gradiente social inverso observado na prevalência desses comportamentos de risco explica, em parte, as desigualdades sociais relacionadas à HA (ALLEN et al., 2017; HAVRANEK et al., 2015).

O mecanismo biológico reúne evidências que relacionam respostas hormonais e imunológicas devidas ao desgaste e estresse desencadeado pela exposição à privação socioeconômica, à ocorrência de HA e de vários transtornos cardiometabólicos como dislipidemia e diabetes (HAVRANEK et al., 2015). Em resposta à privação socioeconômica persistente, células do sistema imunológico adquirem um perfil pró-inflamatório, que mais tarde se expressa como resposta exacerbada a citocinas e sensibilidade diminuída à regulação hormonal. A inflamação crônica resultante está associada ao aumento da pressão arterial (MILLER; CHEN; PARKER, 2011).

Em nível de setor censitário ou bairro, as características socioeconômicas do contexto também influenciam os comportamentos de saúde (LÊ-SCHERBAN et al., 2019; DIEZ-ROUX, 2015; DIEZ-ROUX; MAIR, 2010; CHAIX et al., 2010). Por exemplo, o menor nível socioeconômico do setor censitário/bairro pode refletir negativamente na quantidade e

qualidade dos ambientes de alimentação, atividade física, transporte e assistência à saúde, favorecendo a adoção de hábitos pouco saudáveis relacionados à alimentação e atividade física, e dificultando o acesso aos serviços de saúde, aumentando o risco de desenvolver HA (CHAIX et al., 2010; LÊ-SCHERBAN et al., 2019). Além disso, viver em áreas (setor censitário ou bairro) de maior vulnerabilidade social e econômica, com saneamento precário, habitação insalubre, alta criminalidade e violência, maior exposição a poluição, ruídos e menor quantidade de espaços verdes pode aumentar os níveis de estresse crônico e desgaste biológico, o que contribui para a ocorrência da HA (CHAIX, 2010).

Quanto às características socioeconômicas das cidades, acredita-se que influencie direta e indiretamente a HA e seus fatores de risco, amortecendo ou acentuando padrões sociais por condições socioeconômicas do setor censitário/bairro ou individual. Por exemplo, as diferenças socioeconômicas dos setores censitários/bairros podem ser menores em cidades com nível socioeconômico mais alto, pois, os setores censitários/bairros com nível socioeconômico mais baixo podem se beneficiar dos recursos disponíveis em maior quantidade e/ou qualidade em cidades com nível socioeconômico mais alto, como maior acesso a alimentos saudáveis, cuidados de saúde, infraestrutura de transporte, o que pode facilitar o acesso a recursos em outras partes da cidade (DIEZ-ROUX, 2015; GORYAKIN et al., 2017). As diferenças na HA por condição socioeconômica individual também podem ser menores em cidade com nível socioeconômico mais alto, em virtude dos efeitos favoráveis do nível socioeconômico mais alto da cidade, principalmente entre aqueles com condição socioeconômica individual mais baixo, favorecidos provavelmente, pelos serviços da cidade (DIEZ-ROUX, 2015; GORYAKIN et al., 2017).

Por outro lado, o nível socioeconômico mais baixo da cidade pode resultar em maiores discrepâncias socioeconômicas em nível individual ou do setor censitário/bairro devido ao acesso mais limitado aos recursos da cidade e às proteções sociais mais frágeis para os pobres (STAFFORD; MARMOT, 2003; LUO et al., 2019). Acresce que as interações e oportunidades sociais podem estar mais restritas ao setor censitário/bairro de residência (WANG et al., 2018).

3.3.2 Condição socioeconômica individual e sua relação com a hipertensão arterial na América Latina

A condição socioeconômica individual pode ser mensurada por diversos indicadores, sendo os mais utilizados a renda, a ocupação e a escolaridade. Entretanto, uma recente meta-

análise, envolvendo 51 estudos, concluiu que o nível de escolaridade foi o preditor mais robusto da prevalência de HA, superando a renda e a ocupação (LENG et al., 2015).

A escolaridade destaca-se como um dos principais indicadores socioeconômicos em estudos epidemiológicos por diversas razões (DE MESTRAL; STRINGHINI, 2017). Ela é amplamente disponível para ambos os sexos, apresenta mensuração objetiva e fácil aplicação por meio de questionários, possui altas taxas de resposta e se mantém relativamente estável ao longo do tempo, especialmente quando comparada à ocupação ou à renda (LYNCH; KAPLAN, 2000).

Ainda, a escolaridade é considerada um recurso positivo, pois influencia o acesso ao mercado de trabalho e, consequentemente, determina a posição socioeconômica na idade adulta (GALOBARDES et al., 2006; ROSS; MIROWSKY, 2010). Sob a perspectiva do curso de vida, a escolaridade reflete não apenas as condições socioeconômicas da família de origem, mas também pode capturar desigualdades intergeracionais (DAVEY et al., 1998; DALY et al., 2002). Além disso, diversos autores destacam que a escolaridade promove a aquisição de conhecimentos, habilidades e recursos materiais, sociais e psicológicos, os quais desempenham um papel essencial na adoção de hábitos de vida mais saudáveis (GALOBARDES et al., 2006; ROSS; MIROWSKY, 2010). Por fim, a escolaridade pode também influenciar a forma como os indivíduos compreendem e aplicam informações relacionadas à educação em saúde (DAVEY et al., 1998; DALY et al., 2002).

Em países de alta renda, estudos geralmente relatam uma associação inversa entre nível educacional e HA, sendo esse gradiente educacional inverso mais pronunciado entre mulheres do que entre homens (LENG et al., 2015; NAKAGOMI et al., 2022). Em contrapartida, uma investigação recente que analisou dados de pesquisas domiciliares de 76 países de baixa e média renda, agrupados em seis regiões (América Latina e Caribe, África, Mediterrâneo Oriental, Europa, Sudeste Asiático e Pacífico Ocidental), não identificou uma associação consistente entre escolaridade e HA na maioria das regiões analisadas. Pelo contrário, foi observada uma grande heterogeneidade nos padrões dessa relação entre os países, com resultados variando entre gradientes inversos, associações diretas ou mesmo ausência de associação (KIRSCHBAUM et al., 2022).

Na América Latina, embora algumas evidências também mostrem gradientes inversos (DULGHEROFF et al., 2021; KIRSCHBAUM et al., 2022; BENTO; MAMBRINI; PEIXOTO, 2020; HESSEL; RODRÍGUEZ-LESMES; TORRES, 2020; NISHIDA et al., 2020), os estudos empíricos são mais limitados e sugerem que heterogeneidades importantes no padrão social da HA podem estar presentes (KIRSCHBAUM et al., 2022; JONES et al., 2014). Por exemplo,

uma associação direta entre escolaridade e HA foi encontrada por um estudo (KIRSCHBAUM et al., 2022), enquanto outros estudos não observaram nenhuma associação entre escolaridade e HA (HANNA et al., 2019; JONES et al., 2014, LONGO et al., 2009)

Além disso, os estudos que investigaram a relação entre escolaridade e HA em homens e mulheres também identificaram variabilidade por gênero. Semelhantes aos achados de países de alta renda, em mulheres, os resultados apontam de forma consistente uma relação inversa na associação entre escolaridade e HA (DULGHEROFF et al., 2021; TUMAS et al., 2021; ENES; NUCCI, 2018; ALVES; FAERSTEIN, 2016). Já entre os homens, enquanto alguns estudos encontraram uma associação inversa, porém mais fraca do que em mulheres (DULGHEROFF et al., 2021; MALTA et al., 2011), nenhuma associação foi observada por outros estudos (TUMAS et al., 2021; ALVES; FAERSTEIN, 2016; LAUX et al., 2012).

A maneira como a educação está relacionada à HA varia entre os países e entre os grupos de populações dentro dos países. Essas diferenças podem ser explicada, parcialmente, pela transição nutricional e epidemiológica. As mudanças nos padrões alimentares, estilo de vida e carga de doenças das populações, segundo a abordagem da transição nutricional, são classificadas em cinco estágios (POPKIN, 1998). Esses estágios são: 1) coletar o alimento, dieta rica em carboidratos e fibras e pobre em gordura, acompanhada de atividade física constante; 2) a fome, redução da variedade de alimentos com períodos de escassez aguda; 3) redução da fome, aumento do consumo de frutas, vegetais e proteína animal, e redução de alimentos básicos ricos em amido na dieta; 4) doenças degenerativas, adoção de dietas pouco saudáveis (rica em açúcar, gordura e colesterol) acompanhada, frequentemente, de inatividade física, resultando em um aumento da prevalência de obesidade e doenças degenerativas; 5) na fase mais avançada, as populações experimentam alterações comportamentais e surgi um novo padrão alimentar que está relacionado com a finalidade de prevenir ou retardar doenças degenerativas e prolongar a saúde.

Diferentes estágios da transição nutricional podem ser identificados entre subpopulações geográficas ou socioeconômicas entre e dentro de um país. Em nações de alta renda, indivíduos menos privilegiados, frequentemente associados ao estágio 4 da transição nutricional, apresentam maior probabilidade de desenvolver obesidade e doenças crônicas em comparação aos mais privilegiados, que geralmente estão no estágio 5 (POPKIN, 1998). Por outro lado, em países de baixa renda, os grupos sociais de maior status tendem a se encontrar no estágio 4 da transição nutricional, o que os expõe a um risco elevado de doenças degenerativas. Assim, gradientes diretos podem ser observados entre algumas condições crônicas e o status socioeconômico (POPKIN, 1998).

Na América Latina, os países iniciaram a transição nutricional e epidemiológica em momentos distintos (RIVERA-ANDRADE; LUNA, 2014), o que explica a alta heterogeneidade observada na associação entre escolaridade e HA. Além disso, diferenças importantes podem ser observadas entre cidades e entre regiões dentro de um país latino-americano (RIVERA-ANDRADE; LUNA, 2014; POPKIN et al., 2002).

Em relação às diferenças por gênero observadas na associação entre o nível de escolaridade e HA, é provável que o estresse fora do trabalho e o estresse associado ao menor nível de escolaridade seja mais importante nas mulheres, explicando os resultados observados. Por exemplo, observou-se que mulheres com menor escolaridade podem ter maior risco de determinantes psicossociais de saúde precária, como monoparentalidade, depressão, baixa renda, entre outros, quando comparadas aos homens com a mesma escolaridade (KANDASAMY; ANAND et al., 2018; VEGA, 2019).

3.3.3 Condição socioeconômica contextual e sua relação com a hipertensão arterial na América Latina

Desde a década de 1990, medidas da condição socioeconômica do contexto têm sido consideradas em pesquisa e planejamento relacionadas à saúde (DIEZ-ROUX, 2018). Pessoas com características semelhantes podem experimentar diferentes condições de saúde dependendo de onde vivem, em virtude dos desiguais contextos econômicos, sociais, políticos, culturais, históricos ou geográficos (DIEZ-ROUX, 2010). Assim, o fenômeno contextual manifesta-se como um agrupamento do estado de saúde individual dentro de áreas. Assim dizendo, uma parte das diferenças de saúde entre os indivíduos pode ser atribuída às áreas onde vivem e trabalham (MERLO et al., 2016; MERLO, 2003).

Dessa forma, as medidas de condição socioeconômica do contexto tentam capturar o impacto socioeconômico circunstanciais das áreas geográficas nas quais os indivíduos residem como uma tentativa de ir além do indivíduo para capturar influências contextuais ou locais na saúde (DIEZ-ROUX, 2010; STAFFORD; MARMOT, 2003). Para esse fim, os pesquisadores geralmente se baseiam em dados do censo de seu país (STAFFORD; MARMOT, 2003). Desta forma, dados agregados individuais são usados para construir indicadores contextuais e estes são geralmente relacionados a desemprego, escolaridade, riqueza ou propriedade.

A abordagem de fenômeno contextual corresponde ao conceito estatístico de cluster (agrupamento hierárquico), razão pela qual recomenda-se utilizar abordagem analítica que considere a hierarquia dos dados, como os modelos de regressão multinível, para evitar estimar

incorretamente o efeito de fatores em nível de área sobre a saúde (MERLO, 2003). Nessa abordagem analítica, a dependência da variável resposta entre indivíduos da mesma área é considerada, diferente das análises de regressão habituais em que a independência das medidas individuais é uma suposição que precisa ser respeitada (MERLO, 2003). Esse aspecto é de grande importância para a epidemiologia social, pois contribui com a abordagem de concentrar a intervenção para reduzir as desigualdades na saúde em determinadas áreas geográficas e não apenas em pessoas específicas (MERLO et al., 2006; 2016; MERLO, 2003).

Nos últimos anos, tem crescido o interesse por estudos que incorporaram as características socioeconômicas da área como um determinante adicional das desigualdades na HA usando abordagens multiníveis. Em países de alta renda, grande parte desses estudos reportam que a privação socioeconômica do contexto está associada à HA (MATHESON et al., 2010; KEITA et al., 2014; CASWELL, 2017; CLAUDEL et al, 2018).

Em países de baixa e média renda, esses estudos são escassos e apresentam resultados inconsistentes (ABBA et al., 2021; 2023). Enquanto um estudo, envolvendo 888.925 entrevistados, aninhados em 33.883 bairros de 12 países de baixa e média renda, não encontrou associação com o índice de desenvolvimento humano (IDH) do país, a prevalência de HA foi significativamente maior entre residentes em áreas censitárias com melhores condições socioeconômicas (ABBA et al., 2021). Em direção oposta, um estudo ecológico, envolvendo 138 países de baixa e média renda, observou que países com maior produto interno bruto (PIB), maior taxa de alfabetizados e maior índice de pobreza multidimensional apresentam menor prevalência de HA (ABBA et al., 2023).

Na América Latina, existe uma falta de estudos que estudam a influência dos fatores socioeconômicos em nível de área na ocorrência de HA e, essa limitação é ainda maior para estudos que utilizam abordagem multinível (GUERRERO-AHUMADA, 2017). Encontramos cinco artigos recentes que analisaram essa associação na América Latina e, os achados também foram inconsistentes (PENNER; ALAZRAQUI; AMORIM, 2022; TUMAS et al., 2021; BENTO; MAMBRINI; PEIXOTO, 2020; LUCUMI et al., 2017; WAGNER et al., 2016). Em dois desses artigos, a escolaridade foi utilizada como indicador das condições socioeconômicas do contexto (TUMAS et al., 2021; WAGNER et al., 2016). Enquanto a menor escolaridade do bairro foi significativamente associada à maior chance de HA autorrelatada em mulheres na Argentina, tal associação não foi observada entre escolaridade em nível de cidade com a HA (TUMAS et al., 2021).

Diferenças na associação entre escolaridade da área e HA também foi observada ao usar diferentes definições do desfecho, mesmo mantendo semelhante nível de agregação. Por

exemplo, pessoas que residiam em setores censitários com menor escolaridade apresentaram maior chance de HA definida como PAS e/ou PAD ≥ 140/90 mmHg, mas nenhuma associação foi encontrada ao associar com o uso de medicação anti-hipertensiva (WAGNER et al., 2016).

O Índice de Gini, indicador que reflete a concentração de renda e as desigualdades socioeconômicas de território, também foi citado em dois artigos como medida de contexto (BENTO; MAMBRINI; PEIXOTO, 2020; LUCUMI et al., 2017). Na Colômbia, residentes de departamentos com alta desigualdade de renda apresentaram maior prevalência de HA (definida como PAS e/ou PAD ≥ 140/90 mmHg) (LUCUMI et al., 2017), no Brasil, nenhuma associação foi encontrada entre desigualdade de renda em nível das Unidades Federadas e HA (definida como PAS e/ou PAD ≥ 140/90 mmHg e/ou relato de uso de medicação anti-hipertensiva) (BENTO; MAMBRINI; PEIXOTO, 2020). Mas, segundo o mesmo estudo, as Unidades da Federação brasileiras com maior Índice de Desenvolvimento Humano apresentaram maior prevalência de HA (BENTO; MAMBRINI; PEIXOTO, 2020).

Outro estudo, desenvolvido na Argentina, analisou a pobreza da área definida pela proporção de pessoas com necessidades básicas insatisfeitas ou não atendidas. Os autores reportaram que indivíduos que residiam em setores censitários com maior pobreza tinham maior chance de HA, definida como PAS e/ou PAD ≥ 140/90 mmHg (PENNER; ALAZRAQUI; AMORIM, 2022).

As diferenças entre os resultados encontrados podem ser parcialmente explicadas pelo emprego de indicadores diferentes para medir as condições socioeconômicas em nível de área e métodos para definir HA. Além disso, nos estudos acima mencionados, o tamanho da área estudada variou de bairros para regiões. Portanto, os fatores causais subjacentes à associação entre as condições socioeconômicas da área e HA podem ser muito diferentes. Considerando que tanto os tipos de indicadores quanto o tamanho das áreas incluídas nos estudos analisados foram diferentes, há limitações na comparabilidade.

Acresce que as desigualdades na HA diferiram por sexo (TUMAS et al., 2021; LUCUMI et al., 2017). Nos dois estudos que analisaram a associação entre condições socioeconômicas da área e HA estratificado por sexo, nenhuma associação foi encontrada entre os homens, enquanto a menor escolaridade do bairro (TUMAS et al., 2021) e a maior desigualdade em nível de departamento (LUCUMI et al., 2017) foram associadas a maior chance de HA em mulheres.

4 JUSTIFICATIVA

Tendo em vista que a urbanização pode exacerbar a pobreza e as desigualdades sociais, torna-se de extrema relevância investigar as diferenças sociais da HA em ambientes urbanos. Dado que a HA é o principal fator de risco modificável para doenças cardiovasculares, mortalidade geral e incapacidade na América Latina e Brasil, compreender como as características socioeconômicas individuais e contextuais moldam concomitantemente o padrão social da HA torna-se essencial para o planejamento de políticas urbanas e de saúde focada na equidade em saúde. O entendimento das diferenças sociais em HA em ambientes urbanos pode contribuir no direcionamento efetivo das intervenções de prevenção e tratamento para aqueles que necessitam.

Assim, considerando que a pesquisa sobre HA está concentrada em questões sociodemográficas em nível individual; que no contexto da América Latina, as evidências sugerem heterogeneidade no gradiente social da pressão arterial; que as condições socioeconômicas contextuais desempenham forte influência no desenvolvimento da HA e, que ainda assim, apesar de algumas evidências, o tema tem sido pouco explorado na América Latina e, que as informações disponíveis são inconsistentes, justifica-se esse estudo.

Importa ainda ressaltar que, dos cinco estudos prévios que investigaram a associação entre condições socioeconômicas contextuais e HA no contexto latino americano, apenas dois são brasileiros, diferentes medidas das condições socioeconômicas foram usadas, somente três usaram amostra representativa do país, sendo dois com a população adulta (idade maior ou igual a 18 anos) (TUMAS et al., 2021; LUCUMI et al., 2017) e um com idade maior ou igual a 60 anos (BENTO; MAMBRINI; PEIXOTO, 2020) e, somente um estudo utilizou o mesmo indicador para avaliar as condições socioeconômicas em nível individual e contextual (TUMAS et al., 2021). Adicionalmente, como ressaltado anteriormente, nos dois únicos estudos que conduziram a análise estratificada por sexo, diferenças nas associações entre condições socioeconômicas contextuais e sexo em relação à HA foi relatado (TUMAS et al., 2021; LUCUMI et al., 2017).

Nesse contexto, ao investigarmos essa associação de maneira estratificada por sexo em cidades latino-americanas, estamos capacitados a explorar uma vasta gama de condições urbanas heterogêneas. Essa abordagem certamente contribuirá para um aprofundamento no entendimento das disparidades urbanas relacionadas à HA e também fornecerá insights valiosos para a formulação e implementação de políticas públicas voltadas à promoção da saúde cardiovascular, tanto de forma direta quanto indireta. Exemplificando, iniciativas como o Plano

de Ações Estratégicas para o Enfrentamento das Doenças Crônicas Não Transmissíveis no Brasil e o Plano Regional na América Latina poderão se beneficiar desse conhecimento.

5 OBJETIVOS

5.1 Objetivo Geral

Analisar a asociação entre as características socioeconômicas individuais e contextuais com a hipertensão arterial em adultos e idosos residentes em áreas urbanas latino-americanas.

5.2 Objetivos Específicos

- Investigar como a condição socioeconômica em nível individual e em nível de área está associada à hipertensão arterial em adultos de 230 cidades de oito países latino-americanos e, examinar se estas associações variam por sexo e entre países. **(Artigo 1)**
- Analisar a associação das condições socioeconômicas individuais e contextuais com a hipertensão arterial, segundo o sexo, entre adultos mais velhos residentes em áreas urbanas no Brasil. **(Artigo 2)**

6 MÉTODOS

O primeiro objetivo específico (Artigo 1) da tese foi contemplado por meio de um estudo transversal que analisou dados do Salud Urbana en América Latina/Urban Health in Latin America Project (SALURBAL), uma colaboração internacional que estuda como os ambientes urbanos e as políticas urbanas impactam a saúde dos moradores da cidade em toda a América Latina (DIEZ-ROUX et al., 2018). Para contemplar o segundo objetivo específico (Artigo 2), foram utilizados os dados do projeto de pesquisa ELSI-URBE - "A influência do ambiente físico e social na saúde de adultos brasileiros mais velhos: estudo de base populacional longitudinal multimétodos" sob coordenação do Observatório de Saúde Urbana de Belo Horizonte (OSUBH). O objetivo do ELSI-URBE é identificar os atributos do ambiente físico e social da vizinhança que influenciam a saúde e o bem-estar de adultos mais velhos ao longo do tempo. O projeto está aninhado ao Estudo Longitudinal da Saúde dos Idosos Brasileiros (ELSI-Brasil), uma pesquisa de base domiciliar nacionalmente representativa, coordenada pela Fundação Oswaldo Cruz - Minas Gerais (FIOCRUZ-MG), cujo objetivo principal é examinar a dinâmica do envelhecimento da população brasileira e seus determinantes (LIMA-COSTA et al., 2018). Utilizou-se, também, dadossecundários em nível de setor censitário por meio do Índice de Privação Brasileiro (IBP), uma medida que foi calculada utilizando dados do Censo Demográfico da População Brasileira de 2010 (ALLIK et al., 2020). O IBP, lançado em 2020, é resultado de uma parceria entre pesquisadores do Centro de Integração de Dados e Conhecimentos para Saúde (CIDACS) e da Universidade de Glasgow, na Escócia, e constitui proposta para medir desigualdades sociais no Brasil na escala dos setores censitários (ALLIK et al., 2020).

6.1 Métodos Artigo 1

O SALURBAL, projeto de 5 anos iniciado em abril de 2017, envolve uma grande equipe interdisciplinar multinacional que abrange 11 países da América Latina. Os 11 países incluídos na plataforma das cidades SALURBAL são: Argentina (AR), Brasil (BR), Chile (CL), Colômbia (CO), Costa Rica (CR), El Salvador (SV), Guatemala (GT), México (MX), Nicarágua (NI), Panamá (PA) e Peru (PE).

Para conduzir comparações dentro e entre as cidades, a equipe do projeto SALURBAL, no primeiro momento, identificou 371 cidades com população ≥ 100.000 mil habitantes como o universo de interesse por meio de três diferentes maneiras: administrativamente,

quantitativamente a partir de imagens de satélite e com base em áreas metropolitanas definidas pelo país. Assim, o termo cidade refere-se a uma combinação de unidades administrativas adjacentes (por exemplo, vários municípios) que fazem parte da extensão urbana determinada por imagens de satélite, representado, por exemplo, pelas regiões metropolitanas no Brasil. Em segundo lugar, foram identificadas 1436 sub-cidades, definidas como unidades administrativas (por exemplo, municípios) aninhadas dentro das cidades (QUISTBERG et al., 2018).

Posteriormente, dados do ambiente físico, social e individuais foram coletados, harmonizados e aninhados, sempre que possível, para cidades e sub-cidades. Desta forma, o SALURBAL usa um sistema hierárquico de três níveis: indivíduos aninhados em sub-cidades aninhadas em cidades (QUISTBERG et al., 2018).

Este estudo utilizou dados individuais, obtidos a partir dos inquéritos nacionais de saúde, e dados do ambiente social, obtidos através dos censos demográficos mais recentes de cada país. Para esta análise, incluímos países com dados de hipertensão nas pesquisas nacionais de saúde: Argentina (2013), Brasil (2013), Chile (2010), Colômbia (2007), El Salvador (2014), Guatemala (2002), México (2012) e Peru (2016) (Tabela 1).

Tabela 1: Fonte dos dados dos inquéritos nacionais de saúde e censo demográfico usado no projeto SALURBAL

País	Censo demográfico	Inquéritos Nacionais de Saúde
Argentina	2010	Encuesta Nacional de Factores de Riesgo - ENFR, 2013
Brasil	2010	Pesquisa Nacional de Saúde - PNS, 2013
Chile	2002	Encuesta Nacional de Salud - ENS, 2010
Colômbia	2007	Encuesta Nacional de Salud – ENS, 2007
México	2010	Encuesta Nacional de Salud y Nutricion - ENSANUT, 2012
Peru	2007	Demografia y Salud – ENDES, 2016
El Salvador	2007	Encuesta Nacional de Enfermedades Cronicas no transmisibles en Poblacion Adulta de El Salvador - ENECA, 2014-2015
Guatemala	2002	Encuesta Multi-nacional de Diabetes mellitus y Factores de Riesgo – CAMDI, 2002-2003

6.1.1 Variáveis do estudo

A variável dependente desse estudo foi HA. Os participantes foram definidos como hipertensos se relatassem que um médico havia informado que tinham HA e se relatassem o uso de medicamentos “para baixar a pressão arterial” ou para controlar a hipertensão prescritos por um profissional de saúde (ou seja, ambas as condições deveriam ser atendidas). A HA gestacional foi excluída, exceto na Argentina e na Guatemala, onde não havia informações suficientes para excluir esses casos. Essa definição foi usada para incorporar dados do maior número possível de países, maximizando a comparabilidade entre os países.

As três variáveis independentes investigadas foram: escolaridade em nível individual, de subcidade e de cidade (ambos para medir o status socioeconômico do contexto).

A escolaridade em nível individual foi harmonizada entre os países/pesquisas e classificada em: (1) inferior ao primário; (2) primário: indivíduos que concluíram o ensino fundamental, mas com ensino médio incompleto; (3) secundário: indivíduos com ensino médio completo, ensino superior não universitário completo (por exemplo, escola técnica) ou com ensino superior incompleto; (4) universitário ou superior: indivíduos com nível superior completo ou com pós-graduação completa/incompleta.

A escolaridade em nível de subcidades e de cidades foi construída a partir do percentual da população com 25 anos ou mais que concluiu o ensino médio ou mais e percentual da população com 25 anos ou mais que concluiu o nível universitário ou superior (ORTIGOZA et al., 2021). As variáveis foram padronizadas. Os escores-z foram criados para subcidades, com base nas distribuições de todas as subcidades, e cidades, com base nas distribuições de todas as cidades. Escores mais altos significam alta escolaridade da população (ORTIGOZA et al., 2021).

Outras variáveis incluídas no estudo foram idade (em anos) e sexo.

A análise estatística será apresentada detalhadamente no Artigo 1, contido na seção de resultados deste volume.

6.2 Métodos Artigo 2

O estudo ELSI-Brasil foi delimitado para representar a população brasileira com 50 anos e mais. A amostra foi selecionada a partir dos dados do censo demográfico de 2010 e, seu tamanho, planejado em 10.000 entrevistas, com o propósito de fornecer uma prevalência estimada de 1% (erro amostral de 0,25%) ou uma prevalência de 5% (erro amostral de 0,55%), com um nível de significância de 5% e um desenho amostral de efeito de 1,5 (LIMA-COSTA et al., 2018).

A amostra foi estratificada por município, setor censitário e domicílio). Os municípios foram divididos em quatro estratos de acordo com sua população (≤ 26.700 habitantes, 26.701–135.000 habitantes, 135.001–750.000 habitantes e >750.000 habitantes). Foram selecionados aleatoriamente 70 municípios, sendo 23 com mais de 750.000 habitantes. Para municípios com até 750.000 habitantes, a seleção ocorreu em três estágios (município, setor censitário e domicílio). Para municípios maiores, a seleção foi em dois estágios (setor censitário e domicílio). O sorteio dos domicílios foi feito de forma sistemática, considerando intervalos de 4 casas após uma entrevista efetivada. O primeiro domicílio elegível do setor censitário, foi aquele que possuía uma pessoa de 50 anos ou mais que resida no local. Em cada domicílio selecionado todas as pessoas com 50 anos ou mais de idade (completarem 50 anos até 31 de dezembro de 2015) foram convidadas a participar do estudo e responder o questionário individual (LIMA-COSTA et al., 2018).

A linha de base do ELSI-Brasil, conduzida entre 2015 e 2016, envolveu 9.412 participantes, sendo 7.935 participantes residentes na área urbana, com características semelhantes à população brasileira com 50 anos ou mais, em relação à idade, sexo, região de residência e residência rural ou urbana, entre outras características importantes. A coleta de dados abarcou questionário no domicílio, exames físicos e coleta de material biológico para exames laboratoriais. Maiores detalhes sobre a metodologia do ELSI-Brasil são fornecidos em publicação anterior (LIMA-COSTA et al., 2018).

6.2.1 Variáveis do estudo

O desfecho desse estudo foi HA. Os participantes foram definidos como hipertensos se informassem ter tido diagnóstico médico de HA e a informação foi obtida por meio da pergunta: “Algum médico já lhe disse que o senhor (a) tem hipertensão (pressão alta)?” (não; sim; sim,

apenas durante a gravidez; não sabe/não respondeu). Foram excluídas da análise os participantes que responderam “sim, apenas durante a gravidez” ou “não sabe/não respondeu”.

As variáveis individuais foram idade (em anos) e sexo (feminino; masculino). Além de escolaridade, obtida a partir da pergunta: “Qual o último ano da escola que o(a) Sr(a) foi aprovado(a)?”. Essa pergunta tinha as seguintes opções de resposta: 1) nunca estudou; 2) 1º série do 1º grau; 3) 2º série do 1º grau; 4) 3º série do 1º grau; 5) 4º série do 1º grau, antigo primário ou grupo; 6) 5º série do 1º grau; 7) 6º série do 1º grau; 8) 7º série do 1º grau; 9) 8º série do 1º grau, antigo ginásio; 10) 1º série do 2º grau; 11) 2º série do 2º grau; 12) 3º série do 2º grau, antigo colegial: clássico, científico, normal; 13) supletivo/madureza; 14) superior incompleto; 15) superior completo; 16) especialização/residência médica; 17) mestrado; 18) doutorado. As respostas foram categorizadas em ≤ 4 (categorias 1 a 5); 5 a 8 (categorias 6 a 9); ≥ 9 anos de estudo (categorias 10 a 18).

Para caracterizar a condição socioeconômica do contexto, usamos, em nível de setor censitário, o Índice Brasileiro de Privação. Para o cálculo do IBP, considerou, em uma medida única, a combinação de escores-z de três indicadores de privação na escala de setores censitários ponderados de acordo com a população: 1) percentual de domicílios com renda per capita ≤ 1/2 salário mínimo; 2) porcentagem de pessoas não alfabetizadas, com mais de 7 anos e; 3) média do percentual de pessoas com acesso inadequado a esgoto, água, coleta de lixo e sem banheiro e banheira/chuveiro. O maior valor do escore final representa a área com maior privação, enquanto o menor valor reflete a área com menor privação (ALLIK et al., 2020).

A análise estatística será apresentada detalhadamente no Artigo 2, contido na seção de resultados deste volume.

7 RESULTADOS

7.1 Artigo de resultado 1

Gender differences in the association of individual and contextual socioeconomic status with hypertension in 230 Latin American cities from the SALURBAL study: a multilevel analysis

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List of abbreviations

OR: Odds Ratio
CI: Confidence interval
SD: Standard deviation
IQR: Interquartile ranges
SALURBAL: Salud Urbana en America Latina/Urban Health in Latin America
LMICs: Low- and middle-income countries SES: Socioeconomic status

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Abstract

Background: Despite global interest in gender disparities and social determinants of hypertension, research in urban areas and regions with a high prevalence of hypertension, such as Latin America, is very limited. The objective of this study was to examine associations of individual- and area-level socioeconomic status with hypertension in adults living in 230 cities in eight Latin America countries. **Methods:** In this cross-sectional study, we used harmonized data from 109,184 adults (aged 18-97 years) from the SALURBAL (Salud Urbana en America Latina/Urban Health in Latin America) project. Hypertension was assessed by self-report. Individual-, sub-city- and city-level education were used as proxies of socioeconomic status. All models were stratified by gender. **Results:** Higher individual-level education was associated with lower odds of hypertension among women (university education or higher versus lower than primary: odds ratio [OR] = 0.67, 95% confidence interval [CI] = 0.61-0.74) but higher odds among men (OR = 1.65; 95% CI 1.47-1.86), although in men an inverse association emerged when measured blood pressure was used (OR = 0.86; 95% CI 0.76-0.97). For both genders, living in sub-city areas with higher educational achievement was associated with higher odds of hypertension (OR per standard deviation [SD] = 1.07, 95%CI = 1.02-1.12; OR = 1.11 per SD, 95%CI = 1.05-1.18, for women and men, respectively). The association of city-level education with hypertension varied across countries. In Peru, there was an inverse association (higher city level education was associated with lower odds of hypertension) in women and men, but in other countries no association was observed. In addition, the inverse association of individual-level education with hypertension became stronger (in women) or emerged (in men) as city or sub-city education increased. **Conclusion:** The social patterning of hypertension differs by gender and by the level of analysis highlighting the importance of context- and gender-sensitive approaches and policies to reduce the prevalence of hypertension in Latin America.

Keywords: urban health; hypertension; education; socioeconomic status; Latin America; multilevel analysis.

1. Introduction

Hypertension, a major contributor to cardiovascular disease [1], is a major global health challenge and disproportionately affects populations in low- and middle-income countries (LMICs) [2]. Recently, studies have gone beyond traditional behavioral risk factors and have shown that the individual's socioeconomic conditions and the contextual characteristics of the places where people live are related to hypertension prevalence [3-5]. Although socioeconomic conditions have been identified as important factors in increasing the burden of hypertension in LMICs [1], evidence is limited and results are not always consistent in the context of Latin America [6, 7].

In high-income countries, studies have generally reported an inverse association of hypertension with socioeconomic status (SES) at the individual level [6] and at the area level [8, 9]. In contrast, evidence on the association of individual-level and area-level SES with hypertension in Latin America remains comparatively scarce and conflicting. At the individual level, some studies reported an inverse association of SES with hypertension [3, 4, 10, 11]. At the area level, there have been mixed findings. For example, one study reported no association of hypertension with neighborhood- and city-level education in Argentina [3]. In Brazil, income inequality at the level of Federation Units was not associated with hypertension [4], but another study found that the prevalence of hypertension was significantly higher among residents living in census tracts with lower levels of education [12]. Brazilian Federation Units with a higher Human Development Index had a higher prevalence of hypertension [4]. In Colombia, residents of departments with high-income inequality had a higher prevalence of hypertension [5].

Both individual-level and area-level SES may influence the development of hypertension through a multiplicity of processes. Individual-level SES may be related to hypertension through its impact on behaviors such as diet and physical activity, as well as through stress-related processes [6, 13]. Area-level SES may be a proxy for environmental features such as food, physical activity, health care, and transportation environments [14], and has been correlated with social stressors, such as violence, which may also affect hypertension prevalence [15]. In addition to direct effects, area-level SES can reduce or amplify the effect of individual SES on hypertension [7]. Moreover, both individual-level and area-level SES may influence access to screening, early detection, and treatment of hypertension [16-18].

Latin America has a high prevalence of hypertension in the adult population [2, 19] and a high level of urbanization and inequalities [20], with cities and countries presenting different levels of economic and social development, and different stages of the epidemiological

transition [21]. As the prevalence of cardiovascular risk factors increases as a country's economy grows, the effect of socioeconomic status on hypertension may also change. Therefore, the Latin American context presents a unique opportunity to investigate the associations of individual-level and area-level SES with hypertension. Understanding how social conditions at various levels relate to non-communicable diseases risk factors like hypertension is critical to achieving sustainable development goals [22].

Using unique data compiled and harmonized by the SALURBAL (Salud Urbana en America Latina/Urban Health in Latin America) project [23], we investigated how individual-level and area-level SES are associated with hypertension in adults from 230 cities in eight Latin American countries. In addition, because prior work has found that the social patterning of non-communicable diseases risk factors may vary substantially by gender [3, 6, 8, 10] and country [7, 24, 25], we also examined the extent to which these associations vary by gender and across countries.

2. Methods

Study design

The SALURBAL project compiled and harmonized health, social, and environmental data for all cities above 100,000 inhabitants in eleven Latin American countries [26]. Briefly, SALURBAL defines cities as a single administrative unit (e.g., municipio) or a combination of adjacent administrative units (e.g., several municipios) that are part of the built-up area of the urban agglomeration as determined from satellite imagery. Each “sub-city” is an administrative unit fully nested within a “city”. The “sub-city” units were identified in each country as the smallest geographic administrative units for which health data was easily available. Approximately half of the cities included only one sub-city unit. This study used survey data from 230 cities (encompassing 673 sub-city units) in 8 countries: Argentina, Brazil, Chile, Colombia, El Salvador, Guatemala, Mexico, and Peru (Survey details are provided in Supplementary Material Table S1).

Of 124,743 survey respondents aged 18 years and who resided in SALURBAL cities, we restricted our analyses to those with exposure information both at the individual and area-level, and those with outcome data. The final sample was 109,184 persons from 230 cities (673 sub-cities). Details on exclusions are shown in Figure S1. The median number of individuals per sub-city and city were 65 and 343.5, respectively.

SALURBAL survey data and outcome

SALURBAL compiled, harmonized, and geocoded individual-level data from nationally representative cross-sectional surveys. For this analysis, we included surveys with hypertension data: Argentina (2013), Brazil (2013), Chile (2010), Colombia (2007), El Salvador (2014), Guatemala (2002), Mexico (2012), and Peru (2016). Surveys were generally conducted by government agencies in different countries for purposes of risk factor surveillance often using similar questions.

The outcome was hypertension. Participants were defined as having hypertension if they reported that a physician had told them that they had hypertension and if they reported using medications "to lower blood pressure" or to control hypertension prescribed by a health care provider (i.e., both conditions had to be fulfilled). We have included the use of drugs in the definition to increase specificity. Gestational hypertension was excluded except in Argentina and Guatemala where the survey questions used did not exclude physician-diagnosed hypertension during pregnancy. This definition was used to incorporate data from as many countries as possible while maximizing comparability across countries.

Exposures

The three key exposures investigated were individual-level education, a proxy of individual-level SES, and summary scores of sub-city and city education, used as indicators of area-level SES. The sub-city level was included to capture heterogeneity within cities.

Individual-level education was harmonized across countries/surveys and classified into: (1) less than primary (2) primary: individuals who completed primary education, but with incomplete secondary education; (3) secondary: individuals with complete secondary education, complete non-university postsecondary education (e.g., technical school), or with incomplete university education; (4) university or higher: individuals who completed a university degree or with complete/incomplete graduate studies.

The population educational attainment score refers to educational achievement in the overall population. This measure was created using aggregated census data from the individual level of education: (1) the percentage of the population aged 25 years or older that has completed high school level or above, and (2) the percentage of the population aged 25 years or older that has completed university level or above [27]. A score was created by summing the standardized Z-scores of the two variables. Z scores were created for cities, based on the

distributions of all cities, and sub-cities, based on the distributions of all sub-cities. Higher score values signify better educational achievement in the population [27].

Other variables included individual-level age (in years) and gender.

Statistical Analysis

All analyses were stratified by gender because of previous evidence of gender differences in the associations between SES and hypertension [3, 6, 8]. For analytical purposes, El Salvador and Guatemala were grouped into one analytical unit named Central America. Descriptive statistics, using frequency distributions, means, and standard deviations (SD), are presented by countries and hypertension status.

The associations of individual-level and area-level SES with hypertension were examined using three-level multilevel logistic regression, including a random intercept for city and sub-city. All models were controlled for age. Model 1 included individual- and city-level education and country as fixed effects. Model 2 included individual- and sub-city-level education and country as fixed effects. Model 3 included all the exposures jointly and country as fixed effects. In Model 4, we included multiplicative interactions between city-level education and country by including the corresponding interaction terms in Model 3. To further explore whether there was heterogeneity in the associations by country, we conducted stratified analyses by country and gender (Supplementary Material Figure S2). Since Peru was the only country that presented a statistically significant and inverse association between city-level education and hypertension, we report associations with city level education separately for two groups (group 1: Argentina, Central America, Brazil, Chile, Colombia, and Mexico; group 2: Peru).

To determine if there were interaction between individual- and area-level SES, we estimated a fifth model (Models 5A and 5B) by including in Model 3 an interaction term between individual- and city-level education (Model 5A) and individual- and sub-city-level education (Model 5B). We plotted the predicted probabilities resulting from the models by individual education category and city- and sub-city-level education.

In order to examine the robustness of our results to using measured blood pressure in the subset of the sample where measures were available (n= 50,209) we fitted model 4 using the objective measure to define the outcome: hypertension was defined as systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg or the use of antihypertensive drugs. These analyses excluded Argentina because blood pressure measurements were not

available and were restricted to smaller subsamples in other countries because measurements were not available for all respondents.

The analyses were performed using Stata version 12.0 (StataCorp LP, College Station, USA) and R software. The level of significance was set at 5%. The SALURBAL study protocol was approved by the Drexel University Institutional Review Board with ID #1612005035.

3. Results

The individual-level and area-level characteristics of the 109,184 individuals distributed in 673 sub-cities nested in 230 cities, according to country, are presented in Table 1. The median number of participants per sub-city was 65 (interquartile ranges [IQR] = 123) and per city was 343.5 (IQR = 506). The highest percentage of survey participants lived in Brazil and Mexico (24.2% and 23.8%, respectively), while Chile and Central America had the lowest (2.4% and 2.6%, respectively). The overall proportion of hypertension was 13.0% (95%CI = 12.9-13.1). Argentina and Brazil had the highest proportions of hypertension (17.5% and 16.5%, respectively), while Peru (6.5%) and Colombia (7.7%) had the lowest. The mean age of the population studied was 42.7 years (SD = 16.4) and 57.8% were women.

The proportion of self-reported hypertension was 10.5% (95%CI = 10.2-10.8) for men and 14.8% (95%CI = 14.5-15.1) for women (Table 2). Participants with hypertension were, on average, older and concentrated in the lower education categories as compared with those without hypertension, both for men and women. Also, individuals with hypertension had slightly higher sub-city-level education and lower city-level education than those without hypertension for both sexes.

Table 3 shows associations of individual-, sub-city- and city-level education with hypertension. The random intercepts remained significant for all models in both sexes, indicating residual variability in hypertension between cities and sub-cities. In women, higher individual-level education was associated with lower odds of hypertension in all models. In contrast, higher sub-city-level education was associated with higher odds of hypertension in all models. City-level education was not associated with hypertension even after joint adjustment of the three exposure variables, age, and country-fixed effects (Model 3). However, model 4 reveled heterogeneity in the associations of city education with hypertension by country: higher city-level education was associated with lower odds of hypertension in Peru but no association was observed for Argentina, Brazil, Central America, Chile, Colombia, and Mexico.

In men, higher individual- and sub-city-level education were associated with higher odds of hypertension in all models (Table 3). In contrast, higher city-level education was associated with lower odds of hypertension in the model with joint adjustment of the three exposure variables, age, and country-fixed effects. Exploration of interactions showed that this association was stronger in Peru while no association was observed for Argentina, Brazil, Central America, Chile, Colombia, and Mexico.

Figure 1 shows adjusted predicted probabilities of hypertension for individual education by levels of the city- and sub-city education. Although interaction terms were not always statistically significant, interesting patterns were observed. In women, the inverse association of individual-level education with hypertension became stronger at higher levels of city and sub-city education. In men, inverse associations of hypertension with education appeared to emerge at high levels of sub-city education. Estimates from models with interactions are shown in a supplementary table (Supplementary Material Table S2).

In sensitivity analyses, restricted to persons with measured blood pressure or using antihypertensive drugs, we observed similar results in women in terms of directionality and patterns of associations for all three exposures in the full model (Supplementary Material Table S3). However, in men in contrast to what was observed with self-reported hypertension, the highest individual-level education category was associated with lower odds of hypertension (OR versus less than primary: 1.14 [95%CI= 1.02-1.27], 1.01 [95%CI= 0.91-1.12], 0.86 [95%CI= 0.76-0.97], for primary, secondary and university or higher categories respectively). Findings for the city- and sub-city-level education were similar in directionality to those reported in the main analysis.

4. Discussion

We investigated associations of individual-level and area-level education with hypertension in adults from 230 Latin American cities. We found a clear gradient across individual-level education, but in opposite direction between genders. In women, higher education levels were associated with a lower proportion of hypertension. In men, higher education levels were associated with a higher proportion of hypertension. Although interaction terms between individual-level and area-level education were not always statistically significant, descriptive analyses suggested that an inverse association of individual-level education with hypertension became stronger or emerged as city or sub-city education increased.

Our results also demonstrated that higher sub-city-level education was associated with higher odds of hypertension in both genders. Moreover, the association of city-level education with hypertension varied across countries. In Peru, there was an inverse association (higher city education was associated with lower proportion of hypertension), while in other countries there was no association in women or men.

A recent meta-analysis of 51 studies found that educational attainment was a stronger predictor of hypertension prevalence than income or occupation [6]. However, to our knowledge, transnational studies investigating associations of individual-level and area-level SES with hypertension using the same indicator at different levels and in different countries have not been conducted.

We found that self-reported hypertension was inversely associated with education among women, but positively associated with education among men. Evidence limited from LMICs generally shows a higher prevalence of hypertension in women with lower education levels compared with higher education, while for men, evidence is mixed [3, 11, 28, 29]. Explanations for gender disparities may include more physically demanding jobs for less educated men [30] or differential patterning of other risk factors by SES in women and men [31]. Moreover, being a woman and having low education may be linked to higher exposure to chronic stress conditions, such as informal employment, single parenthood and role overload, violence, and stress at home [32, 33].

Furthermore, women's appearance is heavily emphasized in patriarchal societies [34], with heteronormative gender norms often shaping more educated women's behaviors [35] (e.g. they are more likely to face pressure to adjust their bodies to social expectations) [35]. Surveillance bias may also explain part of the association observed between education and hypertension in men. Men often search less for health systems and medical advice [18] and this could be especially pronounced in lower SES men which could explain the strong positive association of individual-level education with self-reported hypertension that we observed.

Our sensitivity analysis based on objective measures of blood pressure showed a different pattern for individual level education in men: the highest education category had significantly lower odds than the lowest category. This is consistent with the argument that differences in access and utilization of health care by SES in men could explain the positive association of individual-level SES with hypertension that we observed. Of note the gender differences in associations of education with hypertension that we report here as similar to those reported by Braverman et al [24] for diabetes and Mazariego et al [25] for obesity in SALURBAL in previous work.

Our study also showed sub-city and city contextual effects. After accounting for individual education, we found a positive association between sub-city-level education and hypertension for both genders. Lower access to health care (and consequent diagnosis of hypertension) in areas of lower education could at least partly explain this finding [16-18]. However, we observed a similar pattern when objective measures of hypertension were used. In consonance with our findings, a positive association between area-level SES and hypertension was also previously reported in Brazil using objective hypertension measures [4].

The mechanisms underlying a positive association of sub-city education with hypertension may include other factors associated with area-level SES including the nature of work [36], access to and consumption of processed foods [37], sedentary behaviors [38,39], promoted by work and urban environments (e.g., car dependence), or even factors such as levels of pollution, heat, and noise, all of which have been linked to hypertension [40].

Significant associations between city-level education and hypertension were limited to individuals residing in Peru; higher educational attainment of the population at the city level was associated with a lower proportion of hypertension in women and men. While the highest global prevalence of hypertension was observed in some Latin American and Caribbean countries, the lowest global prevalence of hypertension was found in Peru [2, 19] and the stages of the hypertension of the epidemic could be linked to social patterning and differences across cities. Country differences in access to care and the patterning of access to care by city SES could also play a role when self-reported hypertension is used as a hypertension indicator. The positive association between city-level education and hypertension in Peru is a question that deserves additional research.

Our results also suggest possible interactions between contextual- and individual-level education. In women, the inverse association of individual-level education with hypertension became stronger as sub-city and city education increased. In men, the positive association of individual-level education with hypertension was lost, and an inverse gradient emerged (higher education, lower hypertension prevalence) as sub-city education increased. This is consistent with findings from prior works showing that inverse social gradients in cardiovascular risks emerge as contextual education increases [24, 25]. It may be related to the social patterning of risk factors for hypertension that emerges as socioeconomic development increases.

This study has some limitations. First, we use a cross-sectional design, which does not allow us to draw causal inferences; however, descriptive information is also important to public policy. Second, the ascertainment of hypertension status was through self-report, which may have led to differential information bias, with groups with less access to healthcare under-

represented, and consequently, resulting in underestimates of inverse education gradients if lower SES groups have lower access to care. Third, gestational hypertension was not excluded in Argentina and Guatemala. Gestational hypertension data will be limited to some women who were pregnant at the time of the survey. In countries where we have information on current pregnancy (Brazil, Chile, Mexico, Peru and El Salvador), the presence of this condition was reported by approximately 4% of women aged 18 to 49 years, with only 19 (1.8%) of these were considered hypertensive. Therefore, we do not believe this is likely to have had a significant impact on our results. Fourth, we did not adjust for hypertension risk factors such as physical activity, diet, smoking, obesity, and diabetes because we view them as likely mediators of the associations we are investigating [15, 41]. In addition, it is not possible to rule out residual confounding due to unmeasured or unknown factors. Fifth, survey years are not always aligned with the census years from which area-level education information was drawn. Finally, despite efforts to harmonize surveys across countries, some heterogeneity may still exist and affect our results. Nonetheless, to attenuate these potential remaining differences we used the country as fixed effects for the main analyses.

On the other hand, this study has several strengths. To our knowledge, this is the first transnational study to examine the association between individual- and area-level SES with hypertension using the same indicator at different levels. Second, our study included a large sample of individuals (109,184) and cities (230) representing a significant proportion of the urban population of Latin America and used a large harmonized dataset. Third, our multilevel approach allowed us to analyze individual and macro-level contextual factors. In addition, the associations were adjusted for country-fixed effects removing the effect for unmeasured country factors such as differences in healthcare and education systems across countries.

In conclusion, our results demonstrate gender and social inequalities in hypertension in Latin American cities. First, we identified gender differences in the relationship between individual education and hypertension, with higher individual-level education associated with lower odds of hypertension among women and higher odds among men. Second, we identified that higher sub-city-level education was positively associated with hypertension in both women and men. Third, we identified that higher city-level education was associated with lower odds of hypertension in both sexes in Peru. Thus, our results suggest that strategies to deal with the burden of hypertension in LIMCs should adopt equity-based and context-sensitive efforts.

Ethics approval

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects/patients were approved by the Drexel University Institutional Review Board with ID no. 1612005035 and by appropriate site-specific IRBs. In Brazil, this study was approved by the Federal University of Minas Gerais IRB (CAAE: 70209917.00000.5149). For health survey participants, informed consent was obtained from all subjects.

Availability of data and materials

Data are available upon reasonable request. The SALURBAL study obtained data from health and/or statistical agencies within each country. Some data sources are available under restricted access due to data use agreements between the SALURBAL Study and statistical agencies within the country. Requests for the harmonized data can be obtained by contacting the SALURBAL Data Methods Core (salurbal.data@drexel.edu) and after completing data use agreements. To learn more about SALURBAL's dataset, visit https://drexel.edu/lac/ or contact the project at salurbal@drexel.edu.

Competing interests

We declare no competing interests.

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References

1. World Health Organization (WHO). A global brief on hypertension: silent killer, global public health crisis [Internet]. World Health Organization; 2013 [accessed on Aug. 29, 2022]. Available from: https://www.who.int/publications/i/item/a-global-brief-on-hypertension-silent-killer-global-public-health-crisis-world-health-day-2013

2. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. The Lancet. 2021;398(10304):957-980.

3. Tumas N, López SR, Bilal U, Ortigoza F, Roux AVD. Urban social determinants of non-communicable diseases risk factors in Argentina. Health & Place. 2021;77:102611.

4. Bento IC, Mambrini JVDM, Peixoto SV. Contextual and individual factors associated with arterial hypertension among Brazilian older adults (National Health Survey-2013). Revista Brasileira de Epidemiologia. 2020;23:e200078.

5. Lucumi D, Schulz AJ, Roux AVD, Grogan-Kaylor A. Income inequality and high blood pressure in Colombia: a multilevel analysis. Cadernos de saude publica. 2017; 33:e00172316.

6. Leng B, Jin Y, Li G, Chen L, Jin N. Socioeconomic status and hypertension: a meta-analysis. Journal of hypertension. 2015;33(2):221-229.

7. Kirschbaum TK, Sudharsanan N, Manne-Goehler J, De Neve JW, Lemp JM, Theilmann M, et al. The association of socioeconomic status with hypertension in 76 Low- and Middle-Income Countries. J Am Coll Cardiol. 2022;80(8):804-817.

8. Caswell JM. Prevalence of reported high blood pressure in Canada: investigation of demographic and spatial trends. Journal of Public Health. 2017;25(1):49-59.

9. McDoom MM, Palta P, Vart P, Juraschek SP, Kucharska-Newton A, Roux AVD, at al. Late life socioeconomic status and hypertension in an aging cohort: the Atherosclerosis Risk in Communities Study. Journal of hypertension. 2018;36(6):1382.

10. Hessel P, Rodríguez-Lesmes P, Torres D. Socio-economic inequalities in high blood pressure and additional risk factors for cardiovascular disease among older individuals in Colombia: Results from a nationally representative study. Plos one. 2020;15(6):e0234326.

11. Alves RFS, Faerstein E. Educational inequalities in hypertension: complex patterns in intersections with gender and race in Brazil. International journal for equity in health. 2016; 15(1):1-9.

12. Wagner KJP, Boing AF, Subramanian SV, Höfelmann DA, D'Orsi E. Effects of neighborhood socioeconomic status on blood pressure in older adults. Revista de Saúde Pública. 2016:50:78.

13. Lynch J, Kaplan G. Socioeconomic Position. In: Berkman LF, Kawachi I, editors. Social Epidemiology. New yourk: Oxford University Press; 2000. p. 13–35.

14. Lê-Scherban F, Ballester L, Castro JC, Cohen S, Melly S, Moore K, et al. Identifying neighborhood characteristics associated with diabetes and hypertension control in an urban African American population using geo-linked electronic health records. Preventive Medicine Reports. 2019;15:100953.

15. Chaix B, Bean K, Leal C, Thomas F, Havard S, Evans D, et al. Individual/neighborhood social factors and blood pressure in the RECORD Cohort Study: which risk factors explain the associations? Hypertension. 2010;55(3):769-775.

16. Barraza-Lloréns M, Panopoulou G, Díaz BY. Income-related inequalities and inequities in health and health care utilization in Mexico, 2000-2006. Revista Panamericana de Salud Pública. 2013;33:122-130.

17. Almeida G, Sarti FM, Ferreira FF, Diaz MDM, Campino ACC. Analysis of the evolution and determinants of income-related inequalities in the Brazilian health system, 1998-2008. Revista Panamericana de Salud Pública. 2013;33:90-97.

18. Levorato CD, de Mello LM, da Silva AS, Nunes AA. Factors associated with the demand for health services from a gender-relational perspective. Ciência & Saúde Coletiva. 2014;19(4):1263.

19. Ruilope LM, Chagas ACP, Brandao AA, Gómez-Berroterán R, Alcalá JJA, Paris JV, et al. Hypertension in Latin America: Current perspectives on trends and characteristics. Hipertension y riesgo vascular. 2017;34(1):50-56.

20. United Nations Human Settlements Programme. State of the world's cities 2010/2011: Bridging the urban divide. Earthscan, 2010.

21. Rivera-Andrade A, Luna MA. Trends and heterogeneity of cardiovascular disease and risk factors across Latin American and Caribbean countries. Prog Cardiovasc Dis. 2014;57(3):276-85.

22. Becerra-Posada F. Health equity: The linchpin of sustainable development. Rev Panam Salud Pública. 2015;38:5–8.

23. Diez-Roux AV, Slesinski SC, Alazraqui M, Caiaffa WT, Frenz P, Fuchs RJ, et al. A Novel International Partnership for Actionable Evidence on Urban Health in Latin America: LAC-Urban Health and SALURBAL. Global Challenges. 2018;3:1800013.

24. Braverman-Bronstein A, Hessel P, González-Uribe C, Kroker MF, Diez-Canseco F, Langellier B, et al. Association of education level with diabetes prevalence in Latin American cities and its modification by city social environment. J Epidemiol Community Health. 2021;75(9):874-880.

25. Mazariegos M, Auchincloss AH, Braverman-Bronstein A, Kroker-Lobos MF, Ramírez-Zea M, Hessel P, et al. (2022). Educational inequalities in obesity: a multilevel analysis of survey data from cities in Latin America. Public health nutrition. 2022;25(7):1790-1798.

26. Quistberg DA, Diez-Roux AV, Bilal U, Moore K, Ortigoza A, Rodriguez DA, at al. Building a Data Platform for Cross-Country Urban Health Studies: the SALURBAL Study. Journal of Urban Health. 2019;96(2):311-337.

27. Ortigoza AF, Granados JA, Miranda JJ, Alazraqui M, Higuera D, Villamonte G, et al. Characterising variability and predictors of infant mortality in urban settings: findings from 286 Latin American cities. J Epidemiol Community Health. 2021;75(3):264-70.

28. Enes CC, Nucci LB. Gender and schooling inequalities in risk and protective factors for chronic diseases among Brazilian adults. Journal of Public Health. 2018;40(3): e211-e218.

29. Laux TS, Bert PJ, González M, Unruh M, Aragon A, Lacourt CT. Prevalence of hypertension and associated risk factors in six Nicaraguan communities. Ethnicity & disease. 2012;22(2),129.

30. Gregory CO, Dai J, Ramirez-Zea M, Stein AD. Occupation is more important than rural or urban residence in explaining the prevalence of metabolic and cardiovascular disease risk in Guatemalan adults. The Journal of nutrition. 2007;137,1314–1319.

31. World Health Statistics 2019: monitoring health for the SDGs, sustainable development goals. Geneva: World Health Organization; 2019. Licence: CC BY-NC-SA 3.0 IGO.

32. Kandasamy S, Anand SS. Cardiovascular disease among women from vulnerable populations: a review. Canadian Journal of Cardiology. 2018;34(4):450-7.

33. Vega AP. Pobreza feminina desvendando suas raízes. TEL Tempo, Espaço e Linguagem. 2019;10(2):177-200.

34. Heise L, Greene ME, Opper N, Stavropoulou M, Harper C, Nascimento M., et al. Gender inequality and restrictive gender norms: framing the challenges to health. The Lancet. 2019;393(10189):2440–2454.

35. Robinovich J, Ossa X, Baeza B, Krumeich A, van der Borne B. Embodiment of social roles and thinness as a form of capital: a qualitative approach towards understanding female obesity disparities in Chile. Soc Sci Med. 2018; 201: 80–86.

36. Jones A, Mitchel D, Goza F. Lifecourse socioeconomic status and cardiovascular illness in Latin America. Current Sociology. 2014;62(7):1055-1078.

37. Matos RA, Adams M, Sabaté J. Review: The Consumption of Ultra-Processed Foods and Non-communicable Diseases in Latin America. Front Nutr. 2021;24(8):622714. doi: 10.3389/fnut.2021.622714. PMID: 33842521; PMCID: PMC8024529.

38. Bastone ADC, Moreira BDS, Vasconcelos KSDS, Magalhães AS, Coelho DM, Silva, JI. Et al. Time trends of physical activity for leisure and transportation in the Brazilian adult population: results from Vigitel, 2010-2019. Cadernos de Saúde Pública. 2022; 38:e00057222.

39. Luis de Moraes Ferrari G, Kovalskys I, Fisberg M, Gómez G, Rigotti A, Sanabria L YC, et al. Original research Socio-demographic patterning of self-reported physical activity and sitting time in Latin American countries: Findings from ELANS. BMC Public Health. 2019;19(1):1-12.

40. Nieuwenhuijsen MJ. Influence of urban and transport planning and the city environment on cardiovascular disease. Nature reviews cardiology. 2018;15(7):432-438.

41. Nejatinamini S, Campbell DJ, Godley J, Minaker LM, Sajobi TT, McCormack GR. The contribution of modifiable risk factors to socioeconomic inequities in cardiovascular disease morbidity and mortality: A nationally representative population-based cohort study. Preventive Medicine. 2023;171:107497.

Tables

Table 1: Individual-level and area-level characteristics of the analytic sample by country. SALURBAL study (N = 109,184).

	TOTAL	Argentina	Brazil	Chile	Colombia	Mexico	Peru	Central America [a]
Sample characteristics								
Number of participants	109,184	21,286	26,398	2,669	18,142	25,995	11,88	2,814
Number of cities	230	33	27	19	33	91	23	4
Participants per city								
Median (1stQ-3rdQ)	343.5 (135;641)	509 (415;679)	820 (735;1,100)	84 (33;174)	402 (195;630)	188 (89;387)	311 (162;622)	667.5 (250;1,157)
Min – Max	17 - 3,901	23 - 3,901	513 - 2,543	17 - 793	61 - 3,376	17 - 2,370	90 - 3,278	160 – 1,319
Number of sub-cities	673	108	27	70	57	245	149	17
Participants per sub-city								
Median (1stQ-3rdQ)	65 (30;153)	85 (49;338.5)	820 (735;1,100)	20.5 (14;47)	195 (66;402)	62 (33;121)	49 (20;107)	77 (38;160)
Min – Max	5 - 3,092	7 - 885	513 - 2,543	5 - 239	14 - 3,092	14 - 835	5 - 521	18 - 1,319
Area-level characteristics								
City-level education, median (1stQ-3rdQ)	0.13 (-0.66;1.02)	-0.54 (-1.12;-0.33)	0.76 (0.25;1.16)	-1.06 (-1.42;0.69)	-1.17 (-0.86;0.32)	0.25 (-0.95;0.52)	2.93 (1.33;3.49)	-1.71 (-1.71;-0.84)
Sub-city-level education, median (1stQ-3rdQ)	0.25 (-0.56;1.19)	-0.34 (-0.74;-0.07)	1.19 (0.60;1.72)	- 0.65 (-1.08;-0.22)	0.07 (-0.48-0.64)	-0.14 (-0.98;0.57)	1.20 (0.58;2.14)	-1.65 (-1.65;-1.39)
Individual-level characteristics								
Age, mean (SD)	42.7 (16.4)	44.8 (17.9)	43.4 (16.6)	46.8 (17.6)	39.1 (14.0)[b]	43.6 (16.1)	39.7 (15.6)	42.9 (16.6)
Women, n (%)	63,126 (57.8)	11,991 (56.3)	15,692 (59.4)	1,601 (60.0)	10,366 (57.1)	14,760 (56.8)	6,835 (57.5)	1,881 (66.8)
Educational level, n (%)								
Less than primary	18,856 (17.3)	1,982 (9.3)	5,626 (21.3)	284 (10.6)	3,104 (17.1)	5,361 (20.6)	1,516 (12.8)	983 (34.9)
Primary	36,674 (33.6)	7,841 (36.8)	5,724 (21.7)	922 (34.5)	6,269 (34.6)	12,674 (48.8)	2,065 (17.4)	1,179 (41.9)
Secondary	39,310 (36.0)	7,865 (36.9)	10,214 (38.7)	1,239 (46.3)	7,150 (39.4)	5,439 (20.9)	6,845 (57.6)	561 (19.9)
University or higher	14,344 (13.1)	3,598 (16.9)	4,834 (18.3)	227 (8.5)	1,619 (8.9)	2,521 (9.7)	1,454 (12.2)	91 (3.2)
Hypertension, n (%)	14,208 (13.0)	3,725 (17.5)	4,364 (16.5)	358 (13.4)	1,399 (7.7)	3,158 (12.1)	773 (6.5)	431 (15.3)
Women	9,355 (14.8)	2,317 (19.3)	2,891 (18.4)	259 (16.2)	961 (9.3)	2,111 (14.3)	480 (7.0)	336 (17.9)
Men	4,853 (10.5)	1,408 (15.5)	1,473 (13.8)	99 (9.3)	438 (5.6)	1,047 (9.3)	293 (5.8)	95 (10.1)

[a] Central America: El Salvador and Guatemala grouped together.

[b] Residents of Colombia had a lower average age, as the survey in this country did not include individuals over 70 years of age.

Table 2: Individual-level and area-level characteristics of the analytical sample by hypertension status and gender.

	Gender					
	Women			Men		
	No hypertension N = 53,771 (85.2%)	Hypertension N = 9,355 (14.8%)	p-value [a]	No hypertension N = 41,205 (89.5%)	Hypertension N = 4,853 (10.5%)	p-value [a]
Individual characteristics						
Age, mean (SD)	39.8 (15.0)	60.9 (13.6)	<0.001	40.2 (15.2)	59.9 (13.5)	<0.001
Educational level, n (%)			<0.001			<0.001
Less than primary	8,170 (15.2)	3,396 (36.3)		6,092 (14.8)	1,198 (24.7)	
Primary	17,835 (33.2)	3,111 (33.2)		14,112 (34.2)	1,616 (33.3)	
Secondary	20,423 (38.0)	1,904 (20.3)		15,694 (38.1)	1,289 (26.6)	
University or higher	7,343 (13.7)	944 (10.1)		5,307 (12.9)	750 (15.45)	
Contextual characteristics						
Sub-city-level education, mean (SD)	0.31 (1.27)	0.34 (1.27)	<0.001	0.29 (1.26)	0.38 (1.29)	<0.001
City-level education, mean (SD)	0.26 (1.43)	0.11 (1.28)	<0.001	0.26 (1.43)	0.15 (1.29)	<0.001

[a] p-values refer to Kruskal-Wallis tests and chi-square tests (for categorical variables). Comparing hypertension yes/no.

Table 3: Associations of individual-, city- and sub-city-level education, with hypertension in 230 cities in Latin America.

Individual, city, and sub-city characteristics*	Model 1 OR (95%CI)	Model 2 OR (95%CI)	Model 3 OR (95%CI)	Model 4 OR (95%CI)
Women (N = 63,126)				
Individual-level education				
Less than primary	Ref.	Ref.	Ref.	Ref.
Primary	0.99 (0.93-1.06)	0.99 (0.92-1.06)	0.99 (0.92-1.06)	0.98 (0.92-1.05)
Secondary	**0.76 (0.70-0.82)**	**0.75 (0.70-0.81)**	**0.75 (0.70-0.81)**	**0.76 (0.70-0.82)**
University or higher	**0.67 (0.61-0.74)**	**0.66 (0.60-0.73)**	**0.66 (0.60-0.73)**	**0.67 (0.61-0.74)**
City-level education	0.98 (0.93-1.04)		0.95 (0.89-1.01)	
Sub-city-level education		**1.04 (1.01-1.08)**	**1.05 (1.01-1.10)**	**1.07 (1.02-1.12)**
Argentina, Central America, Brazil, Chile, Colombia, and Mexico				
City-level education	-	-	-	1.01 (0.94-1.08)
Peru				
City-level education				**0.79 (0.64-0.97)**
Intercept variance (SE) (city)	**0.0362 (0.1904)**	**0.0373 (0.1931)**	**0.0354 (0.1884)**	**0.0641 (0.2533)**
Intercept variance (SE) (sub-city)	**0.0262 (0.1622)**	**0.0241 (0.1555)**	**0.0258 (0.1608)**	**0.0272 (0.1652)**
Men (N = 46,058)				
Individual-level education				
Less than primary	Ref.	Ref.	Ref.	Ref.
Primary	**1.51 (1.37-1.66)**	**1.49 (1.36-1.64)**	**1.50 (1.36-1.65)**	**1.48 (1.35-1.63)**
Secondary	**1.59 (1.43-1.76)**	**1.56 (1.40-1.73)**	**1.56 (1.40-1.73)**	**1.58 (1.42-1.75)**
University or higher	**1.68 (1.49-1.88)**	**1.63 (1.45-1.83)**	**1.63 (1.45-1.83)**	**1.65 (1.47-1.86)**
City-level education	0.98 (0.92-1.04)		**0.92 (0.85-0.99)**	
Sub-city-level education		**1.06 (1.01-1.12)**	**1.09 (1.03-1.16)**	**1.11 (1.05-1.18)**
Argentina, Central America, Brazil, Chile, Colombia, and Mexico				
City-level education	-	-	-	1.00 (0.92-1.10)
Peru				
City-level education	-	-	-	**0.77 (0.59-0.99)**
Intercept variance (SE) (city)	**0.0221 (0.1487)**	**0.0270 (0.1644)**	**0.0213 (0.1460)**	**0.1001 (0.3164)**
Intercept variance (SE) (sub-city)	**0.0233 (0.1528)**	**0.0154 (0.1244)**	**0.0191 (0.1384)**	**0.0250 (0.1582)**

Ref.: reference group. OR: Odds Ratio. 95%CI: 95% confidence intervals. SE: standard error. Bold values have a p-value<0.05.

***** All models were adjusted for individual age. City- and sub-city-level education (educational attainment score) was standardized to a mean of 0 and a standard deviation (SD) of 1. The OR is estimated for a 1 SD (0.30847) and (0.24469) difference in sub-city- and city-educational attainment scores, respectively. **Model 1:** Individual- and city-level education, adjusted for country-fixed effect. **Model 2:** Individual- and sub-city-level education, adjusted for country-fixed effect. **Model 3:** Individual-, sub-city- and city-level education, adjusted for country-fixed effect. **Model 4:** Model 3 and an interaction term between city-level education and different country groups (p-value for interaction in women = 0.004 and men = 0.012). Combinations of the main effect of city-level education and the interaction coefficient were used to derive estimates for different countries.

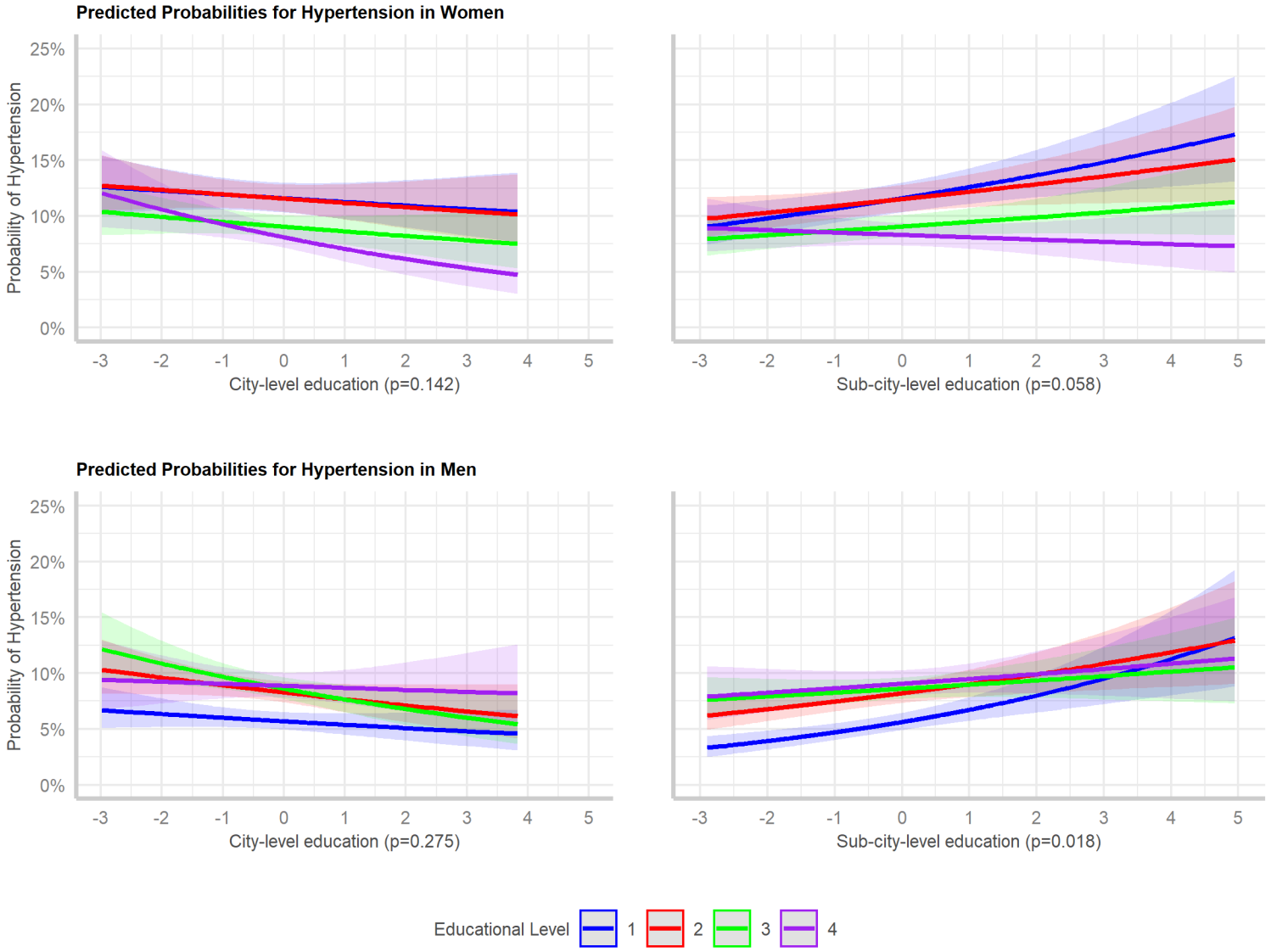

Figure 1: Predicted probabilities of hypertension based on the regression models to assess the effect modification of individual-level education by area-level education. The p-value presented refers to the global interaction test. Education level: 1 = less than primary; 2 = primary; 3 = secondary; 4 = university or higher. Sub-city- and city-educational attainment score values are based on the standardized variable used in the model so the range of values differs from the one presented in Table 1.

Supplemental material

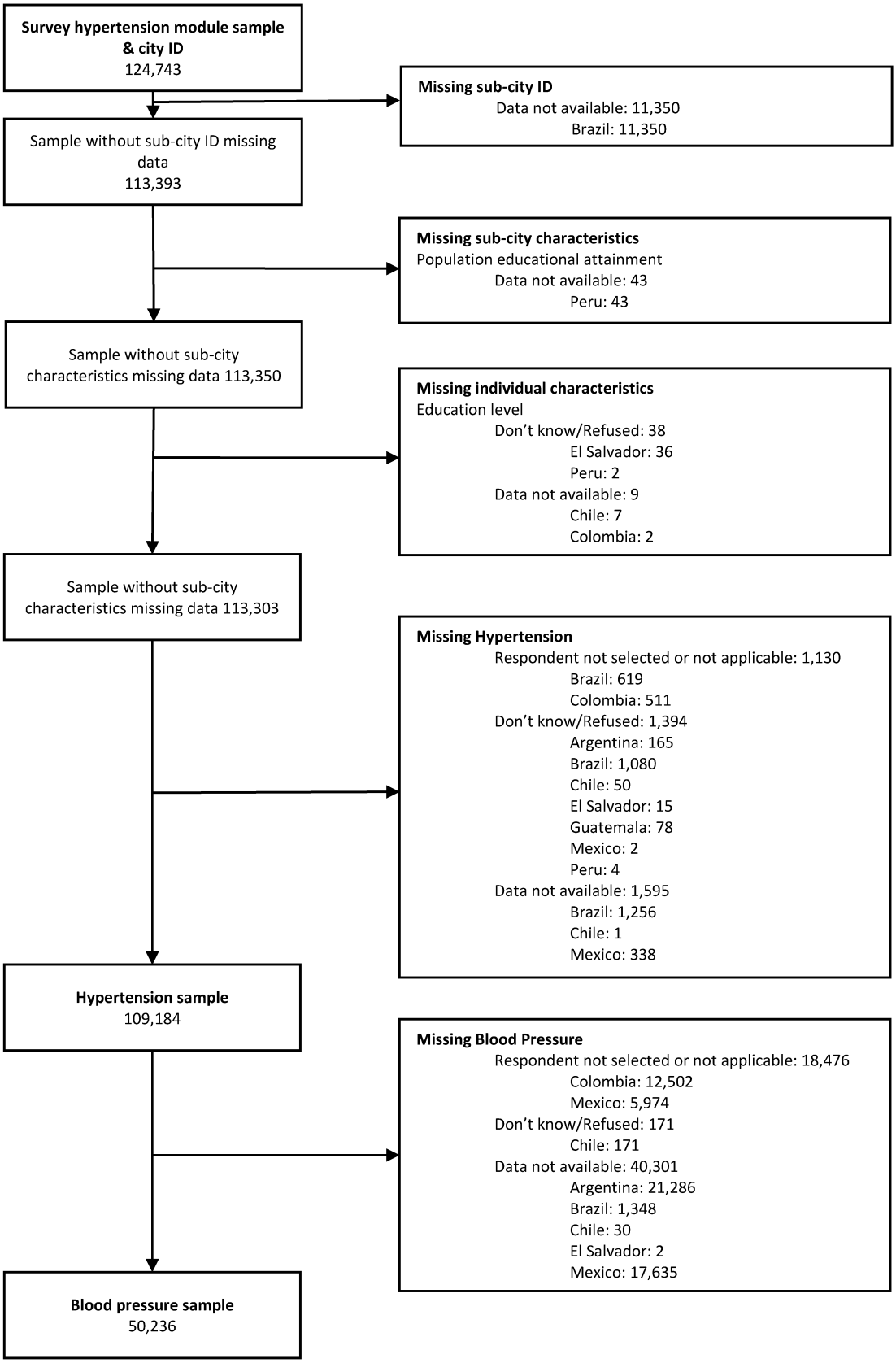

Figure S1. Flowchart of the process used to define the sample used in the paper.

Table S1: Characteristics of the national surveys included in our sample.

Country	Survey	Sample Characteristics	Sampling Strategy
Argentina	Survey: Encuesta Nacional de Factores de Riesgo, ENFR (National Risk Factors Survey) Year: 2013	Age: >18 years Total N: 32,365 N in SALURBAL: 21,451 N selected: 21,451 N used: 21,286	Multistage [Aglomerado censal; área (groups of radio censales); household; person 18 years or older] Stratified [population size; educationlevel of head of household]
Brazil	Survey: Pesquisa Nacional de Saúde, PNS (National Health Survey) Year: 2013	Age: All ages Total N: 64,308 adults 18+ years N in SALURBAL: 29,353 N selected: 29,353 N used: 26,398	Multistage: census tracts or groups of census tracts; households; person 18 years or older Stratified: capital city, metropolitan region, or integrated economic development region, then rest of municipalities; Urban/rural; total household income
Chile	Survey: Encuesta Nacional de Salud, ENS (National Health Survey) Year: 2010	Age: ≥15 years Total N: 5,293 N in SALURBAL: 2,840 N selected: 2,727 adults 18+ years N used: 2,669	Multistage: Comunas; Segments within comunas; household; person 15 years or older Stratified: urban/rural with three groups of population sizes
Colombia	Survey: Encuesta Nacional de Salud, ENS (National Health Survey) Year: 2007	Age: 0 - 69 years Total N: 102,677 (43,182 adults 18-69 years) N in SALURBAL: 43,182 (18,824 adults 18-69 years competed module 2 or module 4) N selected: 18,654 N used: 18,143	Multistage: Municipalities or combination of municipalities if small, Manzanas; household; person adults 18- 69 and all children 17 and under Stratified: region; urbanization of municipal seats; urban/rural municipal population; unsatisfied basic needs
Mexico	Survey: Encuesta Nacional de Salud y Nutricion, ENSANUT (National Survey for Health and Nutrition) Years: 2012	Age: all ages Total N: 46,277 adults 18+ years N in SALURBAL: 26,335 adults N selected: 26,335 N used: 25,995	Multistage: AGEB; Manzana (urban) or pseudo-manzanas withig localidades (rural); Households; 1 person within each of the groups (0-4 years, 5-9 years, 10-19 years, 20 years and older, recent medical service user) Stratified: socioeconomic status of AGEB at the state level
Peru	Survey: Encuesta Nacional de Demografia y Salud, ENDES (National Survey of Demographics and Health) Year: 2016	Age: All ages Total N: 122,368 (32158 adults 18-69 years) N in SALURBAL: 12,597 adults 18+ years N selected: 11,929 N used: 11,880	Multistage: Conglomerado (set of census blocks – urban) or Empadronamiento (set of households – rural); Households; One person within each of the groups (>15 years, females 15-49 years, children <5 years, children <12 years) Stratified: Department; Urban/Rural
El Salvador	Survey: Encuesta Nacional de Enfermedades Cronicas no transmisibles en Poblacion Adulta de El Salvador ENECA Year: 2014-2015	Age: ≥20 years Total N: 4,817 N in SALURBAL: 1,546 N selected: 1,546 N used: 1,495	Two-stage [Segmento censal, groups of dwellings (compacto); all household members 20 years and older]
Guatemala	Survey: Encuesta Multi-nacional de Diabetes mellitus y Factores de Riesgo, CAMDI Year: 2002-2003	Age: ≥20 years Total N: 1,397 N in SALURBAL: 1,397 N selected: 1,397 N used: 1,319	Multistage: Segmento censal, groups of dwell-ings (compacto); all household members 20 years and older

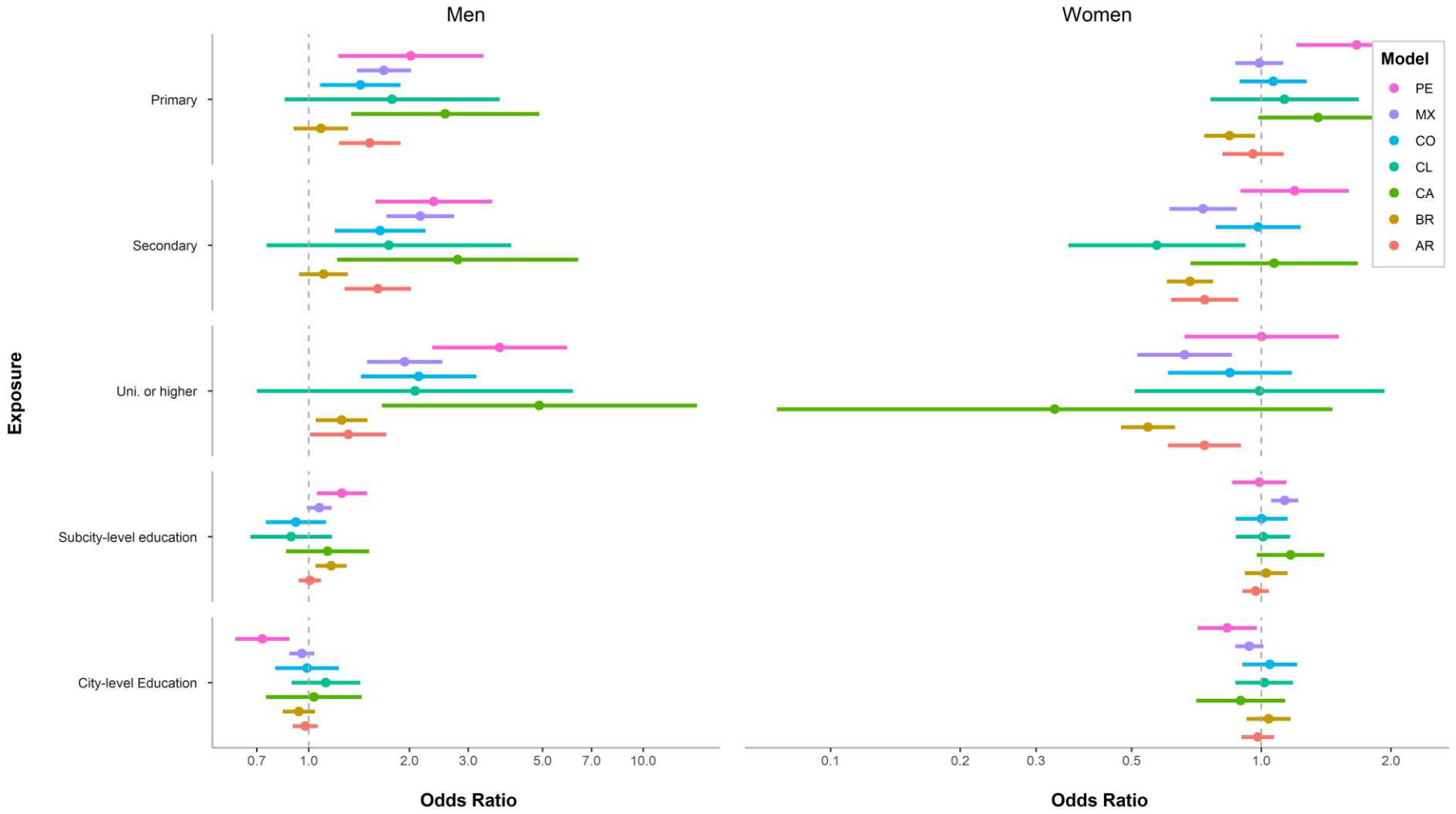

Figure S2. Associations of individual-, city- and sub-city-level education, with hypertension country-stratified. SALURBAL study (N = 109,184).
Multilevel structure: individuals nested within sub-cities, nested within cities. Analyses adjusted by individual age.

Table S2. Associations between Individual-, city- and sub-city-level education with hypertension for models containing an interaction term between individual-level education with city- and sub-city education.

Individual, sub-city and city characteristics (N = 109,184)	*WOMEN* OR (95% CI)	*MEN* OR (95% CI)
Model 5A		
City-level education	0.96 (0.89-1.04)	0.94 (0.85-1.03)
Sub-city-level education	**1.06 (1.01-1.10)**	**1.09 (1.03-1.16)**
Individual-level education		
Less than primary	Ref.	Ref.
Primary	0.99 (0.93-1.06)	**1.49 (1.35-1.65)**
Secondary	**0.75 (0.70-0.81)**	**1.56 (1.41-1.73)**
University or higher	**0.67 (0.61-0.73)**	**1.61 (1.43-1.81)**
Individual education * City education		
Less than primary * City education	0.96 (0.89-1.04)	0.94 (0.85-1.03)
Primary * City education	0.96 (0.85-1.08)	0.92 (0.77-1.09)
Secondary * City education	0.95 (0.84-1.07)	0.87 (0.74-1.04)
University or higher * City education	**0.86 (0.75-0.99)**	0.97 (0.81-1.17)
Intercept variance (SE) (city)	**0.0347 (0.1863)**	**0.0214 (0.1466)**
Intercept variance (SE) (sub-city)	**0.0262 (0.1621)**	**0.0187 (0.1370)**
Global p-value for interactions	0.142	0.275
Model 5B		
City-level education	0.95 (0.89-1.01)	**0.91 (0.85-0.98)**
Sub-city-level education	**1.09 (1.03-1.16)**	**1.20 (1.10-1.31)**
Individual-level education		
Less than primary	Ref.	Ref.
Primary	0.99 (0.92-1.06)	**1.49 (1.36-1.65)**
Secondary	**0.75 (0.70-0.82)**	**1.58 (1.42-1.75)**
University or higher	**0.69 (0.62-0.76)**	**1.67 (1.48-1.88)**
Individual education* Sub-city education		
Less than primary * Sub-city education	**1.09 (1.03-1.16)**	**1.20 (1.10-1.31)**
Primary * Sub-city education	1.06 (0.95-1.19)	1.10 (0.94-1.30)
Secondary * Sub-city education	1.05 (0.93-1.17)	1.04 (0.88-1.23)
University or higher * Sub-city education	0.97 (0.85-1.10)	1.05 (0.88-1.25)
Intercept variance (SE) (city)	**0.0344 (0.1856)**	**0.0200 (0.1417)**
Intercept variance (SE) (sub-city)	**0.0257 (0.1604)**	**0.0196 (0.1401)**
Global p-value for interactions	0.059	**0.018**

Ref.: reference group. OR: Odds Ratio. 95%CI: 95% confidence intervals. SE: standard error. Bold values have a p-value<0.05.

Multilevel structure: individuals nested within sub-cities, nested within cities. Analyses adjusted by age and country-fixed effect. **Interaction model A:** include an interaction term individual-level education*city-level education. **Interaction model B:** include interaction term individual-level education*sub-city-level education. Combinations of the main effect of individual-level education and the interaction coefficient were used to derive the estimates.

Table S3. Sensitivity analyses: associations between individual-, sub-city- and city-level education with hypertension (self-reported vs. objectively measured).

Individual, sub-city and city characteristics (N = 50,236)*	*Self-reported*** OR (95%CI)	*Measured* *** OR (95%CI)
WOMEN (N= 29,806)		
City-level education		
Sub-city-level education	**1.12 (1.04-1.21)**	**1.08 (1.01-1.15)**
Individual-level education		
Less than primary	REF	**REF**
Primary	1.03 (0.92-1.14)	0.97 (0.88-1.06)
Secondary	**0.77 (0.70-0.86)**	**0.70 (0.64-0.77)**
University or higher	**0.63 (0.55-0.72)**	**0.51 (0.45-0.57)**
Brazil, Central America, Chile, Colombia, Mexico		
City-level education	1.07 (0.95-1.21)	1.01 (0.92-1.11)
Peru		
City-level education	**0.76 (0.58-0.99)**	**0.79 (0.64-0.99)**
Intercept variance (SE) (city)	**0.0374 (0.1935)**	**0.0325 (0.1804)**
Intercept variance (SE) (sub-city)	**0.0635 (0.2520)**	**0.0238 (0.1544)**
Global p-value for interactions	**0.000**	**0.002**
MEN (N= 20,403)		
City-level education		
Sub-city-level education	**1.25 (1.14-1.37)**	1.06 (0.99-1.13)
Individual-level education		
Less than primary	REF	REF
Primary	1.22 (1.05-1.42)	**1.14 (1.02-1.27)**
Secondary	**1.31 (1.13-1.52)**	1.01 (0.91-1.12)
University or higher	**1.59 (1.36-1.87)**	**0.86 (0.76-0.97)**
Brazil, Central America, Chile, Colombia, Mexico		
City-level education	1.03 (0.90-1.18)	0.99 (0.89-1.10)
Peru		
City-level education	**0.72 (0.53-0.96)**	0.93 (0.73-1.17)
Intercept variance (SE) (city)	**0.0344 (0.1855)**	**0.0472 (0.2174)**
Intercept variance (SE) (sub-city)	**0.0191 (0.1384)**	**0.0220 (0.1483)**
Global p-value for interactions	**0.000**	**0.436**

Ref.: reference group. OR: Odds Ratio. 95%CI: 95% confidence intervals. SE: standard error. Bold values have a p-value<0.05.

* These analyses excluded Argentina because blood pressure measurements were not available and were restricted to smaller subsamples in other countries because measurements were not available for all respondents.

** Participants were defined as having hypertension if they reported that a physician told them that they had hypertension and if they reported using medications to lower blood pressure prescribed by a healthcare provider (i.e., both conditions had to be fulfilled).

*** Hypertension was defined as systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg or use of antihypertensive drugs.

Models: Individual-, sub-city- and city-level education, an interaction term between city-level education and different country groups, and fixed control for age. Combinations of the main effect of city-level education and the interaction coefficient were used to derive estimates for different countries.

7. 2 Artigo de Resultado 2

Gender Differences in Social Determinants of Hypertension Among Older Brazilian Adults Residing in Urban Areas: A Multilevel Approach from the ELSI-Urbe

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List of abbreviations

ELSI-Brazil: Brazilian Longitudinal Study of Aging
OSUBH-UFMG: Belo Horizonte Urban Health Observatory of the Universidade Federal de Minas Gerais
IBP: Brazilian Deprivation Index
CIDACS: Center for Data and Knowledge Integration for Health
SD: Standard Deviation
CI: Confidence Interval
OR: Odds Ratio
ICC: Intraclass Correlation Coefficient
MOR: Median Odds Ratio

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Abstract

Despite interest in the social determinants of hypertension, research investigating the effects of individual- and contextual socioeconomic conditions in highly unequal urban areas, such as Latin America, remains limited. This paper describes gender disparities in association between individual and contextual socioeconomic conditions with hypertension among older adults residing in urban areas of Brazil. Data from 6,767 participants from the baseline (2015-2016) of the Brazilian Longitudinal Study of Aging (ELSI-Brazil), a cohort with a nationally representative sample of community-dwelling adults aged ≥50 years, were analyzed. Hypertension was self-reported. The measure of individual socioeconomic condition was individual education, and the contextual measure was the Brazilian Deprivation Index (IBP; acronym in Portuguese) of the census tract of the participant's residence. Multilevel logistic regression models (individuals and census tracts), adjusted for age and stratified by gender, were used. The prevalence of hypertension according to individual education and the IBP differed between men and women. In women, higher individual education (≥ 9 years versus ≤ 4 years of schooling) was associated with a lower chance of hypertension (odds ratio [OR]= 0.62; 95% confidence interval [CI]= 0.52–0.74), and residing in census tracts with higher deprivation was associated with a higher chance of hypertension (OR per standard deviation [SD]= 1.04; 95%CI= 1.01–1.09). In men, there was no significant association between individual education or IBP and hypertension. Our results suggest that public policies addressing this disease's burden in middle- and low-income countries, such as Brazil, should adopt gender-sensitive strategies and consider the context in which these individuals reside.

Keywords: urban health; hypertension; education; socioeconomic position; socioeconomic deprivation; multilevel analysis.

1. Introduction

The prevalence of hypertension, the leading cause of cardiovascular diseases and premature death [,1], is decreasing in high-income countries but increasing in low- and middle-income countries [2]. In these regions, rapid population aging and urbanization have been recognized as important determinants of the growing burden of hypertension and its risk factors [3]. Urban living exposes individuals to higher pollution levels (air, water, light, and noise), increased stress, and reduced access to green spaces [3]. Moreover, urban environments contribute to nutritional transition, decreased physical activity, and higher access to tobacco and alcohol [4]. Initially observed among wealthier populations, these changes began to be concentrated among more disadvantaged populations [3]. However, studies investigating the social gradient of hypertension among urban residents in low- and middle-income countries are limited and show inconsistent results [5-7].

Evidence from high-income countries shows that socioeconomic disadvantages are associated with a higher prevalence of hypertension, particularly among women [8, 9]. In contrast, the pattern of association is less clear in low- and middle-income countries, where both positive and negative gradients of association are observed throughout socioeconomic development and epidemiological transitions [5-7]. A cross-sectional study gathering data from household surveys from 76 low- and middle-income countries revealed considerable heterogeneity in the association between socioeconomic conditions and hypertension. For instance, in Peru, there was a positive association between education and hypertension, whereas in Brazil, a negative association was observed [5]. Beyond individual socioeconomic conditions, contextual socioeconomic conditions (e.g., residential areas or neighborhoods) are also linked to hypertension [8-12]. A previous study demonstrated that residing in a neighborhood with a lower socioeconomic level was associated with an increase in blood pressure over time and the incidence of hypertension during a follow-up period of 9.7 years [11]. Additionally, research indicates that older individuals [10] and women [12] are more susceptible to the characteristics of the environment where they live.

Individual and contextual conditions can contribute to the development of hypertension through multiple processes. At the individual level, socioeconomic conditions can influence health behaviors and stress-related processes [9]. Contextual socioeconomic conditions, in turn, encompass environmental characteristics such as the availability of physical spaces for purchasing healthy foods, the presence of safe places for physical activity, transportation services, and access to healthcare services [13,14]. Additionally, residing in areas characterized

by greater social vulnerability – due to factors like poor sanitation, unhealthy housing, high crime rates, violence, and inadequate investment in human capital – can elevate chronic stress levels, thereby contributing to the development of hypertension [14].

Brazil, a highly urbanized country with a middle-income economy, has 15.6% of its population classified as older adults [15]. In recent decades, Brazil has experienced unequal social and economic progress, which has exacerbated existing socioeconomic and health inequalities [16]. Thus, the country offers a favorable context to explore the relationship between individual and contextual socioeconomic conditions and hypertension among older adults. This understanding is crucial for developing urban and health policies aimed at enhancing equity.

This goal study was to investigate the association between individual and contextual socioeconomic conditions and hypertension, by gender, among older adults residing in urban areas of Brazil. We hypothesized that poor individual and contextual socioeconomic conditions would be associated with a higher prevalence of hypertension. In addition, differences by individual and contextual socioeconomic conditions on hypertension would be higher among women than men.

2. Methods

Study design and data source

This cross-sectional study used data from the project “ELSI-Urbe - "The influence of the physical and social environment on the health of older Brazilian adults: a longitudinal multimethod population-based study” under the coordination of the Belo Horizonte Urban Health Observatory of the Universidade Federal de Minas Gerais (OSUBH-UFMG). The objective of ELSI-Urbe is to identify the attributes of the neighborhood’s physical and social environment that influence the health and well-being of older adults over time. This project is nested within the Brazilian Longitudinal Study of Aging (ELSI-Brazil), a population-based longitudinal study, representative of the non-institutionalized Brazilians aged 50 and over [17]. The present study used baseline data from the ELSI-Brazil.

Our study also used the Brazilian Deprivation Index (IBP, acronym in Portuguese), an indicator calculated based on the data from the 2010 Demographic Census [18]. The IBP, released in 2020, is the result of a partnership between researchers from the Center for Data and Knowledge Integration for Health (Centro de Integração de Dados e Conhecimentos para Saúde

– CIDACS) and the University of Glasgow, in Scotland, and aims to measure social inequalities in the smallest areas (census tracts) in Brazil [18].

Study sample

The ELSI-Brazil baseline was carried out between 2015 and 2016. To ensure that the sample represents the urban and rural areas of municipalities of all sizes, the sample was recruited using a design with selection stages, combining stratification of the primary sampling units (municipalities), census tracts, and households. The final baseline sample involved 9,412 individuals residing in 712 census tracts from 70 municipalities across five Brazilian geographic macroregions. Detailed information regarding study design and recruitment methods was published elsewhere [17]. The ELSI-Brazil was approved by the Ethics Committee of the Oswaldo Cruz Foundation – Minas Gerais (CAAE: 34649814.3.0000.5091); all participants or legal guardians have signed an informed consent.

The eligible population for this study consisted of participants residing in urban areas. Our analyses were restricted to eligible individuals who completed their interviews independently, without the assistance of an informant (proxy), and who had available information on both the outcome and exposure at both the individual and contextual levels.

Dependent Variable

Hypertension

Participants were defined as having hypertension if they reported that a physician had told them that they had hypertension. The information was obtained through the following question: “Has a doctor ever told you that you have hypertension (high blood pressure)?” (“no”; “yes”; “yes, only during pregnancy”; “didn’t know/didn’t answer”). Participants who answered “yes, only during pregnancy” or “didn’t know/didn’t answer” were excluded from the analysis.

Independent Variables

Individual-level education

Individual-level education was obtained from the question: “What was the highest grade in school that you completed?”. The question had the following answer options: 1) never studied; 2) 1st grade (Elementary School); 3) 2nd grade (Elementary School); 4) 3rd grade (Elementary School); 5) 4th grade (Elementary School); 6) 5th grade (Elementary School); 7) 6th grade

(Middle School); 8) 7th grade (Middle School); 9) 8th grade (Middle School); 10) 9th grade (High School); 11) 10th grade (High School); 12) 11/12th grade (High School); 13) school for adults; 14) some college (incomplete); 15) complete college; 16) specialization/medical residency; 17) Master's degree; 18) Doctoral degree (Ph.D.). The answers were categorized into ≤ 4 (categories 1 to 5); 5 to 8 (categories 6 to 9); ≥ 9 years of education (categories 10 to 18).

Brazilian Deprivation Index (IBP)

The IBP was used as a continuous variable to characterize the contextual socioeconomic condition at the census tract level. This measure was calculated using information on income, education, and housing conditions: 1) percentage of households with a per capita income ≤ 1/2 minimum wage; 2) percentage of illiterate individuals over 7 years of age; and 3) average percentage of people with inadequate access to sewage, water, garbage collection, and without a bathroom, bathtub/shower. A score was created by summing the z-scores of the three indicators at the weighted census tract scale according to the population. A higher final score represents an area with higher deprivation, while a lower value reflects an area with lesser deprivation [18].

Other Variables

Other variables included in the present study were age (in years) and gender (female; male).

Statistical analysis

All analyses were stratified by gender. Initially, descriptive statistics were performed using frequency distributions (%), means, and standard deviations (SD) according to the hypertension status. Posteriorly, age-adjusted hypertension prevalence estimates and their respective 95% confidence intervals (95% CI) were calculated according to individual education categories (≤ 4, 5-8, ≥ 9 years of education) and the tertiles of the IBP of the census tract (the 1st tertile corresponds to the stratum with the least deprivation and the 3rd tertile to the stratum with the greatest deprivation). The IBP was categorized into tertiles only for this analysis. Adjusted prevalence estimates were calculated using a binary logistic regression model.

Bivariate and adjusted associations between the outcome and independent variables were analyzed using two-level multilevel logistic regression (individuals and census tracts), including a random effect for the census tract. First, we adjusted a model without independent variables but with a random effect at the census tract level to assess the contribution of variability between census tracts to hypertension (Model 1). Model 2 included individual education and Model 3 included individual education and the IBP. Models 2 and 3 were adjusted for age (in years). Odds ratios (OR) and their respective 95% CI were estimated.

A sensitivity analysis was conducted using measured blood pressure to assess the robustness of the findings. hypertension was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg and/or the use of antihypertensive drugs. Additionally, a sensitivity analysis was performed considering only census tracts with at least three eligible older adults, as some census tracts had a small number of older adults in the sample. All estimates accounted for sampling weights and the complex sample design. The survey command (svy) was used for descriptive analysis. Analyses were performed using the statistical software STATA version 17, with a significance level of 5%.

3. Results

Among the 9,412 participants at the cohort baseline, 7,935 (84.3%) resided in urban areas and were eligible for the present analysis. Of these, 85.3% completed the interview independently, without the assistance of an informant, and provided complete information for all variables of interest, thus being included in the study. Therefore, the final sample comprised 6,767 participants distributed across 605 census tracts nested within 69 Brazilian municipalities. The median number of participants per census tract was 11.2 (minimum = 1; maximum = 24), with 2.9% of census tracts having fewer than five participants (n = 18) (Table 1).

Table 2 displays the descriptive characteristics and bivariate analysis according to the hypertension status for the total sample and stratified by gender. The mean age of participants was 61.6 years (SD = 9.1), with 54.4% being women, and 44.3% having between 0 and 4 years of education. The mean age was 62.0 years (SD = 9.5) for women and 61.1 years (SD = 8.6) for men. Regarding individual education, 45.6% of women and 42.7% of men had up to 4 years of education. The overall prevalence of hypertension was 51.4% (95% CI = 49.3–53.6%) (data not shown in table), with a significantly higher prevalence among women (57.8%; 95% CI = 54.4–61.1%) compared to men (42.2%; 95% CI = 38.9–45.6%).

The bivariate analysis indicated that women are 28% more likely to report hypertension compared to men. For both genders, age showed a positive association with hypertension. Among women, higher education levels were associated with lower odds of hypertension, while residing in census tracts with higher deprivation was associated with higher odds of this disease. Among men, those with 9 years or more of education exhibited lower odds of hypertension (Table 2).

Figure 1 depicts the age-adjusted prevalence of hypertension for the total sample and stratified by gender, according to individual education categories and tertiles of the IBP of the census tract. The prevalence of hypertension showed a statistically significant dose-response gradient concerning individual education only among women, with a higher prevalence observed among those with lower education levels (≤ 4 years) (Figure 1A). Similarly, a significant dose-response gradient in the prevalence of hypertension was observed across the tertiles of the IBP, also only among women, with a higher prevalence among those residing in census tracts with higher deprivation (3rd IBP tertile) (Figure 1B).

Table 3 presents the adjusted associations between individual education, IBP of the census tract, and hypertension, stratified by gender. Model 3 results show that the odds of hypertension were 38% lower among women with 9 years or more of education compared to those with 4 years or fewer of education. Additionally, IBP was positively associated with hypertension among women, indicating that higher deprivation of the census tract was associated with higher odds of women reporting hypertension. For men, neither individual education nor IBP was significantly associated with hypertension.

The sensitivity analyses using measured blood pressure yielded similar results to those reported in the main analysis, in terms of the direction and pattern of the association between the two independent variables analyzed and the outcome (Supplementary Table 1). Similarly, multilevel models that included only census tracts with at least three eligible older adults also showed results comparable to those observed in the main analysis (data not shown).

4. Discussion

The present study examined the association between socioeconomic conditions at different levels (individual and contextual) and hypertension in a nationally representative sample of older Brazilian adults residing in urban areas. Our findings showed an inverse association between individual education and hypertension among women. Additionally,

residing in census tracts with higher deprivation increased the odds of hypertension among women. In contrast, no significant association was observed among men.

Research conducted in high-income countries shows a higher prevalence of hypertension among individuals with lower levels of education compared to those with higher education, with this association being more consistent and stronger among women [8,19]. Data from low- and middle-income countries, including those from Latin America, show variability in educational gradients [6,7,20]. For instance, a recent study analyzing data from eight Latin American countries (Argentina, Brazil, Chile, Colombia, El Salvador, Guatemala, Mexico, and Peru) found that higher education was associated with lower odds of hypertension in women and higher odds in men [6]. Studies examining the association between education and hypertension among urban residents in Argentina [7] and Brazil [20] also observed an inverse association in women but no association in men. Thus, our findings regarding the association between education and hypertension align with those reported among women in high-income countries and Latin America, and they support previous Latin American studies that reported no association among men. Previous research has also documented stronger inverse educational gradients in obesity and diabetes mellitus among women, whereas these gradients have been weaker or opposite among men in Latin America [21,22].

While the reasons for observed gender differences remain unclear, several explanations linking higher education to a decreased risk of hypertension in women warrant consideration. Education may provide greater benefits for women and compensate for potential disparities in access to other resources such as income, power, and authority [23]. Furthermore, the distribution of risk factors and access to healthcare based on socioeconomic position may differ between men and women [24,25]. The chronic stress stemming from work and home environments, such as informal employment, single motherhood, role overload, and experiences of violence, may also affect men and women differently [26,27].

In the present study, we also found that census tract deprivation, as measured by the IBP, is associated with hypertension, but the patterns vary by gender. Among women, residing in deprived census tracts increases the odds of hypertension. However, this association was not significant among men. Similar results were observed in a recent study conducted in Argentina among participants aged 18 years and over [7]. There are several plausible pathways through which census tract and/or neighborhood socioeconomic deprivation may contribute to hypertension. These include aspects of the neighborhood's built environment such as availability of processed food outlets, physical activity facilities, healthcare access, transportation options, and exposure to environmental pollutants [13,14].

Differential psychosocial stress may also explain the gender disparities found in our study regarding the relationship between census tract deprivation and hypertension. Individuals living in areas of higher socioeconomic deprivation report greater daily difficulties and higher exposure to chronic social stressors in terms of both frequency and severity [28-29]. These experiences can lead to biological wear and tear, resulting in early health deterioration [30], and chronic hyperactivity or hypoactivity of allostatic systems [31], contributing to the development of hypertension [32]. Therefore, being a woman and residing in census tracts with higher socioeconomic deprivation may indicate greater distress and stress, given that women are more likely than men to experience chronic stress situations [26,27]. Additionally, sex hormones that regulate the hypothalamic-pituitary-adrenal axis response to psychological stress act differently between men and women [33].

Among the limitations of this study, we acknowledge the use of the IBP, which was constructed using data from the 2010 Demographic Census and may not reflect changes in deprivation distribution over the past decade. To address this, we utilized data from the baseline of the ELSI-Brazil collected in 2015-2016, shortly after the census. Furthermore, we are aware that other risk factors for hypertension, such as physical inactivity, unhealthy dietary habits, and obesity, were not included in our analyses. However, most of these factors are likely mediators of the associations investigated [14,34] and our interest was to investigate the overall effect and not the direct association between exposure and outcome. Therefore, residual confounding due to unmeasured or unknown factors cannot be entirely ruled out.

The main strength of the present study lies in the fact that the analyzed sample is representative of the Brazilian population aged 50 years and over, which enhances the generalizability of our findings. Additionally, no previous study conducted in Brazil has investigated the relationship of hypertension with census tract socioeconomic deprivation on an urban scale and from a gender perspective. It is important to note that we chose to present the results based on the self-reported measure of hypertension due to the advantages of this assessment method, including simplicity of measurement, ease of application, and low cost (35). This approach has been widely used in population surveys [35] and in other epidemiological studies [6,7,20], especially in low- and middle-income countries. Our sensitivity analyses, using blood pressure objective measures to classify hypertension, yielded similar results (Supplementary Table 1), and are additional strengths.

In conclusion, our study reinforces evidence that individual and contextual socioeconomic conditions are associated with hypertension and highlights variations by gender. Lower individual education and higher IBP of the census tract (indicative of higher deprivation)

were linked to increased odds of hypertension among women, whereas such associations were not observed among men. These findings underscore the importance of addressing social and gender disparities in health planning for controlling hypertension among older Brazilian adults. Therefore, implementing and intensifying public policies aimed at addressing social determinants – such as poverty alleviation and improving access to quality education among socioeconomically disadvantaged groups – is crucial. Furthermore, considering intra-urban disparities, there is a need for more targeted actions to support vulnerable groups, including enhancing access to essential services, promoting conditional cash transfers, and implementing urban interventions that foster healthy environments in both living and working contexts, particularly for women.

Ethics approval

The ELSI-Brazil was approved by the Ethics Committee of the Oswaldo Cruz Foundation – Minas Gerais (CAAE: 34649814.3.0000.5091). All participants or legal guardians have signed an informed consent.

Availability of data and material

The data that support the findings of this study are available on the ELSI-Brazil homepage after registration (https://elsi.cpqrr.fiocruz.br/en/home-english/en-data-access/).

Competing interests

We declare no competing interests.

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Author Contributions

DMC, ACSA, and WTC conceived the study. DMC and ACSA performed the statistical analyses. DMC drafted the first version of the manuscript. BSM, LSB and MFLC participated in or supported data collection. All authors participated in the interpretation of results and approved the final version of the manuscript.

References

1. GBD - Global Burden of Disease Risk Factor Collaborators. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet; v. 396, n. 10258, p.1223-1249, 2020.
2. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. The Lancet. 2021;398(10304):957-980.
3. Schutte AE, Srinivasapura Venkateshmurthy N, Mohan S, Prabhakaran D. Hypertension in low-and middle-income countries. Circulation research. 2021;128(7):808-826, 2021.
4. Stringhini S, Bovet P. Socioeconomic status and risk factors for non-communicable diseases in low-income and lower-middle-income countries. Lancet Global Health. 2017;5(3):e230-e231.
5. Kirschbaum TK, Sudharsanan N, Manne-Goehler J, De Neve JW, Lemp JM, Theilmann M, et al. The association of socioeconomic status with hypertension in 76 Low- and Middle-Income Countries. J Am Coll Cardiol. 2022;80(8):804-817.
6. Coelho DM, de Souza Andrade AC, Silva UM, Lazo M, Slesinski SC, Quistberg A, et al. Gender differences in the association of individual and contextual socioeconomic status with hypertension in 230 Latin American cities from the SALURBAL study: a multilevel analysis. BMC Public Health. 2023;23:1532.
7. Tumas N, López SR, Bilal U, Ortigoza F, Roux AVD. Urban social determinants of non-communicable diseases risk factors in Argentina. Health & Place. 2021;77:102611.
8. Leng B, Jin Y, Li G, Chen L, Jin N. Socioeconomic status and hypertension: a meta-analysis. Journal of hypertension. 2015;33(2):221-229.
9. Nakagomi A, Yasufuku Y, Ueno T, Kondo K. Social determinants of hypertension in high-income countries: A narrative literature review and future directions. Hypertension Research. 2022;45(10):1575-1581.
10. Buys DR, Howard VJ, McClure LA, Buys KC, Sawyer P, Allman RM, et al. Association between neighborhood disadvantage and hypertension prevalence, awareness, treatment, and control in older adults: results from the University of Alabama at Birmingham Study of Aging. Am J Public Health 2015; 105(6): 1181-8.
11. Claudel SE, Adu-Brimpong J, Banks A, Ayers C, Albert MA, Das SR, et al. Association between neighborhood-level socioeconomic deprivation and incident hypertension: a

longitudinal analysis of data from the Dallas heart study. American heart journal. 2018; 204:109-118.

12. Gustafsson PE, Hammarström A, San Sebastian M. Cumulative contextual and individual disadvantages over the life course and adult functional somatic symptoms in Sweden. The European Journal of Public Health. 2015;25(4):592-597.
13. Lê-Scherban F, Ballester L, Castro JC, Cohen S, Melly S, Moore K, et al. Identifying neighborhood characteristics associated with diabetes and hypertension control in an urban African American population using geo-linked electronic health records. Preventive Medicine Reports. 2019;15:100953.
14. Chaix B, Bean K, Leal C, Thomas F, Havard S, Evans D, Jégo B, Pannier B. Individual/neighborhood social factors and blood pressure in the RECORD Cohort Study: which risk factors explain the associations? Hypertension 2010; 55(3):769-775.
15. IBGE- Instituto Brasileiro de Geografia e Estatística. Ministério do Planejamento e Orçamento. Censo Demográfico 2022. População por idade e sexo: pessoas de 60 anos ou mais de idade. Resultados do universo. Brasil, Grandes Regiões e Unidades da Federação - Rio de Janeiro: IBGE, 2023. Available in https://biblioteca.ibge.gov.br/visualizacao/livros/liv102038.pdf.
16. Caiaffa WT, Andrade ACS, Sales, ADF, Coelho, DM. Saúde Urbana, cidades e a interseção de sistemas: panorama, agendas, gaps e oportunidades rumo à equidade, sustentabilidade, resiliência e promoção em saúde. Rio de Janeiro: Fiocruz, 2021.
17. Lima-Costa MF, Andrade FB, Souza Jr PRB, Neri AL, Oliveira Duarte YA, Castro-Costa E, et al. The Brazilian Longitudinal Study of Aging (ELSI-BRAZIL): objectives and design. Am J Epidemiol. 2018;187(7):1345-53.
18. Allik, M. Ramos D, Agranonik M, Pinto Júnior EP, Ichihara MY, Barreto ML, et al. Developing a small-area deprivation measure for Brazil: Technical report. National Institute for Health Research; 2020.
19. Neufcourt L, Deguen S, Bayat S, Zins M, Grimaud O. Gender differences in the association between socioeconomic status and hypertension in France: A cross-sectional analysis of the CONSTANCES cohort. PLoS One. 2020 Apr 20;15(4):e0231878.
20. Alves RFS, Faerstein E. Educational inequalities in hypertension: complex patterns in intersections with gender and race in Brazil. International journal for equity in health. 2016; 15(1):1-9.
21. Braverman-Bronstein A, Hessel P, González-Uribe C, Kroker MF, Diez-Canseco F, Langellier B, et al. Association of education level with diabetes prevalence in Latin

American cities and its modification by city social environment. J Epidemiol Community Health. 2021;75(9):874-880.

22. Mazariegos M, Auchincloss AH, Braverman-Bronstein A, Kroker-Lobos MF, Ramírez-Zea M, Hessel P, et al. (2022). Educational inequalities in obesity: a multilevel analysis of survey data from cities in Latin America. Public health nutrition. 2022;25(7):1790-1798.
23. Ross CE, Mirowsky J. Gender and the health benefits of education. Sociol Q. 2010;51:1-19.
24. Levorato CD, de Mello LM, da Silva AS, Nunes AA. Factors associated with the demand for health services from a gender-relational perspective. Ciência & Saúde Coletiva. 2014;19(4):1263.
25. World Health Statistics 2019: monitoring health for the SDGs, sustainable development goals. Geneva: World Health Organization; 2019. Licence: CC BY-NC-SA 3.0 IGO.
26. Kandasamy S, Anand SS. Cardiovascular disease among women from vulnerable populations: a review. Canadian Journal of Cardiology. 2018;34(4):450-7.
27. Vega AP. Pobreza feminina desvendando suas raízes. TEL Tempo, Espaço e Linguagem. 2019;10(2):177-200.
28. Bak CK, Tanggaard Andersen P, Bacher I, Draghiciu Bancila D. The association between socio-demographic characteristics and perceived stress among residents in a deprived neighbourhood in Denmark. Eur J Pub Health. 2012;22(6):787-792.
29. Muennig P, Sohler N, Mahato B. Socioeconomic status as an independent predictor of physiological biomarkers of cardiovascular disease: evidence from NHANES. Prev Med. 2007;45(1):35-40.
30. Geronimus AT. The weathering hypothesis and the health of African-American women and infants: evidence and speculations. Ethn Dis. 1992;2(3):207-221.
31. McEwen BS. Protective and damaging effects of stress mediators. N Engl J Med. 1998;338(3):171-179.
32. Keita AD, Judd SE, Howard VJ, *et al.* Associations of neighborhood area level deprivation with the metabolic syndrome and inflammation among middle- and older- age adults. BMC Public Health. 2014;14:1319.
33. Pasquali R. The hypothalamic-pituitary-adrenal axis and sex hormones in chronic stress and obesity: pathophysiological and clinical aspects. Ann N Y Acad Sci. 2012;1264:20-35.
34. Nejatinamini S, Campbell DJ, Godley J, Minaker LM, Sajobi TT, McCormack GR. The contribution of modifiable risk factors to socioeconomic inequities in cardiovascular

disease morbidity and mortality: a nationally representative population-based cohort study. Prev Med. 2023;171:107497.

35. Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. Departamento de Vigilância de Doenças e Agravos não Transmissíveis e Promoção da Saúde. Vigitel Brasil 2016: vigilância de fatores de risco e proteção para doenças crônicas por inquérito telefônico. Brasília: Ministério da Saúde; 2017.

Figures and Tables

Table 1: Distribution of participants by census tract. ELSI-Brazil, 2015-2016.

	Total [1]	**Women [1]**	**Men [1]**
Number of participants	6,767	3,876	2,891
Number of census tracts	605	553	590
Participants per census tract			
Median (Minimum – Maximum)	11.2 (1 - 24)	7.0 (1 - 16)	4.9 (1 - 14)
< 3 participants per census tract, n (%)	18 (2.9)	60 (10.8)	104 (17.6)

[1] Unweighted.

Table 2: Characteristics of study participants and bivariate analysis1 stratified by gender. ELSI-Brazil, 2015-2016.

	Total Sample	Hypertension		
		Yes	No	OR (95% CI)
TOTAL SAMPLE				
Individual Characteristics				
Age, mean (SD)	61.6 (9.1)	63.3 (9.4)	59.7 (8.4)	**1.04 (1.03-1.05)*** **
Gender, %				
Men	45.6	42.2	49.0	1.00
Women	54.4	57.8	51.0	**1.28 (1.15-1.43)*** **
Individual Education, %				
≤ 4 years	44.3	49.7	38.5	1.00
5 to 8 years	23.3	22.6	24.0	**0.74 (0.65-0.85)*** **
≥ 9 years	32.4	27.7	37.5	**0.58 (0.51-0.66)*** **
Contextual Characteristic				
Brazilian Deprivation Index, mean (SD)	- 1.21 (1.65)	- 1.16 (1.68)	- 1.25 (1.62)	1.01 (0.98-1.04)
n (unweighted)	6,767	3,581	3,186	
WOMEN				
Individual Characteristics				
Age, mean (SD)	62.0 (9.5)	63.9 (9.9)	59.8 (8.5)	**1.05 (1.04-1.06)*** **
Individual Education, %				
≤ 4 years	45.6	52.4	37.4	1.00
5 to 8 years	22.5	22.1	23.1	**0.71 (0.59-0.85)*** **
≥ 9 years	31.9	25.5	39.5	**0.48 (0.41-0.56)*** **
Contextual Characteristic				
Brazilian Deprivation Index, mean (SD)	- 1.20 (1.67)	- 1.10 (1.73)	- 1.31 (1.58)	**1.06 (1.02-1.10)** **
n (unweighted)	3,876	2,190	1,686	
MEN				
Individual Characteristics				
Age, mean (SD)	61.1 (8.6)	62.6 (8.5)	59.7 (8.4)	**1.03 (1.02-1.04)*** **
Individual Education, %				
≤ 4 years	42.7	46.1	39.6	1.00
5 to 8 years	24.2	23.4	25.0	0.82 (0.67-1.01)
≥ 9 years	33.1	30.5	35.4	**0.76 (0.62-0.92)** **
Contextual Characteristic				
Brazilian Deprivation Index, mean (SD)	- 1.21 (1.62)	- 1.23 (1.59)	- 1.19 (1.64)	0.96 (0.92-1.01)
n (unweighted)	2,891	1,391	1,500	

SD: standard deviation. OR: odds ratio. CI: confidence interval. Significance level: **<0.01, ***<0.001.
[1]The bivariate model between individual and contextual characteristics and arterial hypertension was carried out using multilevel analysis with a random effect at two levels: individual nested in the census tract.
All estimates considered the sampling weights and the complex sample design.

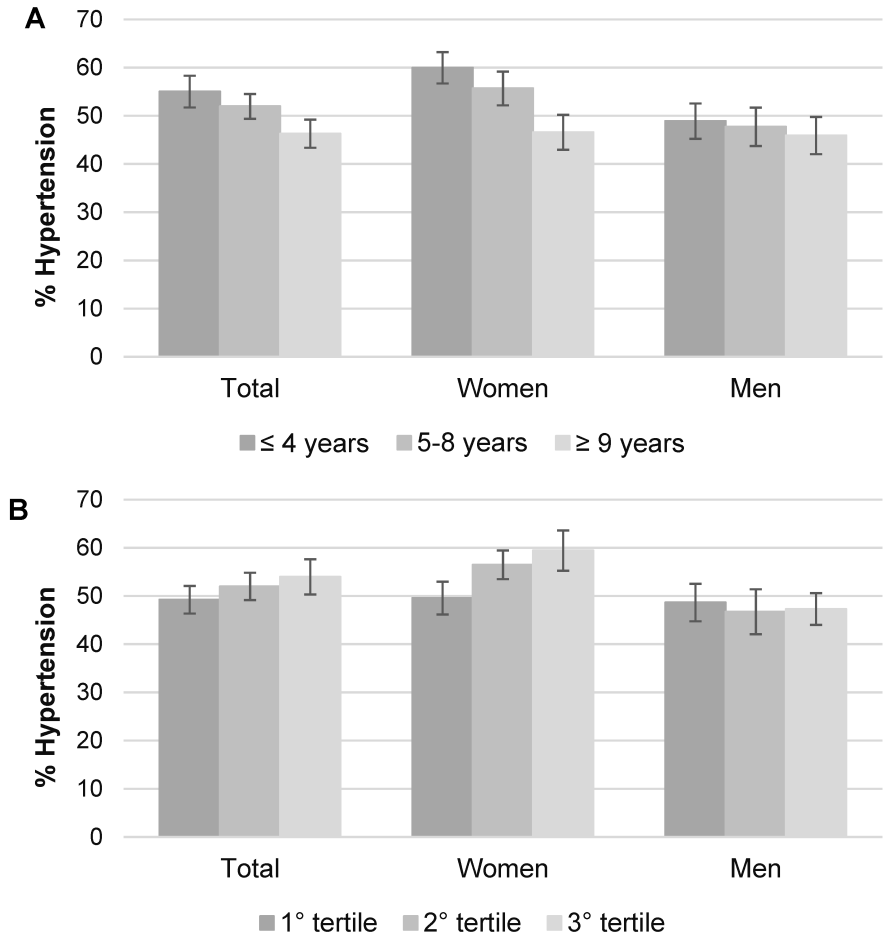

Figure 1: Prevalence of arterial hypertension adjusted[1] by age according to: a) individual education and b) Brazilian Deprivation Index (IBP) of the census tract (in tertiles). ELSI-Brazil, 2015-2016.

[1] Age adjustment was conducted using the age distribution of the sample.

Table 3: Adjusted associations between individual education, Brazilian Deprivation Index (IBP) of the census tract, and arterial hypertension, stratified by gender, for older Brazilian adults residing in urban areas. ELSI-Brazil, 2015-2016.

	Model 1	**Model 2**	**Model 3**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**
WOMEN			
Individual Education			
≤ 4 years		1.00	1.00
5 to 8 years		0.85 (0.71-1.02)	0.88 (0.73-1.06)
≥ 9 years		**0.59 (0.50-0.70)****	**0.62 (0.52-0.74)****
Brazilian Deprivation Index		--	**1.04 (1.01-1.09)***
Random parameters			
Variance (standard error)	0.02 (0.04)	0.025 (0.04)	0.019 (0.042)
MEN			
Individual Education			
≤ 4 years		1.00	1.00
5 to 8 years		0.95 (0.77-1.18)	0.92 (0.75-1.14)
≥ 9 years		0.89 (0.73-1.09)	0.84 (0.68-1.04)
Brazilian Deprivation Index		--	0.95 (0.90-1.00)
Random parameters			
Variance (standard error)	0.21 (0.07)	0.15 (0.07)	0.14 (0.07)

OR: odds ratio. CI: confidence interval. Significance level: *<0.05, **<0.01.
The Brazilian Deprivation Index of the census tract was standardized to mean 0 and standard deviation (SD) 1.
Model 1: Null model (random effect at the census tract level).
Model 2: Model 1 + Education and age.
Model 3: Model 2 + Brazilian Deprivation Index.
All estimates considered the sampling weights and the complex sample design.

Supplemental material

Supplementary Table 1: Adjusted associations between individual education, Brazilian Deprivation Index (IBP) of the census tract, and measured arterial hypertension[1], stratified by gender, for older Brazilian adults residing in urban areas. ELSI-Brazil, 2015-2016.

	Model 1	**Model 2**	**Model 3**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**
WOMEN			
Individual Education			
≤ 4 years		1.00	1.00
5 to 8 years		1.01 (0.83-1.23)	1.07 (0.87-1.30)
≥ 9 years		**0.63 (0.52-0.75)****	**0.68 (0.56-0.82)****
Brazilian Deprivation Index		--	**1.07 (1.02-1.12)***
Random parameters			
Variance (standard error)	0.05 (0.04)	0.05 (0.05)	0.041 (0.05)
MEN			
Individual Education			
≤ 4 years		1.00	1.00
5 to 8 years		1.03 (0.83-1.26)	1.01 (0.81-1.24)
≥ 9 years		0.91 (0.75-1.10)	0.87 (0.71-1.06)
Brazilian Deprivation Index		--	0.96 (0.91-1.01)
Random parameters			
Variance (standard error)	0.14 (0.07)	0.09 (0.0677)	0.082 (0.07)

The sample used in the sensitivity analysis was the same as the main analysis (n = 6,767).
[1]Arterial hypertension was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg and/or use of antihypertensive drugs.
OR: odds ratio. CI: confidence interval. Significance level: *<0.05, **<0.01.
The Brazilian Deprivation Index of the census tract was standardized to mean 0 and standard deviation (SD) 1.
Model 1: Null model (random effect at the census tract level)
Model 2: Model 2 + Education and age.
Model 3: Model 2 + Brazilian Deprivation Index.
All estimates considered the sampling weights and the complex sample design.

8 CONSIDERAÇÕES FINAIS

A associação entre as condições socioeconômicas individuais e contextuais e os eventos relacionados à saúde, como a HA, é um tema cada vez mais investigado no mundo e vem ganhando atenção especial nos países da América Latina, região onde 80% das pessoas vivem em cidades.

Em relação às condições socioeconômicas em nível individual, os achados desta tese mostram, de forma consistente, que a maior escolaridade está associada a menor chance de HA (medida objetiva e autorreferida) em mulheres adultas latino-americanas e brasileiras com 50 anos ou mais. Em homens, a associação foi inconsistente. Homens latino-americanos de maior escolaridade tiveram menor chance de HA obtida a partir da medida objetiva e maior chance de HA autorreferida. Nenhuma associação significativa foi observada em homens brasileiros mais velhos.

Quanto às condições socioeconômicas em nível de contexto ou área, no Brasil, a maior privação no setor censitário foi associada a maior chance de HA em mulheres e, nenhuma associação significativa foi observada em homens. Na América Latina, a maior escolaridade em nível de subcidade foi associada a maiores chances de HA em ambos os sexos. Ainda, a associação da escolaridade em nível de cidades com a HA variou entre os países. No Peru, a maior escolaridade em nível de cidade foi associada a menor chance de HA, enquanto em outros países (Argentina, Brasil, Chile, Colômbia, El Salvador, Guatemala, México, analisando conjuntamente) não houve associação em mulheres ou homens.

Desta forma, os resultados encontrados nesta tese fornecem informações importantes ao evidenciar disparidades de gênero na associação entre condição socioeconômica individual e contextual, avaliada em diferentes escalas geográficas, com a HA entre adultos latino-americanos e brasileiros mais velhos. Assim, as intervenções poderiam ser direcionadas para: (a) aumentar a escolaridade e reduzir as desigualdades no acesso à educação, na qualidade da educação e/ou nos resultados educacionais nas cidades e nos países, (b) implementar e/ou intensificar políticas públicas que contemplem a redução da pobreza, como a transferência condicionada de renda, (c) intervenções em nível populacional (estratégias e políticas comunitárias que mudam o ambiente: regulamentação do marketing de alimentos e bebidas; reformulação de alimentos, ambientes promotores de saúde, redução da poluição) e (d) intervenções direcionadas aos mais vulneráveis para reduzir as desigualdades (serviços de saúde acessíveis e de qualidade, bem como intervenções multicomponentes no local de trabalho e na escola).

Em resumo, considerando os impactos da HA na saúde a curto e longo prazo e a alta urbanização na América Latina, é imperativo mitigar o ônus enfrentado pelos grupos mais desfavorecidos. As políticas precisam de ser sensíveis às formas como as desigualdades na HA se manifestam em diferentes contextos sociais e econômicos e como podem variar entre países e cidades. Reduzir as desigualdades socioeconômicas e de gênero nas cidades torna-se crucial para alcançar os objetivos do desenvolvimento sustentável relacionados à diminuição das doenças crônicas não transmissíveis na América Latina.

REFERÊNCIAS

1. ABBA, M. S. et al. Influence of contextual socioeconomic position on hypertension risk in low-and middle-income countries: disentangling context from composition. **BMC Public Health**, v. 21, p. 1-13, 2021.
2. ABBA, M. S. et al. Socioeconomic Macro-Level Determinants of Hypertension: Ecological Analysis of 138 Low-and Middle-Income **Countries. Journal of Cardiovascular Development and Disease**, v. 10, n. 2, p. 57, 2023.
3. ALLEN, L. et al. Socioeconomic status and non-communicable disease behavioural risk factors in low-income and lower-middle-income countries: a systematic review. **Lancet Global Health**, v. 5, n. 3, p. e277-e289, 2017.
4. ALLIK, M. et al. Developing a small-area deprivation measure for Brazil: Technical report. **National Institute for Health Research**; 2020.
5. ALMEIDA, G. et al. Analysis of the evolution and determinants of income-related inequalities in the Brazilian health system, 1998-2008. **Revista Panamericana de Salud Pública**, v. 33, n. 2, p. 90-97, 2013.
6. ALVES, L. et al. Socioeconomic inequalities in the prevalence of nine established cardiovascular risk factors in a Southern European population. **Plos One**, v. 7, n. 5, e7158, 2012.
7. ALVES, R. F. S.; FAERSTEIN, E. Educational inequalities in hypertension: complex patterns in intersections with gender and race in Brazil. **International journal for equity in health**, v. 15, n. 1, p. 1-9, 2016.
8. ANENBERG, S. C. et al. Particulate matter-attributable mortality and relationships with carbon dioxide in 250 urban areas worldwide. **Scientific reports**, v. 9, n. 1, p. 11552, 2019.
9. ASTELL-BURT, T.; FENG, X. Urban green space, tree canopy and prevention of cardiometabolic diseases: a multilevel longitudinal study of 46 786 Australians. **International journal of epidemiology**, v. 49, n. 3, p. 926-933, 2020.
10. BACKHOLE, K. et al. Sex differences in the relationship between socioeconomic status and cardiovascular disease: a systematic review and meta-analysis. **J Epidemiol Community Health**, v. 71, p. 550–7, 2017.
11. BARRAZA-LLORÉNS, M.; PANOPOULOU, G.; DÍAZ, B. Y. Income-related inequalities and inequities in health and health care utilization in Mexico, 2000-2006. **Revista panamericana de salud publica**, v. 33, n. 2, p. 122-130, 2013.

12. BARROSO, W. K. S. et al. Brazilian guidelines of hypertension–2020. **Arquivos brasileiros de cardiologia**, v. 116, p. 516-658, 2021.
13. BAUMGARTNER, J.; BRAUER, M.; EZZATI, M. The role of cities in reducing the cardiovascular impacts of environmental pollution in low-and middle-income countries. BMC medicine, v. 18, n. 1, p. 1-11, 2020.
14. BENTO, I. C.; MAMBRINI, J. V. M.; PEIXOTO, S. V. Contextual and individual factors associated with arterial hypertension among Brazilian older adults (National Health Survey-2013). **Revista Brasileira de Epidemiologia**, v. 23, 2020.
15. BRASIL. Ministério da Saúde. Instituto Brasileiro de Geografia e Estatística. Ministério do Planejamento, Orçamento e Gestão. Pesquisa Nacional de Saúde: 2013. **Percepção do estado de saúde, estilos de vida e doenças crônicas. Brasil, grandes regiões e unidades da federação** [Internet]. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística; 2014.
16. BRASIL. Ministério da Saúde. Secretaria de Vigilância em Saúde. Departamento de Análise em Saúde e Vigilância de Doenças Não Transmissíveis. **Plano de ações estratégicas para o enfrentamento das doenças crônicas e agravos não transmissíveis no Brasil, 2021 – 2030.** Brasília: Ministério da Saúde, 2022.
17. BRASIL. Ministério da Saúde. Secretaria de Vigilância em Saúde. **VIGITEL 2016:** vigilância de fatores de risco e proteção para doenças crônicas por inquérito telefônico. Brasília: Ministério da Saúde, 2017.
18. BROOK, R. D. et al. Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association. **Circulation**, v. 121, n. 21, p. 2331-2378, 2010.
19. CAIAFFA, W. T. Saúde Urbana, cidades e a interseção de sistemas: panorama, agendas, gaps e oportunidades rumo à equidade, sustentabilidade, resiliência e promoção em saúde. **Rio de Janeiro: Fiocruz**, 2021.
20. CAIAFFA, W. T. et al. Saúde urbana:" a cidade é uma estranha senhora, que hoje sorri e amanhã te devora". **Ciência & Saúde Coletiva**, v. 13, p. 1785-1796, 2008.
21. CAMPOS-NONATO, I. et al. Hipertensión arterial en adultos mexicanos: prevalencia, diagnóstico y tipo de tratamiento. Ensanut MC 2016. **Salud pública de México**, v. 60, n. 3, p. 233-243, 2018.
22. CAREY, R. M. et al. Prevention, detection, evaluation, and management of high blood pressure in adults: synopsis of the 2017 American College of Cardiology/American Heart

Association Hypertension Guideline. **Annals of internal medicine**, v. 168, n. 5, p. 351-358, 2018.

23. CASWELL, J. M. Prevalence of reported high blood pressure in Canada: investigation of demographic and spatial trends. **Journal of Public Health**, v. 25, p. 49-59, 2017.
24. CHAIX, B. et al. Individual/neighborhood social factors and blood pressure in the RECORD Cohort Study: which risk factors explain the associations?. **Hypertension**, v. 55, n. 3, p. 769-775, 2010.
25. CHOR, D. et al. Prevalence, awareness, treatment and influence of socioeconomic variables on control of high blood pressure: results of the ELSA-Brasil Study. **PLOS one**, v. 10, n. 6, p. e0127382, 2015.
26. CHRISTINE, P. J. et al. Individual-and area-level SES in diabetes risk prediction: the multi-ethnic study of atherosclerosis. **American journal of preventive medicine**, v. 53, n. 2, p. 201-209, 2017.
27. CLAUDEL, S. E. et al. Association between neighborhood-level socioeconomic deprivation and incident hypertension: a longitudinal analysis of data from the Dallas heart study. **American heart journal**, v. 204, p. 109-118, 2018.
28. DALY, M. C. et al. Optimal indicators of socioeconomic status for health research. **Am J Public Health**, v. 92, n. 7, p. 1151-7, 2002.
29. DAVEY, S. G. et al. Education and occupational social class: which is the more important indicator of mortality risk? **Journal of Epidemiology and Community Health**, v. 52, p. 153-60, 1998.
30. DE MESTRAL, C.; STRINGHINI, S. Socioeconomic status and cardiovascular disease: an update. **Curr Cardiol Rep**, v. 19, n. 11, p. 115, 2017.
31. DELUCCHI, A. M. et al. National registry of hypertension. epidemiological characteristics of hypertension in argentina. The RENATA-2 study. **Revista Argentina de Cardiología**, v. 85, n. 4, p. 340-346, 2017.
32. DIEZ-ROUX, A. V. et al. A novel international partnership for actionable evidence on urban health in Latin America: LAC-urban health and SALURBAL. **Global challenges**, v. 3, n. 4, p. 1800013, 2018.
33. DIEZ-ROUX, A. V. Health in cities: is a systems approach needed?. Cadernos de saude publica, v. 31, p. 9-13, 2015.
34. DIEZ-ROUX, A. V.; MAIR, C. Neighborhoods and health. **Annals of the New York academy of sciences**, v. 1186, n. 1, p. 125-145, 2010.

35. DULGHEROFF, P. T. et al. Educational disparities in hypertension, diabetes, obesity and smoking in Brazil: a trend analysis of 578 977 adults from a national survey, 2007–2018. **BMJ open**, v. 11, n. 7, 2021.
36. ENES, C. C.; NUCCI, L. B. Gender and schooling inequalities in risk and protective factors for chronic diseases among Brazilian adults. Journal of Public Health, v. 40, n. 3, p. e211-e218, 2018.
37. FERNÁNDEZ-ÁLVAREZ, R. Inequitable distribution of green public space in Mexico City: an environmental injustice case. **Economía, sociedad y territorio**, v. 17, n. 54, p. 399-428, 2017.
38. FURUYAMA, A. et al. Extrapulmonary translocation of intratracheally instilled fine and ultrafine particles via direct and alveolar macrophage-associated routes. **Archives of toxicology**, v. 83, p. 429-437, 2009.
39. GALOBARDES, B. et al. Indicators of socioeconomic position (part 2). **Journal of epidemiology and community health**, v. 60, n. 2, p. 95, 2006.
40. GBD - Global Burden of Disease Risk Factor Collaborators. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. **Lancet**; v. 396, n. 10258, p.1223-1249, 2020.
41. GORYAKIN, Y.; ROCCO, L.; SUHRCKE, M. The contribution of urbanization to non-communicable diseases: Evidence from 173 countries from 1980 to 2008. **Economics & Human Biology**, v. 26, p. 151-163, 2017.
42. GUERRERO AHUMADA, A. O. **Socioeconomic inequalities in blood pressure in Chilean adults**. 2017. Tese de Doutorado. University College London, London, 2017.
43. HANNA, D. R. et al. Prevalence and correlates of diagnosed and undiagnosed hypertension in the indigenous Kuna population of Panamá. **BMC Public Health**, v. 19, p. 1-9, 2019.
44. HAVRANEK, E. P. et al. Social determinants of risk and outcomes for cardiovascular disease: a scientific statement from the American Heart Association. **Circulation**, v. 132, n. 9, p. 873-898, 2015.
45. HEALTH–AMERICAS, The Lancet Regional. Latin America and Caribbean's path to improve hypertension control: time for bolder, tougher actions. **Lancet Regional Health-Americas**, v. 9, 2022.
46. HESSEL, P.; RODRÍGUEZ-LESMES, P.; TORRES, D. Socio-economic inequalities in high blood pressure and additional risk factors for cardiovascular disease among older individuals in Colombia: Results from a nationally representative study. **Plos one**, v. 15, n. 6, p. e0234326, 2020.

47. INSTITUTE FOR HEALTH METRICS AND EVALUATION (IHME). GBD Compare Data Visualization. Seattle: IHME; 2021.
48. INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). **Pesquisa nacional de saúde, 2019: percepção do estado de saúde, estilos de vida, doenças crônicas e saúde bucal: Brasil e grandes regiões**. Rio de Janeiro: IBGE, 2020.
49. INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). **Síntese de indicadores sociais: uma análise das condições de vida da população brasileira: 2016** / IBGE, Coordenação de População e Indicadores Sociais. - Rio de Janeiro: IBGE, 2016.
50. JIWANI, S. S. et al. The shift of obesity burden by socioeconomic status between 1998 and 2017 in Latin America and the Caribbean: a cross-sectional series study. **Lancet Global Health**, v. 7, n. 12, p. e1644-e1654, 2019.
51. JONES, A.; MITCHEL, D.; GOZA, F. Lifecourse socioeconomic status and cardiovascular illness in Latin America. Current Sociology, v. 62, n. 7, p. 1055-1078, 2014.
52. JULIÃO, N. A.; SOUZA, A.; GUIMARÃES, R. R. M. Trends in the prevalence of systemic arterial hypertension and health care service use in Brazil over a decade (2008-2019). **Ciência & Saúde Coletiva**, v. 26, p. 4007-4019, 2021.
53. KANDASAMY, S.; ANAND, S. S. Cardiovascular disease among women from vulnerable populations: a review. **Canadian Journal of Cardiology**, v. 34, n. 4, p. 450-457, 2018.
54. KEITA, A. D. et al. Associations of neighborhood area level deprivation with the metabolic syndrome and inflammation among middle-and older-age adults. **BMC public health**, v. 14, p. 1-9, 2014.
55. KIRSCHBAUM, T. K. et al. The association of socioeconomic status with hypertension in 76 low-and middle-income countries. **Journal of the American College of Cardiology**, v. 80, n. 8, p. 804-817, 2022.
56. LAMELAS, P. et al. Prevalence, awareness, treatment and control of hypertension in rural and urban communities in Latin American countries. **Journal of hypertension**, v. 37, n. 9, p. 1813-1821, 2019.
57. LAUX, T. S. et al. Prevalence of hypertension and associated risk factors in six Nicaraguan communities. Ethnicity & disease, v. 22, n. 2, p. 129, 2012.
58. LE BRON, A. M. W. et al. John Henryism, socioeconomic position, and blood pressure in a multi-ethnic urban community. **Ethn Dis**, v. 25, n. 1, p. 24-30, 2015. pmid: 25812248.
59. LENG, B. et al. Socioeconomic status and hypertension: a meta-analysis. **Journal of hypertension**, v. 33, n. 2, p. 221-229, 2015.

60. LÊ-SCHERBAN, F. et al. Identifying neighborhood characteristics associated with diabetes and hypertension control in an urban African-American population using geo-linked electronic health records. **Preventive Medicine Reports**, v. 15, p. 100953, 2019.
61. LEVORATO, C. D. et al. Factors associated with the demand for health services from a gender-relational perspective. **Ciencia & saude coletiva**, v. 19, n. 4, p. 1263, 2014.;19(4):1263.
62. LIMA-COSTA, M. F. et al. The Brazilian Longitudinal Study of Aging (ELSI-Brazil): objectives and design. **Am J Epidemiol**, v. 187, n.7, p. 1345-53, 2018.
63. LONGO, G. Z. et al. Prevalence of high blood pressure levels and associated factors among adults in Southern Brazil. **Arquivos Brasileiros de Cardiologia**, v. 93, p. 387-394, 2009.
64. LORET DE MOLA, U. et al. On the use of hedonic price indices to understand ecosystem service provision from urban green space in five Latin American megacities. **Forests**, v. 8, n. 12, p. 478, 2017.
65. LUCUMI, D. I. et al. Income inequality and high blood pressure in Colombia: a multilevel analysis. **Cadernos de saude publica**, v. 33, p. e00172316, 2017.
66. LUO, Y. et al. Individual-level and area-level socioeconomic status (SES) and schizophrenia: cross-sectional analyses using the evidence from 1.9 million Chinese adults. **BMJ open**, v. 9, n. 9, p. e026532, 2019.
67. LYNCH, J.; Kaplan, G. Socioeconomic position. In: Berckman LF, Kawashi I, Glymour M, editors. Social Epidemiology. New York: Oxford University Press, v. 1, p. 13-35, 2000.
68. MALTA, D. C. et al. Prevalence of arterial hypertension according to different diagnostic criteria, National Health Survey. **Revista brasileira de epidemiologia**, v. 21, 2018.
69. MALTA, D. C.; MOURA, E. C. de; MORAIS NETO, O. L. de. Gender and schooling inequalities in risk and protective factors for chronic diseases among Brazilian adults, through telephone survey. 2011.
70. MALTA, D. C.; SILVA JR, J. B da. O Plano de Ações Estratégicas para o Enfrentamento das Doenças Crônicas Não Transmissíveis no Brasil e a definição das metas globais para o enfrentamento dessas doenças até 2025: uma revisão. **Epidemiologia e Serviços de Saúde**, v. 22, n. 1, p. 151-164, 2013.
71. MARKEVYCH, I. et al. Exploring pathways linking greenspace to health: Theoretical and methodological guidance. **Environmental research**, v. 158, p. 301-317, 2017.
72. MARQUES, A. P. et al. Factors associated with arterial hypertension: a systematic review. **Ciência & Saúde Coletiva**, v. 25, p. 2271-2282, 2020.

73. MATHESON, F. I. et al. Neighbourhood chronic stress and gender inequalities in hypertension among Canadian adults: a multilevel analysis. **Journal of Epidemiology & Community Health**, v. 64, n. 8, p. 705-713, 2010.
74. MENDES, P. M. et al. Association between perceived racial discrimination and hypertension: findings from the ELSA-Brasil study. **Cadernos de saude publica**, v. 34, 2018.
75. MERLO, J. et al. A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena. **Journal of Epidemiology & Community Health**, v. 60, n. 4, p. 290-297, 2006.
76. MERLO, J. et al. An original stepwise multilevel logistic regression analysis of discriminatory accuracy: the case of neighbourhoods and health. **PloS one**, v. 11, n. 4, p. e0153778, 2016.
77. MERLO, J. Multilevel analytical approaches in social epidemiology: measures of health variation compared with traditional measures of association. **Journal of Epidemiology & Community Health**, v. 57, n. 8, p. 550-552, 2003.
78. MILLER, G. E.; CHEN E.; PARKER, K. J. Psychological stress in childhood and susceptibility to the chronic diseases of aging: moving toward a model of behavioral and biological mechanisms. **Psychol Bull**. v. 137, n. 6, p. 959-997, 2011.
79. MILLS, K. T.; STEFANESCU, A.; HE, J. The global epidemiology of hypertension. **Nature Reviews Nephrology**, v. 16, n. 4, p. 223-237, 2020.
80. MOREIRA, J. P. L.; ALMEIDA, R. M. V. R.; LUIZ, R. R. Accuracy of self-reported arterial hypertension in Brazil: systematic review and meta-analysis. **International Journal of Cardiovascular Sciences**, v. 34, p. 114-120, 2021.
81. MURRAY, E. T. et al. Life Course models of socioeconomic position and cardiovascular risk factors: 1946 Birth Cohort. **Annals of epidemiology**, vol. 21, n. 8, p. 589-597, 2011.
82. NAKAGOMI, A. et al. Social determinants of hypertension in high-income countries: A narrative literature review and future directions. **Hypertension Research**, v. 45, n. 10, p. 1575-1581, 2022.
83. NCD-RisC - NCD Risk Factor Collaboration. Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. **Lancet**, v. 398, p.957–80, 2021.

84. NEJATINAMINI, S. et al. The contribution of modifiable risk factors to socioeconomic inequities in cardiovascular disease morbidity and mortality: A nationally representative population-based cohort study. **Preventive Medicine**, v. 171, p. 107497, 2023.
85. NISHIDA, W. et al. Education across the life-course and hypertension in adults from Southern Brazil. **Ciência & Saúde Coletiva**, v. 25, n. 8, p. 3063-3074, 2020.
86. ORGANIZAÇÃO PAN-AMERICANA DA SAÚDE (OPAS). **Plano Estratégico da Organização Pan-Americana de Saúde, 2014-2019.** Washington: DC: OPAS, 2014. Disponível em: <https://www.paho.org/hq/dmdocuments/2017/paho-strategic-plan-por-2014-2019.pdf> Acesso em: 20 nov 2022.
87. ORTIGOZA, A. F. et al. Characterising variability and predictors of infant mortality in urban settings: findings from 286 Latin American cities. **J Epidemiol Community Health**, v. 75, n. 3, p. 264-270, 2021.
88. PARDO-CRESPO, M. R. et al. Comparison of individual-level versus area-level socioeconomic measures in assessing health outcomes of children in Olmsted County, Minnesota. **J Epidemiol Community Health**, 2013.
89. PASSI-SOLAR, A. et al. Hypertension care cascade in Chile: a serial cross-sectional study of national health surveys 2003-2010-2017. **BMC Public Health**, v. 20, n. 1, p. 1-11, 2020.
90. PERNER, M. S.; ALAZRAQUI, M.; AMORIM, L. D. Social inequalities between neighborhoods and cardiovascular disease: a multilevel analysis in a Latin American city. **Ciência & Saúde Coletiva**, v. 27, p. 2597-2608, 2022.
91. POPKIN, B.M. An overview on the nutrition transition and its health implications: the Bellagio meeting. **Public health nutrition**, v. 5, n. 1A, p. 93-103, 2002.
92. PRABHAKARAN, D. et al. Exposure to particulate matter is associated with elevated blood pressure and incident hypertension in urban India. **Hypertension**, v. 76, n. 4, p. 1289-1298, 2020.
93. PUOLAKKA, E. et al. Childhood socioeconomic status and arterial stiffness in adulthood: the cardiovascular risk in Young Finns Study. **Hypertension**, v. 70, n. 4, p. 729-735, 2017.
94. QUISTBERG, D. A. et al. Building a data platform for cross-country urban health studies: the SALURBAL study. Journal of urban health, v. 96, p. 311-337, 2019.
95. RIVERA-ANDRADE, A.; LUNA, M. A. Trends and heterogeneity of cardiovascular disease and risk factors across Latin American and Caribbean countries. **Progress in cardiovascular diseases**, v. 57, n. 3, p. 276-285, 2014.
96. ROSS, C. E.; MIROWSKY, J. Gender and the health benefits of education. **The Sociological Quarterly**, v. 51, n. 1, p. 1-19, 2010.

97. SANTOS, S. M.; CHOR, D.; WERNECK, G. L. Demarcation of local neighborhoods to study relations between contextual factors and health. **International journal of health geographics,** v. 9, p. 1-15, 2010.

98. SCHUTTE, A.E. et al. Hypertension in low-and middle-income countries. **Circulation research**, v. 128, n. 7, p. 808-826, 2021.

99. SPARRENBERGER, F. et al. Does psychosocial stress cause hypertension? A systematic review of observational studies. **Journal of human hypertension**, v. 23, n. 1, p. 12-19, 2009.

100. STAFFORD, M.; MARMOT, M. Neighbourhood deprivation and health: does it affect us all equally?. **International journal of epidemiology**, v. 32, n. 3, p. 357-366, 2003.

101. STRINGHINI, S.; BOVET, P. Socioeconomic status and risk factors for non-communicable diseases in low-income and lower-middle-income countries. **Lancet Global Health**, v. 5, n. 3, p. e230-e231, 2017.

102. SZWARCWALD, C. L. et al. National Health Survey in Brazil: design and methodology of application. **Ciênc Saúde Colet**, v. 19, p. 333-42, 2014.

103. TUMAS, N. et al. Urban social determinants of non-communicable diseases risk factors in Argentina. **Health & place**, v. 77, p. 102611, 2022.

104. UNGER, T. et al. 2020 International Society of Hypertension global hypertension practice guidelines. **Hypertension**, v. 75, n. 6, p. 1334-1357, 2020.

105. UNITED NATIONS (UN). The Millennium development goals report 2015. New York: UN, 2015.

106. UNPD (United Nations, Department of Economic and Social Affairs, Population Division). World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420). https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf (New York: United Nations, 2019).

107. VEGA, A. P. Pobreza feminina desvendando suas raizes. **TEL Tempo, Espaço e Linguagem**, v. 10, n. 2, p. 177-200, 2019.

108. VILLARREAL-ZEGARRA, D.; CARRILLO-LARCO, R. M.; BERNABE-ORTIZ, A. Short-term trends in the prevalence, awareness, treatment, and control of arterial hypertension in Peru. **Journal of human hypertension**, v. 35, n. 5, p. 462-471, 2021.

109. WAGNER, K. J. P. et al. Effects of neighborhood socioeconomic status on blood pressure in older adults. **Revista de Saúde Pública**, v. 50, p. 78, 2016.

110. WANG, Q. et al. Urban mobility and neighborhood isolation in America's 50 largest cities. **Proceedings of the National Academy of Sciences**, v. 115, n. 30, p. 7735-7740, 2018.

111. WEBER, M. A. et al. Clinical practice guidelines for the management of hypertension in the community: a statement by the American Society of Hypertension and the International Society of Hypertension. **J Hypertens**, v.32, n.1, p.3-15, 2014.

112. WILLIAMS, B. et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension: The Task Force for the management of arterial hypertension of the European Society of Cardiology (ESC) and the European Society of Hypertension (ESH). **European heart journal**, v. 39, n. 33, p. 3021-3104, 2018.

113. WORLD HEALTH ORGANIZATION (WHO) & UN-HABITAT. **Global report on urban health: equitable healthier cities for sustainable development**. World Health Organization. 2016. Disponível em: http://www.who.int/iris/handle/10665/204715. Acesso em: 19 Maio. 2019.

114. WORLD HEALTH ORGANIZATION (WHO). **Global status report on noncommunicable diseases 2014**. Geneva: WHO, 2014.

115. WORLD HEALTH ORGANIZATION (WHO). **World Health Day 2013. A global brief on hypertension: silent killer, global public health crisis.** Genebra, 2013. Disponível em: < http://ish-world.com/downloads/pdf/global_brief_hypertension.pdf >. Acesso em: 29 jul. 2019.

ANEXO I - ARTIGO DE RESULTADOS 1 NO FORMATO PUBLICADO NO PERÍODO BMC PUBLIC HEALTH

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RESEARCH

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Gender differences in the association of individual and contextual socioeconomic status with hypertension in 230 Latin American cities from the SALURBAL study: a multilevel analysis

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Abstract

Background Despite global interest in gender disparities and social determinants of hypertension, research in urban areas and regions with a high prevalence of hypertension, such as Latin America, is very limited.

The objective of this study was to examine associations of individual- and area-level socioeconomic status with hypertension in adults living in 230 cities in eight Latin America countries.

Methods In this cross-sectional study, we used harmonized data from 109,184 adults (aged 18–97 years) from the SALURBAL (Salud Urbana en America Latina/Urban Health in Latin America) project. Hypertension was assessed by self-report. Individual-, sub-city- and city-level education were used as proxies of socioeconomic status. All models were stratified by gender.

Results Higher individual-level education was associated with lower odds of hypertension among women (university education or higher versus lower than primary: odds ratio [OR] = 0.67, 95% confidence interval [CI] = 0.61–0.74) but higher odds among men (OR = 1.65; 95%CI 1.47–1.86), although in men an inverse association emerged when measured blood pressure was used (OR = 0.86; 95%CI 0.76–0.97). For both genders, living in sub-city areas with higher educational achievement was associated with higher odds of hypertension (OR per standard deviation [SD] = 1.07, 95%CI = 1.02–1.12; OR = 1.11 per SD, 95%CI = 1.05–1.18, for women and men, respectively). The association of city-level education with hypertension varied across countries. In Peru, there was an inverse association (higher city level education was associated with lower odds of hypertension) in women and men, but in other countries no association was observed. In addition, the inverse association of individual-level education with hypertension became stronger (in women) or emerged (in men) as city or sub-city education increased.

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Conclusion The social patterning of hypertension differs by gender and by the level of analysis highlighting the importance of context- and gender-sensitive approaches and policies to reduce the prevalence of hypertension in Latin America.

Keywords Urban health, Hypertension, Education, Socioeconomic status, Latin America, Multilevel analysis

Background

Hypertension, a major contributor to cardiovascular disease [1], is a major global health challenge and disproportionately affects populations in low- and middle-income countries (LMICs) [2]. Recently, studies have gone beyond traditional behavioral risk factors and have shown that the individual's socioeconomic conditions and the contextual characteristics of the places where people live are related to hypertension prevalence [3–5]. Although socioeconomic conditions have been identified as important factors in increasing the burden of hypertension in LMICs [1], evidence is limited and results are not always consistent in the context of Latin America [6, 7].

In high-income countries, studies have generally reported an inverse association of hypertension with socioeconomic status (SES) at the individual level [6] and at the area level [8, 9]. In contrast, evidence on the association of individual-level and area-level SES with hypertension in Latin America remains comparatively scarce and conflicting. At the individual level, some studies reported an inverse association of SES with hypertension [3, 4, 10, 11]. At the area level, there have been mixed findings. For example, one study reported no association of hypertension with neighborhood- and city-level education in Argentina [3]. In Brazil, income inequality at the level of Federation Units was not associated with hypertension [4], but another study found that the prevalence of hypertension was significantly higher among residents living in census tracts with lower levels of education [12]. Brazilian Federation Units with a higher Human Development Index had a higher prevalence of hypertension [4]. In Colombia, residents of departments with high-income inequality had a higher prevalence of hypertension [5].

Both individual-level and area-level SES may influence the development of hypertension through a multiplicity of processes. Individual-level SES may be related to hypertension through its impact on behaviors such as diet and physical activity, as well as through stress-related processes [6, 13]. Area-level SES may be a proxy for environmental features such as food, physical activity, health care, and transportation environments [14], and has been correlated with social stressors, such as violence, which may also affect hypertension prevalence [15]. In addition to direct effects, area-level SES can reduce or amplify the effect of individual SES on hypertension [7]. Moreover, both individual-level and area-level SES may influence access to screening, early detection, and treatment of hypertension [16–18].

Latin America has a high prevalence of hypertension in the adult population [2, 19] and a high level of urbanization and inequalities [20], with cities and countries presenting different levels of economic and social development, and different stages of the epidemiological transition [21]. As the prevalence of cardiovascular risk factors increases as a country's economy grows, the effect of socioeconomic status on hypertension may also change. Therefore, the Latin American context presents a unique opportunity to investigate the associations of individual-level and area-level SES with hypertension. Understanding how social conditions at various levels relate to non-communicable diseases risk factors like hypertension is critical to achieving sustainable development goals [22].

Using unique data compiled and harmonized by the SALURBAL (Salud Urbana en America Latina/Urban Health in Latin America) project [23], we investigated how individual-level and area-level SES are associated with hypertension in adults from 230 cities in eight Latin American countries. In addition, because prior work has found that the social patterning of non-communicable diseases risk factors may vary substantially by gender [3, 6, 8, 10] and country [7, 24, 25], we also examined the extent to which these associations vary by gender and across countries.

Methods

Study design

The SALURBAL project compiled and harmonized health, social, and environmental data for all cities above 100,000 inhabitants in eleven Latin American countries [26]. Briefly, SALURBAL defines cities as a single administrative unit (e.g., municipio) or a combination of adjacent administrative units (e.g., several municipios) that are part of the built-up area of the urban agglomeration as determined from satellite imagery. Each "sub-city" is an administrative unit fully nested within a "city". The "sub-city" units were identified in each country as the smallest geographic administrative units for which health data was easily available. Approximately half of the cities included only one sub-city unit. This study used survey

data from 230 cities (encompassing 673 sub-city units) in 8 countries: Argentina, Brazil, Chile, Colombia, El Salvador, Guatemala, Mexico, and Peru (Survey details are provided in Supplementary Material Table S1).

Of 124,743 survey respondents aged 18 years and who resided in SALURBAL cities, we restricted our analyses to those with exposure information both at the individual and area-level, and those with outcome data. The final sample was 109,184 persons from 230 cities (673 sub-cities). Details on exclusions are shown in Figure S1. The median number of individuals per sub-city and city were 65 and 343.5, respectively.

SALURBAL survey data and outcome

SALURBAL compiled, harmonized, and geocoded individual-level data from nationally representative cross-sectional surveys. For this analysis, we included surveys with hypertension data: Argentina (2013), Brazil (2013), Chile (2010), Colombia (2007), El Salvador (2014), Guatemala (2002), Mexico (2012), and Peru (2016). Surveys were generally conducted by government agencies in different countries for purposes of risk factor surveillance often using similar questions.

The outcome was hypertension. Participants were defined as having hypertension if they reported that a physician had told them that they had hypertension and if they reported using medications "to lower blood pressure" or to control hypertension prescribed by a health care provider (i.e., both conditions had to be fulfilled). We have included the use of drugs in the definition to increase specificity. Gestational hypertension was excluded except in Argentina and Guatemala where the survey questions used did not exclude physician-diagnosed hypertension during pregnancy. This definition was used to incorporate data from as many countries as possible while maximizing comparability across countries.

Exposures

The three key exposures investigated were individual-level education, a proxy of individual-level SES, and summary scores of sub-city and city education, used as indicators of area-level SES. The sub-city level was included to capture heterogeneity within cities.

Individual-level education was harmonized across countries/surveys and classified into: (1) less than primary (2) primary: individuals who completed primary education, but with incomplete secondary education; (3) secondary: individuals with complete secondary education, complete non-university postsecondary education (e.g., technical school), or with incomplete university education; (4) university or higher: individuals who completed a university degree or with complete/incomplete graduate studies.

The population educational attainment score refers to educational achievement in the overall population. This measure was created using aggregated census data from the individual level of education: (1) the percentage of the population aged 25 years or older that has completed high school level or above, and (2) the percentage of the population aged 25 years or older that has completed university level or above [27]. A score was created by summing the standardized Z-scores of the two variables. Z scores were created for cities, based on the distributions of all cities, and sub-cities, based on the distributions of all sub-cities. Higher score values signify better educational achievement in the population [27].

Other variables included individual-level age (in years) and gender.

Statistical analysis

All analyses were stratified by gender because of previous evidence of gender differences in the associations between SES and hypertension [3, 6, 8]. For analytical purposes, El Salvador and Guatemala were grouped into one analytical unit named Central America. Descriptive statistics, using frequency distributions, means, and standard deviations (SD), are presented by countries and hypertension status.

The associations of individual-level and area-level SES with hypertension were examined using three-level multilevel logistic regression, including a random intercept for city and sub-city. All models were controlled for age. Model 1 included individual- and city-level education and country as fixed effects. Model 2 included individual- and sub-city-level education and country as fixed effects. Model 3 included all the exposures jointly and country as fixed effects. In Model 4, we included multiplicative interactions between city-level education and country by including the corresponding interaction terms in Model 3. To further explore whether there was heterogeneity in the associations by country, we conducted stratified analyses by country and gender (Supplementary Material Figure S2). Since Peru was the only country that presented a statistically significant and inverse association between city-level education and hypertension, we report associations with city level education separately for two groups (group 1: Argentina, Central America, Brazil, Chile, Colombia, and Mexico; group 2: Peru).

To determine if there were interaction between individual- and area-level SES, we estimated a fifth model (Models 5A and 5B) by including in Model 3 an interaction term between individual- and city-level education (Model 5A) and individual- and sub-city-level education (Model 5B). We plotted the predicted probabilities

resulting from the models by individual education category and city- and sub-city-level education.

In order to examine the robustness of our results to using measured blood pressure in the subset of the sample where measures were available ($n=50,209$) we fitted model 4 using the objective measure to define the outcome: hypertension was defined as systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg or the use of antihypertensive drugs. These analyses excluded Argentina because blood pressure measurements were not available and were restricted to smaller subsamples in other countries because measurements were not available for all respondents.

The analyses were performed using Stata version 12.0 (StataCorp LP, College Station, USA) and R software. The level of significance was set at 5%. The SALURBAL study protocol was approved by the Drexel University Institutional Review Board with ID #1612005035.

Results

The individual-level and area-level characteristics of the 109,184 individuals distributed in 673 sub-cities nested in 230 cities, according to country, are presented in Table 1. The median number of participants per sub-city was 65 (interquartile ranges [IQR] = 123) and per city was 343.5 (IQR = 506). The highest percentage of survey participants lived in Brazil and Mexico (24.2% and 23.8%, respectively), while Chile and Central America had the lowest (2.4% and 2.6%, respectively). The overall proportion of hypertension was 13.0% (95%CI = 12.9–13.1). Argentina and Brazil had the highest proportions of hypertension (17.5% and 16.5%, respectively), while Peru (6.5%) and Colombia (7.7%) had the lowest. The mean age of the population studied was 42.7 years (SD = 16.4) and 57.8% were women.

The proportion of self-reported hypertension was 10.5% (95%CI = 10.2–10.8) for men and 14.8% (95%CI = 14.5–15.1) for women (Table 2). Participants with hypertension were, on average, older and concentrated in the lower education categories as compared with those without hypertension, both for men and women. Also, individuals with hypertension had slightly higher sub-city-level education and lower city-level education than those without hypertension for both sexes.

Table 3 shows associations of individual-, sub-city- and city-level education with hypertension. The random intercepts remained significant for all models in both sexes, indicating residual variability in hypertension between cities and sub-cities. In women, higher individual-level education was associated with lower odds of hypertension in all models. In contrast, higher sub-city-level education was associated with higher odds of hypertension in all models. City-level education was not associated with hypertension even after joint adjustment of the three exposure variables, age, and country-fixed effects (Model 3). However, model 4 reveled heterogeneity in the associations of city education with hypertension by country: higher city-level education was associated with lower odds of hypertension in Peru but no association was observed for Argentina, Brazil, Central America, Chile, Colombia, and Mexico.

In men, higher individual- and sub-city-level education were associated with higher odds of hypertension in all models (Table 3). In contrast, higher city-level education was associated with lower odds of hypertension in the model with joint adjustment of the three exposure variables, age, and country-fixed effects. Exploration of interactions showed that this association was stronger in Peru while no association was observed for Argentina, Brazil, Central America, Chile, Colombia, and Mexico.

Figure 1 shows adjusted predicted probabilities of hypertension for individual education by levels of the city- and sub-city education. Although interaction terms were not always statistically significant, interesting patterns were observed. In women, the inverse association of individual-level education with hypertension became stronger at higher levels of city and sub-city education. In men, inverse associations of hypertension with education appeared to emerge at high levels of sub-city education. Estimates from models with interactions are shown in a supplementary table (Supplementary Material Table S2).

In sensitivity analyses, restricted to persons with measured blood pressure or using antihypertensive drugs, we observed similar results in women in terms of directionality and patterns of associations for all three exposures in the full model (Supplementary Material Table S3). However, in men in contrast to what was observed with self-reported hypertension, the highest individual-level education category was associated with lower odds of hypertension (OR *versus* less than primary: 1.14 [95%CI = 1.02–1.27], 1.01 [95%CI = 0.91–1.12], 0.86 [95%CI = 0.76–0.97], for primary, secondary and university or higher categories respectively). Findings for the city- and sub-city-level education were similar in directionality to those reported in the main analysis.

Discussion

We investigated associations of individual-level and area-level education with hypertension in adults from 230 Latin American cities. We found a clear gradient across individual-level education, but in opposite direction between genders. In women, higher education levels were associated with a lower proportion of hypertension. In men, higher education levels were associated with a higher proportion of hypertension. Although interaction terms between individual-level and area-level education

Table 1 Individual-level and area-level characteristics of the analytic sample by country. SALURBAL study ($N = 109,184$)

	TOTAL	Argentina	Brazil	Chile	Colombia	Mexico	Peru	Central America [a]
Sample characteristics								
Number of participants	109,184	21,286	26,398	2,669	18,142	25,995	11,880	2,814
Number of cities	230	33	27	19	33	91	23	4
Participants per city								
Median (1stQ-3rdQ)	343.5 (135;641)	509 (415;679)	820 (735;1,100)	84 (33;174)	402 (195;630)	188 (89;387)	311 (162;622)	667.5 (250;1,157)
Min – Max	17 - 3,901	23 - 3,901	513 - 2,543	17 - 793	61 - 3,376	17 - 2,370	90 - 3,278	160 - 1,319
Number of sub-cities	673	108	27	70	57	245	149	17
Participants per sub-city								
Median (1stQ-3rdQ)	65 (30;153)	85 (49;338.5)	820 (735;1,100)	20.5 (14;47)	195 (66;402)	62 (33;121)	49 (20;107)	77 (38;160)
Min – Max	5 - 3,092	7 - 885	513 - 2,543	5 - 239	14 - 3,092	14 - 835	5 - 521	18 - 1,319
Area-level characteristics								
City-level education, median (1stQ-3rdQ)	0.13 (-0.66;1.02)	-0.54 (-1.12;-0.33)	0.76 (0.25;1.16)	-1.06 (-1.42;0.69)	-1.17 (-0.86;0.32)	0.25 (-0.95;0.52)	2.93 (1.33;3.49)	-1.71 (-1.71;-0.84)
Sub-city-level education, median (1stQ-3rdQ)	0.25 (-0.56;1.19)	-0.34 (-0.74;-0.07)	1.19 (0.60;1.72)	- 0.65 (-1.08;-0.22)	0.07 (-0.48-0.64)	-0.14 (-0.98;0.57)	1.20 (0.58;2.14)	-1.65 (-1.65;-1.39)
Individual-level characteristics								
Age, mean (SD)	42.7 (16.4)	44.8 (17.9)	43.4 (16.6)	46.8 (17.6)	39.1 (14.0)[b]	43.6 (16.1)	39.7 (15.6)	42.9 (16.6)
Women, n (%)	63,126 (57.8)	11,991 (56.3)	15,692 (59.4)	1,601 (60.0)	10,366 (57.1)	14,760 (56.8)	6,835 (57.5)	1,881 (66.8)
Educational level, n (%)								
Less than primary	18,856 (17.3)	1,982 (9.3)	5,626 (21.3)	284 (10.6)	3,104 (17.1)	5,361 (20.6)	1,516 (12.8)	983 (34.9)
Primary	36,674 (33.6)	7,841 (36.8)	5,724 (21.7)	922 (34.5)	6,269 (34.6)	12,674 (48.8)	2,065 (17.4)	1,179 (41.9)
Secondary	39,310 (36.0)	7,865 (36.9)	10,214 (38.7)	1,239 (46.3)	7,150 (39.4)	5,439 (20.9)	6,845 (57.6)	561 (19.9)
University or higher	14,344 (13.1)	3,598 (16.9)	4,834 (18.3)	227 (8.5)	1,619 (8.9)	2,521 (9.7)	1,454 (12.2)	91 (3.2)
Hypertension, n (%)	14,208 (13.0)	3,725 (17.5)	4,364 (16.5)	358 (13.4)	1,399 (7.7)	3,158 (12.1)	773 (6.5)	431 (15.3)
Women	9,355 (14.8)	2,317 (19.3)	2,891 (18.4)	259 (16.2)	961 (9.3)	2,111 (14.3)	480 (7.0)	336 (17.9)
Men	4,853 (10.5)	1,408 (15.5)	1,473 (13.8)	99 (9.3)	438 (5.6)	1,047 (9.3)	293 (5.8)	95 (10.1)

[a] Central America: El Salvador and Guatemala grouped together

[b] Residents of Colombia had a lower average age, as the survey in this country did not include individuals over 70 years of age

Table 2 Individual-level and area-level characteristics of the analytical sample by hypertension status and gender

	Gender					
	Women			Men		
	No hypertension	Hypertension	*p*-value[a]	No hypertension	Hypertension	*p*-value[a]
	N = 53,771 (85.2%)	*N* = 9,355 (14.8%)		*N* = 41,205 (89.5%)	*N* = 4,853 (10.5%)	
Individual characteristics						
Age, mean (SD)	39.8 (15.0)	60.9 (13.6)	< 0.001	40.2 (15.2)	59.9 (13.5)	< 0.001
Educational level, n (%)			< 0.001			< 0.001
Less than primary	8,170 (15.2)	3,396 (36.3)		6,092 (14.8)	1,198 (24.7)	
Primary	17,835 (33.2)	3,111 (33.2)		14,112 (34.2)	1,616 (33.3)	
Secondary	20,423 (38.0)	1,904 (20.3)		15,694 (38.1)	1,289 (26.6)	
University or higher	7,343 (13.7)	944 (10.1)		5,307 (12.9)	750 (15.45)	
Contextual characteristics						
Sub-city-level education, mean (SD)	0.31 (1.27)	0.34 (1.27)	< 0.001	0.29 (1.26)	0.38 (1.29)	< 0.001
City-level education, mean (SD)	0.26 (1.43)	0.11 (1.28)	< 0.001	0.26 (1.43)	0.15 (1.29)	< 0.001

[a] *p*-values refer to Kruskal–Wallis tests and chi-square tests (for categorical variables). Comparing hypertension yes/no

were not always statistically significant, descriptive analyses suggested that an inverse association of individual-level education with hypertension became stronger or emerged as city or sub-city education increased.

Our results also demonstrated that higher sub-city-level education was associated with higher odds of hypertension in both genders. Moreover, the association of city-level education with hypertension varied across countries. In Peru, there was an inverse association (higher city education was associated with lower proportion of hypertension), while in other countries there was no association in women or men.

A recent meta-analysis of 51 studies found that educational attainment was a stronger predictor of hypertension prevalence than income or occupation [6]. However, to our knowledge, transnational studies investigating associations of individual-level and area-level SES with hypertension using the same indicator at different levels and in different countries have not been conducted.

We found that self-reported hypertension was inversely associated with education among women, but positively associated with education among men. Evidence limited from LMICs generally shows a higher prevalence of hypertension in women with lower education levels compared with higher education, while for men, evidence is mixed [3, 11, 28, 29]. Explanations for gender disparities may include more physically demanding jobs for less educated men [30] or differential patterning of other risk factors by SES in women and men [31]. Moreover, being a woman and having low education may be linked to higher exposure to chronic stress conditions, such as informal employment, single parenthood and role overload, violence, and stress at home [32, 33].

Furthermore, women's appearance is heavily emphasized in patriarchal societies [34], with heteronormative gender norms often shaping more educated women's behaviors [35] (e.g. they are more likely to face pressure to adjust their bodies to social expectations) [35]. Surveillance bias may also explain part of the association observed between education and hypertension in men. Men often search less for health systems and medical advice [18] and this could be especially pronounced in lower SES men which could explain the strong positive association of individual-level education with self-reported hypertension that we observed.

Our sensitivity analysis based on objective measures of blood pressure showed a different pattern for individual level education in men: the highest education category had significantly lower odds than the lowest category. This is consistent with the argument that differences in access and utilization of health care by SES in men could explain the positive association of individual-level SES with hypertension that we observed. Of note the gender differences in associations of education with hypertension that we report here as similar to those reported by Braverman et al. [24] for diabetes and Mazariego et al. [25] for obesity in SALURBAL in previous work.

Our study also showed sub-city and city contextual effects. After accounting for individual education, we found a positive association between sub-city-level education and hypertension for both genders. Lower access to health care (and consequent diagnosis of hypertension) in areas of lower education could at least partly explain this finding [16–18]. However, we observed a

Table 3 Associations of individual-, city- and sub-city-level education, with hypertension in 230 cities in Latin America

Individual, city, and sub-city characteristics[a]	Model 1 OR (95%CI)	Model 2 OR (95%CI)	Model 3 OR (95%CI)	Model 4 OR (95%CI)
Women (*N* = 63,126)				
Individual-level education				
Less than primary	Ref	Ref	Ref	Ref
Primary	0.99 (0.93-1.06)	0.99 (0.92-1.06)	0.99 (0.92-1.06)	0.98 (0.92-1.05)
Secondary	**0.76 (0.70-0.82)**	**0.75 (0.70-0.81)**	**0.75 (0.70-0.81)**	**0.76 (0.70-0.82)**
University or higher	**0.67 (0.61-0.74)**	**0.66 (0.60-0.73)**	**0.66 (0.60-0.73)**	**0.67 (0.61-0.74)**
City-level education	0.98 (0.93-1.04)		0.95 (0.89-1.01)	
Sub-city-level education		**1.04 (1.01-1.08)**	**1.05 (1.01-1.10)**	**1.07 (1.02-1.12)**
Argentina, Central America, Brazil, Chile, Colombia, and Mexico				
City-level education	-	-	-	1.01 (0.94-1.08)
Peru				
City-level education				**0.79 (0.64-0.97)**
Intercept variance (SE) (city)	**0.0362 (0.1904)**	**0.0373 (0.1931)**	**0.0354 (0.1884)**	**0.0641 (0.2533)**
Intercept variance (SE) (sub-city)	**0.0262 (0.1622)**	**0.0241 (0.1555)**	**0.0258 (0.1608)**	**0.0272 (0.1652)**
Men (*N* = 46,058)				
Individual-level education				
Less than primary	Ref	Ref	Ref	Ref
Primary	**1.51 (1.37-1.66)**	**1.49 (1.36-1.64)**	**1.50 (1.36-1.65)**	**1.48 (1.35-1.63)**
Secondary	**1.59 (1.43-1.76)**	**1.56 (1.40-1.73)**	**1.56 (1.40-1.73)**	**1.58 (1.42-1.75)**
University or higher	**1.68 (1.49-1.88)**	**1.63 (1.45-1.83)**	**1.63 (1.45-1.83)**	**1.65 (1.47-1.86)**
City-level education	0.98 (0.92-1.04)		**0.92 (0.85-0.99)**	
Sub-city-level education		**1.06 (1.01-1.12)**	**1.09 (1.03-1.16)**	**1.11 (1.05-1.18)**
Argentina, Central America, Brazil, Chile, Colombia, and Mexico				
City-level education	-	-	-	1.00 (0.92-1.10)
Peru				
City-level education	-	-	-	**0.77 (0.59-0.99)**
Intercept variance (SE) (city)	**0.0221 (0.1487)**	**0.0270 (0.1644)**	**0.0213 (0.1460)**	**0.1001 (0.3164)**
Intercept variance (SE) (sub-city)	**0.0233 (0.1528)**	**0.0154 (0.1244)**	**0.0191 (0.1384)**	**0.0250 (0.1582)**

Combinations of the main effect of city-level education and the interaction coefficient were used to derive estimates for different countries

Model 1: Individual- and city-level education, adjusted for country-fixed effect. Model 2: Individual- and sub-city-level education, adjusted for country-fixed effect. Model 3: Individual-, sub-city- and city-level education, adjusted for country-fixed effect. Model 4: Model 3 and an interaction term between city-level education and different country groups (*p*-value for interaction in women = 0.004 and men = 0.012)

Bold values have a *p*-value < 0.05

Ref. Reference group, *OR* Odds Ratio, *95%CI* 95% confidence intervals, *SE* Standard error

[a] All models were adjusted for individual age. City- and sub-city-level education (educational attainment score) was standardized to a mean of 0 and a standard deviation (SD) of 1. The OR is estimated for a 1 SD (0.30847) and (0.24469) difference in sub-city- and city-educational attainment scores, respectively

similar pattern when objective measures of hypertension were used. In consonance with our findings, a positive association between area-level SES and hypertension was also previously reported in Brazil using objective hypertension measures [4].

The mechanisms underlying a positive association of sub-city education with hypertension may include other factors associated with area-level SES including the nature of work [36], access to and consumption of processed foods [37], sedentary behaviors [38, 39], promoted by work and urban environments (e.g., car dependence), or even factors such as levels of pollution, heat, and noise, all of which have been linked to hypertension [40].

Significant associations between city-level education and hypertension were limited to individuals residing in Peru; higher educational attainment of the population at the city level was associated with a lower proportion of hypertension in women and men. While the highest global prevalence of hypertension was observed in some Latin American and Caribbean countries, the lowest global prevalence of hypertension was found in Peru [2, 19] and the stages of

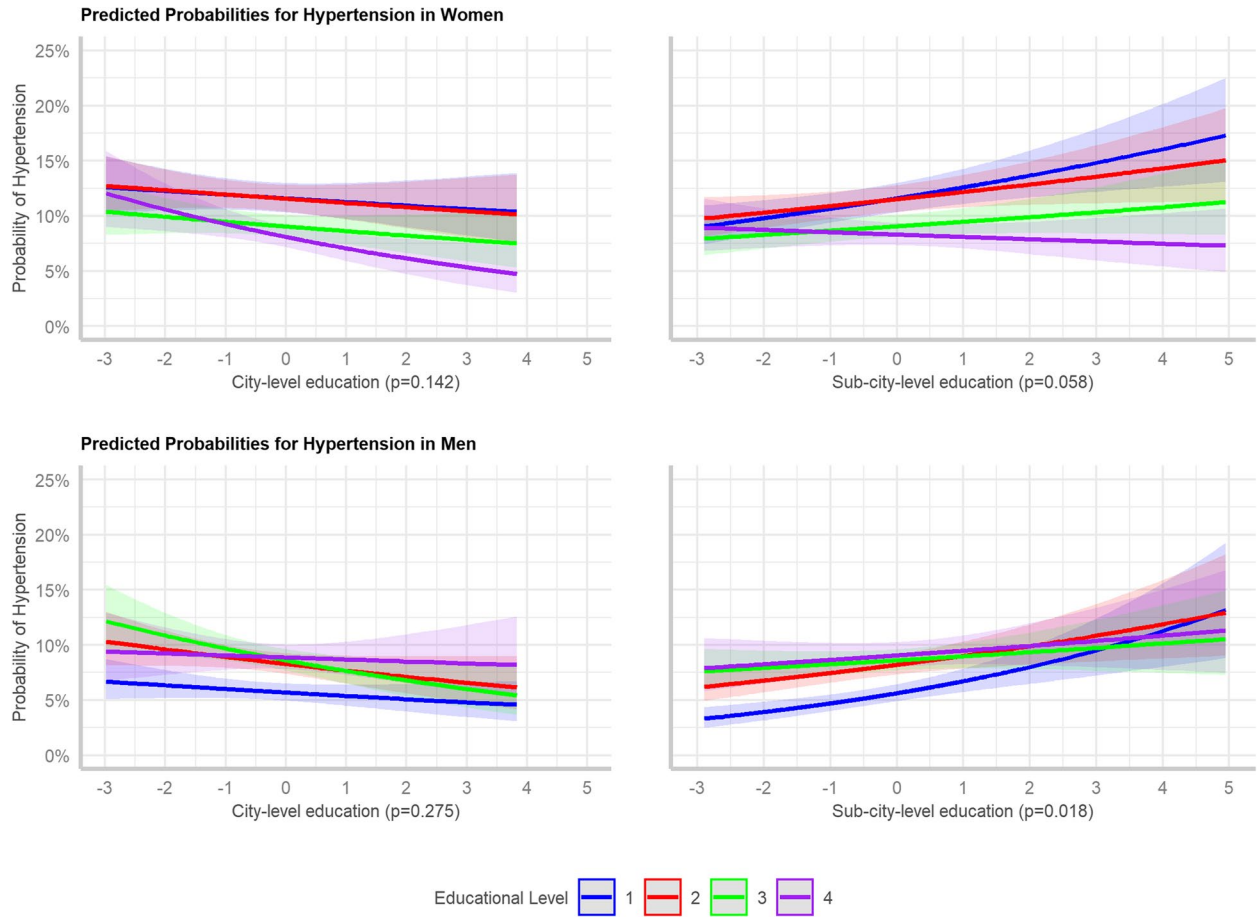

Fig. 1 Predicted probabilities of hypertension based on the regression models to assess the effect modification of individual-level education by area-level education. The *p*-value presented refers to the global interaction test. Education level: 1 = less than primary; 2 = primary; 3 = secondary; 4 = university or higher. Sub-city- and city-educational attainment score values are based on the standardized variable used in the model so the range of values differs from the one presented in Table 1

the hypertension of the epidemic could be linked to social patterning and differences across cities. Country differences in access to care and the patterning of access to care by city SES could also play a role when self-reported hypertension is used as a hypertension indicator. The positive association between city-level education and hypertension in Peru is a question that deserves additional research.

Our results also suggest possible interactions between contextual- and individual-level education. In women, the inverse association of individual-level education with hypertension became stronger as sub-city and city education increased. In men, the positive association of individual-level education with hypertension was lost, and an inverse gradient emerged (higher education, lower hypertension prevalence) as sub-city education increased. This is consistent with findings from prior works showing that inverse social gradients in cardiovascular risks emerge as contextual education increases [24, 25]. It may be related to the social patterning of risk factors for hypertension that emerges as socioeconomic development increases.

This study has some limitations. First, we use a cross-sectional design, which does not allow us to draw causal inferences; however, descriptive information is also important to public policy. Second, the ascertainment of hypertension status was through self-report, which may have led to differential information bias, with groups with less access to healthcare under-represented, and consequently, resulting in underestimates of inverse education gradients if lower SES groups have lower access to care. Third, gestational hypertension was not excluded in Argentina and Guatemala. Gestational hypertension data will be limited to some women who were pregnant at the time of the survey. In countries where we have information on current pregnancy

(Brazil, Chile, Mexico, Peru and El Salvador), the presence of this condition was reported by approximately 4% of women aged 18 to 49 years, with only 19 (1.8%) of these were considered hypertensive. Therefore, we do not believe this is likely to have had a significant impact on our results. Fourth, we did not adjust for hypertension risk factors such as physical activity, diet, smoking, obesity, and diabetes because we view them as likely mediators of the associations we are investigating [15, 41]. In addition, it is not possible to rule out residual confounding due to unmeasured or unknown factors. Fifth, survey years are not always aligned with the census years from which area-level education information was drawn. Finally, despite efforts to harmonize surveys across countries, some heterogeneity may still exist and affect our results. Nonetheless, to attenuate these potential remaining differences we used the country as fixed effects for the main analyses.

On the other hand, this study has several strengths. To our knowledge, this is the first transnational study to examine the association between individual- and area-level SES with hypertension using the same indicator at different levels. Second, our study included a large sample of individuals (109,184) and cities (230) representing a significant proportion of the urban population of Latin America and used a large harmonized dataset. Third, our multilevel approach allowed us to analyze individual and macro-level contextual factors. In addition, the associations were adjusted for country-fixed effects removing the effect for unmeasured country factors such as differences in healthcare and education systems across countries.

In conclusion, our results demonstrate gender and social inequalities in hypertension in Latin American cities. First, we identified gender differences in the relationship between individual education and hypertension, with higher individual-level education associated with lower odds of hypertension among women and higher odds among men. Second, we identified that higher sub-city-level education was positively associated with hypertension in both women and men. Third, we identified that higher city-level education was associated with lower odds of hypertension in both sexes in Peru. Thus, our results suggest that strategies to deal with the burden of hypertension in LIMCs should adopt equity-based and context-sensitive efforts.

Abbreviations

OR	Odds Ratio
CI	Confidence interval
SD	Standard deviation
IQR	Interquartile ranges
SALURBAL	Salud Urbana en America Latina/Urban Health in Latin America
LMICs	Low- and middle-income countries
SES	Socioeconomic status

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-023-16480-3.

Additional file 1: Figure S1. Flowchart of the process used to define the sample used in the paper. **Table S1.** Characteristics of the national surveys included in our sample. **Figure S2.** Associations of individual-, city- and sub-city-level education, with hypertension country-stratified. SALURBAL study ($N = 109,184$). **Table S2.** Associations between Individual-, city- and sub-city-level education with hypertension for models containing an interaction term between individual-level education with city- and sub-city education. **Table S3.** Sensitivity analyses: associations between individual-, sub-city- and city-level education with hypertension (self-reported vs. objectively measured).

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Authors' contributions

DMC, ACSA, and WTC conceived the study. DMC, ACSA, and UMS performed the statistical analyses. UMS prepared Supplemental Fig. 2. DMC drafted the first version of the manuscript. ML, CS, AQ, AVDR and AALF participated in or supported data collection. All authors participated in the interpretation of results and approved the final version of the manuscript.

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Availability of data and materials

Data are available upon reasonable request. The SALURBAL study obtained data from health and/or statistical agencies within each country. Some data sources are available under restricted access due to data use agreements between the SALURBAL Study and statistical agencies within the country. Requests for the harmonized data can be obtained by contacting the SALURBAL Data Methods Core (salurbal.data@drexel.edu) and after completing data use agreements. To learn more about SALURBAL's dataset, visit https://drexel.edu/lac/ or contact the project at salurbal@drexel.edu.

Declarations

Ethics approval and consent to participate

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects/ patients were approved by the Drexel University Institutional Review Board with ID no. 1612005035 and by appropriate site-specific IRBs. In Brazil, this

study was approved by the Federal University of Minas Gerais IRB (CAAE: 70209917.00000.5149). For health survey participants, informed consent was obtained from all subjects.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. World Health Organization (WHO). A global brief on hypertension: silent killer, global public health crisis: World Health Day 2013. Geneva: World Health Organization; 2013. [cited 2022 Aug 29]. Available from: https://apps.who.int/iris/handle/10665/79059.
2. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. Lancet. 2021;398(10304):957–80.
3. Tumas N, López SR, Bilal U, Ortigoza F, Roux AVD. Urban social determinants of non-communicable diseases risk factors in Argentina. Health Place. 2021;77:102611.
4. Bento IC, Mambrini JVDM, Peixoto SV. Contextual and individual factors associated with arterial hypertension among Brazilian older adults (National Health Survey-2013). Rev Bras Epidemiol. 2020;23:e200078.
5. Lucumi D, Schulz AJ, Roux AVD, Grogan-Kaylor A. Income inequality and high blood pressure in Colombia: a multilevel analysis. Cad Saude Publica. 2017;33:e00172316.
6. Leng B, Jin Y, Li G, Chen L, Jin N. Socioeconomic status and hypertension: a meta-analysis. J Hypertens. 2015;33(2):221–9.
7. Kirschbaum TK, Sudharsanan N, Manne-Goehler J, De Neve JW, Lemp JM, Theilmann M, et al. The association of socioeconomic status with hypertension in 76 low- and middle-income countries. J Am Coll Cardiol. 2022;80(8):804–17.
8. Caswell JM. Prevalence of reported high blood pressure in Canada: investigation of demographic and spatial trends. J Public Health. 2017;25(1):49–59.
9. McDoom MM, Palta P, Vart P, Juraschek SP, Kucharska-Newton A, Roux AVD, et al. Late life socioeconomic status and hypertension in an aging cohort: the atherosclerosis risk in communities study. J Hypertens. 2018;36(6):1382.
10. Hessel P, Rodríguez-Lesmes P, Torres D. Socio-economic inequalities in high blood pressure and additional risk factors for cardiovascular disease among older individuals in Colombia: results from a nationally representative study. PLoS One. 2020;15(6):e0234326.
11. Alves RFS, Faerstein E. Educational inequalities in hypertension: complex patterns in intersections with gender and race in Brazil. Int J Equity Health. 2016;15(1):1–9.
12. Wagner KJP, Boing AF, Subramanian SV, Höfelmann DA, D'Orsi E. Effects of neighborhood socioeconomic status on blood pressure in older adults. Rev Saude Publica. 2016;50:78.
13. Lynch J, Kaplan G. Socioeconomic position. In: Berkman LF, Kawachi I, editors. Social epidemiology. New yourk: Oxford University Press; 2000. p. 13–35.
14. Lê-Scherban F, Ballester L, Castro JC, Cohen S, Melly S, Moore K, et al. Identifying neighborhood characteristics associated with diabetes and hypertension control in an urban African American population using geo-linked electronic health records. Prev Med Rep. 2019;15:100953.
15. Chaix B, Bean K, Leal C, Thomas F, Havard S, Evans D, et al. Individual/neighborhood social factors and blood pressure in the RECORD Cohort Study: which risk factors explain the associations? Hypertension. 2010;55(3):769–75.
16. Barraza-Lloréns M, Panopoulou G, Díaz BY. Income-related inequalities and inequities in health and health care utilization in Mexico, 2000–2006. Rev Panam Salud Publica. 2013;33:122–30.
17. Almeida G, Sarti FM, Ferreira FF, Diaz MDM, Campino ACC. Analysis of the evolution and determinants of income-related inequalities in the Brazilian health system, 1998–2008. Rev Panam Salud Publica. 2013;33:90–7.
18. Levorato CD, de Mello LM, da Silva AS, Nunes AA. Factors associated with the demand for health services from a gender-relational perspective. Cien Saude Colet. 2014;19(4):1263.
19. Ruilope LM, Chagas ACP, Brandao AA, Gómez-Berroterán R, Alcalá JJA, Paris JV, et al. Hypertension in Latin America: Current perspectives on trends and characteristics. Hipertens Riesgo Vasc. 2017;34(1):50–6.
20. United Nations Human Settlements Programme (UN-HABITAT). State of the world's cities 2010/2011: bridging the urban divide. London: United Nations Human Settlements Programme; 2010. [cited 2022 Jul 27]. Available from: https://unhabitat.org/state-of-the-worlds-cities-20102011-cities-for-all-bridging-the-urban-divide.
21. Rivera-Andrade A, Luna MA. Trends and heterogeneity of cardiovascular disease and risk factors across Latin American and Caribbean countries. Prog Cardiovasc Dis. 2014;57(3):276–85.
22. Becerra-Posada F. Health equity: the linchpin of sustainable development. Rev Panam Salud Pública. 2015;38:5–8.
23. Diez-Roux AV, Slesinski SC, Alazraqui M, Caiaffa WT, Frenz P, Fuchs RJ, et al. A novel international partnership for actionable evidence on urban health in Latin America: LAC-Urban Health and SALURBAL. Global Chall. 2018;3:1800013.
24. Braverman-Bronstein A, Hessel P, González-Uribe C, Kroker MF, Diez-Canseco F, Langellier B, et al. Association of education level with diabetes prevalence in Latin American cities and its modification by city social environment. J Epidemiol Community Health. 2021;75(9):874–80.
25. Mazariegos M, Auchincloss AH, Braverman-Bronstein A, Kroker-Lobos MF, Ramírez-Zea M, Hessel P, et al. Educational inequalities in obesity: a multilevel analysis of survey data from cities in Latin America. Public Health Nutri. 2022;25(7):1790–8.
26. Quistberg DA, Diez-Roux AV, Bilal U, Moore K, Ortigoza A, Rodriguez DA, et al. Building a data platform for cross-country urban health studies: the SALURBAL study. J Urban Health. 2019;96(2):311–37.
27. Ortigoza AF, Granados JA, Miranda JJ, Alazraqui M, Higuera D, Villamonte G, et al. Characterising variability and predictors of infant mortality in urban settings: findings from 286 Latin American cities. J Epidemiol Community Health. 2021;75(3):264–70.
28. Enes CC, Nucci LB. Gender and schooling inequalities in risk and protective factors for chronic diseases among Brazilian adults. J Public Health. 2018;40(3):e211–8.
29. Laux TS, Bert PJ, González M, Unruh M, Aragon A, Lacourt CT. Prevalence of hypertension and associated risk factors in six Nicaraguan communities. Ethn Dis. 2012;22(2):129.
30. Gregory CO, Dai J, Ramirez-Zea M, Stein AD. Occupation is more important than rural or urban residence in explaining the prevalence of metabolic and cardiovascular disease risk in Guatemalan adults. J Nutr. 2007;137:1314–9.
31. World Health Organization (WHO). World health statistics 2019: monitoring health for the SDGs, sustainable development goals. Geneva: World Health Organization; 2019. Licence: CC BY-NC-SA 3.0 IGO. [cited 2022 Aug 15]. Available from: https://www.who.int/publications/i/item/9789241565707.
32. Kandasamy S, Anand SS. Cardiovascular disease among women from vulnerable populations: a review. Can J Cardiol. 2018;34(4):450–7.
33. Vega AP. Pobreza feminina desvendando suas raízes. TEL Tempo, Espaço e Linguagem. 2019;10(2):177–200.
34. Heise L, Greene ME, Opper N, Stavropoulou M, Harper C, Nascimento M, et al. Gender inequality and restrictive gender norms: framing the challenges to health. Lancet. 2019;393(10189):2440–54.
35. Robinovich J, Ossa X, Baeza B, Krumeich A, van der Borne B. Embodiment of social roles and thinness as a form of capital: a qualitative approach

towards understanding female obesity disparities in Chile. Soc Sci Med. 2018;201:80–6.
36. Jones A, Mitchel D, Goza F. Lifecourse socioeconomic status and cardiovascular illness in Latin America. Curr Sociol. 2014;62(7):1055–78.
37. Matos RA, Adams M, Sabaté J. Review: the consumption of ultra-processed foods and non-communicable diseases in Latin America. Front Nutr. 2021;24(8):622714. https://doi.org/10.3389/fnut.2021.622714. PMID: 33842521; PMCID: PMC8024529.
38. Bastone ADC, Moreira BDS, Vasconcelos KSDS, Magalhães AS, Coelho DM, Silva JI, et al. Time trends of physical activity for leisure and transportation in the Brazilian adult population: results from Vigitel, 2010–2019. Cad Saúde Pública. 2022;38:7222.
39. Luis de Moraes Ferrari G, Kovalskys I, Fisberg M, Gómez G, Rigotti A, Sanabria LYC, et al. Original research Socio-demographic patterning of self-reported physical activity and sitting time in Latin American countries: findings from ELANS. BMC Public Health. 2019;19(1):1–12.
40. Nieuwenhuijsen MJ. Influence of urban and transport planning and the city environment on cardiovascular disease. Nat Rev Cardiol. 2018;15(7):432–8.
41. Nejatinamini S, Campbell DJ, Godley J, Minaker LM, Sajobi TT, McCormack GR. The contribution of modifiable risk factors to socioeconomic inequities in cardiovascular disease morbidity and mortality: a nationally representative population-based cohort study. Prev Med. 2023;171:107497.

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