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Urban residence and elevated blood pressure among migrant women in South Africa

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ABSTRACT

This paper demonstrates that internal migration may be contributing to rising non-communicable disease risk in low- and middle-income countries in gendered and geographically differentiated ways. With 2018 baseline data from the Migrant Health Follow-Up Study, we investigate the relationship between internal migration and elevated blood pressure (BP) among 2163 rural-origin men and women in South Africa, testing for sex differences. To examine the influence of place, we test whether the migration-BP relationship differs by migrants' destination locations, controlling for household composition, social support, prior migration, and housing quality. We find that migration is associated with elevated BP only among women, and that this association is greatest for migrants living in Tembisa township. Our research underscores that gender and migration are important social determinants of noncommunicable disease risk in low-resource, rapidly-urbanizing settings.

Eighty-five percent of the 15 million premature non-communicable disease (NCD)-related deaths occur in low- and middle-income countries (LMIC) each year, with elevated blood pressure (BP) constituting the leading metabolic risk factor for NCDs (WHO, 2021). Consequently, understanding what drives the high prevalence and rising incidence of BP in transitioning contexts is an increasingly urgent public health priority. Global agenda-setting organizations like the World Health Organization acknowledge that economically vulnerable populations are especially at risk of suffering and dying from NCDs, but our understanding of the social and behavioral correlates and predictors of elevated BP remains limited. In addition to LMICs being resource poor in terms of healthcare infrastructure and services, LMICs are also characterized by high levels of geographic mobility that may affect the NCD burden in ways we do not yet understand. In this paper we investigate whether and in what ways migration and urbanization affect NCD risk as assessed by elevated BP. We also consider what role gender plays in the migration-BP relationship. Any associations between migration and health are likely to be gendered given that processes of migration for men and women are distinct. We hypothesize that sex differences in the migration-BP relationship are likely to manifest not only for biological reasons but because BP is influenced by psycho-social stressors that are patterned by gendered migration systems and urban environments. We use sex-stratified models to assess how migration matters differentially for men and women.

Our contribution extends previous work that has shown female migrants in LMICs to be especially vulnerable to poor health in general (Ginsburg et al., 2016), and to elevated BP in particular (Pheiffer, 2021). With baseline data from the Migrant Health Follow-Up Study (MHFUS) collected in 2018, we examine the relationship between internal migration and elevated BP and we test for sex differences in this relationship. We then examine whether the migration-BP relationship differs by migrants' destination locations, and test whether this relationship can be explained by household composition, social support, migration experience, and housing quality. To the extent that these factors help to explain the migration-BP relationship, we expect their inclusion in regression analyses to reduce or eliminate any statistically significant association between migration and BP, and for different sets of predictors to be significantly associated with BP variation for men and women. As a robustness check, we employ the Karlson–Holm–Breen (KHB) method as a formal test of mediation of these factors (Karlson and Holm, 2011).

The MHFUS follows a cohort of 18–40-year-old rural residents of South Africa's Agincourt Health and Socio-Demographic Surveillance Site (AHDSS) primarily to urban destination locations when they move, providing a unique opportunity to assess the relationship between migration and health among women and men in this vulnerable,

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geographically-mobile population (Ginsburg et al., 2021).

1. Background

1.1. Gendered patterns of migration in LMICs

Over the past several decades, much has been made of the "feminization of migration," a phrase that has been used extensively to describe the increase in women's participation in migration streams globally. It is most often used with reference to international migration (Gabaccia, 2016), but it has been used to describe internal migration patterns as well (Bilsborrow, 1992; Mberu, 2015). Much of this work documents that women now often make up a large—if not equal—share of migratory flows globally. Beyond the quantification of women's participation in migration with sex ratios, relatively little has been written about how migration patterns and experiences are gendered. Women are sometimes found to be more likely to make shorter-distance rural-rural moves—likely for reasons of marriage or family compared with men who move primarily to urban places for economic reasons (Kanaiaupuni, 2000; Camlin et al., 2014; Chort et al., 2017). Female rural-urban migrants are sometimes found to be selected on education and report the pursuit of furthering education to be a primary reason for moving (Chort et al., 2017; Yilma and Regassa, 2019).

From this sparse literature, two stylized narratives of the female migrant emerge: the first is that of the short-distance rural-rural migrant who marries, joins a new family, and remains near her origin community; the second is of a relatively educated, aspirational rural-urban woman who moves in pursuit of an opportunity for better employment or education. The former narrative fits with the traditional representation of women in the migration literature (Ravenstein, 1885, 1889), and the latter is the female version of the conventional male labor migrant. The most common narrative around changes in migration patterns is that women are now less the former type of migrant and more the latter. While this may be true (although we would argue—this remains an empirical question for specific populations), the migration experiences of women are likely much more diverse and complex as young women navigate familial obligations, personal aspirations, and connections to home. Migration might afford women more opportunity and independence, but female migrants still need to function within gendered roles and expectations (Kehler, 2001; Camlin et al., 2014; Goebel, 2015; Sandoval-Cervantes, 2017). This may be even more so in LMICs, as women not only negotiate the mechanics of movement and labor force entry but also negotiate the shifting patterns of gender relations in societies in transition. Certainly, women face different sets of calculi and exposures to their personal safety and health than men—although much more work is needed to understand these differences.

1.1.1. Gender and health in LMICs

It has been well-documented that health outcomes are gendered: men and women have differential risks of morbidity and mortality that cannot be explained exclusively by biological differences or processes. Women in South Africa, for example, die disproportionately from diabetes, cerebrovascular, and hypertensive diseases whereas TB and HIV are the primary causes of death among men (StatsSA, 2020). Such differences are, in part, attributable to known behavioral risk factors. Men's disproportionate mortality from TB, for example, often stems from delayed testing and treatment, behaviors that are informed by beliefs about illness and masculinity (Daniels et al., 2021). Women, in the context of health and nutrition transitions, continue to exhibit higher levels of overweight than men, a gap that is widening both over time and in association with greater gender inequality. Interestingly, LMIC women also tend to have healthier dietary patterns than men, and lower blood pressure levels, especially pre-menopause. Biological sex differences may play a role, such as maintenance of pregnancy weight gain among women, and sex hormone variations and menopause influencing blood pressure and type 2 diabetes. Yet, there is much still unknown about the sociocultural and psychosocial domains that may differ between men and women that influence health behaviors and biomarker risk factors. Improved understanding of gendered differences in diet and health is difficult to achieve with extant national level data in global reports since they often lack contextual factors influencing gendered patterns. Our paper takes advantage of extensive socio-demographic, geographic, health, and behavioral information to examine such potential differences, and the possible relationship with psychosocial stressors, to explain elevated BP among migrant women.

1.2. Migration and health

Our objective is to consider how gendered aspects of social life structures the migration experience and results in differential health consequences for men and women. The preceding paragraphs outlined the argument for why we expect gender differences in migration, and gender differences in health, respectively, but the literature is surprisingly silent on the ways in which gender interactively and simultaneously structures migration and health. In other words, we are left wanting for explanations of why women suffer a health penalty in terms of elevated BP—and therefore elevated NCD risk—when they migrate and resettle within the borders of their own country.

Within the Southern African Development Community, the importance of applying a gendered lens to understanding migration and health dynamics has been recognized (Sonke Gender Justice, 2019). In migrant destinations, women may experience greater isolation due to the type of employment they engage in and face greater risks to their personal safety than men (WHO, 2018). Social and environmental conditions at migrant destinations are therefore important determinants of women's health. In South Africa, spatial segregation remains a feature of many urban areas and rural migrants entering cities often encounter crowded living conditions, informal housing, and a lack of access to services (Visagie and Turok, 2020). These conditions vary appreciably within urban regions, although many studies remain limited to investigating only an urban-rural dichotomy. The impact of living conditions on migrant's health, with a particular focus on gender, is nevertheless limited. While women are increasingly participating in migration to access employment in South Africa (Camlin et al., 2014), much research has focused on households and families left behind (e.g.: Schatz et al., 2015) and less is known about the structure and composition of women's households at destinations. Social networks and social support play a significant role in health and in shaping health behaviors (Berkman and Krishna, 2014), which may also have distinct gender dimensions (Curran and Saguy, 2001; Curran and Rivero-Fuentes, 2003). Thus, how social structures connect to the process of migration to, in turn, influence health in gendered ways is an important area of investigation.

2. Data, measures, and method

2.1. Data and sample

The MHFUS drew a simple random sample of 3800 adults aged 18–40 from the rural Agincourt Health and Demographic Surveillance Site (AHDSS) in Mpumalanga Province, northeast South Africa. Initial household visits were conducted in 2017 to obtain contact information for the 3800 AHDSS residents; contact information was obtained for 3491. Of these, 3102 were successfully contacted and interviewed in 2018–2019 during the Wave 1 data collection; 2467 respondents were interviewed in person by one of two fieldwork teams (one based at the AHDSS field headquarters in rural Mpumalanga and the other at the University of the Witwatersrand School of Public Health in Johannesburg). One hundred and fifty respondents did not consent to having anthropometrics or BP measured. A further 635 respondents were interviewed over the phone and had no BP measurements.

Respondents are not missing anthropometric and BP measurements at random. Phone interviews were conducted with individuals who were living in very remote locations and/or who we were not able to reach physically after multiple attempts. Respondents interviewed telephonically were significantly older than in-person interviewees. They were also more likely to be migrants and to be employed compared with respondents in the in-person sample. Those who completed in-person interviews but who did not consent to having measurements taken were older, more likely to be migrants, and more likely have completed secondary education.

As is standard in studies of BP, we exclude 57 women who reported being pregnant at the time of interview and 3 women who may have been pregnant (either refused to answer the question on pregnancy status or did not know whether they were pregnant), resulting in a sample of 2258 respondents with valid anthropometry and BP measures. A further 126 cases were excluded for missing values on covariates of interest, yielding an analytical sample of 2163 individuals, consisting of 1096 women and 1067 men. All analyses are weighted to account for sample non-response to render the sample representative of the AHDSS population. After presenting the results, we also discuss further the matters of sample composition and reduction of potential biases.

2.2. Measures

Table 1 summarizes the measures used in the analyses. The outcome variable is diastolic BP, which is an average of the second two of three diastolic BP measurements taken towards the end of the MHFUS interview. BP was measured with an appropriate upper-arm inflation cuff after an initial 10-min seated rest period, with 3-min of rest between each of the three BP measurements. Measurements were taken using an Omron HEM907 XL digital BP monitor (Omron Healthcare, IL). We analyze BP because it is a well-known and treatable risk factor for cardiometabolic disease associated with the rise of NCD risk in LMICs (Lawes et al., 2008). We present results for diastolic BP since diastolic and systolic BP are highly correlated (0.71 in this sample), and the findings we present are consistent for systolic BP (Table 2, supplemental appendix). We retain individuals in the sample who currently report taking BP medication since access and adherence to BP medication could be a result of migration status – i.e., it could be on the causal pathway. We do, however, test the sensitivity of the results to the inclusion of the 27 individuals in the analytic sample (22 women, 5 men) who report taking BP medications (Table 5, supplemental appendix). The results remain robust regardless of their inclusion.

The primary migration variable is a binary indicator of migration status, defined as respondents who currently live outside of the AHDSS compared with those residing within the study site (see Ginsburg et al., 2021 for a discussion of migrant definitions in MHFUS). We also present regression results for current residence location, which decomposes migration status into a categorical indicator for whether a respondent resides in one of the top 6 migrant destination locations (Tembisa, Pretoria, Daveyton, Mamelodi, Germiston, and Witbank), or elsewhere in South Africa compared with the referent of living within the AHDSS. Tembisa, Pretoria, Daveyton, Mamelodi and Germiston are urban locations located within the Gauteng province approximately 400 km southeast of the AHDSS. Witbank is 300 km southeast of the AHDSS in Mpumalanga province, located off the N4 highway – the primary artery connecting the AHDSS to Johannesburg.

Covariates included in the regression models are age group, high school completion, employment status, the number of household members, a chronic illness diagnosis, an indicator for alcohol consumption, an indicator for fast food consumption, and an indicator of whether a respondent has accessed healthcare services within the past 12 months. We also control for body mass index (BMI). Adiposity is associated with urban environments early in economic development and nutrition transitions (Malik et al., 2013), although rural-urban differences in temporal changes in BMI and obesity are becoming more complex due to historical, political-economic, and social influences (NCD Risk Factor Collaboration, 2019). BP is positively associated with BMI, and the role of social factors such as gender on BP are very likely influenced by BMI (Cois and Ehrlich, 2014).

We check the robustness of the results to inclusion of measures of household and family composition, social support, prior migration experience, and housing quality. For household and family composition, we examine whether a respondent has children below age 15 as of 1 January 2018. We prefer this measure over one that includes only children within the household since migrants are likely to have children with whom they are not co-resident. We capture headship when a respondent self-reports being the current head of household. We assess the presence of social support through an indicator of whether a respondent has least one friend or relative living nearby their current location—which, for migrants, is in their destination location. No social support means a respondent reports having neither a friend nor a relative living nearby. Prior migration experience is captured by the number of 6-month residence spells a respondent has spent outside of AHDSS since age 15, not including their current migration spell if they are a migrant. We measure housing quality as a binary indicator of whether a respondent lives in informal housing compared with living in formal housing.

Table 1
Summary of measures.

Variable	Measure
Dependent Variable	
Diastolic BP	Average of the second two of three BP readings
Independent Variables	
Migration Status	0–Current usual residence inside the AHDSS site (ref.) 1–Current usual residence outside of the AHDSS site
Current Residence	0–Agincourt HDSS (ref.) 1–Tembisa 2–Pretoria 3–Daveyton 4–Witbank 5–Mamelodi 6–Germiston 7–Other South Africa
Covariates	
Age group (years)	0–18-24 (ref.) 1–25-29 2–30-34 3–35 +
Educational status	0–No schooling, primary school only, or did not complete high school (ref.) 1–Completed high school or has any higher education
Employment	0–Unemployed or Inactive in the labor market (ref.) 1–Employed full or part time in any sector
Household members	Number of members in the household, excluding the participant
Chronic Illness	0–Has not been diagnosed with a chronic illness (ref.) 1–Has been diagnosed with a chronic illness
Fast Food Consumption	0–Never or rarely (less than once per week) consumes fast food (ref.) 1–Consumes fast food at least once per week
Alcohol Consumption	0–Never or rarely (less than once per week) consumes alcohol (ref.) 1–Consumes alcohol at least once per week
Healthcare access	0–Accessed healthcare a year or more ago (ref.) 1–Accessed healthcare within the last year
Body mass index	Calculated from height and weight measurements according to the standard BMI formula
Potential Mediators	
Number of Children	Number of children under age 15 as of 1 January 2018
Headship	0–Respondent not the household head (ref.) 1–Respondent self-reports being household head
Social Support	0–Has no family or friends living nearby (ref.) 1–Has at least one family or friend living nearby
Prior Migration	Number of prior migration spells lasting 6+ months since age 15
Informal Housing	0–Respondent resides in formal housing (ref.) 1–Respondent resides in any type of informal housing

3. Method

We stratify all analyses by sex. An initial pooled model fully interacted by sex (Table 1, supplemental appendix) indicated potentially important differences in migrant status and covariates by sex, which led us to employ a sex-stratified approach. In this study, we measure and report biological sex, but we interpret any observed sex differences as resulting from gendered migration systems and experiences. Thus, we use "sex" when reporting our findings, and "gender" in our interpretation of the findings. This language-use is consistent with our interest in the psycho-social (rather than biological) correlates of elevated BP. We present descriptive statistics for this sample by sex and migration status (Table 2). In Table 3, we present results from OLS regressions. For men and women separately, we present three models: a migrant-only model, a model with the full set of covariates, and third model with migration decomposed into current residence location. We then check the robustness of the migration-BP estimates to the inclusion of potential mediators in Table 4A (men) and Table 4B (women). We verify these results with formal mediation analysis using Karlson-Holm-Breen (KHB) method and report the results in supplemental tables 6A (men) and 6B (women) in the appendix. We report statistically significant results at one and five percent significance levels, and marginally significant results at the ten percent level.

4. Results

4.1. Descriptive results

The male and female samples do not differ markedly in terms of their age distributions or secondary education completion status, but more than half of men are employed (52.1%) compared with less than a third of women (29.3%; Table 2). About half the sample completed secondary school, split nearly evenly by sex. Women live in larger households with an average of 4.2 members (not including themselves) compared with 3.0 members among male respondents. Men and women differ appreciably in terms of key health behaviors and health outcomes. More men than women consume alcohol (36.3% vs 2.5%) and consume fast food (25.8% vs 16.0%). Women report chronic illness with greater frequency than men (18.9% vs 7.03%), and report accessing healthcare in the past year more often (72.2% vs 36.2%). Mean BMI is 23.4 kg/m^2 among men and 27.7 kg/m^2 among women. Average BP for men and women is 128.8/78.4 mmHg and 120.5/77.0 mmHg respectively.

About a third of men (35.8%) are migrants (residing now outside of the origin community) compared with a quarter (24.4%) of women. By far the most common destination location among migrants is Tembisa, a township located northeast of Johannesburg in the Gauteng province. Tembisa houses 4.8% of women and 7.8% of men in the MHFUS sample, representing 19.2% and 21.8% of female and male migrants. Other top destinations include Pretoria (6.0% of female and 5.8% of male migrants), Daveyton (6.8% of female and 4.8% of male migrants), Witbank (8.3% of female and 10.1% of male migrants), Mamelodi (4.1% of female and 3.2% of male migrants) Germiston (3.0% of female and 4.8% of male migrants). Thus, we observe that while there are sex differences in destination community, these are modest. Men have more prior migration experience than women: women on average experienced 0.7 previous migration spells (5th percentile = 0; 95th percentile = 2) and men experienced 0.9 (5th percentile = 0; 95th percentile = 3). Men report fewer children (0.7) than women (1.2) and nearly half of the men in the sample are the household head (47.2%) compared with less than a quarter of women (22.3%). Most men (71.4%) and women (76.8%) report having social support in the form of a family member or friend nearby where they live. Few respondents live in informal housing—with slightly more men reporting an informal living arrangement (5.6%) compared with women (3.0%). All respondents who report living in

Table 2
Descriptive Statistics of Baseline Migrant Health Follow-Up Study Sample, by sex and by migrant status.

	Women (N = 1096)	Men (N = 1067)	p-value	Migrants (N = 648)	Nonmigrants (N = 1515)	p-value
	Mean (SD)/Percent	Mean (SD)/Percent		Mean (SD)/Percent	Mean (SD)/Percent	
Sex						$p < 0.001$
Female				41.4	54.4	
Male				58.6	45.6	
Age Group			NS.			$p < 0.001$
18–24	33.3	34.0		25.0	37.3	
25–29	24.5	28.2		32.1	23.8	
30–34	23.7	22.4		25.2	22.1	
35+	18.5	15.5		17.8	16.8	
Completed High School	52.5	55.3	NS.	72.7	45.9	$p < 0.001$
Employed	29.3	52.1	$p < 0.001$	64.0	30.5	$p < 0.001$
Household Members	4.2 (2.7)	3.0 (2.7)	$p < 0.001$	1.4 (1.8)	4.6 (2.7)	$p < 0.001$
Chronic Illness Diagnosis	18.9	7.03	$p < 0.001$	6.2	13.7	$p < 0.001$
Consumes Fast Food	16.0	25.8	$p < 0.001$	27.5	18.0	$p < 0.001$
Consumes Alcohol	2.5	36.3	$p < 0.001$	23.6	17.3	$p < 0.05$
Healthcare access in past 12 months	72.2	36.2	$p < 0.001$	50.6	56.0	$p = 0.05$
Average Diastolic BP	77.0 (10.3)	78.4 (10.0)	$p < 0.001$	80.1 (10.4)	76.6 (9.8)	$p < 0.001$
Average Systolic BP	120.5 (13.2)	128.8 (11.7)	$p < 0.001$	126.9 (14.2)	123.7 (12.6)	$p < 0.001$
BMI	27.7 (6.4)	23.4 (4.3)	$p < 0.001$	25.9 (5.7)	25.5 (6.0)	N.S.
Migrant	24.4	35.8	$p < 0.001$	100.0	0.0	
Current Residence			$p < 0.001$			
Agincourt AHDSS	75.6	64.2		0.0	100.0	
Tembisa	4.8	7.8		21.0		
Pretoria	1.5	2.1		5.9		
Daveyton	1.6	1.7		5.6		
Witbank	2.0	3.6		9.3		
Mamelodi	0.91	1.1		3.4		
Germiston	0.73	1.7		50.9		
Other South Africa	12.86	17.7				
Prior Migration Spells	0.66 (0.81)	0.94 (1.0)	$p < 0.001$	1.6 (0.83)	0.45 (0.73)	$p < 0.001$
Number of Children	1.2 (1.0)	0.71 (0.9)	$p < 0.001$	0.9 (0.95)	1.0 (1.0)	N.S.
Household Head	22.3	47.3	$p < 0.001$	71.8	18.8	$p < 0.001$
Social Support	71.4	76.8	$p < 0.05$	87.6	82.1	$p < 0.05$
Informal Housing	3.0	5.6	$p < 0.05$	14.4	0	$p < 0.001$

Table 3
Regression results: Diastolic Blood Pressure - migration status by sex.

	Male						Female					
	1		2		3		4		5		6	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Migrant	2.889***	0.628	0.128	0.762			3.795***	0.787	4.315***	0.860		
Current Residence (ref. AHDSS)												
Tembisa					1.35	1.152					7.026***	1.875
Pretoria					−1.93	1.561					4.131	2.980
Daveyton					0.173	2.163					2.801	2.290
Witbank					0.553	1.659					6.006**	2.658
Mamelodi					−2.253	2.44					6.719*	3.656
Germiston					1.897	1.868					5.08***	1.631
Other					−0.286	0.935					3.042***	0.979
Age (ref. 18–24)												
Age 25–29			3.5***	0.717	3.441***	0.721			1.247*	0.737	1.211	0.740
Age 30–34			4.712***	0.859	4.597***	0.868			4.741***	0.886	4.716***	0.884
Age 35+			5.373***	1.005	5.339***	1.002			5.591***	0.881	5.617***	0.878
Completed Highschool (ref. did not complete)			0.276	0.61	0.216	0.616			−0.104	0.647	−0.259	0.656
Employed (ref. not employed)			−0.721	0.664	−0.788	0.668			−1.692**	0.717	−1.654**	0.718
Household members			−0.322**	0.127	−0.33***	0.127			0.082	0.124	0.092	0.123
Body Mass Index			0.541***	0.076	0.555***	0.077			0.420***	0.049	0.415***	0.050
Chronic Illness (ref. no chronic illness)			−1.248	1.193	−1.318	1.211			0.387	0.842	0.374	0.839
Healthcare Access in past 12 months (ref. no access)			0.755	0.633	0.797	0.636			−0.548	0.678	−0.575	0.665
Consumes Fast Food (ref. rarely consumes)			−0.431	0.665	−0.402	0.674			1.109	0.823	1.226	0.812
Consumes Alcohol (ref. rarely consumes)			2.108***	0.598	2.052***	0.600			0.0245	1.851	0.334	1.815
Constant	77.373***	0.381	63.165***	1.748	62.995***	1.772	76.134***	0.338	62.23***	1.712	62.38***	1.71
Observations	1067		1067		1067		1096		1096		1096	
R-squared	0.020		0.158		0.161		0.027		0.167		0.174	

Standard errors are in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.
Note: Regressions are weighted.

Table 4A
Regression results: Diastolic Blood Pressure - mechanisms, men.

	1		2		3		4		5		6	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Migrant	0.128	0.762	0.048	0.763	−0.444	0.811	−0.026	0.784	0.111	0.762	−0.138	0.789
Number of children			0.989***	0.373								
Headship					1.798**	0.853						
Social Support							−0.548	0.693				
Prior Migration									−0.21	0.355		
Informal Housing											1.828	1.308
Constant	63.165***	1.748	63.536***	1.737	62.648***	1.756	63.593***	1.847	63.202***	1.751	63.091***	1.744
Observations	1067		1067		1067		1067		1067		1067	
R-squared	0.158		0.164		0.161		0.158		0.158		0.159	

***p < 0.01, **p < 0.05, *p < 0.1.
Note: Regressions are weighted; models control for full set covariates.

Table 4B
Regression results: Diastolic Blood Pressure - mechanisms, women.

	1		2		3		4		5		6	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Migrant	4.315***	0.86	4.304***	0.858	3.953***	0.894	4.292***	0.875	4.328***	0.861	4.675***	0.913
Number of children			−0.103	0.331								
Headship					1.735**	0.858						
Social Support							−0.136	0.697				
Prior Migration									0.902*	0.492		
Informal Housing											−2.775	1.709
Constant	62.23***	1.712	62.237***	1.71	61.581***	1.762	62.319***	1.777	62.056***	1.721	62.131***	1.718
Observations	1096		1096		1096		1096		1096		1096	
R-squared	0.167		0.167		0.17		0.167		0.17		0.169	

***p < 0.01, **p < 0.05, *p < 0.1.
Note: Regressions are weighted; models control for full set covariates.

informal housing are migrants.

Migrants and non-migrants differ in important dimensions, driven in part by the sex composition of the sample described above. More migrants are male (54.5%). Migrants are also older and have higher socioeconomic status. Most migrants completed secondary school (72.7%) and are employed (64.0%) compared with fewer than half of non-migrants graduated (45.9%) and employed (30.5%). Migrants also live in significantly smaller (1.4 members) households than non-migrants (4.6 members) on average. Migrants are less healthy than non-migrants across most dimensions: migrants consume more alcohol (23.6% vs. 17.3%) and fast food (27.5% vs.18.0%), they have higher systolic and diastolic BP (126.9/80.1 mmHg vs. 123.7/76.6 mmHg), and fewer migrants have accessed healthcare in the past year compared with non-migrants (50.6% vs. 56.0%). Current migrants have more prior migration experience (1.6 migration spells) than non-migrants (0.45 migration spells). Whereas only 18.8 percent of non-migrants are heads of their households, 71.8% of migrants report headship in their destination household. There is no difference in the reported number of children between migrants and non-migrants. Most of the sample reports having social support—with the share reporting a nearby friend or family member slightly higher among migrants (87.6) than among non-migrants (82.1).

4.2. Regression results

Table 3 presents OLS regression results of three models each for men (models 1–3) and women (models 4–6): a migration-only model, a fully adjusted model with a dichotomous indicator for migration status, and a fully adjusted model with migration operationalized as current residence. In the migration-only models, migration is significantly associated with elevated diastolic BP among both men (Table 3, model 1) and women (Table 3, model 4). Migration status is associated with 2.9 mmHg higher diastolic BP among men and 3.8 mmHg higher diastolic BP among women ($p < 0.01$). Once covariates are included in the model, the association between migration and BP is reduced to 0.13 mmHg and is no longer statistically significant in the male sample (Table 3, model 2). Among women, the relationship between migration status and BP remains highly significant with the addition of covariates (Table 3, model 5): migration is associated with 4.3 mmHg higher BP controlling for age, high school completion, employment status, household size, BMI, chronic illness, recent healthcare access, fast food and alcohol consumption ($p < 0.01$).

Of the covariates included, older age and higher BMI are significantly associated with higher BP among both men and women. Among women, employment is inversely associated with BP whereas larger household size is inversely associated with BP among men. Alcohol consumption is associated with 2.11 mmHg higher diastolic BP among men ($p < 0.05$) and is not significantly associated with BP among women.

The dichotomous migration variable is decomposed into current residence location in Table 3, models 3 and 5. This alternative model specification captures the relationship between specific urban locations and BP, net of controls. Consistent with the dichotomous migration specification, there is no association with current residence and BP among men. In contrast, among women, residence in Tembisa, Witbank, and Germiston is associated with elevated BP. Residence in Tembisa is associated with the greatest elevation in BP with 7.0 mmHg higher BP compared with residing within the AHDSS ($p < 0.01$); residence in Witbank is associated with 6.0 mmHg higher BP ($p < 0.05$) and residence in Germiston is associated with 5.1 mmHg higher BP ($p < 0.01$). The relationship between residence in Mamelodi and BP is marginally significant ($p < 0.1$).

4.2.1. Potential mediators

Table 4A (men) and Table 4B (women) show OLS regressions that examine the robustness of the results presented in Tables 2 and 3 to the addition of potential mediators, each added to the fully adjusted dichotomous migration models in Table 3. For men, the number of children and household headship are statistically significant and reduce the coefficient on the migration variable from 0.13 to 0.05 and -0.4 respectively. Among men, each additional child is associated with 1 mmHg higher BP ($p<0.05$). Headship is associated with 1.8 mmHg higher BP compared with not being the household head ($p<0.05$), all else constant.

For women, only household headship (Table 4B, model 2) is significantly associated with elevated BP. Headship for women is associated with 1.7 mmHg higher BP ($p < 0.05$) compared with not being the household head, all else constant. Inclusion of headship reduces the migrant coefficient from 4.3 mmHg to 4.0 mmHg. Prior migration experience is marginally significant (Table 4B, model 5) and its inclusion slightly increases the coefficient on the migration variable. Across all models and mechanisms, migrant status remains robustly associated with elevated BP and statistically significant for women.

4.3. Robustness checks

Results from formal mediation analysis (Tables 6A and 6B, supplemental appendix) largely echo the regression results in Tables 4A and 4B: only headship significantly mediates the migration-BP relationship among women. We also conduct median regressions for both systolic and diastolic BP to examine the sensitivity of our estimates to the distribution of BP values (not shown). We find that the migration-BP relationship in terms of diastolic BP remains robust, but that the relationship might be more sensitive to asymmetry in terms of systolic BP. Specifically, clusters of elevated systolic BP among migrant women, and clusters of low systolic BP among men in part drive the migration systolic-BP findings. We also repeat the analysis using logistic regression with hypertension (defined as having BP $\geq$ 140/90 mmHg or on anti-hypertensive medication) as the outcome instead of OLS regression and a continuous BP variable (Table 3, supplemental appendix). The results are robust: female migrants have 2.3 times the odds of being hypertensive as men ($p < 0.01$), all else constant. There is no significant association between migration status and hypertension among men once covariates are included in the models. We prefer the continuous outcome because this specification captures elevations in BP that may not cross the hypertension cutoff in this relatively young 18–40 age group – including those who are prehypertensive and may become at risk for hypertensive diseases as they age.

5. Discussion

South Africa, like other LMICs, is facing a double burden of disease with high levels of infectious diseases and a rise in NCDs. Elevated BP is one risk factor for cardiovascular disease that is of increasing public health concern. Two national surveys, South Africa's 2012 National Health and Nutrition Examination Survey and the 2016 Demographic and Health Survey reported hypertension prevalence of 38.4% and 48.2% (Kandala et al., 2013), with significantly greater hypertension in KwaZulu Natal and Mpumalanga (the AHDSS study site location) provinces and in urban participants. Strikingly, even in younger age groups (24–35), average BP is pre-hypertensive (Shisana et al., 2013). Sex differences in hypertension have also been observed using data from the National Income Dynamics Study (Cois and Ehrlich, 2014). Our paper echoes these findings and shows the social determinants of elevated BP differ by sex in South Africa. We contribute that migration is uniquely consequential for BP among women in transitioning contexts like South Africa. We further extend current knowledge by testing a series of mechanisms proposed in the sociological literature and find that none of these factors adequately explains the BP penalty migrant women experience.

Descriptively, men's BP is higher on average than women's, but in a multivariate framework, migration is not significantly associated with elevated BP among men either as a dichotomous indicator of migration status or operationalized as place of current residence. Men's BP is, however, sensitive to headship, total household size, and the presence of children. Having a larger number of adult household members might reduce the stress of economic provision since income sources may be more diversified, but a larger number of children fathered likely means more financial responsibility. Alternative specifications (not shown) indicate that sending remittances is associated with lower BP among men. These associations suggest that there is likely an important relationship between economic provision and health for young men.

In contrast, women's BP is sensitive to migration status with evidence of place-specific variation in BP. Residing in Tembisa is associated with diastolic BP that is a striking 7.0 mmHg higher than for women who reside in the AHDSS. Notably, there is no evidence that residence in Tembisa is associated with elevated BP among men, despite that a similar share of female and male migrants reside there. Tembisa is South Africa's second largest township after Soweto, located 18 miles northeast of South Africa's largest city Johannesburg. Tembisa covers an area of 12.5 square miles and houses nearly half a million people. Tembisa is home to a demographically heterogeneous and socio-economically diverse community that contains pockets of severe multidimensional poverty (Mushongera et al., 2017). With high population density, unemployment, and crime, as well as potential transport challenges given the location of the township on the periphery of the city (COGTA, 2020), Tembisa may present a particularly stressful urban environment. That residence in Tembisa matters differentially by sex suggests that women's health might be particularly vulnerable to contextual factors associated with township residence such as violence and crime, lack of services, or sparse social networks – although without more geographic and qualitative detail it is difficult to parse which aspects matter most. Finally, as expected, female household headship likely reflects greater responsibility and potential psychosocial stress, which may manifest as higher diastolic BP. Notably, these nuances in sex-specific associations of men and women's BP are obscured in pooled analyses that examined both men and women simultaneously.

In terms of migration, we find for women that rural-urban migration has a large, robust, and independent association with BP, net of age, SES, health, and health behavior controls. This result is consistent with findings that examine geographic mobility using nationally representative panel data in South Africa (Pheiffer, 2021). While men in the MHFUS have, on average, higher BP than women, female migrants suffer a health penalty that is not evident for men once household characteristics and health behaviors are taken into account. In testing whether various mechanisms related to household and family composition, migration experience, housing, and social support mediate this sex-specific BP-migration relationship, we find that none of the factors examined fully explain the health penalty migrant women exhibit in terms of BP when compared with rural-staying women. Indeed, the size of the coefficient and strength of the significance is somewhat attenuated, but the direction, magnitude, and significance persist.

With baseline data, we cannot eliminate the possibility that the BP penalty among migrant women is driven by selection processes. Other studies have found evidence of negative health selection among women in LMICs (Kendall and Anglewicz, 2018), but primarily with reference to HIV status. It remains possible that women with high BP are more likely to move, but we find no evidence that women disproportionately migrate for reasons of poor health; only one respondent in the baseline MHFUS survey reported health ("sickness") to be the primary reason for any—both current and past—moves out of the AHDSS. Selection on elevated BP among female migrants might represent a stress response to undesirable rural living conditions, thwarted aspirations, or rejection of traditional gender roles present in rural areas that increase the probability of migration. Indeed, some have argued that rural women in South Africa are the most disadvantaged in both their families and communities (Kehler, 2001). Still, the men and women in our sample all have origins in the same rural district; thus, selection on heterogeneity across wide-ranging rural territory is of less concern. In addition, because this health penalty exists across different reasons for migration (not shown) it is unlikely that the average migration experience among women across all reasons for migration is produced by unhappy or unfavorable rural-origin conditions unique to women. More research is needed on the gendered dimensions of migrant *selection* to be able to untangle selection processes from the effect of migration on women's health.

It is also plausible that migration is associated with a large and significant increment in women's BP independent of the covariates examined in this paper. There is likely an intricate interplay of gender norms, expectations, and behaviors that govern the process of migration in South Africa (Pedraza, 1991; De Jong, 2000; Camlin et al., 2014) with marked implications for women's health. We suggest that migration is a previously understudied risk factor for hypertension among women in transitioning contexts like South Africa. This is consistent with findings from multi-site research that finds health disadvantages (in terms of mortality) among migrant women who return to rural areas (Ginsburg et al., 2016). Qualitative studies of internal migrants in urban informal settlements in South Africa have highlighted migrants form attachments to urban destination places for economic and material reasons, but they also remain deeply attached to rural origin places for reasons of history, ancestry, family, and culture. Urban residence—especially where social networks are limited—can render migrants feeling isolated and unmoored from cultural practices that provide comfort and stability. This dislocation may be more severe for female migrants. While migration is a common experience for rural young people—and perhaps even important for prestige, rural origin places remain "home" even among many long-time urban residents (Njwambe et al., 2019; Bank, 2015).

Poverty and unemployment in rural origin communities often "push" migrants toward cities, but urban insecurity and nostalgia produce strong and continuing attachment to origin places. Some qualitative evidence suggests that returning home might be easier for women if they struggle in urban destinations than for men because expectations to provide for the rural household is less burdensome for women (Njwambe et al., 2019), but women are arguably more vulnerable to crowded, unsanitary, unsafe, and stressful urban living environments that produce social isolation. Women might also continue to bear responsibilities of caring for children, parents, and parents-in-law in rural households while they are in urban destination places—stress-producing physical and emotional work that may not be adequately captured by measures of family and household composition (Hatch and Posel, 2018). If women are expected to make more frequent visits home, their patterns of migration might also be characterized by more transitions into—and out of—migration (Williams et al., 2011). Our analyses suggest that prior migration is associated with elevated BP among women, all else constant (Table 4B, model 5). This might be because stressors associated with repeated returns to rural areas might induce future migration, or that repeat migration produces greater stress through increased residential instability. Future longitudinal data will allow us to untangle the gender-specific nature of these processes – and help us to understand the health implications associated with rural-to-urban coming-and-going for women.

The MHFUS study provides needed health data on an understudied population that is uniquely vulnerable to psychosocial stressors due to social and physical dislocation, new and chronic nutritional exposures, and disruptions in healthcare. The anthropometry and BP information collected in MHFUS offer rare insight into objective measures of health. A limitation of these data is that we have measured urban exposure as the number of 6+ month migration spells, which might not capture exposure adequately for those who have one long migration spell rather than several shorter ones. With these baseline data we have also not captured long term patterns of diet and physical activity, which is important for understanding BP. Nevertheless, the extensive socio-economic, health, and migration information collected by MHFUS is unparalleled in most LMIC contexts in what it can tell us about the relationship between migration and health. Further rounds of the survey will yield the data necessary to analyze these important aspects, and changes over time.

In general, there is little empirical work to guide how female internal migrants experience social and emotional dislocation from rural origin communities because of migration; the migration literature has not yet studied what expectations fall on female migrants in the same way it has for male migrants. Future work on this topic might investigate how gender structures expectations on young people when they migrate, and how gender norms about caring for family members or participating in family/household rituals affect male and female migrants differently. More knowledge about the unique contours of women's vulnerabilities and the structure of their social networks are likely to be particularly fruitful dimensions for elucidating how gender structures health outcomes for migrants in contexts like South Africa.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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