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Effect of rural-to-urban within-country migration on cardiovascular risk factors in low and middle income countries: A systematic review

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Abstract

Context—Limited information is available of effects of rural-to-urban within-country migration on cardiovascular (CV) risk factors in low and middle income countries (LMIC).

Objective—We performed a systematic review of studies evaluating these effects and having rural and/or urban control groups.

Study Selection—Two teams of investigators searched observational studies in MEDLINE, Web of Science and Scopus until December 2010. Studies evaluating international migration were excluded.

Data Extraction—Three investigators extracted the information stratified by gender. We captured information on 17 known CV risk factors.

Results—Eighteen studies (n=58,536) were included. Studies were highly heterogeneous with respect to study design, migrant sampling frame, migrant urban exposure, and reported CV risk factors. In migrants, commonly reported CV risk factors –systolic and diastolic blood pressure, body mass index, obesity, total cholesterol, and LDL– were usually higher or more frequent than the rural group, and usually lower or less frequent than the urban group. This gradient was usually present in both genders. Anthropometric (waist-to-hip ratio, hip/waist circumference, triceps

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skinfolds) and metabolic (fasting glucose/insulin, insulin resistance) risk factors usually followed the same gradient, but conclusions are weak due to information paucity. Hypertension, HDL, fibrinogen and C-reactive protein did not follow any pattern.

Conclusions—In LMIC, most but not all CV risk factors have a gradient of higher or more frequent in migrants than in the rural groups but lower or less frequent than the urban groups. Such gradients may or may not be associated to differential CV events and long-term evaluations remain necessary.

Keywords

emigration and immigration; cardiovascular system; risk factors; income; meta-analysis as topic

INTRODUCTION

Non-communicable diseases (NCDs) kill people mostly in low- and middle-income countries (LMIC).[1] The Grand Challenges report highlights the need to study the impact of poverty and urbanization on NCDs.[2] Urbanization is occurring at a fast rate in LMIC, which may be associated with less physical activity, poorer nutritional habits, and rapidly growing prevalence of cardiovascular (CV) risk factors, CV disease (CVD) and other NCDs.[3] Rural-to-urban migration is one of the key larger drivers of urbanization in LMIC. Thus, the evaluation of the impact of rural to urban migration on CV risk factors is relevant due to its huge public health consequences.

The effect of international migration to developed countries on CV risk factors and CVD has been systematically studied.[4] As a result of the unique pattern and rate at which migration is occurring within LMIC, international migration results cannot be inferred to these settings. In LMIC, differences in design and patient characteristics make it difficult to reach a definitive conclusion on the effects on CV risk factors [5-9]. Also, it is not known whether the effect of rural to urban migration is uniform across CV risk factors and across LMIC. Finally, the effect on emerging CV risk factors such as fibrinogen, HOMA insulin resistance, or C-reactive protein could also be evaluated in the most recent studies.

We conducted a systematic review of observational studies evaluating the effect of rural-to-urban within-country migration on CV risk factors in LMIC. We hypothesized that migrants would have a worse CV risk profile than rural individuals and better CV risk profile than urban individuals.

METHODS

Study selection

A comprehensive literature search using PubMed-Medline, The Web of Science, and Scopus until December 31, 2010 was conducted. The following keywords were used: migration, emigration, immigration, residential mobility, transient and migrants, rural population, urban population, cardiovascular risk factors and cardiovascular disease. The search strategy of PubMed is available in the Appendix (Web only). We searched observational studies published in any language, performed in LMIC as defined by the World Bank.[10] We excluded studies of international migration or those from high income countries. A formal protocol was developed for this project.

Rural to urban migration was defined as the individual's self-report or objective information of birth in a rural setting and, at the time of the study, self-report or objective ascertainment of urban residence. Three types of control groups were possible: a) a rural comparison

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group, where migrants originated from the same area, b) an urban comparison group, where migrants share the same urban environment and c) both a rural and an urban comparison group. This strategy excluded studies focusing only on differences between rural and urban settings. Sampling frames for migrants were classified as: i) random sample of migrants from urban population, ii) cohort of people born in a rural area who moved to an urban area and were traced, iii) rural individuals selected and their family members followed up in urban area (sib-pair); and iv) population level survey where migration was based on a retrospective question ("were you born here?").

A list of retrieved articles was reviewed independently by 2 groups of investigators based in USA and Peru in order to choose potentially relevant articles, and disagreements were discussed and resolved. When multiple articles for a single study had been published, we used the most relevant publication and supplemented it, if necessary, with data from the other publications.

Data extraction

Data extraction was performed independently by 3 investigators (AVH, VP, AD). Disagreement was resolved by consensus. Using a standardized data extraction form, we collected information on lead author, year of study or publication year, study design, sample size, sampling frames for migrants, length of urban exposure, age of migration, average age, percentage of male participants, and 17 CV risk factors for migrants and control groups.

Outcomes

CV risk factors we collected were systolic blood pressure (SBP), diastolic blood pressure (DBP), hypertension; total cholesterol (TC), low density lipoprotein (LDL) cholesterol, high density lipoprotein (HDL) cholesterol; body mass index (BMI), obesity; triceps skinfolds thickness, waist circumference, hip circumference, waist-to-hip ratio (WHR); fibrinogen, C-reactive protein (CRP); fasting glucose, fasting insulin, and homeostasis model assessment (HOMA) scores, a validated measure of insulin resistance. Extracted information was stratified by gender. In the case of repeated measures, extracted information corresponded to the longest follow-up.

Study quality assessment

The order of quality of studies was considered as follows: 1) prospective cohort study, 2) retrospective cohort study, 3) case-control study, and 4) cross-sectional study. Also, we systematically assessed other key points of study quality proposed by the MOOSE collaboration.[11] These key points were: 1. clear identification of study population, 2. clear definition of outcome and outcome assessment, 3. independent assessment of outcome parameters (i.e. ascertainment of outcomes done by researchers other than the ones involved in the study), 4. selective loss during follow-up, and 5. important confounders and/or prognostic factors identified. Each point was rated as Yes/No. If the description was unclear, we considered that this as 'no'.

Statistical analysis

Our systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement.[12] Differences between migrants and either rural or urban control groups are shown as absolute differences (i.e. migrant minus control) and its 95% Confidence Intervals (CI) for both continuous and categorical CV risk factors. Non-normally distributed risk factors were described in some studies as geometric means, and we extracted them as published.

A high degree of heterogeneity among studies was expected and therefore we did not combine all studies in a formal meta-analysis. Taking into account the sources of heterogeneity, three subgroup meta-analyses were pre-specified: 1. studies with similar characteristics including cross sectional design, random sampling frame, and >5 years of urban exposure; 2. cross-sectional studies; and 3. studies published after 1990. Subgroup meta-analyses were stratified by gender, as differences were expected between genders.

DerSimonian and Laird random effects models were used for meta-analyses.[13] For dichotomous CV risk factors, we used the Mantel-Haenzel (M-H) method to calculate pooled odds ratios (OR) and 95% CIs. For continuous CV risk factors, we used the Inverse Variance method to calculate Mean Differences (MD) and 95% CIs. Statistical heterogeneity was evaluated with the Cochran Chi-square (χ^2) and the I^2 statistics. Funnel plots were used to evaluate publication bias for the meta-analyses. All analyses were stratified by gender. We used Review Manager (RevMan 5.0, Oxford, UK; The Cochrane Collaboration, 2008).

RESULTS

Study Characteristics

A total of 394 citations were identified and screened, of which 80 were retrieved for detailed assessment. Of these, 62 did not fit our criteria (Figure 1). Thus, 18 studies were chosen in the qualitative synthesis,[5-9,14-26] including 58,536 individuals (Table 1). Studies included mostly adults, with very few individuals <15 years-old.

Fourteen studies were cross-sectional, one was a retrospective cohort,[26] and three were prospective cohorts.[7,17,23] Studies were heterogeneous with respect to several characteristics. These studies were reported between 1964 and 2010. Fifteen studies compared the migrant group to the rural control group, and nine studies reported the years of urban exposure for the migrant group (urban exposure ≥ 6 months, and mostly >5 years). Sampling frames for migrants were also heterogeneous: random sampling in eight studies, a traced cohort in six studies, a population survey in three studies, and a sib-pair strategy in one study.

All studies clearly identified the study population and defined the outcome and outcome assessment (Table 1w, Web only). None of studies independently assessed the outcomes, and four studies had a selective loss of patients during follow-up.[7,17,23,26] Six studies identified important confounders or prognostic factors[6,8,9,18,25,26] and adjusted the association between migration and the CV risk factors.

The most commonly reported CV risk factors were SBP (13 studies), DBP (13 studies), hypertension (11 studies), BMI (11 studies), obesity (four studies), TC (six studies), LDL (five studies) and HDL (four studies). Hypertension was defined as BP ≥140/90 in only six studies, all of them published after 1990. Other CV risk factors including WHR, waist and hip circumference, triceps skinfolds, fasting glucose and insulin, HOMA scores, fibrinogen and CRP, were reported by fewer studies.

Effect of rural-to-urban migration on commonly reported CV risk factors

In most of the studies, values or rates in migrants were higher than the rural group, and lower than the urban group. Nine out of 12 studies showed higher SBP levels in migrants vs. rural (range 0.9 to 11.9 mmHg, significant differences in seven), and five out of six studies shower lower SBP in migrants vs. urban (range −0.2 to −8.3 mmHg, significant differences in two) (Table 2). Ten out of 12 studies reported higher DBP in migrants vs. rural (range 1.5 to 13.9 mmHg, significant differences in nine), and three out of five studies showed lower

DBP in migrants vs. urban (range −1.2 to −4.9 mmHg, significant differences in two) (Table 3). Eight out of nine studies showed higher hypertension rates for migrants vs. rural (range 2.3% to 25.3%, significant differences in five), and two out of four studies reported non-significant lower hypertension rates for migrants vs. urban (range −0.7% to −16.6%) (Table 2w, Web only).

Nine out of 10 studies reported higher BMI values in migrants vs. rural (range 0.2 to 3.8 kg/m^2, significant differences in six), and all of the four studies showed significant lower BMI values in migrants vs. urban (range −0.3 to −1.3 kg/m^2) (Table 4). Two studies showed higher obesity rates in migrants vs. rural (range 0.2% to 18.1%, one with significant differences), and two studies showed significant lower obesity rates in migrant vs. urban (range −3.9% to −13.1%) (Table 3w, web only).

All of the five studies showed higher TC levels in migrants vs. rural (range 4.0 to 35.1 mg/dL, significant differences in four); all of the three studies showed non-significant lower TC levels in migrants vs. urban (range −1.9 to −4.1 mg/dL) (Table 4w, Web only). Three out of four studies reported significantly higher LDL levels in migrants vs. rural (range 5.3 to 30.3 mg/dL); two out of three studies reported non-significant lower LDL levels in migrants vs. urban (range −1.0 to −3.9 mg/dL) (Table 5w, Web only). Finally, two out of three studies showed lower HDL levels in migrants vs. rural (range −0.1 to −1.8 mg/dL, one significant difference); one out of two studies showed lower HDL levels in migrants vs. urban (absolute difference 1.2 mg/dL) (Table 6w, Web only).

Effect of rural-to-urban migration on uncommonly reported CV risk factors

In two studies[8,9] WHR values in migrants were significantly higher than in the rural and urban (range 0.01 to 0.06, and −0.01, respectively). Three studies[7,9,20] showed larger waist circumference levels in migrants vs. rural (range 0.6 to 12.0 cm, significant differences in two); one study[9] showed shorter waist circumference levels in migrants vs. urban (difference −3.3 cm, 95% CI −1.4 to −5.2). In one study,[9] a significant larger hip circumference was shown in migrants vs. rural (difference 7.0 cm, 95% CI 6.1-8.0) and significant shorter hip circumference in migrants vs. urban (difference −4.5 cm, 95% CI −2.9 to −6.1). Two studies[9,16] showed larger triceps skinfolds thickness in migrants vs. rural (range 0.1 to 10.9 mm, one significant difference); one study reported significantly shorter triceps skinfolds thickness in migrants vs. urban (difference −8.9 mm, 95% CI −5.5 to −12.3).

Two out of three studies[7,9,20] reported higher mean or geometric mean glucose values in migrants vs. rural; two studies[9,24] reported lower mean or geometric mean glucose values in migrants vs. urban. Three studies[8,9,20] showed higher mean or geometric mean fasting insulin levels in migrants vs. rural; two of the studies[8,9] also showed lower fasting insulin levels in migrants vs. urban. The mean or geometric means of HOMA scores were significantly higher in migrants vs. rural in two studies;[9,20] in one study[9] the geometric mean of the HOMA score was significantly lower in migrants vs. urban. Geometric means of fibrinogen and CRP in migrants were significantly higher vs. rural, and similar to the values in urban.[9]

The observed gradient for most of commonly and uncommonly reported CV risk factors among migrants, rural and urban groups was found in both males and females separately.

Meta-analyses in subgroups of studies

Due to limited availability of CV risk factors, we only included SBP, DBP, and BMI in these meta-analyses. Substantial heterogeneity of effects among studies and no evidence of publication bias were seen in all three sets of meta-analyses.

Five studies[6,92,20-22] fulfilled our first pre-specified criteria of being cross-sectional studies, with a random sampling frame for migrants, and with at least 5 years of urban exposure for migrants. No differences were found between migrants and rural individuals in terms of SBP, DBP or BMI. A pattern of significantly lower SBP (MD −3.5 mmHg, 95% CI −5.6 to −1.4) and lower DBP (MD −3.0 mmHg, 95% CI −4.2 to −1.72) in migrants vs. urban was seen overall and for both males and females.

Fourteen studies were cross-sectional (Table 1) fulfilling our second pre-specified criteria, and thirteen studies were published after 1990 (Table 1) fulfilling our third criteria. Gradients were similar to the overall results for SBP, DBP and BMI on these subgroups.

DISCUSSION

Main findings

Studies conducted in LMIC evaluating the effect of within-country migration on CV risk factors showed substantial heterogeneity with respect to design, sample size, time of urban exposure, migrant sampling frame, and reported CV risk factors between migrants and rural or urban individuals. In general, when observing the absolute differences between migrants and comparison groups, a gradient for most of the commonly reported CV risk factors was noted: higher values or rates in migrants in comparison to rural individuals, and lower values or rates in migrants in comparison to urban individuals. This gradient was also seen in most of the studies when evaluating males and females separately. Nevertheless, against our hypothesis, some CV risk factors such as hypertension rates, HDL, fibrinogen and CRP levels did not follow any gradient.

What the current literature reports

The effect of international migration to developed countries on CV risk factors has been systematically studied by McKay et al.[4] These migrants are exposed not only to increased consumption of saturated fats and sugars and sedentary behavior but also to stressful life conditions. International migrants have poorer health and more disadvantaged CV risk factor profile than non-migrants, and this profile may worsen with increasing duration of stay in the urban environment.

Rural-to-urban within-country migration is a very common phenomenon in LMIC countries,[5] largely due to economic reasons. Its effects on CV risk factors have been poorly studied,[26] mostly for blood pressure/hypertension and BMI/obesity. Even less information is available for lipid profiles[27] or emerging and newer CV risk factors (e.g. CRP, fasting insulin, HOMA scores, fibrinogen).[9]

In the context of LMIC, urban-rural comparisons are of limited relevance in examining the effects of urban migration as the urbanization process in these countries is due to growth of existing urban populations, expansion of urban boundaries, and rural-to-urban migration.[28] Also particular genetic, cultural and life-style backgrounds of migrants and urban individuals further limit the value of urban-rural comparisons. However, several urban-rural comparisons of CV risk factors have been published in the literature. Comparisons of urban and rural areas in sub-Saharan Africa[29] and India[30] showed higher rates of hypertension, obesity and adverse lipid profiles for urban individuals; however, no differences between urban and rural areas for these risk factors have lately been found in China.[31]

What our study adds to current literature

We hypothesized that there would be a gradient with worse CV profile for the urban individuals than for migrants and worse for migrants than for rural individuals. This was the case for most of the CV risk factors; in most cases reported differences were significant. Some CV risk factors such as hypertension rates, HDL, fibrinogen and CRP levels did not follow any gradient. It seems implausible that these CV risk factors are not modified by migration given significant modifications of major risk factors, but recent reports, at least for blood pressure levels, suggest that the patterns of change following migration are very complex and do not necessarily follow the expected gradient.[23,32] An alternative explanation may include the scarcity of studies. Our chosen studies did not evaluate the effect of modified CV risk factors on CV events, and the gradients may or may not be associated to differential CV events across groups in the future. Thus, long-term longitudinal evaluations are necessary.

The gradient urban-migrant-rural for most of CV risk factors seems relevant in the context of studies with substantial heterogeneity. Recognizing the sources of heterogeneity, we secondarily analyzed three subgroups of studies. Cross-sectional and after 1990 subgroups of studies showed similar gradients between urban, migrant and rural as seen in all studies. The subgroup of cross-sectional studies with random sampling of migrants and at least 5 years of urban exposure for migrants showed lower SBP and DBP for migrants in comparison to urban individuals and non-significant differences between migrants and rural individuals. Although subgroup results should be taken with caution as heterogeneity of effects remained significant in all three subgroups of studies, they may highlight potential changes of gradient with longer urban exposure for migrants.

There was a notorious paucity of information on other important anthropometric risk factors (e.g. WHR, hip circumference, triceps skinfolds thickness) or metabolic and inflammation risk factors (e.g. glucose, fasting insulin, insulin resistance scores, fibrinogen, CRP). Our conclusions for these infrequently reported risk factors are weak at this moment and deserve further reevaluation in the future.

Only 6 studies[6,8,9,18,25,26] provided adjusted values of CV risk factors or adjusted estimates of the differences between migrants and controls. Adjusters included age, BMI, gender, socioeconomic status, education, occupation, marital status, physical activity, initial health status, and altitude. Most of these studies were published in 2009 and 2010, with the exception of the Yi Migrant[6] and Yi People[18] studies. Our main and secondary analyses were based on unadjusted values of CV risk factors, and therefore some bias may be present in our association measures between migration groups. Combination of adjusted metrics was not possible given the different sets of confounders adjusted for, the heterogeneity of studies, and the limited number of studies.

Limitations

First, we included studies that were heterogeneous with respect to several characteristics and therefore a meta-analysis of all studies was not possible. Pre-specified subgroups of more homogeneous studies also showed significant heterogeneity and subgroup results should be taken with caution. Second, we evaluated unadjusted differences between groups, as only unadjusted values were published by authors for most of the studies. Few recent studies provided adjusted values for a few of the CV risk factors we used in our analyses. Third, publication bias is always a concern in a systematic review; however we decreased it in our study by having no language restrictions, by using a comprehensive study search strategy in 4 literature engines, and by involving 2 groups of investigators with at least 2 researchers in each group. Fourth, we expect some differences on the effect of within-country migration on

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CV risk factors across different countries and continents. We could not explore this hypothesis given the few numbers of studies available. Finally, the scarcity of reporting of several metabolic and inflammatory risk factors did not allow reaching stronger conclusions of the effect of migration on them.

Conclusions

Studies investigating the effect of rural-to-urban within-country migration on CV risk factors in LMIC are highly heterogeneous. Most of CV risk factors in migrants follow a gradient: higher or more frequent than in the rural groups, and lower or less frequent than the urban groups. Furthermore, some CV risk factors, such as hypertension rates, HDL, fibrinogen and CPR levels did not follow a pattern. Such gradients may or may not be associated to differential CV events across groups and long-term longitudinal evaluations of such associations remain necessary.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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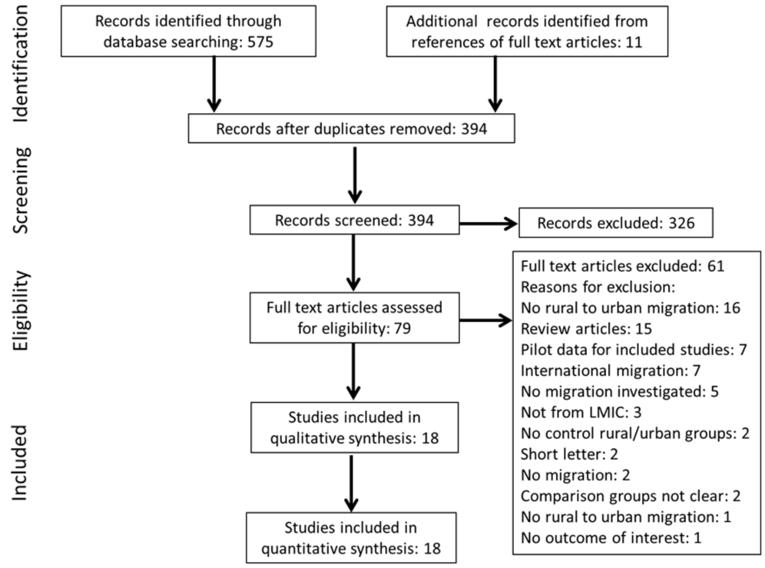

Figure 1.

Search strategy profile of the systematic review.

Table 1

Characteristics of studies included in the systematic review.

Study, Publication year	Years conducted, Country	Total sample	Mean age or age groups / % of young individuals	% Male	Migrant population	Rural population	Urban population	Urban exposure	Study design	Sampling frame	Reported CV risk factors
Cruz-Coke[14], 1964	1962-1963, Chile	179	32.9 6% <20 years-old and 2% <10 years-old	47	A group of Chilean Polynesian population who migrated to mainland Chile	Isolated Chilean Polynesian population living in its own ecological niche	N/A	Not reported	Cross-Sectional	Traced cohort	DBP
Benyoussef[15], 1974	1970, Senegal	469	≤30y: 234 (49%); 31-40y: 113 (24%); >40y: 122 (26%) 22% <20 years-old	52	Random sample drawn from a census of native Serers, from a particular tribe, living in certain parts of Dakar	A cluster-random sample of native Serers living in one of 65 villages in Niakhar county	N/A	Not Reported	Cross-Sectional	Random Sample	BP, cholesterol, weight, hematocrit, mental health
Nadim[5], 1978	1976, Iran	1428	40-49y: 815 (57%); 50-59y: 613 (43%) 0% <20 years-old	40	Cluster-random sample from East Azerbaijan living in West Teheran, Iran	A cluster-random sample of rural areas of East Azerbaijan	A cluster-random sample of non-migrants from East Azerbaijan, living in West Teheran	Not reported	Cross-Sectional	Random Sample	BP, hypertension, obesity (ponderal index)
Poulter[16], 1984	1980, Kenya	1171	≤34y: 571 (49%); 35-54y: 385 (33%); ≥55y: 215 (18%) 0% <20 years-old	41	Random sample of Luo Tribe members originated from Siaya District, Nyanza Province, Kenya, and now living in poor urban slums of Nairobi, Kenya drawn from a census	A random sample of individuals living in Siaya District, Nyanza Province, Kenya	N/A	Not Reported	Cross-Sectional	Traced cohort	BP, BMI, weight, skinfolds
Poulter[17], 1990	1981-1985, Kenya	206	<20y: 260 (41%); 20-29y: 288 (45%); ≥30y: 89 (4%) 1% <15 years-old	60	All individuals who had migrated from ruralWestern Kenya (Luo Tribe) to Nairobi (poor slum communities) on a permanent basis was identified and followed-up in Nairobi, Kenya	Local controls, matched for age and sex, were selected from the same Luo tribe villages	N/A	2y	Prospective Cohort	Traced cohort	BP, weight, pulse rate, serum sodium, and potassium, urine sodium, potassium, and creatinine
He Migrant[6], 1991	1989, China	14505	32.7 0% <15 years-old	61	All Yi people who had migrated to the county seats (Butuo, Meigu and Zhaojue) or Xichang city 5 or more years prior to the survey	A cluster-random sample of Liangshan Yi people from remote mountain districts of Sichuan province, Southwestern China for at least 5 years	A cluster-random sample of Han people residing in Xichang city or Country seats (Butuo, Meigu, Zhaojue)	Median: 10y, Mean: 14.9y	Cross-Sectional	Random Sample	BP, hypertension, BMI, physical activity
He People[18], 1991	1986-1988, China	6618	31.1 0% <10 years-old	53	Yi People and their families employed at a power plant, paper	A cluster-random sample of Liangshan Yi People living in	Han people and their families employed at a	Not reported	Cross-Sectional	Random Sample	BP, BMI, heart rate, nutrient intake,

Study, Publication year	Years conducted, Country	Total sample	Mean age or age groups / % of young individuals	% Male	Migrant population	Rural population	Urban population	Urban exposure	Study design	Sampling frame	Reported CV risk factors
					mill, hospital, middle school, and the government agency, in Puge county seat	remote mountain districts drawn from a census	power plant, a paper mill, a hospital, a middle school, and the government agency in Puge county seat.				electrolyte serum and urine concentrations
Yamauchi[19], 2001	1994-1995, Papua New Guinea	56	20-30y: 18 (32%); 30-40y: 25 (45%); >40y: 13 (23%) 0% <20 years-old	52	Volunteers from two villages in Tari Basin, comprising of almost the entire adult population	N/A	Volunteers from three settlements in Port Moresby selected to match the age distribution of their village counterparts	Average: 15y	Cross-Sectional	Traced cohort	BMI, physical activity
Lindgarde[20], 2004	N/A, Peru	210	35.5 % of young individuals not available	0	Women of indigenous Andean ascent (Quechua) who had been residing in northern suburbs of Lima, Peru	Convenience sample of women residing in small rural villages at high altitude in the Cuzco region	N/A	89% for >20y	Cross-Sectional	Random Sample	BP, BMI, waist circumference, % body fat, body fat mass, glucose, insulin, HOMA index, leptin
Hollenberg[21], 2005	1999, Panama	458	38.3 0% < 18 years-old	43	Random sample drawn from a census of people of Kuna origin (O positive blood) and long term residents (≥ 5 years) of Abayala, Panama city	Kuna Amerinds residing in their indigenous home in the island of Ailigandi (Caribbean island off the coast of Panama)	N/A	>5 y	Cross-Sectional	Random Sample	BP, BMI, weight, mental health
Ramirez-Zea[7], 2005	1969-2004, Guatemala	1311	32.3 0% <18 years-old	45	People living in Guatemala City and who were participants of a longitudinal growth and development study (1969 and 1977) and born in rural East Guatemala	People residing in or near their native villages and who were participants of a longitudinal growth and development study (1969 and 1977) and born in rural East Guatemala	N/A	Not Reported	Prospective cohort	Traced cohort	BP, BMI, waist circumference, plasma glucose, total cholesterol, triglycerides, LDL, HDL, skinfolds, waist/hip ratio, abdomen/hip ratio, body fat, physical activity
McCullough[22], 2006	1999, Panama	311	37.4 0% <18 years-old	39	A random sample of Kuna families residing in Vera Cruz, Panama City drawn from a census	Kuna Amerinds residing in their indigenous home in the island of Ailigandi (Caribbean island off the coast of Panama)	N/A	Average: 20y	Cross-Sectional	Random Sample	BP, BMI, weight, cholesterol, urinary electrolytes (urea, sodium, potassium, calcium, magnesium)

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Study, Publication year	Years conducted, Country	Total sample	Mean age or age groups / % of young individuals	% Male	Migrant population	Rural population	Urban population	Urban exposure	Study design	Sampling frame	Reported CV risk factors
Unwin[23], 2006	N/A, Tanzania	323	29.2 0% <15 years-old	48	Individuals living in the rural district of Morogoro, Tanzania, who migrated to Dar es Salaam for at least 6 months	For each migrant, an age and sex matched non-migrant was identified in Morogoro, Tanzania	N/A	6 mo	Prospective Cohort	Traced cohort	BP, BMI, weight, waist, cholesterol, triglycerides, LDL, HDL, HbA1c
Szklarska[24], 2008	2006, Poland	863	43 0% <16 years-old	43	Convenience sample of people living in Wroclaw, Poland who migrated after the age of 16y and recruited during a health screening program	N/A	Convenience sample of people living in Wroclaw, Poland, those who were born in Wroclaw or migrated before 16 years of age	Not Reported	Cross-Sectional	Population Survey	BP, BMI, waist/hip ratio, skinfolds, cholesterol, HDL, LDL, triglycerides, glucose
Khan[25], 2009	2004, Bangladesh	2807	30.7 12% <20 years-old and 0% <10 years-old	0	Women who had moved from countryside or town to urban center, or who lived in country-side town when <12y-old	N/A	Women who were living in an urban area when<12-old, and did not move to urban city	Not reported	Cross-Sectional	Population Survey	Overweight, Obesity
Ebrahim[8], 2010	2005-2007, India	6510	41.1 0% <17 years-old	58	Factory workers for 4 cities and their coresident spouses were recruited. They were rural-urban migrants using employer records as a sampling frame	Each migrant worker and spouse invited one nonmigrant full sibling of the same sex and closest to them in age still residing in their rural place of origin	A 25% random sample of nonmigrants invited to participate. Nonmigrants were also asked to invite a sib who resided in the same city but did not work in the factory	86% for >10y	Cross-Sectional	Sib-Cohort	BMI, waist/hip ratio, % body fat, BP, cholesterol, triglycerides, blood glucose, fasting insulin, HOMA score, fat intake, metabolic equivalent tasks (METs)
Lu[26], 2010	1997-2000, Indonesia	20122	29.7 0% <18 years-old	46	Identified from the 1997 and 2000 waves of the Indonesia Family Life Survey, representing 83% of the population	Identified from the 1997 and 2000 waves of the Indonesia Family Life Survey, representing 83% of the population	N/A	Not Reported	Retrospective Cohort	Population Survey	Hypertension, mental health
Miranda[9], 2010	2007, Peru	989	48 0% <30 years-old	47	Stratified random sample of individuals born in Ayacucho but now residing in urban shanty town of Lima, Peru, drawn from updated census	Stratified random sample of local residents of San Jose de Secce in Ayacucho was drawn from an updated census	Stratified random sample of individuals born and permanently living in urban shanty town of Lima, Peru	Average: 32y	Cross-Sectional	Random Sample	BP, hypertension, BMI, skinfolds, waist-to-hip ratio, fasting glucose, diabetes, lipoprotein profile, hypercholesterolemia C-reactive protein, fibrinogen

Table 2

Systolic Blood Pressure (SBP) in mmHg for the migrant, rural and urban groups

Study	SBP Migrants Mean (SD) [n]			SBP Rural Mean (SD) [n]			SBP Urban Mean (SD) [n]			Absolute difference M vs. R (95% CI)	Absolute difference M vs. U (95% CI)
	Male	Female	All	Male	Female	All	Male	Female	All		
Nadim[5]	134.9 (23.1)[278]	141.8 (24.9)[414]	138.1 (24.6)[692]	119.7 (20.2)[176]	127.9 (26.2)[203]	126.2 (23.7)[379]	137.3 (21.1)[117]	136.5 (23.1)[240]	138.4 (24.1)[357]	11.90 (8.89,14.91)	−0.30 (−3.40,2.80)
Poulter[16]	128.2 (15.2)[220]	119.5 (13.7)[90]	124.7 (14.7)[310]	122.1 (18.3)[264]	120.0 (18.3)[597]	121.4 (18.7)[861]	-	-	-	3.30 (1.24,5.36)	-
Poulter[17]	125.6 (10.9)[43]	113.7 (9.9)[20]	121.0 (13.3)[63]	117.0 (11.4)[82]	106.2 (9.2)[61]	112.2 (12.1)[143]	-	-	-	8.80 (4.96,12.64)	-
He Migrant[6]	113 (14)[1656]	106 (12.8)[919]	111.0 (13.6)[2575]	110.8 (12.3)[5023]	111.2 (12.6)[3218]	110.8 (12.5)[8241]	114.5 (14.6)[2173]	108.1 (15.3)[1516]	112.2 (15.2)[3689]	0.20 (−0.39,0.79)	−1.20 (−1.92,−0.48)
He People	107.3 (11.6)[316]	101.6 (13.0)[201]	105.7 (12.6)[517]	101.2 (9.7)[2522]	101.1 (9.4)[2436]	101.1 (9.5)[4958]	108.3 (12.1)[638]	102.1 (11.2)[505]	105.0 (12.4)[1143]	4.60 (3.48,5.72)	0.70 (−0.60,2.00)
Lindgarde[20]	-	96 (11)[105]	96 (11) [105]	-	97 (10) [105]	97 (10)[105]	-	-	-	−1.00 (−3.84,1.84)	-
Hollenberg[21]	115[146]	100.5[179]	107.0 (17.7)[325]	104.4[51]	95.2[82]	98.7 (13.8)[133]	-	-	-	8.30 (5.27,11.33)	-
Ramirez-Zea[7]	118.4 (11.6)[143]	113.0 (15.3)[202]	115.4 (13.7)[345]	116 (11)[424]	107 (12)[542]	111.3 (12.1)[966]	-	-	-	4.10 (2.47,5.73)	-
McCullough[22]	-	-	102 (14.7)[178]	-	-	98.2 (13.8)[133]	-	-	-	3.80 (0.61,6.99)	-
Unwin[23]	-	-	116.2 (21.3)[153]	-	-	118.9 (18.9)[170]	-	-	-	−2.70 (−7.11,1.71)	-
Szklarska[24]	128.3 (15.6)[99]	115.2 (16.2)[178]	120.9 (17.8)[277]	-	-	-	128.6 (16.1)[268]	118.3 (16.8)[318]	123.1 (17.8)[586]	-	−2.20 (−4.74,0.34)
Ebrahim[8] *	125.1 (17.1)[1127]	118.9 (16.0)[985]	122.7 (17.0)[2112]	122.9 (15.6)[1459]	118.9 (16.9)[652]	121.8 (16.2)[2111]	125.7 (17.7)[1201]	119.4 (16.8)[1086]	122.9 (17.8)[2287]	0.90 (−0.10,1.90)	−0.20 (−1.23,0.83)
Miranda[9]	123.5 (14.9) [280]	116.6 (16.9)[309]	119.9 (16.4)[589]	125.2 (17.4)[95]	117.1 (19.1)[106]	120.9 (18.7)[201]	132.2 (23.2)[92]	124.7 (22.2)[107]	128.2 (22.9)[199]	−1.00 (−3.90,1.90)	−8.30 (−11.75,−4.85)

* adjusted for occupation, age, age group, and factory including a random effect of sibling pair.

Table 3

Diastolic Blood Pressure (DBP) in mmHg for the migrant, rural and urban groups

Study	DBP Migrants Mean (SD) [n]			DBP Rural Mean (SD) [n]			DBP Urban Mean (SD) [n]			Absolute difference M vs. R (95% CI)	Absolute difference M vs. U (95% CI)
	Male	Female	All	Male	Female	All	Male	Female	All		
Cruz-Coke[14]	-	-	86.8 (12.2)[50]	-	-	84.2 (9.4)[129]	-	-	-	2.60 (−1.15,6.35)	-
Nadim[5]	83.5 (15.3)[278]	87.1 (16.3)[414]	86.0 (16.0)[692]	71.5 (14.2)[176]	73.6 (15.2)[203]	72.1 (13.7)[379]	85.5 (15.6)[117]	84.7 (16.0)[240]	84.7 (15.3)[357]	13.90 (12.08,15.72)	1.30 (−0.68,3.28)
Poulter[16]	70.8 (14.5)[220]	67.2 (11.4)[90]	70.1 (13.0)[310]	68.1 (11.4)[264]	66.8 (11.2)[597]	67.4 (11.3)[861]	-	-	-	2.70 (1.07,4.33)	-
Poulter[17]	66.3 (14.0)[43]	61.7 (9.3)[20]	65.7 (10.0)[63]	53.1 (12.2)[82]	54.9 (9.6)[61]	53.5 (11.7)[143]	-	-	-	12.20 (9.07,15.33)	-
He Migrant[6]	70.9 (11.6)[1656]	65.2 (10.1)[919]	68.7 (11.6)[2575]	66.3 (12)[5023]	65.8 (11.8)[3218]	66.1 (12.1)[8241]	72.6 (10.4)[2173]	67.7 (10.3)[1516]	70.4 (10.5)[3689]	2.60 (2.08,3.12)	−1.70 (−2.26,−1.14)
He People[18]	69.6 (10.1)[316]	63.2 (8.8)[201]	67.2 (10.1)[517]	63.0 (7.2)[2522]	62.5 (7.0)[2436]	62.6 (7.1)[4958]	69.2 (9.1)[638]	63.4 (7.6)[505]	66.6 (9.0)[1143]	4.60 (3.71,5.49)	0.60 (−0.42,1.62)
Lindgarde[20]	-	66 (6) [105]	66 (6) [105]	-	59 (9) [105]	59 (9) [105]	-	-	-	7.00 (4.93,9.07)	-
Hollenberg[21]	74.2[146]	64.9[179]	69.1 (13.7)[325]	61.7[51]	57.9[82]	59.4 (6.9)[133]	-	-	-	9.70 (7.80,11.60)	-
Ramirez-Zea[7]	73.7 (10.5)[143]	71.5 (11.0)[202]	72.4 (10.4)[345]	72 (9)[424]	69 (9)[542]	70.9 (9.3)[966]	-	-	-	1.50 (0.26,2.74)	-
McCullough[22]	-	-	64 (16) [178]	-	-	58.4 (8.1)[133]	-	-	-	5.60 (2.88,8.32)	-
Unwin[23]	-	-	70.3 (12.0)[153]	-	-	73.2 (10.0)[170]	-	-	-	−2.90 (−5.32,−0.48)	-
Szklarska[24]	82.2 (9.5)[99]	75.5 (10)[178]	78.8 (9.6)[277]	-	-	-	84.8 (11.2)[268]	77.6 (10.6)[318]	80.0 (12.1)[586]	-	−1.20 (−2.70,0.30)
Miranda[9]	74 (9.2)[280]	69 (8.7)[309]	71.3 (9.3)[589]	76.1 (8.9)[95]	72.5 (9.2)[106]	74.2 (9.2)[201]	79.1 (11.8)[92]	73.7 (10.6)[107]	76.2 (11.5)[199]	−2.90 (−4.38,−1.42)	−4.90 (−6.67,−3.13)

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Table 4

Body mass index (BMI) in Kg/m^2 for the migrant, rural, and urban groups

Study	BMI Migrants Mean (SD) [n]			BMI Rural Mean (SD) [n]			BMI Urban Mean (SD) [n]			Absolute difference M vs. R (95% CI)	Absolute difference M vs. U (95% CI)
	Male	**Female**	**All**	**Male**	**Female**	**All**	**Male**	**Female**	**All**		
Poulter[16]	20.5 (2.6)[220]	21.8 (3.0)[90]	20.8 (2.9)[310]	20.0 (2.9)[264]	20.1 (3.0)[597]	20.2 (3.0)[861]	-	-	-	0.60 (0.22,0.98)	-
He People[18]	20.2 (2.3)[316]	20.9 (2.6)[201]	20.3 (2.5)[517]	18.9 (2.3)[2522]	18.9 (2.5)[2436]	18.9 (2.4)[4958]	20.5 (2.3)[638]	20.6 (2.3)[505]	20.6 (2.4)[1143]	1.40 (1.17,1.63)	−0.30 (−0.56,−0.04)
Yamauchi[19]	26.4 (3.3)[14]	25.5 (3.1)[15]	25.9 (4.0)[29]	24.8 (1.6)[11]	23.2 (3)[9]	24.4 (2.2)[20]	-	-	-	1.50 (−0.25,3.25)	-
Lindgarde[20]	-	25.1 (4.7)[105]	25.1 (4.7)[105]	-	24.6 (3.9)[105]	24.6 (3.9)[105]	-	-	-	0.50 (−0.67,1.67)	-
Hollenberg[21]	22.6[146]	23.6[179]	23.1[325]	22.4[51]	22.5[82]	22.5[133]	-	-	-	0.6 **	-
Ramirez-Zea[7]	26.0 (4.0)[143]	27.0 (3.8)[202]	26.5 (3.8)[345]	24.3 (3.4)[424]	26.8 (4.9)[542]	25.4 (4.6)[966]	-	-	-	1.10 (0.61,1.59)	-
McCullough[22]	-	-	23.4 (4)[178]	-	-	22.6 (3.5)[133]	-	-	-	0.80 (−0.04,1.64)	-
Unwin[23]	-	-	24.0 (1.6)[153]	-	-	23.6 (1.0)[170]	-	-	-	0.40 (0.11,0.69)	-
Szklarska[24]	26.9 (3.1)[99]	24.4 (4.4)[178]	25.1 (4.1)[277]	-	-	-	27.2 (4.1)[268]	24.5 (4.8)[318]	25.9 (4.5)[586]	-	−0.80 (−1.40,−0.20)
Ebrahim[8] *	24 (3.4)[1127]	25.2 (3.2)[985]	24.6 (3.4)[2112]	21.9 (3.9)[1459]	22.5 (3.9)[652]	22.0 (4.0)[2111]	24.3 (3.5)[1201]	25.9 (3.4)[1086]	25.0 (3.5)[2287]	2.60 (2.38,2.82)	−0.40 (−0.60,−0.20)
Miranda[9]	25.9 (3.5)[280]	28 (4.7)[309]	27 (4.3)[589]	22.9 (2.1)[95]	23.5 (3.2)[106]	23.2 (2.7)[201]	26.8 (4)[92]	29.5 (6.1)[107]	28.3 (5.4)[199]	3.80 (3.29,4.31)	−1.30 (−2.13,−0.47)

*adjusted for occupation, age, age group, and factory including a random effect of sibling pair.

**No standard errors available for groups.