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Associations of parental internal migration with child growth and nutritional status in low- and middle-income countries: A systematic review

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ABSTRACT

Five to 50% of people in low- and middle-income countries (LMICs) report having ever migrated internally. Studies suggest internal (within-country) migration may influence health within and across generations. This review aims to collate evidence of associations of parental internal migration and child growth and nutritional status in LMICs.

Observational studies of children with parents who had migrated internally within their resident country, with a non-migrant reference group and outcomes relating to child growth and nutritional status were eligible. Full research articles in peer-reviewed journals from 2000 onwards were included, with no country/setting/language restrictions. The search was conducted in June 2024 in Embase/Global Health/MEDLINE, WoS, Proquest Central, Global Index Medicus, and Google Scholar using relevant keywords. The Newcastle-Ottawa Scale assessed risk of bias. The protocol was registered on PROSPERO (CRD42023423895).

Twelve studies were identified from China, India, Mexico, Peru, Tanzania, South Africa, and Turkey, most of which focussed on early childhood, and all but one found associations. Of studies comparing rural-urban migrants to *rural non-migrants* (n=5), migration was associated with reduced risk of child undernutrition and improved linear growth, particularly for children born at urban destination, but also increased weight growth and overweight. In comparison to *urban non-migrants* (n=11), findings were mixed and showed children of *rural-urban migrants* had greater/similar levels of undernutrition and poorer growth or greater levels of overweight in early life but better linear growth in late childhood/adolescence.

This review identifies internal migration as a determinant of child health in LMICs and thus suggests it should be considered when designing policies and interventions to improve child health.

1. Introduction

Migration is defined as the movement of an individual or household from their usual place of residence to another place (IOM, 2020). It can take many forms, depending on the underlying reasons, whether it occurs within a country or across borders, and whether it occurs permanently or temporarily. *Internal* migration describes migration that occurs *within* national borders. There is no agreed international standard for defining internal migration; differences in units of time, distance, and characteristics of the migrants may impact estimates of its magnitude and consequences (Newbold and Kempf-Leonard, 2005).

No global estimates of internal migration exist, primarily due to the lack of data in some countries and the different ways in which internal migration is defined across time and space in countries that do have data. The Comparing Internal Migration Around the GlobeE (IMAGE) project attempts to address this by bringing together national censuses, surveys and population registers and adjusting for country-specific geographic or administrative divisions to allow for cross-country comparisons (UNESA. Cross, 2013). In their most recent and largest cross-country report they found that, in 2005, there were over 763 million people who had migrated internally at some point in their lifetime across 66 countries, which was more than three times the number of international migrants at the time (UNESA. Cross, 2013). Close to 65% of lifetime internal migrants were in Africa, Asia, Latin America and the Caribbean (UNESA. Cross, 2013). The IMAGE project data also highlight substantial variation across countries. For example, a study from 2015 showed an incidence of recent migration, measured over the preceding five years, of close to 30% in Cameroun, Senegal, Chile and Panama, but only 5% in India, Egypt and Mexico (Bell et al., 2015).

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Abbreviations

DHS	Demographic and Health Surveys
LMICs	low- and middle-income countries
CI	confidence interval
SD	standard deviation
BMI	body mass index
WHO	World Health Organization
HAZ_{WHO}	height-for-age z score, WHO reference
WAZ_{WHO}	weight-for-age z score, WHO reference
WHZ_{WHO}	weight-for-height z score, WHO reference
BAZ_{WHO}	BMI-for-age z score, WHO reference

These differences have been attributed to different levels of economic development and other factors influencing migration, such as spatial inequalities, government policies, cultural norms, conflict and violence, and geography (Bell et al., 2015; Rees et al., 2017).

Numerous studies, as far back as the 19th century in Britain, have shown migrants and non-migrants to differ in terms of health (Darlington et al., 2016). Migration may broadly influence health of migrants through the costs and experiences of migrating, adaptation or acculturation at destination, and/or differential exposures between migrants and non-migrants to important determinants of health such as social networks, education, and housing (Darlington et al., 2016; Selod and Shilpi, 2021). It may also influence health for the sending communities (e.g. through remittances migrants send home) and receiving communities (e.g. by putting more pressure on local services). Conversely, health can also influence migratory decisions (Darlington et al., 2016; Selod and Shilpi, 2021). Despite this, much of the evidence on migration and health and attention from global public health organizations have been on more developed settings and/or international migration (IOM, 2020; Selod and Shilpi, 2021).

With increased national income, urbanization and the globalization of food production, all countries go through a nutrition transition characterized by a shift from traditional diets and more labour-intensive lifestyles towards a unified (western) global diet and lifestyle (Darlington et al., 2016; Selod and Shilpi, 2021). These changes typically take place in urban areas first and have led to large inequalities whereby children in rural areas have high levels of undernutrition but lower overnutrition compared to urban areas where we see the opposite (Darlington et al., 2016). Though increasing obesity in rural areas has led to a greater double burden of malnutrition in many LMICs (Darlington et al., 2016).

Today in low- and middle-income countries (LMICs), as was the case in higher income countries in the 1900s, internal migration primarily occurs towards more urbanized areas, contributing to further urbanization and hence to increased exposure to environments which may pose new challenges to health and well-being. Notably, migration between rural and urban areas has caused a rapid nutrition transition among migrant households, away from traditional rural diets and behaviours towards more urban lifestyles. While this has led to easier access to a greater diversity of food, it has also led to a greater consumption of processed foods richer in fat, sugar and salt, and to more sedentary behaviours (Bowen et al., 2011; Peters et al., 2019; Popkin, 1994; Cockx et al., 2022).

In adult migrants, rural to urban migration has been associated with increased obesity and associated cardio-vascular and endocrine disease, primarily driven by improvements in socio-economic circumstances (Bowen et al., 2011; Peters et al., 2019; Cockx et al., 2022; Bernabe-Ortiz et al., 2017; Ebrahim et al., 2010; Hilmers et al., 2016). In low-income urban settings in Kenya and India, however, both overweight and undernutrition have been found to co-exist (Kimani-Murage et al., 2015; Nguyen et al., 2019). In 2010, it was estimated that on average 30% of underweight and stunted children in LMICs lived in cities (Paciorek et al., 2013). Urban poverty in LMICs has been increasing and it is estimated that a third of urban dwellers live in slum informal settlements, of which migrants make up a large proportion (Lucci et al., 2018; Tacoli et al., 2015).

Internal migration is also likely to have intergenerational effects as parental wealth, neighbourhood environment, lifestyle, mental and physical health have all been shown to be important determinants of child physical health and development (Maggi et al., 2010; Martorell and Zongrone, 2012; Wells et al., 2016; Stewart, 2007). Indeed, studies suggest that parental internal migration to be associated with poorer mental and physical health and lower immunization in some settings (Akkaya-Kalayci et al., 2015; Sun et al., 2016; Rodriguez et al., 2017; Crocker-Buque et al., 2017; Awoh and Plugge, 2016; Cockx, 2022). This review collates existing evidence of intergenerational associations on child growth and nutritional status specifically with an aim to understand if parental internal migration, particularly towards urban areas, is associated with child growth and nutritional status in LMICs. This review is reported in accordance with the PRISMA guidelines (Page et al., 2021).

Based on the literature described previously, we hypothesized that:

a. The offspring of parents who migrated from rural to urban areas would grow up in better socio-economic circumstances and more abundant and/or accessible food environments compared to the offspring of parents who remained in rural areas. This in turn would mean greater physical growth, but also more risk of developing obesity (as found in research on adult migrants).
b The effects described in a. would likely differ depending on the child's place of birth, migration status, and age at migration. We therefore further hypothesized that, among children of migrant parents, those born in rural areas would have poorer growth and less risk of obesity compared to those born in urban areas and that children who experience migration (i.e. who were born prior to parental migration) would have poorer outcomes due to the stress and disruption that could be associated with this.

2. Methods

2.1. Protocol and registration

The review protocol was registered on the PROSPERO registry of systematic reviews (CRD42023423895) (Page et al., 2021; Schiavo, 2019).

2.2. Eligibility criteria

Studies were only considered if they were full research articles and had been published in peer-reviewed journals between 2000 and 2024. We made no restrictions on country (within the LMIC World Bank classification on income (The World by Income and, 2023)), setting or language. The following additional eligibility criteria were applied:

2.2.1. Population

The population of interest consisted of children from birth to 19 years with one or two internal migrant parent(s) living in LMICs (World Bank classification (The World by Income and, 2023)). The child's own migration status was not a criterion as described in the next section.

2.2.2. Exposure

The exposure was defined as having one or both parents who had migrated internally within the country of residence. Only studies that used keywords describing internal migration such as 'internal migration', 'within-country migration' and 'rural-urban migration' were considered. No keywords relating to specific types of internal migration (e.g., labour migration) were used as an initial exploratory search

indicated that the chosen broader migration keywords would allow most types of internal migration to be captured. Only studies of internal displacement were not captured (as these generally do not use migration terminology) but we chose to maintain their exclusion as these studies did not meet our selection criteria (as these mostly took place in camps and provided no information on type of place of origin/destination or a comparative non-migrant group) and had already been explored in other reviews (e.g. (Gooding et al., 2024; Choudhary et al., 2023; Talukdar et al., 2024)). Studies relating to children left behind after parental migration were also excluded as there were considered outside the scope of this review and have been reviewed elsewhere (Fellmeth et al., 2018). No restrictions were made on how a given study defined parental internal migration (e.g., in terms of age at migration, duration, or rural/urban type of place of origin and destination). None were also made on when or where the child was born so that comparisons could be made between children who had migrated with the parent(s) and been born after parental migration, should this information be available.

2.2.3. Comparison

Only studies which had children whose parents did not migrate internally as the comparison group were included.

2.2.4. Outcomes

Outcomes included any which related to child physical (weight and/or linear) growth and nutritional status. These could be measured or reported.

2.2.5. Study design

Only observational studies were considered. We excluded experimental studies, literature reviews, systematic reviews, methodology reports, validation studies, and studies that collected data for other purposes. Grey literature was not searched.

2.3. Search strategy

A search was carried out in June 2024 Embase/Global Health/MEDLINE, Web of Science, Proquest Central, Global Index Medicus, and Google Scholar databases as recommended by Bramer et al. (2017). The search used keywords for internal migration, growth and nutritional status and child age range. Database-specific search terms and parameters are provided in Supplementary File 1.

2.4. Selection process and data extraction

The studies from each database were extracted to EndNote reference manager (Philadelphia, PA, 2013) where they were combined. Two reviewers (ER and AVV) independently identified and removed duplicates, using both the automatic duplicate identification function in EndNote and manual identification, before screening the titles and abstracts to exclude irrelevant studies and then screening full texts to ensure both eligibility and relevance. Any discrepancies between reviewers were discussed and taken up with co-authors if required.

Study characteristics, including location, migration definition, migration groups compared, child age, outcomes, study design, data source, statistical methods, and findings were extracted to a computer spreadsheet by each reviewer and then compared. Results and synthesis methods were then discussed with co-authors and the summary results subsequently provided through harvest plots and a table. We found insufficient studies with comparable outcomes to perform a meta-analysis.

2.5. Risk of bias assessment

An assessment of risk of bias was made for each study included in the review based on criteria reflecting its external validity (e.g., how generalisable are the results to all children of the same age in LMICs) and internal validity (e.g., are the results valid and to what extent might they be due to other unidentified factors). The Newcastle-Ottawa Scale was used as guidance, either the original version for case-control and cohort studies or the adapted version for cross-sectional studies depending on the study design (Wells et al., 2000; Herzog et al., 2013). Broadly the main topics considered in the risk of bias assessment were sample selection, group comparability, and outcome or exposure assessment. Further detail of the tools used are provided in Supplementary File 2. Note that none of the studies included in this review were cohort studies and therefore only scales for case-control and cross-sectional studies were used.

Based on the responses to the questions under each topic, each study was given a risk of bias score out of ten. The assessment was made by each reviewer independently and then compared; any discrepancies were discussed with co-authors. An overview of the assessment is provided in the results.

3. Results

3.1. Study characteristics

3.1.1. Overview

In total, 968 records were identified across the searched databases, of which 136 were duplicates (Fig. 1).

Of these remaining 832 records, a further 756 were excluded as they were either off-topic, not full research articles, not studies of humans, or out of the date range. Secondary screening to assess the eligibility and relevance of the studies led to the exclusion of 65 additional records; the reasons are shown in Fig. 1.

A total of 12 studies were included in the review (Cockx, 2022; Reyes et al., 2004; Azcorra et al., 2009; Lu et al., 2015; Hu et al., 2014; Kumar et al., 2016; Prusty and Keshri, 2015; Mishra et al., 2022; Wang, 2019; Choudhary and Parthasarathy, 2009; Santas and Eryurt, 2020; Rougeaux et al., 2022). The harvest plots below show study numbers across growth/nutritional outcome and childhood period for comparisons against urban non-migrants in Fig. 2 and comparisons against rural non-migrants in Fig. 3. Eleven of the studies made comparisons between migrants and urban non-migrants (Fig. 2). Nine of these focussed on migrants in urban areas (i.e. rural-urban or urban-urban migrants), two focussed on urban-rural migrants, and one did not specify. Four of the studies made comparisons between migrants and rural non-migrants (Fig. 3). Two of these looked at migrants in both rural areas and urban areas (i.e. rural-rural and rural-urban migrants) and two others did not specify. Most studies (n=9) focussed on younger children up to the age of 6 years, one study included children aged 7–10 years, another children aged 11–18 years, and one included all ages up to 19 years. The studies comparing migrants to urban non-migrants almost all centred on early childhood (Fig. 2) while studies comparing migrants to rural non-migrants included children across different periods of childhood (Fig. 3). The most common outcomes assessed related to growth and nutritional status, most often stunting.

Few LMICs were represented in the studies. Most studies were from India and China, one was from Turkey, one from South Africa, one from Tanzania, one from Peru and two from Mexico, though only the Peruvian study, Indian studies and one of the Chinese studies were national studies.

A summary of each study's characteristics and main findings is given in Table 1. One of the studies was a cohort study (Cockx, 2022), another was a case-control study (Reyes et al., 2004), and the rest were cross-sectional. All the studies were peer-reviewed journal articles published between 2003 and 2022. Sample sizes ranged from 423 children to over 199 000. Most studies used data collected in the mid-2000s to mid-2010s, though two studies used data from the late 1990s.

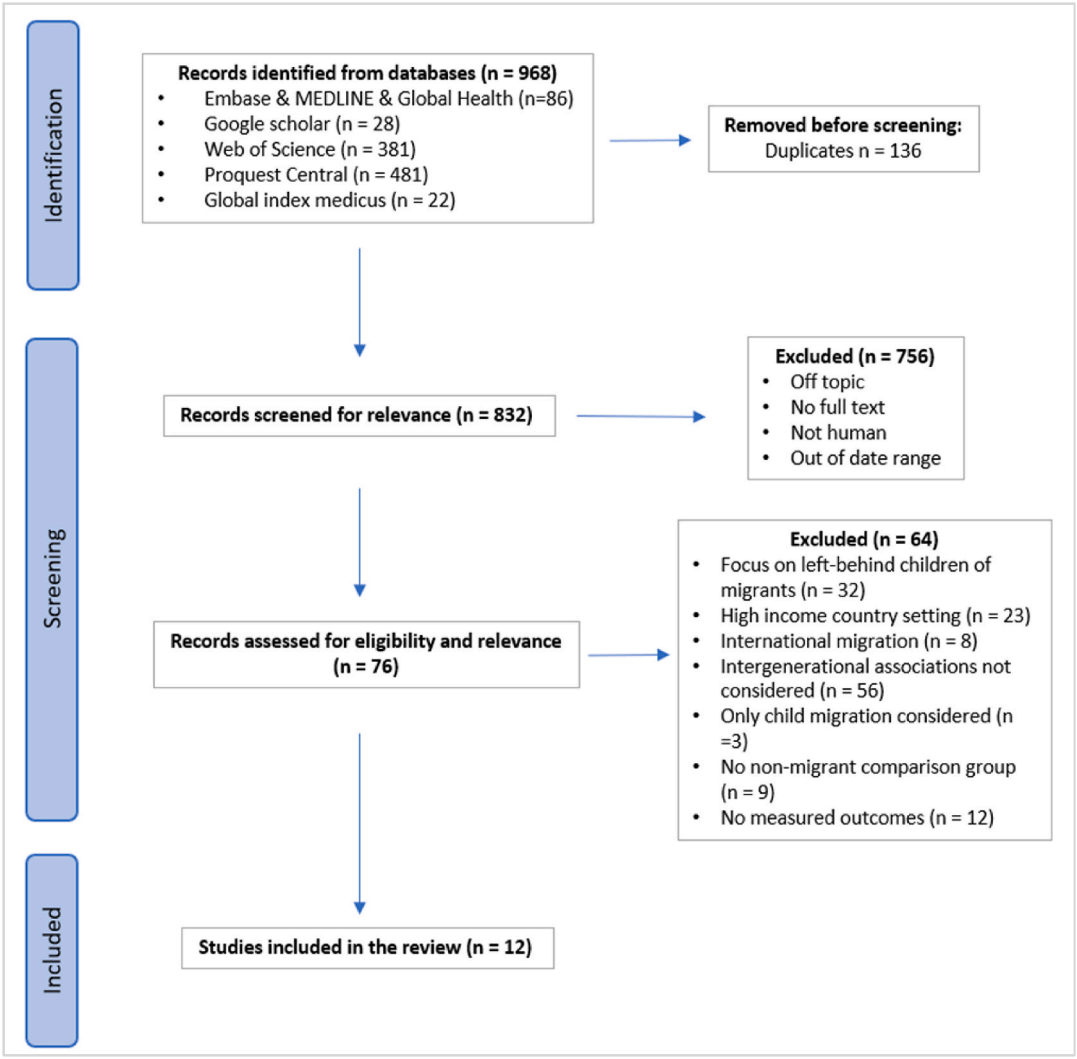


Fig. 1. Flow diagram for the systematic review of internal migration and child growth and nutritional status in low- and middle-income countries.
Description: This is a flow diagram showing the steps of the systematic review including identification, screening, and inclusion and the numbers of studies within each.

3.1.2. Definition of migration

The way internal migration was defined varied significantly across studies. The Tanzanian study relied on parental place of residence at baseline and follow-up and used this to categories people into four groups: rural non-migrant, rural-rural migrant, rural-urban migrant to a town, and rural-urban migrant to a city (Cockx, 2022). Migration was further categorized into whether the child had migrated with their parent or was born afterwards (Cockx, 2022).

The four Indian studies, the Peruvian study, and the Turkish study used data based on the Demographic & Health Survey (DHS) Program, which means the focus was on the mother's migration status (as this is the main respondent in the DHS) (Kumar et al., 2016; Prusty and Keshri, 2015; Mishra et al., 2022; Choudhary and Parthasarathy, 2009; Santas and Eryurt, 2020; Rougeaux et al., 2022; Croft et al., 2018). The DHS does not include migration questions, instead one can estimate migration history using questions on current place of residence (usually categorized as rural [countryside] or urban [town, city, large/capital city]), duration in current place of residence, type of previous place of residence (usually classified in the same way as current residence), and type of residence at birth (usually classified in the same way as current residence). Only women who report not having always lived in their current place of residence are asked about type of previous residence and residence at birth. The Peruvian study used all the information available, defining non-migrants based on having always lived in their current place of residence and not showing any change in residence over time (Rougeaux et al., 2022). These were further divided into rural and urban based on their current area of residence. Migrants were categorized, based on the type of area of current residence and either previous or birth place of residence, into rural-rural, rural-urban, urban-urban, and rural-urban migrants (Rougeaux et al., 2022). The Turkish study only considered urban residents and used maternal birth and current type of place of residence to classify children into three migration groups (urban non-migrant, rural-urban migrant and urban-rural migrant) (Santas and Eryurt, 2020). One of the Indian studies followed the same process and categorization, but they further classified the migrant groups into early or not early based on the mother's years in current place of residence (with early being defined as less than 5 years in current residence) (Choudhary and Parthasarathy, 2009). The authors however only carried out full analyses comparing *early* rural-urban migrants and urban non-migrants. The other Indian studies appear to have used the same DHS variables; however, they did not provide sufficient information to assess how migration groups were defined (Kumar et al., 2016; Prusty and Keshri, 2015; Mishra et al., 2022).

In China, the Hukou registration system, which allocates a rural or urban registration to individuals, is often used by researchers to assess if a person is a migrant based on whether they reside in a different type of

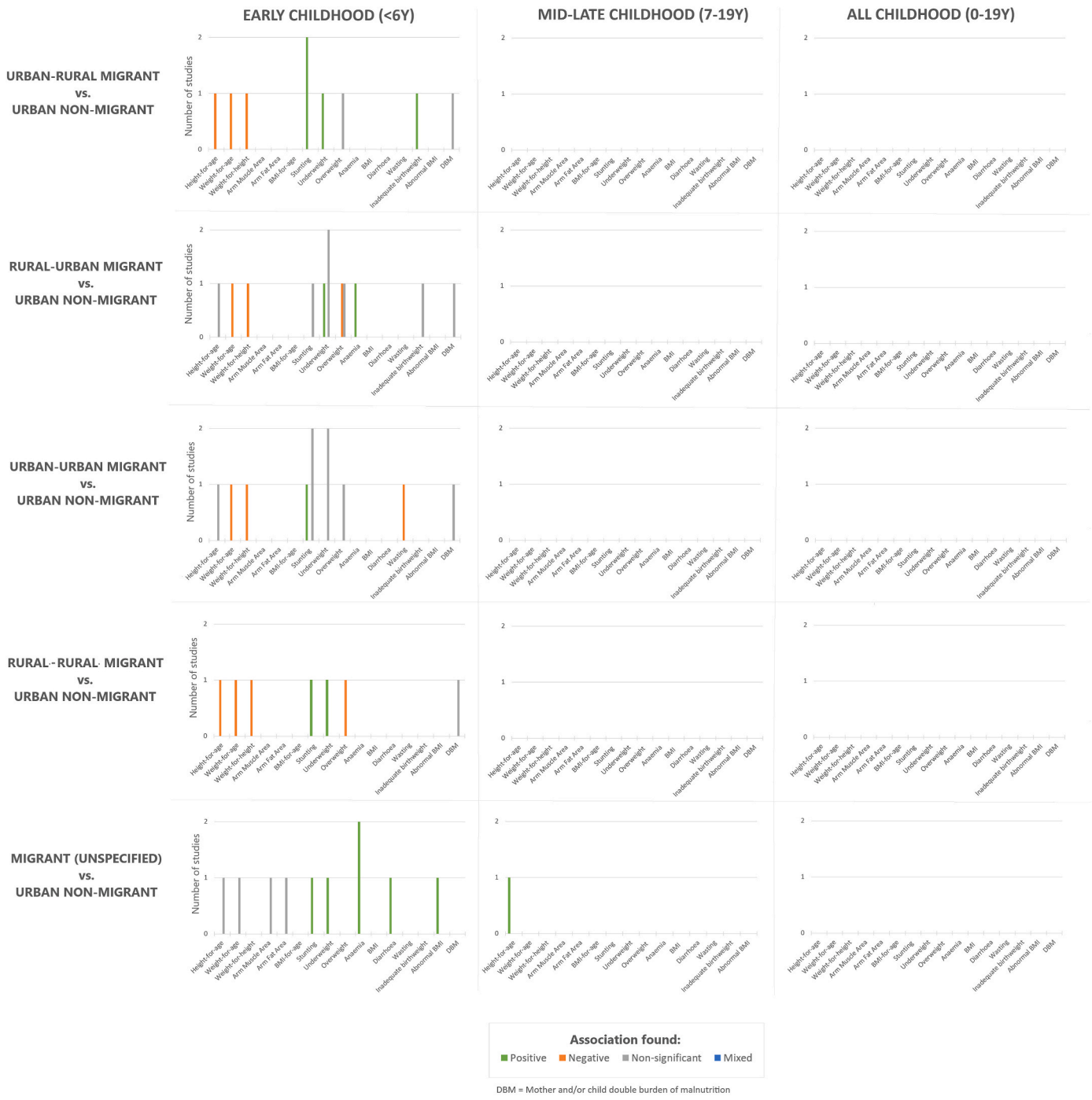


Fig. 2. Harvest plot showing child health outcomes assessed for studies comparing migrants to urban non-migrants.
Description: This is a harvest plot describing studies comparing migrants to urban non-migrants. It shows the number of studies within each type of child health outcome and by age category of the child.

area to their registration area. Hu et al. categorized participant children into a migrant group if at least one parent was registered in a different type of area to the place of the study (the city of Pinghu) and had lived there for at least 6 months (Hu et al., 2014). We therefore assume these migrants were rurally registered and were therefore rural-urban. Wang et al. also defined migrants as those whose Hukou was different from that of their place of residence (Wang, 2019). They did not specify the type of place of residence, so we assume the migrant group contained both rural-urban and urban-rural migrants. Like Hu et al. we also assume that the migrant group excluded those who migrated between similar types of areas (i.e. rural to rural or urban to urban). Wang et al. further categorized non-migrants as either rural or urban based on the child's place of birth and never having migrated with parents (Wang, 2019). These children may nonetheless have had one or more migrant parents and been 'left-behind' as the authors did not specify if they reside with their parents. Finally, Lu et al.'s Chinese study provided little information on how their migration groups were defined (Lu et al., 2015). They described the migrant group as being rural-urban but not how they defined this. For the other groups the authors simply described these as 'local city' – which we assumed to mean urban non-migrant- and 'immigrant origin areas' – which also likely meant non-migrant, but it is unclear if these were rural or urban or both. Neither Hu et al. nor Lu

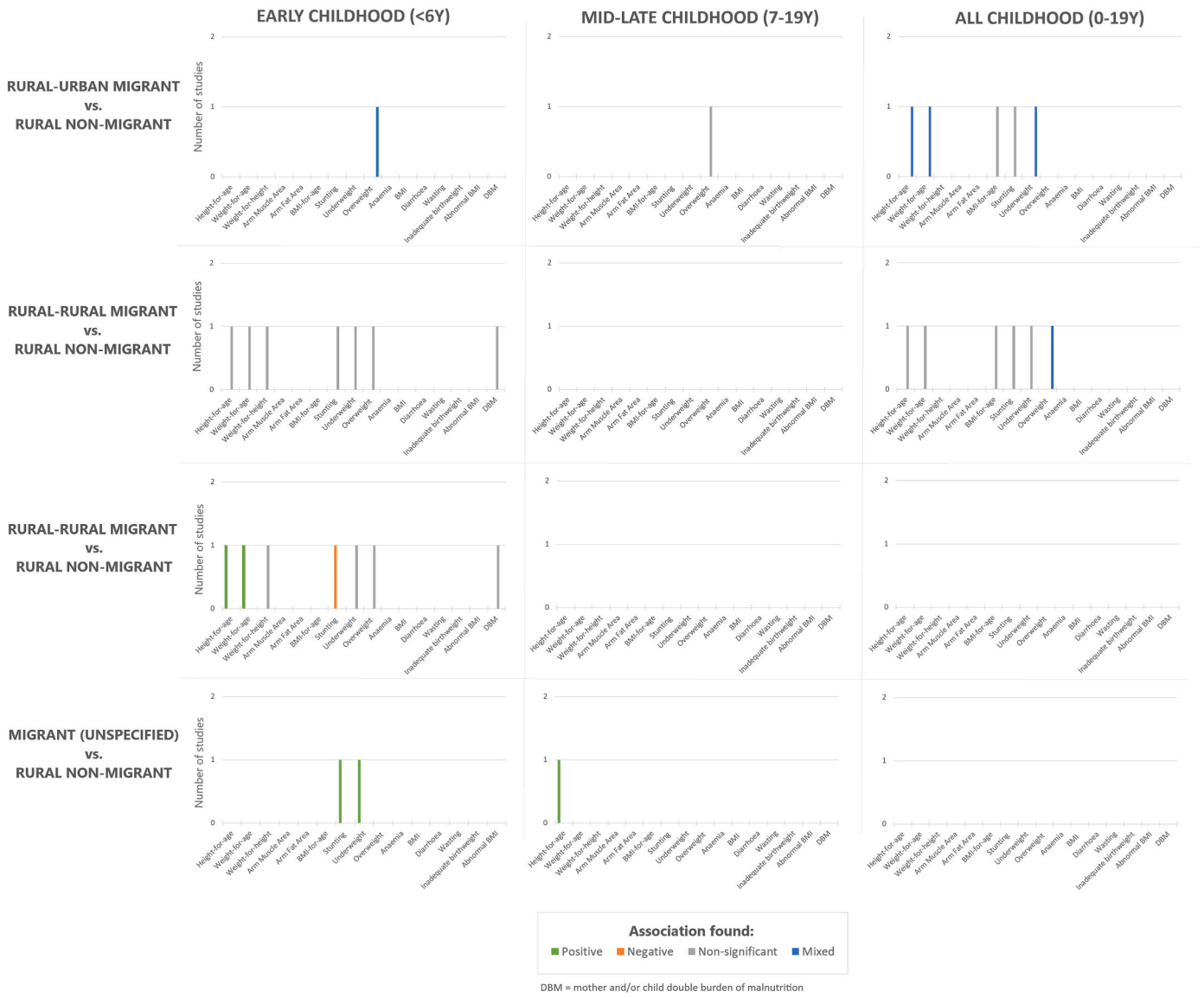


Fig. 3. Harvest plot showing child health outcomes assessed for studies comparing migrants to rural non-migrants.
Description: This is a harvest plot describing studies comparing migrants to rural non-migrants. It shows the number of studies within each type of child health outcome and by age category of the child.

et al.'s Chinese studies mentioned whether or not the child migrated with their parents (Lu et al., 2015; Hu et al., 2014).

One of the Mexican study defined migration as both parents migrating in the past two years and categories included rural non-migrant, urban non-migrant, rural-rural migrant and rural-urban migrant (Reyes et al., 2004). They did not however specify if this was self-reported nor whether those who had migrated more than two years prior were classed as non-migrants or excluded entirely. The other Mexican study defined the migrant group as one or both parents being born outside of Merida city (where the study took place) and having migrated there as an adult (origin unspecified) and the non-migrant group as either being born in Merida city or having migrated there as a child (Azcorra et al., 2009). Neither study mentioned child migration status.

3.1.3. Outcomes

As detailed in Table 1, several studies explored height and/or weight growth as World Health Organization (WHO) reference height-for-age z scores (HAZ_{WHO}) (Cockx, 2022; Mishra et al., 2022; Wang, 2019; Rougeaux et al., 2022), weight-for-age z scores (WAZ_{WHO}) (Cockx, 2022; Mishra et al., 2022; Rougeaux et al., 2022), weight-for-height z score or (WHZ_{WHO}) (Mishra et al., 2022; Rougeaux et al., 2022), and/or BMI-for-age z scores BAZ_{WHO}) (Cockx, 2022). Several also looked at nutritional cut-offs calculated from these z scores, including: stunting (defined as $HAZ_{WHO} < -2$ standard deviations [SD] below the reference median) (Cockx, 2022; Reyes et al., 2004; Prusty and Keshri, 2015; Choudhary and Parthasarathy, 2009; Rougeaux et al., 2022), underweight ($WAZ_{WHO} < -2$ SD above reference median) (Cockx, 2022; Prusty and Keshri, 2015; Mishra et al., 2022; Rougeaux et al., 2022), overweight from WHZ_{WHO} ($WHZ_{WHO} > 2$ SD above reference median) (Rougeaux et al., 2022), and overweight from BAZ_{WHO} ($BAZ_{WHO} > 1$ SD above reference median in children aged 5–19 years or $BAZ_{WHO} > 2$ SD above reference median for children 0–5 years) (Cockx, 2022). These studies all used the WHO 2006 growth reference except two which used NCHS/WHO 1977 growth standards (Reyes et al., 2004; Choudhary and Parthasarathy, 2009). The other Mexican study assessed height-for-age and weight-for-age z scores using Center for Disease Control and Prevention 2000 reference data (Azcorra et al., 2009). The Turkish study assessed nutritional status as stunting using standard height-for-age z score cut-offs and overweight using standard weight-for-age or

Table 1
Characteristics of studies in the systematic review of internal migration and child growth and nutritional status in low- and middle-income countries (N = 11).

Authors	Study location	Data source & study year	Child age	Migration definition & classification	Outcomes	Sample N	Findings (N.S diff = Non significant difference [p-value>0.05]; OR = odds ratio; SE = standard error; CI = confidence interval)	Risk of bias score
Azcorra et al., 2009	Merida, Mexico	Primary data, 2006-07	4–6 years	Migrants = 1/both parent(s) born outside Merida city & migrated there at 18 y+ (origin not specified); non-migrants = both parents born in Merida or migrated <18y.	• Height-for-age z score (HAZ, CDC 2000) • Weight-for-age z score (WAZ, CDC 2000) • Arm muscle area (AMA, estimated from mid-upper arm circumference and triceps skinfold thickness) • Arm fat area (estimated from AMA and upper arm area)	423	**Migrant vs urban non-migrant:** No association found. Depending on the outcomes, adjustments were made for family income, socioeconomic status, child sex, age, birthweight, gestational age, maternal height, birth order, presence of maternal febrile episodes, child lipids/carbohydrates intake, high protein diet, or area newness.	6/10
Cockx, 2022	Kagera, Tanzania	Kagera Health and Development Survey, 2004 &/2010	<20 years (mean 5.5 years)	Parental residence (rural, town or city) at baseline (1991/94) and follow-up (2004 and/or 2010). Child migration status also specified (based on timing of birth in relation to parental migration).	• HAZ (up to 19 years, WHO 2006) •WAZ (up to 10 years, WHO 2006) • BMI-for-age z score (BAZ; up to 19 years, WHO 2006) • Stunting (HAZ <2SD) • Underweight (WAZ<2SD) Overweight (at < 5 years as BAZ>2SD or 5–19 years as BAZ> 1SD)	15094	**Rural-rural migrant vs rural non-migrant:** < overweight if age <5 years (coeff: −0.44 [SE: 0.026]) or 5–19 years (−0.046 [0.019]) *if born before migration only* N.S diff. all other outcomes **Rural-urban (TOWN) migrant vs rural non-migrant:** N.S diff. all outcomes **Rural-urban (CITY) migrant vs rural non-migrant:** > HAZ (0.512 [0.233]), WAZ (0.540 [0.173]), overweight at age <5 years (0.093 [0.050]) < underweight (−0.087 [0.043]) N.S diff stunting (−0.113 [0.088]), BMI-for-age (0.306 [0.241]), overweight 5–19 years (0.099 [0.072]) (Coefficients larger for HAZ and underweight and smaller for WAZ if born after migration) *Adjusted for child's sex, birth order, year of observation, and age-cohort fixed effects; the parent's sex, birth order, and age-group fixed effects; and the parent's relation to the household head, schooling-for-age, marital status, height, and survey wave fixed effects in 1991/1994.*	**8/10**
Choudhary and Parthasarathy, 2009	Mumbai, India	National Family Health Survey (NFHS) II, 1998-99	<3 years	Urban non-migrant, rural-urban and urban-urban migrants; based on mother's number of years in current area of residence and type of area of previous residence. Early migrant = migrated in last 5 years.	Stunting (HAZ<2SD, NCHS/WHO 1977)	481	**Urban non-migrant vs urban-urban early migrants:** < stunting (−1.65 z value [0.0559] or 9 % less) *Adjusted for number of children, child sex, age, standard of living, family planning worker visits, maternal low BMI, high education, media exposure.* ***Note that all other analyses only compared different migrant groups to each other (and not to non-migrants) and are therefore not included here.***	**4/10**
Hu et al., 2014	Pinghu, China	Primary data, 2011	7–23 months	Migrant = neither parent registered in Pinghu & at least one parent living in Pinghu for 6+ months; local = at least one parent was registered as a Pinghu permanent resident.	Anaemia (hemoglobin <110 g/L)	988	**Migrant vs local:** > anaemia (prevalence ratio: 1.86 [95% CI: 1.40,2.47]) *Adjusted for child age and sex.* **Additional factors:** - decreased risk of anaemia with age - parental socio-economic circumstances did not impact the findings	**7/10**

(*continued on next page*)

Table 1 (*continued*)

Authors	Study location	Data source & study year	Child age	Migration definition & classification	Outcomes	Sample N	Findings (N.S diff = Non significant difference [p-value>0.05]; OR = odds ratio; SE = standard error; CI = confidence interval)	Risk of bias score
							- breastfeeding at 6 months and a non-diverse and iron-rich diet partly explained the anaemia risk in the migrant group	
Kumar et al., 2016	India	NFHS III, 2005-06	0–4 years	Migrant and urban non-migrant; based on mother's number of years in current area of residence and type of area of previous residence.	• BMI (from height and weight, not defined) • Anaemia (not defined) • Diarrhoea (not defined)	13815	**Migrant (origin unspecified) vs urban non-migrant:** > abnormal (low/high) BMI (OR: 1.378, p < 0.001) > anaemia (OR: 1.163, p < 0.05) > diarrhoea (OR: 1.236, p < 0.05) *Adjusted for child age, sex, birth order, birth size, religion, caste, maternal education, mass media exposure & wealth.* No comparisons made by rural-urban/urban-urban migration pathway.	**5/10**
Lu et al., 2015	Shanghai, China	Primary data, 2010-11	7–10 years	Rural-to urban migrant, local city, immigrant origin areas. No definitions provided.	• Height • Weight • Sitting height • BMI (weight/height^2) • Overweight and obesity (from BMI, cut-off undefined)	2457	**For all outcomes means/prevalence:** Local city > rural-urban migrant > immigrant origin areas (p < 0.0001) *No adjusted comparisons made between groups.*	**5/10**
Mishra et al., 2022	India	NFHS VI, 2015-16	12–59 months	Migrant defined as less than 4 years in current place of residence; non-migrant not defined. Based on maternal response. Rural/urban origin not specified.	• Stunting (HAZ<2SD, WHO 2006) • Underweight (WAZ <2SD, WHO 2006)	199 448	**Urban non-migrant vs migrant:** > underweight (OR: 1.16 [95%CI: 1.10,1.20]) > stunting (OR: 1.14 [1.09, 1.18]) **Rural non-migrant vs migrant:** > underweight (OR: 1.23 [1.19,1.25]) > stunting (OR: 1.24 [1.20, 1.26]) *Adjusted for mother age, birth order of the child, mother's education, wealth quintile, caste, religion?*	**4/10**
Prusty and Keshri, 2015	India	NFHS III, 2005-06	<5 years	Urban non-migrant, rural-urban and urban-urban migrants; based on mother's years in current area of residence and type of area of previous residence.	• Stunting (HAZ<2SD, WHO 2006) • Underweight (WAZ <2SD, WHO 2006) • Wasting (WHZ <2SD, WHO 2006)	18834	**Rural-urban migrant vs urban non-migrant:** N.S diff. stunting (OR: 0.99 [95 % CI: 0.88,1.11]) N.S diff. wasting (OR: 0.88 [0.77, 1.01) N.S diff. underweight (OR: 1.00 [0.89, 1.12]) **Urban-urban migrant vs urban non-migrant:** N.S diff. stunting (OR: 0.99 [0.89,1.11]) < wasting (OR: 0.76 [0.66,0.87], p < 0.01) N.S diff. underweight (OR: 0.90 [0.80, 1.02]) *Adjusted for child age, sex, birth order, religion, caste, maternal age, education, current exposure to mass media & wealth.*	**3/10**
Reyes et al., 2004	El Sinai, Acapulco, Mexico	Primary data, 1998	6–23 months	Parental migration in the past two years; classified as rural-urban migrants, rural-rural migrants, urban non-migrant, rural non-migrant.	Stunting (HAZ <2SD, NCHS 1977)	656	**Rural-urban migrant vs urban non-migrant:** > stunting (OR: 1.57 [95% CI: 0.95,2.59]) **Rural-rural migrant vs rural non-migrant:** No association found (no results reported)	**5/10**

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Table 1 (*continued*)

Authors	Study location	Data source & study year	Child age	Migration definition & classification	Outcomes	Sample N	Findings (N.S diff = Non significant difference [p-value>0.05]; OR = odds ratio; SE = standard error; CI = confidence interval)	Risk of bias score
							Adjusted for child age, sex, maternal literacy, and per capita family income in area.	
Rougeaux et al., 2022	Peru	Peru Demographic and Health Survey, 2017	<5 years	Non-migrant: urban or rural, Migrant: urban-urban, rural-urban, rural-rural migrant, urban-rural; based on mother's childhood and/or previous and current area of residence. Time since migration (<5 years or +) and child timing of birth (before/during or after migration) also considered.	• HAZ (WHO 2006) • WAZ (WHO 2006) • WHZ (WHO 2006) • Stunting (HAZ <2SD) • Underweight (WAZ<2SD) • Overweight (WHZ >1SD)	10910	**Rural-urban migrant vs urban non-migrant:** <WAZ (coeff: −0.2 [95% CI:-0.3,-0.01]), WHZ (−0.2 [-0.3,-0.1]), and overweight (OR: 0.6 [0.4,0.8]) N.S diff HAZ (−0.1 [-0.1,0.00]), stunting (OR: 1.0 [0.7,1.3])), underweight (1.1 [0.7,1.9]), double burden of malnutrition [DBM] (0.9 [0.6, 1.2]) **Urban-urban migrant vs urban non-migrant:** <WAZ (−0.1 [-0.2,0.0]) and WHZ (−0.1 [-0.2,0.0]) N.S diff HAZ (0.0 [-0.1,0.01]), stunting (OR: 1.0 [0.8,1.3])), underweight (0.9 [0.6,1.5]), overweight (0.8 [0.6,1.1]), and DBM (1.0 [0.7, 1.3]) **Rural-rural migrant vs urban non-migrant:** <HAZ (−0.5 [-0.6,-0.4]), WAZ (−0.5 [-0.6, −0.5]), WHZ (−0.3 [-0.4,-0.2]), and overweight (0.5 [0.3,0.8]) >Stunting (2.4 [1.8,3.2]), underweight (2.2 [1.3,3.8]) and DBM (1.6 [1.1,2.3]) **Urban-rural migrant vs urban non-migrant:** <HAZ (−0.3 [-0.4,-0.2]), WAZ (−0.4 [-0.5, −0.3]), WHZ (−0.3 [-0.4,-0.2]), and overweight (0.4 [0.2,0.6]) >Stunting (1.7 [1.3,2.3]), underweight (1.8 [1.0,3.0]) N.S diff DBM (1.2 [0.8,1.8]) *In urban children results varied both by child timing of birth (birth after migration = > overweight) and type of area of residence (> linear growth in children of migrants [vs non-migrants] in the capital and towns but not small cities). N.S diff by timing of birth in rural children, nor by time since migration across all children. All analyses adjusted for maternal schooling, ethnicity, height, age and child birth order, age, & sex.*	**7/10**
Santas and Eryurt, 2020	Turkey	Turkey Demographic and Health Survey, 1993–2013	<5 years	Urban non-migrant, rural-urban migrant, urban-rural migrant; based on mother's childhood and current area of residence.	• Inadequate birthweight (from maternal report of birthweight, not defined) • Stunting (HAZ <2SD, no reference specified) • Overweight for age/height (WAZ/WHZ >2SD, no	N = 6519, 8576, 8075, 7405, 9746 in 1993, 1998, 2003, 2008, 2013	**Rural-urban migrant vs urban non-migrant:** N.S diff inadequate birthweight (OR: 0.024) N.S diff stunting (OR: 1.075) > overweight/obesity for height (OR: 1.287, p < 0.01) > overweight/obesity for age (OR: 2.216, p < 0.01)	**6/10**

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Table 1 (*continued*)

Authors	Study location	Data source & study year	Child age	Migration definition & classification	Outcomes	Sample N	Findings (N.S diff = Non significant difference [p-value>0.05]; OR = odds ratio; SE = standard error; CI = confidence interval)	Risk of bias score
					reference specified, in 2013 only)		**Urban-rural migrant vs urban non-migrant:** > inadequate birthweight (OR: 1.214, p < 0.05) > stunting (OR: 1.647, p < 0.01) N. S diff. overweight/obesity for height (OR: 0.817) N. S diff. overweight/obesity for age (OR: 0.788) *Adjusted for child age, gender, maternal education, current residential area, childhood residential area (and study year for the stunting and birthweight model).*	
Wang, 2019	China	China Education Panel Survey, 2014-15	11–18 years	Urban children = urban born, parent migration unspecified; rural children = rural born + parents never migrated to an urban area; migrant children = registered elsewhere + migrated 1+ years ago with parents.	HAZ (WHO 2006)	7772	**Migrant vs rural children:** > HAZ (coeff: 0.153 [SE: 0.029]) **Migrant vs urban children:** > HAZ (coeff: 0.165 [0.026]) *Adjusted for child sex, age, ethnicity, family socio-economic conditions.* *Differences decreased as level of paternal education increased but remained.*	7/10

Description: This table provides an overview of the characteristics of each study, including the sample age and size, migration definition used, outcomes assessed and main findings.

weight-for-height cut-offs, without specifying what the reference data was (Santas and Eryurt, 2020).

One of the Mexican studies used skinfold thickness, an estimate of body fatness, for calculations of arm muscle area and arm fat area (Azcorra et al., 2009). One Chinese study assessed overweight but did not provide any information on how this measure was created (Lu et al., 2015). In the study from Turkey, authors assessed inadequate birthweight but a definition was also not provided (Santas and Eryurt, 2020). Other nutritional outcomes assessed included anaemia (using the WHO recommended cut-off of haemoglobin level <110 g/L [43] and a non-specified cut-off [44]), and diarrhoea prevalence (Kumar et al., 2016). Two studies used simple anthropometric measurements with no adjustments for age and sex, including height, weight, sitting height and BMI (Lu et al., 2015; Kumar et al., 2016). The Chinese study specified that BMI was defined as weight/(height^2) while the Indian study provided no information (Lu et al., 2015; Kumar et al., 2016).

Additionally, mother and child double burden of malnutrition was assessed in the Peruvian study, defined as either overweight/obesity in the mother with a child with wasting/underweight/stunting, or a mother with thinness and a child with overweight, or a child who had both stunting and overweight (Rougeaux et al., 2022). Child estimations were based on nutritional status cut-offs defined above while maternal ones were based on her BMI (as weight/height^2) from height and weight provided in the DHS.

3.1.4. Analyses

All the studies conducted regression analyses to assess the association between migration category and a given outcome, except one Chinese study which only provided prevalence for each group with no further comparative statistical analyses (Lu et al., 2015). Of the studies that used regression methods, all adjusted for covariates. One of the Chinese studies adjusted for child age and sex only, while the other studies adjusted for covariates reflecting family socio-economic conditions (such as parental income and education) and ethnic background. One study adjusted for maternal BMI (Choudhary and Parthasarathy, 2009) and two studies adjusted for maternal height (Cockx, 2022; Azcorra et al., 2009). One study also considered child dietary factors, such as lipid and protein intake, as confounders (Azcorra et al., 2009).

3.1.5. Assessment of bias

Over half the studies used high quality datasets which were representative of the population of interest, but it was unclear whether the data was dealt with in the appropriate manner to allow generalisability of the findings (such as adjusting for survey design). The Indian studies, the Turkish study, the Peruvian study, and one of the Chinese studies used nationally representative data (Kumar et al., 2016; Prusty and Keshri, 2015; Mishra et al., 2022; Wang, 2019; Choudhary and Parthasarathy, 2009; Santas and Eryurt, 2020; Rougeaux et al., 2022). However, none of the Indian studies nor the Turkish study reported using the survey weights provided with the data and recommended for use by the DHS Program (which oversees all of the datasets used in these studies) to adjust for the complex survey design and nonresponse and thus allowing any results to be considered representative of the population of interest (Croft et al., 2018). Aside from the Peruvian study, none of the studies using national data reported missing data nor described how these were dealt with. The Kagera Health and Development Survey (KHDS) used in the study from Tanzania is designed to be representative of the population of the region of Kagera and has a complex survey design allowing for this; the author did not however discuss whether their data was representative of the region nor whether they had used the sample weights made available and recommended in the KHDS (Cockx, 2022; Ainsworth et al., 2004). All the other studies included in the review used smaller samples in specific cities or areas where participants were purposively selected and are therefore less likely to be generalisable to the migrant and non-migrant populations of interest compared to the studies mentioned previously.

There is no standard or validated definition of migration and for this reason each study used a different approach to defining their migrant group. Migration was generally defined based on the mother or a/both parent(s) having lived in a different place prior and used information on place of registration and/or residence as assessed and reported by the survey teams, making the information somewhat more reliable and detailed than self-reports of migration status (which none of the studies used). However,for the most part the definitions were unclear and lacked sufficient information to determine important aspects such as the pathway of migration (as often rural/urban type of place of origin and/or destination were not provided) and whether the child had also migrated.

There is also no standard definition for 'rural' or 'urban' areas. It is likely that this will have different between studies as, for example, DHS studies usually rely on definitions used by the country's national authorities (Victora et al., 2017). Comparisons of results between studies of different countries should therefore be made with caution. The use of broad rural or urban areas may also mask heterogeneity within these. Though DHS data on urban areas of residence is usually provided as smaller geographical entities (such as town, small city or large city), studies will often merge these into one urban group to make statistical analyses possible and/or interpretation easier. It is possible that findings would have differed if geographic areas had been broken down into smaller entities.

All the studies, aside from one of the Chinese ones (Lu et al., 2015), used regression analyses to assess differences in child outcomes by internal migration and adjusted these for potential confounding factors. Instead, this study compared means or prevalence using simple statistical tests (Lu et al., 2015). While adjusting for confounders has allowed most studies to provide reliable estimates of association between exposure and outcome, several of the studies included confounders (such as current media exposure and socio-economic circumstances) which could be deemed to be on the causal pathway between the two, making them potential mediators rather than confounders (Kumar et al., 2016; Prusty and Keshri, 2015; Mishra et al., 2022; Wang, 2019; Choudhary and Parthasarathy, 2009). This means the findings could be biased and potentially under- or over-reporting differences in child outcomes between migration groups.

Though most studies clearly defined their outcomes and used recommended measures of child growth or nutritional status such as HAZ_{WHO} and stunting as $HAZ_{WHO} < 2SD$ of international reference data, some studies either did not report how their outcomes were measured (Lu et al., 2015; Kumar et al., 2016; Santas and Eryurt, 2020) and/or used measures which did not consider age and sex as recommended for assessing growth and nutritional status in children (Lu et al., 2015; Kumar et al., 2016; de Onis et al., 2007) making the findings unreliable. Additionally, almost none of the studies reported patterns of missing data and it is therefore unclear whether estimates could be biased and conclusions invalid.

Other aspects of the studies might have impacted bias, such as the way migration groups (e.g. rural-urban migrants) were defined and the timing of assessment of different measures which could have introduced problems of generalisability and causality. These are further discussed in subsequent sections.

Based on the risk of bias assessment and findings described above, overall, one study stands out as having the lowest risk of bias (Cockx, 2022) and two as having high risk of bias (Lu et al., 2015; Kumar et al., 2016) with others likely having low to moderate levels.

3.2. Findings

Of the 12 studies included, one found no association between parental migration and any child outcome (Azcorra et al., 2009). All the other studies found an association between migrant and non-migrant groups and outcomes to varying degrees depending on the characteristics of migration (child birth before/after maternal migration, age at migration, and time since migration or acculturation). These findings are described in more detail below.

3.2.1. Parental migration status

In their longitudinal study of Tanzanian children, the author showed that, compared to *rural non-migrants*, rural-urban migrants had greater height and weight growth and were more likely to be overweight under the age of 5 years (but not between 5 and 19 years) primarily when they had migrated to cities rather than towns (Cockx, 2022). Similarly, in one of the cross-sectional Chinese studies, the authors showed that migrant children aged 11–18 years had greater linear growth than rural non-migrant children but also than urban non-migrants and with similar coefficients (Wang, 2019). Though, as highlighted previously, it's not clear if these migrants were rural-urban, urban-rural or both. In one the of the Indian studies, internal migration was found to be associated with lower odds of underweight and stunting in children (below 5 years) of migrants when compared to non-migrants in both rural and urban areas, though differences were larger in the former (Mishra et al., 2022). Nonetheless, the authors did not have sufficient information to compare different pathways of migration, and their results should be interpreted with caution as migrants only included recent migrants (<4 years) and it is not clear if longer term migrants were included in the analyses (as non-migrants) or excluded entirely (Mishra et al., 2022). In Peru, it was found that compared to rural non-migrants, urban-rural migrants had greater linear and weight growth and a lower probability of stunting (Rougeaux et al., 2022). There were no differences for overweight and the double burden of malnutrition (Rougeaux et al., 2022).

The findings from studies comparing migrants to *urban non-migrants* were mixed. Having a rural-urban migrant parent appeared to be associated with a higher risk of infant stunting compared to urban non-migrants in the older Mexican study (Reyes et al., 2004) but not in larger, more recent Indian, Peruvian and Turkish studies (Prusty and Keshri, 2015; Santas and Eryurt, 2020; Rougeaux et al., 2022). In Peru, however, differences emerged when type of urban area was considered: compared to non-migrants, a lower risk of stunting was found for children of migrant mothers, particularly rural-urban migrant mothers, living in the capital city or towns but not in small cities (Rougeaux et al., 2022). One Chinese study also found a greater risk of anaemia in infants of rural-urban migrants compared to urban non-migrants (Hu et al., 2014). In Indian children under 5 years, having a migrant parent was associated with higher odds of 'abnormal BMI' (which included both low and high BMI, though they report that low BMI was more common), anaemia, and diarrhoea than urban non-migrant children (Kumar et al., 2016). However, like in another of the Indian studies, they did not compare different pathways of migration (Kumar et al., 2016; Mishra et al., 2022). In the text they nonetheless reported that maternal rural provenance was associated with a higher prevalence of anaemia but not abnormal BMI (Kumar et al., 2016). One study assessed stunting differences for children below the age of 3 years in Mumbai, India, finding find that children of urban non-migrants had significantly lower stunting (~9% less) than children of urban-urban *early* migrants (Choudhary and Parthasarathy, 2009). However, they did not make any further comparisons of non-migrants with later migrants or rural-urban migrants.

Three studies assessed overweight in children of migrants compared to urban non-migrants. The Turkish study showed a greater risk of overweight in children under 5 years born to rural-urban migrant women whereas in Peru it was the opposite (Santas and Eryurt, 2020; Rougeaux et al., 2022). However, in Peru children born after maternal rural-urban migration had a higher risk of overweight than those born before/during (Rougeaux et al., 2022). Though one of the Chinese studies found a lower prevalence of overweight in rural-migrant children compared to local urban children, they did not test this further (Lu et al., 2015). Note that in the Turkish study, women who indicated the same type of residence in childhood and at the time of the survey were considered non-migrant, however this suggests the group could have

included migrants who moved between rural areas and between urban areas (Santas and Eryurt, 2020).

Two studies considered urban-rural migrants in comparison with urban non-migrants. Turkish children below 5 years of urban-rural women were found to have higher odds of inadequate birthweight and stunting than children of urban non-migrants but no differences for overweight/obesity (Santas and Eryurt, 2020). In the Peruvian study children of rural-urban migrants appeared to have greater linear and weight growth, lower stunting and possibly greater overweight compared to urban non-migrants, though this was not tested statistically (Rougeaux et al., 2022).

None of the studies considered frequency of migration or the occurrence of multiple pathways.

3.2.2. Timing of migration and child migration status

Only three studies gave information on timing of migration and child's migration status. One Chinese study specified that children in the migrant group had migrated with their parents/carers but they did not provide any information on the age at which this occurred (Kumar et al., 2016). The Tanzanian study indicated that they had included both children born before and after parental migration and compared their findings between the two groups, showing that rural-urban (city) migration was associated with even greater height growth and lower weight growth compared to rural non-migrants for children born *after* migration (i.e. in the city) (Cockx, 2022).

Comparisons by child timing of birth in relation to maternal migration were also made in the Peruvian study. The authors found greater linear growth, weight growth and overweight and lower stunting in those born after maternal urban-urban and rural-urban migration compared to before/during, though differences were small and not all statistically significant (Rougeaux et al., 2022). For rural-rural and urban-rural migrants there was no evidence of any differences (Rougeaux et al., 2022).

The Indian studies did not specify the child's timing of birth in relation to maternal migration and therefore likely included children born both before and after migration in their samples, as the DHS datasets used normally include both and no exclusions were mentioned here (Kumar et al., 2016; Prusty and Keshri, 2015; Mishra et al., 2022; Choudhary and Parthasarathy, 2009).

Compared to Mishra et al.'s Indian study, which only included recent migrants, the three other Indian studies (of children under 5 years of age) considered maternal migration at any time in the mother's life and therefore most mothers would likely have migrated before their child's birth (Kumar et al., 2016; Prusty and Keshri, 2015; Mishra et al., 2022; Choudhary and Parthasarathy, 2009). This would have also been the case for the Turkish study as they used similar data (Santas and Eryurt, 2020). In other studies of very young children, it is also assumed they were born close to or after migration (Reyes et al., 2004; Hu et al., 2014).

3.2.3. Time since migration and acculturation

In additional analyses carried out in the Tanzanian study, it was found that a child's number of years in an urban environment post-migration was positively associated with HAZ but there were no differences for stunting (Cockx, 2022).

In one Indian study, the authors reported that a longer time since migration was associated with a greater likelihood of their child being undernourished (low BMI), but diarrhoea and anaemia were higher in recent migrants (Kumar et al., 2016). They did not distinguish between rural and urban destinations however, and time since migration was only discussed in the text and not considered in the regression analyses (Kumar et al., 2016).

In Peru, the authors found no significant differences when comparing recent migrant (<5 years) and longer-term migrants (Rougeaux et al., 2022).

3.2.4. Causality

Most of the studies included in the review were observational and cross-sectional and therefore could not infer a causal association between parental migration and child outcomes. While internal migration could have an impact on child growth and nutritional health, it is also possible that selection effects, whereby those who migrate have different characteristics (like better socio-economic conditions or health) than those who do not migrate, may be influencing both migration decisions and intergenerational health causing their association to be overestimated (Urquia and Gagnon, 2011).

In the Tanzanian study, they attempted to control for selection by comparing children of migrant and non-migrant siblings and adjusting for baseline parental characteristics (sex, age, birth order, relation to the household head, schooling-for-age, marital status, and height) (Cockx, 2022). Their findings showed that selection effects do play a role but do not fully explain the association between parental migration and child outcomes (Cockx, 2022).

Most of the other studies adjusted for covariates which may have reflected selection effects, such as maternal height (reflecting maternal early health and socio-economic circumstances; Rougeaux et al., 2022), maternal literacy (Reyes et al., 2004), caregiver/maternal education (Kumar et al., 2016; Prusty and Keshri, 2015; Mishra et al., 2022; Choudhary and Parthasarathy, 2009; Santas and Eryurt, 2020; Rougeaux et al., 2022) and ethnicity (Kumar et al., 2016; Prusty and Keshri, 2015; Mishra et al., 2022; Wang, 2019; Santas and Eryurt, 2020; Rougeaux et al., 2022). Some studies also adjusted for factors like income, family planning visits, maternal BMI, and mass media exposure; however, these indicated current rather than pre-migration socio-economic and health conditions and therefore did not necessarily adjust for selection into migration (Azcorra et al., 2009; Kumar et al., 2016; Prusty and Keshri, 2015; Mishra et al., 2022; Wang, 2019; Choudhary and Parthasarathy, 2009).

3.2.5. Mechanisms

Using mediation analyses, the Tanzanian study explored different factors that may have changed or occurred with rural-urban (city) migration and could have explained the associations between internal migration and child health and education outcomes, including income, living conditions (floor material), access to clean drinking water, maternal fertility, and household education level (Cockx, 2022). They found that increased household income and better living conditions explained some, but not all, of the associations found between rural-city migration and growth and nutritional status outcomes. Reduced fertility, increased household education and improved access to drinking water did not play a major part in explaining their findings (Cockx, 2022).

Though most of the other studies also considered current socio-economic circumstances, such as income, standards of living or wealth, these were treated as confounders and their mediating effects were not considered (Reyes et al., 2004; Azcorra et al., 2009; Kumar et al., 2016; Prusty and Keshri, 2015; Mishra et al., 2022; Wang, 2019; Choudhary and Parthasarathy, 2009).

Changes in access to food and dietary habits could also mediate the association between internal migration and child health and their inclusion in adjusted analyses may explain the reduced associations in some studies. In China it was reported that breastfeeding at 6 months and diets that were not diverse nor rich in iron partly explained the higher risk of child anaemia they had found in the migrants compared to the locals (Hu et al., 2014). One of the Indian studies also suggested that delayed breastfeeding and less use of oral rehydration therapy when the child had diarrhoea may have explained the poorer outcomes in rural-urban compared to urban-urban migrants, they did not however explore this in their statistical analyses (Kumar et al., 2016). In another it was found that migrant women from rural areas had significantly lower BMI than those from urban areas, though this was also not explored as a mechanism for child outcomes (Choudhary and

Parthasarathy, 2009).

4. Discussion

This review identified 12 studies exploring internal parental migration and child growth and/or nutritional status in LMICs. Overall, most studies suggested that parental/maternal internal migration was associated with child growth and nutritional status, however, findings were mixed in terms of the direction and strength of the associations, and there were varying levels of potential bias.

Five studies compared migrants to *rural non-migrants* and these generally suggested that migration was associated with both greater child growth and risk of overweight and lower risk of undernutrition. One study assessed child and parent *rural-urban* migration in Tanzania in 2004–2010 and found that for those who had migrated to cities (but not to tows) there was a reduced risk of undernutrition and improved linear growth, and increased weight growth and risk of being overweight (Cockx, 2022). Linear growth was also increased and undernutrition and weight growth decreased in children born after migration (Cockx, 2022). Similarly, a study in Chinese children aged 7–10 years in 2010–11 found greater height and weight growth and overweight and obesity in children of migrants (Lu et al., 2015), though it was not clear if the comparison group was rural non-migrant or both rural and urban non-migrant combined. Furthermore, unlike all other studies in this review, they only used summary comparative statistics rather than adjusted regression analyses. Another study conducted on adolescents in China in 2014–15 also found parental migration associated with greater linear growth but they did not specify rural/urban place of origin or destination of migrants (Wang, 2019). Only the Peruvian study compared migrants within rural areas to rural non-migrants, finding that children <5 years born to urban-rural migrant mothers had greater linear and weight growth and a lower risk of stunting (Rougeaux et al., 2022).

In studies comparing migrants to *urban non-migrants* (eleven in total), findings were mixed. These showed children of *rural-urban migrants* had greater levels of undernutrition and poorer growth under 2 years of age in China in 2011 and Mexico in 1998 (Reyes et al., 2004; Hu et al., 2014) but not in children under 5 years of age in India in 2005–6 and Turkey in 1993–2013 (where there were no differences, Prusty and Keshri, 2015; Santas and Eryurt, 2020), better linear growth in late childhood/adolescence in China in 2014–15 (Wang, 2019), and higher odds of being overweight in early childhood in Turkey in 1993–2013 and Peru in 2017 (Santas and Eryurt, 2020; Rougeaux et al., 2022).

In contrast, two studies comparing *urban-urban migrants* to *urban non-migrants* in India showed migration to associated with lower levels of undernutrition in children under 5 years in 2005–6 and 3 years in 1998–99 respectively (Prusty and Keshri, 2015; Choudhary and Parthasarathy, 2009). In contrast the Peruvian study in children under 5 years found lower weight growth but no differences for other outcomes (Rougeaux et al., 2022). Another study comparing growth and nutritional status in 2006–07 in Mexican children aged 4–6 years of migrant parents (of unspecified origin) to urban non-migrants found no associations (Azcorra et al., 2009). These differences could reflect differences in setting, contexts, and experiences of migration, and whether the child migrated with parents, but they could possibly also stem from different analytic approaches such as in defining migration and adjustments for confounding and selection effects. It is also possible that the impacts of migration on child growth and nutritional health change as children age and acculturate to their place of destination.

Selection effects were defined in response to an epidemiological paradox whereby migrants appeared to be in better health than non-migrants despite living in or coming from more disadvantaged circumstances (Urquia and Gagnon, 2011). Pre-migration migrant characteristics, such as gender, SECs, and health may be both associated with migratory decisions and post-migration health leading to an under- or over-estimation of the impacts of migration on health depending on whether we have positive or negative selection. The broader health and migration literature primarily reports this within contexts of international migration; however, several studies suggest these effects can also occur with internal migration in LMICs (Urquia and Gagnon, 2011; Nauman et al., 2015; Lu, 2008; Torun et al., 2002; Anglewicz et al., 2018; Ginsburg et al., 2021). Among the studies included in our review, the Tanzanian study found that selection effects may indeed explain some, but not all, of the greater growth and better nutritional status seen in migrant compared to (rural) non-migrant children (Cockx, 2022). In contrast in adults in Indonesia, Thailand and Malawi selection effects were found to fully explain physical health outcomes whereas in Guatemala no selection effects were found (Nauman et al., 2015; Lu, 2008; Torun et al., 2002; Anglewicz et al., 2018). None of the other studies in our systematic review considered selection effects. Though some adjusted for factors like maternal education and height which would have reflected pre-migration socio-economic conditions, other socio-economic factors were measured post-migration and therefore would not likely have reflected selection effects. In the Tanzanian study analysis of explanatory factors, improvements in income and living conditions partly explained the greater growth found among children of rural-urban migrants compared to rural non-migrants (Cockx, 2022). Similarly in adults, the increased risk of overweight and obesity with rural-urban migration has been attributed to improvements in socio-economic circumstances (Rees et al., 2017; Hilmers et al., 2016). However, this may vary across settings as in some countries, overweight and obesity are increasingly seen in rural areas and among the poorest (Popkin et al., 2020). These complexities could help explain the mixed findings in studies comparing migrants to non-migrants in urban areas.

There is a lack of data on the proportion of urban poor that are made up of migrants as migration status and/or informal settlements are often left out of data (Tacoli et al., 2015). It is however estimated that migrants make up an important portion of the urban poor (Tacoli et al., 2015; Hennessey, 2021). Problems of access to healthy diets in the urban poor likely increase risks of malnutrition which may manifest as both undernutrition and overweight at the individual and/or household level (Bakhtiari and Cockerham; Delisle, 2008; Vilar-Compte et al., 2021; Khan and Kraemer, 2009). Urban poverty is associated with increased overcrowding and poorer sanitation and access to clean water, which may result in illnesses affecting child growth and nutritional status (Campbell and Campbell, 2007; Coburn et al., 2002; Corburn et al., 2019). Migrants in urban areas have also been found to have a much greater exposure to air pollution which has been proposed to negatively impact child linear growth (Carrasco-Escobar et al., 2020; Sinharoy et al., 2020).

In children, however, associations of internal migration and growth and nutritional status persisted after considering socio-economic circumstances at the destination; in the Tanzanian study it was proposed that changes in nutritional environments may have explained the associations further, though this was not explored in this study or any other. As mentioned previously, rural to urban migration has been associated with more dietary diversity and more fruit and vegetable consumption compared to rural non-migrants, but it has also been associated with greater consumption of convenience foods high in fat, salt and sugar, and more sedentary lifestyles (Bowen et al., 2011; Peters et al., 2019; Cockx et al., 2022; Stern et al., 2010). This could explain both the higher linear growth and greater risk of overweight found in children of rural-urban migrants compared to rural non-migrants in this review. Findings were however mixed in studies comparing rural-urban migrants to urban non-migrants which warrants further investigation into the role of changes in nutrition and dietary behaviours that occur with migration. Notably, future studies should explore whether the association of rural-urban migration and child growth and nutrition may vary by the country's stage of the nutrition transition and the level of urbanization. While there may be direct impacts of post-migration environment on child outcomes, there are likely to be, particularly in early life, indirect effects through maternal health and behavioural pathways

(Anglewicz et al., 2019). Maternal obesity before, during and after pregnancy has been associated with offspring obesity; this may occur due to shared genetic pathways, physiological and nutritional pathways in pregnancy, breastfeeding and child feeding behaviours – all of which are associated with weight gain (Thompson, 2013; Classen and Thompson, 2016). Though some of the studies in this review suggested patterns of breastfeeding, infant feeding, and household diet composition could be potential explanatory factors in the association of migration and child growth and nutritional status, these were not explored analytically.

In the Tanzanian study, comparisons of children born before and after maternal rural-urban migration which showed lower linear growth in the former suggests that rural place of birth and exposures in early life may be detrimental (Cockx, 2022). A study of adults who had migrated from rural to urban in adolescence indicated that, even though some catch-up growth may occur, an early rural exposure will likely have a lasting negative impact on height (Coly et al., 2006). For children born before rural-urban migration, they may also have been exposed to undernutrition in utero with potential negative impacts on foetal growth and long-term metabolic health, particularly with subsequent exposure to obesogenic urban environments (Belkacemi et al., 2010; Martins et al., 2007; Wells, 2018). It is possible that a mother's own rural upbringing may have influenced her height and, subsequently, the growth and nutritional health of her offspring (Martorell and Zongrone, 2012; Bramer et al., 2017; Reyes et al., 2004; Han et al., 2012). This could help explain why rural-urban migrant children had greater stunting and anaemia than non-migrants in two of the studies included (Reyes et al., 2004; Hu et al., 2014). Similarly, one of the Indian studies found greater stunting in rural-urban migrant compared to urban-urban migrants, though this was reduced after adjusting for confounders (Choudhary and Parthasarathy, 2009).

For the most part however, the studies identified in this review did not report if children of migrant parents had migrated with their parents or were born afterwards. As such, for those who migrated between rural and urban areas, we do not know what kind of environment the child was exposed to during important developmental periods. The age of exposure to rural environments may be particularly important. Indeed, a study conducted in South Africa (not included in this review as it did not meet the observational study criteria) found that maternal and child rural-urban migration was associated with lower linear and weight growth in early childhood but greater height growth at 8 years compared to urban non-migrants (Christodoulou et al., 2022). Though none of the studies included in the review explored age at migration, it could help explain negative associations between rural-urban migration and growth in younger children and positive ones in older children in our studies (Reyes et al., 2004; Hu et al., 2014; Wang, 2019). Note however that the ages reported in the studies relate to the time of measurement of the outcomes and do not necessarily reflect the timing of migration.

As most studies did not report whether children had migrated with their parents, we also do not know if they were exposed to the process of migration. Migration can come with increased levels of stress, particularly for those who migrate in situations of emergency and/or with limited socio-economic resources to support them. In adults, internal migration has been associated with poorer mental health, though more so when migration occurred without family (Meyer et al., 2017; Capazario and Kollamparambil, 2022). This may in turn impact child health. For example, it was found that Ecuadorian mothers who were depressed were more likely to consume snacks and processed foods and the authors also suggested poor maternal mental health may impact some aspects of parenting such as preparing meals, as others have also found (Thompson et al., 2022). It is possible that migration may increase stress due to the context in which migration occurs and/or circumstances at arrival. For women, this may have effects in pregnancy through placenta and foetal development changes or postnatally by altering breastmilk composition and maternal behaviours which may in turn impact child physical growth (Lewis et al., 2016; Kingston and Tough, 2014; Beijers et al., 2014; Nath et al., 2017). This would however only be relevant to women who migrate close to or during pregnancy, which is likely to represent a minority of all migration. In the Peruvian study, it was reported that a quarter of women had migrated near the time or during pregnancy; the two groups could not however be separated due to lack of precision of the DHS age data used (Rougeaux et al., 2022). In the Tanzanian study, based on the reasons reported in their baseline survey, the author suggested migration occurred primarily as an investment rather than as a coping strategy to shocks; reasons for migration were not discussed in the other studies and it is unclear whether this may have moderated the associations. It is possible that for families who migrate in situations of emergency (like conflict) we would see poorer child health outcomes compared to those who migrate for marital or other socio-economic reasons, due to negative intergenerational psychological and physical effects and the child's own direct experiences of the emergency (if they were born at the time) (Devakumar et al., 2014).

There were insufficient studies to allow for comparisons between different pathways of migration such as urban-urban and rural-urban migration. In addition, most studies compared migrants with non-migrants at the place of current residence and therefore limited inference could be made about the effects of the process of migration itself (which would require comparison with non-migrants at place of origin). For most part, the studies were cross-sectional and did not allow causal inference. Though most studies adjusted for covariates reflecting child and parental demographic, ethnic and socio-economic characteristics, these varied across studies, limiting the ability to compare findings. Furthermore, some of the covariates considered like current income, wealth or maternal BMI would have been on the causal pathway and therefore reflecting mediation rather than confounding. This may have led to underestimation of associations and explain null findings in some of the studies. At the same time, selection effects were not considered in most studies which could have led to an overestimate of associations. A few studies adjusted for maternal education and height, emulating maternal childhood pre-migration conditions, but this likely would not have sufficiently accounted for selection effects. In the Tanzanian study, it was suggested that both parental migration as well as child migration and rural exposure prior to this may influence growth and nutritional status. Despite likely including both children who had and had not migrated with their parents, most studies did not consider these two groups separately and may there have underestimated or overestimated the effect of parental migration. Furthermore, the effects of child migration may have varied depending on the age at migration which none of the studies considered. Though studies reported the age of the child at the time of data collection, it was for the most part unclear how long prior migration had taken place. Finally, none of the studies collected and/or reported any information on reason for migration, which could have influenced the results. However, the migration literature suggests that most long-term/permanent internal migration occurs for economic, educational and marital reasons.

5. Conclusion

Overall, the studies in this review suggest that parental internal migration, and particularly migration between rural and urban areas, is associated with child physical growth and nutritional health. Compared to rural non-migrants, children of rural-urban migrants were found to be both taller and more overweight, particularly if born after migration. Compared to urban non-migrants, patterns were less clear, likely due to different analytic approaches and contexts across studies. The findings echo patterns of increased risk of overweight and obesity seen in adult rural-urban migrants in LMICs. Though migration-related changes in wealth and living standards likely explain these associations to some extent, maternal nutrition and stress pathways and migration-related nutritional transitions may offer further explanations.

Many questions are left unanswered. Most importantly, it is unclear

if there is a causal association after considering selection effects. Longitudinal studies are needed to investigate this further. It is also unclear how, if the associations are indeed causal, children might be affected differently depending on their place of birth, their age at migration, their pathway of migration and time spent at destination. These studies should also consider how rural and urban areas are defined and whether any heterogeneity within these may influence associations between migration and child health. Finally, more research is needed to understand what, aside from migration-relation socio-economic changes, may explain the impact of internal migration on child growth and nutritional status. As the climate crisis unfolds, more consideration should be placed on the contexts in which migration occurs and whether this may have different implications for child growth and nutritional outcomes.

CRediT authorship contribution statement

Emeline Rougeaux: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Adriana Vázquez-Vázquez:** Writing – review & editing, Validation, Methodology, Investigation, Formal analysis, Data curation. **Laura Busert-Sebela:** Writing – review & editing, Validation, Methodology. **Mary Fewtrell:** Writing – review & editing, Validation, Supervision. **Jonathan C.K. Wells:** Writing – review & editing, Validation, Supervision.

Ethics approval and consent to participate

The manuscript presents secondary data analyses only and therefore does not require ethical approval.

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Declaration of competing interest

The authors declare that they have no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2025.117899.

Data availability

Data will be made available on request.

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