

# Birth and Health Outcomes of Children Migrating With Parents: A Systematic Review and Meta-Analysis

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**Objective:** To examine the birth and health outcomes of children migrating with parents internationally and domestically, and to identify whether the healthy migration effect exist in migrant children.

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Chang R, Li C, Qi H, Zhang Y and Zhang J (2022) Birth and Health Outcomes of Children Migrating With Parents: A Systematic Review and Meta-Analysis. Front. Pediatr. 10:810150. doi: 10.3389/fped.2022.810150 **Methods:** Five electronic databases were searched for cross-sectional, case-control, or cohort studies published from January 1, 2000 to January 30, 2021 and written by English language, reporting the risk of health outcomes of migrant children (e.g., birth outcome, nutrition, physical health, mental health, death, and substance use) We excluded studies in which participants' age more than 18 years, or participants were forced migration due to armed conflict or disasters, or when the comparators were not native-born residents. Pooled odd ratio (OR) was calculated using random-effects models.

**Results:** Our research identified 10,404 records, of which 98 studies were retrained for analysis. The majority of the included studies (89, 91%) focused on international migration and 9 (9%) on migration within country. Compared with native children, migrant children had increased risks of malnutrition [OR 1.26 (95% Cl 1.11–1.44)], poor physical health [OR 1.34 (95% Cl 1.11–1.61)], mental disorder [OR 1.24 (95% Cl 1.00–1.52)], and death [OR 1.11 (95% Cl 1.01–1.21)], while had a lower risk of adverse birth outcome [OR 0.92 (95% Cl 0.87–0.97)]. The difference of substance use risk was not found between the two groups.

**Conclusion:** Migrant children had increased risk of adverse health outcomes. No obvious evidence was observed regarding healthy migration effect among migrant children. Actions are required to address the health inequity among these populations.

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# INTRODUCTION

Migration is a global phenomenon with nearly one in seven individuals being a migrant (1). The majority are labor migrants who relocate to more developed areas, seeking employment opportunities, either internationally or domestically. Others are forced migrants because of wars, conflicts, or natural disasters. A growing number of children are compelled to migrate with their parents. According to the International Organization for Migration, the number of children

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migrating with their families beyond a country's border reached 37.9 million in 2019 (1). Similarly, the number of children migrating within a country (e.g., from rural to urban) is also spiking. In China, about 20.8% of the migrant population in 2010 were children younger than 14 years old (2).

Migrants are usually at a relatively lower socioeconomic ladder and have less access to public welfare, such as healthcare services and education (3). However, migrant adults present similar or better health outcomes compared to native populations in multiple health indices, including pregnancy outcomes, selfreported health, and adult mortality (4, 5). This phenomenon, known as the "migrant paradox" or "healthy migrant effect," has been much debated (6). Evidence regarding the impacts of migration on migrant children's health status is inconsistent. Some migrant children experienced overall better health outcomes than the native-born children. In Portugal, children who migrated from other counties have a lower risk of being low birth weight (LBW) and small for gestational age (SGA) than native children (5). In contrast, the migratory process can generate unfavorable social and medical care conditions, placing the health of migrant children at risk. International migrant children in European and American countries have worse physical health (7), more mental health problems (8), and increased risks of fetal and infant mortality (9). These inconsistent observations may be related to population origins, migration types, and health indices used in the studies (10-12). Therefore, it is important to systematically examine the health status of migrant children and to understand the extent the health of these children is affected by migration and how the impacts may vary in regard to various health outcomes at birth and in later life.

No comprehensive assessment is available regarding the health status of migrant children across all the key areas of health. To address this study gap, we performed a systematic review and meta-analysis to evaluate the impact of migration on major health indicators, including children's birth outcome, nutrition, physical health, mental health, death, and substance use. We also examined whether the migration type (international or internal) differentially influences the health of these children. This is in response to the debate regarding the migrant paradox among children populations.

# **METHODS**

### **Search Strategy and Selection Criteria**

For this systematic review and meta-analysis, we searched five electronic databases, including PubMed, Embase, Web of Science, Cochrane, and Scopus from January 1, 2000 to January 30, 2021. The full search strategy is provided in the **Appendix**. Based on literature review, we decided to investigate six categories of health outcomes: birth outcomes, nutrition, physical health, mental health, death, and substance use. We searched observational studies (e.g., cohort, case-control, or cross-section) reporting the risk of health outcomes that included migrant children aged 0–18 years. Both internal and international migrations were included. We defined international migrant children as those with at least one foreign-born parent, irrespective of the child's birth place, including firstgeneration and second-generation immigrants (13). Internal migrant children refer to children who have lived in the host city for more than 6 months while holding a non-local household residency, such as rural-to-urban migration (14). The comparator group consisted of native-born children (e.g., children and both parents without migration background) (15). We excluded the studies on refugee children who migrated due to armed conflict, disasters, or political, religious or ethnic persecution. Those with a comparator group of non-natives were also excluded. The initial literature search and screening to assess eligibility was done by two reviewers (HQ and Y). Any discrepancies about study inclusion were resolved through discussion with RX. Data were extracted by two reviewers (RX and CN) and checked by two others (HQ and Y). Studies that reported results as odds ratios (ORs) or included data that enable the calculation of ORs were retained for analysis. This study is reported in accordance with the PRISMA guidelines (16) (Appendix).

We summarized the health outcomes from all the included studies as follows. Birth outcomes included low birth weight (LBW), high birth weight (HBW), and preterm birth. Nutritional outcomes were overweight/obesity, underweight, and iron deficiency anemia. Physical health included oral, gastrointestinal, respiratory, allergic, and congenital diseases. Mental health covered depression, attention deficit hyperactivity disorder (ADHD), autistic spectrum disorder (ASD), schizophrenia, suicide attempt. Deaths referred to fetal, perinatal, neonatal, postneonatal, and infant deaths. Substance use included tobacco, alcohol, and cannabis (**Appendix**).

### **Data Analysis**

The quality assessment for all included studies was done independently by two reviewers (RX and HQ) using an adapted version of the Newcastle Ottawa Scale (**Appendix**). Studies with a high or unclear risk of bias across five or more domains were assessed as having high risk of bias. For each article ultimately included, we extracted data on the name of authors, publishing year, study country, study design, age of participants, sample size, and health outcomes using self-designed data extraction sheets. We also extracted ORs or recalculated pertinent ORs using available data.

We estimated pooled OR with 95% confidence intervals (CIs) for the risk of health outcomes using a random-effects model. The  $I^2$  statistic was used to estimate the proportion of total variation among the pooled studies due to heterogeneity. We performed subgroup analyses of study region (e.g., Europe vs. non-Europe) to assess the source of heterogeneity. Subgroup analyses were also conducted per migration type if possible, and the risk of each health outcome was assessed by host countries (the countries with at least two studies in each selected health outcome). We explored the potential risk of publication bias using Begg's and Egger's tests. We used forest plots to show the OR and 95% CIs for each study and the pooled estimates. A sensitivity analysis was performed to assess the robustness of our conclusions by excluding studies with quality score less than five. We used meta-regression to assess the effect of sample



size (continuous), study design (cross-section vs. non- crosssection), publish year (<2010 vs.  $\geq$ 2010), and participant's age (continuous) on health outcomes. All statistical analyses were done using Stata (version 12.0). The study was registered with PROSPERO (number: CRD42021214115).

# RESULTS

### **Characteristics of the Included Studies**

Among 10,404 references identified through the literature search, full-text copies of 1,009 articles were retrieved and screened, with 98 articles selected for analysis. The PRISMA flow diagram and study characteristics were shown in **Figure 1** and **Table 1**. Among the 98 included articles, 90.8% (89) involved international migration, 66.3% (65) studies were

conducted in European countries, and 75.5% (74) were crosssectional studies. Overall, 79.6% (78) of studies included children <10 years of age. The quality of the included studies varied, with 24.5% (24) studies bearing high or unclear risk of bias (**Appendix**). Birth outcomes were most commonly examined (n = 55), followed by physical health status (n = 34), nutrition status (n = 29), death (n =28), mental health status (n = 16), and substance use (n =8) (**Appendix**).

# **Birth Outcomes**

Migrant children had a lower risk of adverse birth outcome [OR 0.92 (95% CI 0.87–0.97)] than non-migrant children, including lower risk of LBW [OR 0.86 (95% CI 0.79–0.94)] and preterm birth [OR 0.90 (95% CI 0.84–0.97)] (**Figure 2A**).

**TABLE 1** | Characteristics of the included studies (N = 98).

Author [reference]	Year	Country	Design	Age	No. of migrants	No. of controls	Health outcome	Measurement/Instrument
Kana et al. (5)	2019	Portugal	CS	_	386	8,171	Birth outcome (LBW, Preterm birth)	LBW: birth weight <2,500 g Preterm birth: delivered at < 37 completed weeks
Gillet et al. (9)	2014	Belgium	CS	_	129,200	261,566	Birth outcome (LBW, Preterm birth) Death (Neonatal death, Post-neonatal death, Infant death)	LBW: birth weight <2,500 g Preterm birth: Gestational age (week)<37 Infant death was defined as the sum of early neonatal (death at 0–6 days), late neonatal (7–27 days), and post-neonatal (28–364 days) deaths.
Cebolla- Boado and Salazar (17)	2016	Spain	CS	_	71,758	287,153	Birth outcome (LBW, HBW)	LBW: birth weight $\leq$ 2,500 g HBW: birth weight >4,000 g
Forna et al. (18)	2003	US	Cohort	_	13,465	36,439	Birth outcome (LBW, Preterm birth)	LBW: birth weight <2,500 g Preterm birth: delivery before 37 weeks' gestation
Sandra et al. (19)	2015	Spain	CS	-	72,567	599,660	Birth outcome (LBW, HBW)	LBW: birth weight <2,500 g HBW: birth weight >4,000 g
Besharat et al. (20)	2014	Sweden	Cohort	_	336	2,181	Birth outcome (LBW, HBW, Preterm)	LBW: birth weight <2,500 g HBW: birth weight (gram) $\geq$ 4,000 g Preterm birth: delivered at < 37 completed weeks
Racape et al. (21)	2016	Belgium	CS	_	334,150	1,029,471	Birth outcome (LBW) Death (Perinatal death)	LBW: birth weight <2,500 g Perinatal death: fetal deaths from 22 weeks of gestation until 7 days after birth
Lehti et al. (22)	2013	Finland	CC	_	347	5,300	Birth outcome (LBW, Preterm) Mental health (ASD)	LBW: birth weight <2,500 g Preterm birth: Gestational age <37 weeks ASD: clinical assessment ICD-9/ICD-10
Milewski and Peters (23)	2014	Germany	Cohort	-	427	1,214	Birth outcome (LBW, HBW)	LBW: birth weight <2,500 g HBW:birth weight ≥4,000 g
Ratnasiri et al. (24)	2020	US	CS	_	446,724	611,253	Birth outcome (LBW, Preterm birth) Death (Neonatal death, Post-neonatal death)	LBW: birth weight <2,500 g Preterm birth: Gestational age (week)<38 Neonatal death: death before 28 days of age Post-neonatal death: death at 28d-1year
Hessol and Fuentes- Afflick (25)	2014	US	CS	_	410,284	231,190	Birth outcome (LBW, HBW, Preterm birth)	LBW: birth weight <2,500 g HBW: birth weight $\geq$ 4,000 g Preterm birth: <37 completed weeks' gestation
Castello et al. (26)	2012	Spain	CS	_	5,926	15,782	Birth outcome (LBW, Preterm birth)	LBW: birth weight <2,500 g Preterm birth: Gestational age <37 weeks
Juarez and Revuelta- Eugercios (27)	2014	Spain	CS	_	323,856	1,061,924	Birth outcome (LBW, HBW, Preterm birth)	LBW: birth weight <2,500 g HBW: macrosomia >4,500 g Preterm birth: <37 completed gestational weeks
Fuster et al. (28)	2014	Spain	CS	_	412,906	1,874,913	Birth outcome (LBW, preterm) Death (fetal death)	LBW: birth weight <2,500 g Preterm birth: gestational age <38 week Fetal death: the number of late fetal deaths per 1,000 deliveries (both live births and fetal deaths)
Racape et al. (29)	2010	Belgium	Cohort	_	56,061	74,767	Birth outcome (LBW, Preterm birth) Death (Fetal mortality, Neonatal mortality, Post- neonatal mortality)	LBW: birth weight <2,500 g Preterm birth: Gestational age <37weeks Fetal mortality: fetal deaths of 22 or more weeks of gestation; Neonatal mortality: death at 0-27 days of life per 1,000 live births; Post-neonatal mortality: death at 28–364 days of life per 1,000 live births
Glick et al. (30)	2009	US	Cohort	_	2,300	7,300	Birth outcome (LBW)	LBW: birth weight <2,500 g

Author [reference]	Year	Country	Design	Age	No. of migrants	No. of controls	Health outcome	Measurement/Instrument
Farre (31)	2013	Spain	CS	_	233,518	1,773,102	Birth outcome (LBW, Preterm birth) Death (Perinatal death)	LBW: birth weight <2,500 g Preterm birth: Gestational age (week)<38 Perinatal death: death within 24 h after birth
Nancy et al. (32)	2015	US	CS	_	305	1,361	Birth outcome (LBW)	LBW: Birth weight <2,500 g
Lehti et al. (33)	2016	Finland	CC	_	1,730	47,803	Birth outcome (LBW, Preterm) Mental health (ADHD)	LBW: birth weight <2,500 g Preterm birth: gestational age <37 weeks ADHD: clinical assessment ICD-9/ICD-10
Gissler et al. (34)	2003	Sweden	CS	_	34,357	110,008	Birth outcome (LBW) Death (Fetal death, Neonatal death, Perinatal death)	LBW: birth weight <2,500 g Death at the age of 7 days (stillbirth, early neonatal death or living at the end of the perinatal period).
Madan et al. (35)	2006	US	CS	_	2,418,501	4,005,671	Birth outcome (LBW) Death (Neonatal death, Post-neonatal death)	LBW: birth weight <2,500 g Neonatal deaths: death before 28 days or age per 1,000 live births) Post-neonatal deaths: 28 days to 1 year
Auger et al. (36)	2008	Canada	CS	_	43,396	54,954	Birth outcome (LBW, Preterm birth)	LBW: birth weight <2,500 g Preterm birth: delivery at <37 completed weeks of gestation
Bastola et al. (37)	2020	Finland	CS	_	31,454	350,548	Birth outcome (LBW, HBW, Preterm birth) Death (Post-neonatal death, Neonatal death, Fetal death)	LBW: birth weight <2,500 g HBW: birth weight≥4,000 g Preterm birth: ≤36 week + 6 days Post-neonatal death: 28 days to 1 year or death Neonatal mortality: death of a live-borr
Marcon et al. (38)	2011	Italy	CS	3–14 years	641	2,980	Birth outcome (LBW, HBW) Physical health (Pneumonia, Eczema)	child within the first 28 days of life Fetal death: Stillbirths LBW: birth weight <2,500 g HBW: birth weight >4,200 g Pneumonia and Eczema: Self-reported symptoms
Besharat Pour et al. (39)	2017	Sweden	Cohort	_	299	1,979	Birth outcome (HBW, Preterm birth)	HBW: Birth weight≥4,000 g Preterm birth: Gestational age <38 weeks
Reeske et al. (40)	2013	Germany	Cohort	-	384	903	Birth outcome (HBW)	HBW: Birth weight≥4,000 g
(40) Choi et al. (41)	2019	Australia	Cohort	_	601,299	1,735,724	Death (Neonatal death, Fetal death) Birth outcome (Preterm birth)	Death <28 days among livebirths Preterm birth: Gestational age <37 weeks
Essen et al. (42)	2000	Sweden	CS	_	5,211	10,784	Birth outcome (Preterm birth) Death (Perinatal death)	Preterm birth: Gestational age <37 weeks Perinatal death: stillbirth (fetus >28 weeks of gestation) and death within the first week of life
Vik et al. (43)	2019	Norway	CS	_	198,520	115,6444	Death (fetal death) Birth outcome (Preterm birth)	Stillbirth: a pregnancy loss at ≥22weeks of gestation or with a birthweight ≥500 g if data on gestational age were missing Moderately preterm: gestational age 28–36 weeks
Anil Kumar (44)	2016	India	CS	0–4 years	11,327	2,488	Nutrition (Overweight/ obesity, Anemia) Physical health (Diarrhea)	Overweight/obesity: BMI scores Anemia: blood hemoglobin level Diarrhea: self-reported
Liu et al. (45)	2016	China	CS	5–12 years	3,057	6,860	Nutrition (Overweight/ Obesity)	World Health Organization reference 2007 Overweight: $+1$ SD $<$ BMI-for-age z-score $\leq +2$ SD); Obesity: BMI-for-age z-score $> +2$ SD

Author [reference]	Year	Country	Design	Age	No. of migrants	No. of controls	Health outcome	Measurement/Instrument
Ji et al. (14)	2016	China	CS	10.7 ± 0.94 years	991	650	Nutrition (Overweight/ Obesity) Physical health (Caries experience, Diarrhea)	Overweight/obesity: based on cutoff c the Working Group on Obesity of China Caries: referred to those in both deciduous and permanent teeth Diarrhea: Parents reported symptom
Lin et al. (46)	2011	Taiwan	CS	7–12 years	157	519	Nutrition (Overweight) Mental health (Depression)	Overweight: BMI≥85th percentile based on Department of Health criteria, Taiwan ROC. Depression: The "Depression Screen Scale for Children and Adolescents" developed by Kao-Pin Chang
De Carli et al. (47)	2018	Italy	CS	11–12 years	353	847	Nutrition (Overweight/obesity, Underweight)	The International Obesity Task Force cut-offs
Zulfiqar et al. (48)	2018	Australia	Cohort	2–11 years	1,799	2,434	Nutrition (Overweight/obesity)	The International Obesity Task Force standard
Maximova et al. (13)	2011	Canada	CS	11.2 ± 1.1 years	5,261	1,131	Nutrition (Overweight/obesity)	The International Obesity Task Force standard
Lindstrom et al. (49)	2014	Sweden	CS	15–16 years	2,423	7,195	Nutrition (Overweight/obesity) Physical health (Asthma) Substance use (Tobacco use)	Boy: overweight/obesity 23.29–28.29/28.30; girl: 23.94–29.10/29.11
Esteban- Gonzalo et al. (50)	2014	Spain	CS	13–17 years	335	1,742	Nutrition (Overweight/ obesity) Mental health (Depression) Substance use (Tobacco use)	Overweight/obesity: using the BMI age- and gender-specific cut-offs proposed by Cole et al.) 27, Depression: self-reported medical diagnosis of depression Tobacco use: self-reported questionnaire
Besharat Pour et al. (51)	2014	Sweden	Cohort	8 years	561	2,028	Nutrition (Overweight/obesity)	Age- and sex-adjusted BMI corresponding to adult BMI $\geq 25 \text{ kg/m}^2$
Furthner et al. (52)	2017	Austria	CS	13.8 years	827	2,103	Nutrition (Overweight/Obesity)	Overweight: 85th–95th BMI percentile Obesity: ≥95th BMI percentile
Burgi et al. (53)	2010	Switzerland	CS	5.1 ± 0.60 years	391	151	Nutrition (Overweight/obesity)	International Obesity Task Force (IOTF)
lguacel et al. (54)	2018	Spain	Cohort	2.0–9.9 years	1,156	7,427	Nutrition (Overweight/Obesity)	extended International Obesity Task Force criteria
Khanolkar et al. (55)	2013	Sweden	CS	4–5 years	1,286	9,342	Nutrition (Overweight/Obesity)	International Obesity Task Force
Thi et al. (56)	2019	Germany	CS	5–7 years	1,080	2,623	Nutrition (Overweight/Obesity)	BMI is above the 90th percentile according to the BMI reference systems of Kromeyer-Hauschild
Will et al. (57)	2005	Germany	CS	6–7 years	258	265	Nutrition (Overweight/Obesity)	The International Obesity Task Force, using international reference values based on data from six countries
Zhou et al. (58)	2018	Germany	CS	_	19,245	31,441	Nutrition (Overweight/obesity)	BMI≥90th percentile based on the German national reference
Méroc et al. (15)	2019	Belgium	CS	10–11 years	2,319	553	Nutrition (Overweight/obesity)	The International Obesity Task Force standard
Labree et al. (59)	2015	Finland	CS	8–9 years	397	1,546	Nutrition (Overweight/Obesity, Underweight)	The International Obesity Task Force standard

Author [reference]	Year	Country	Design	Age	No. of migrants	No. of controls	Health outcome	Measurement/Instrument
Brettschneider et al. (60)	2011	Germany	CS	11–17 years	518	2,949	Nutrition (Overweight)	BMI >90th percentile based on the national German reference
/orwieger et al. (61)	2018	Germany	CS	7.57 ± 0.42 years	245	508	Nutrition (Abdominal obesity)	WHtR ≥0.5
<b>lagel et al.</b> 62)	2009	Germany	CS	7.6 ± 0.4 years	317	762	Nutrition (Overweight/obesity)	The International Obesity Task Force standard
Beyerlein et al. (63)	2014	Germany	CS	3–17 years	474	8,507	Nutrition (Overweight)	International Obesity Task Force (IOTF
Prusty and Keshri (64)	2015	India	CS	0–59 months	13,220	5,617	Nutrition (Underweight)	WFA-Z<-2SD
Saunders et al. (65)	2016	Canada	CS	12–72 months	1,244	1,268	Nutrition (Anemia)	Hemoglobin level <110 g/L (WHO recommendation)
Hu et al. (66)	2014	China	CS	6–23 months	667	321	Nutrition (Anemia)	Hemoglobin level <110 g/L (WHO recommendation)
lulihn et al. 67)	2010	Sweden	Cohort	13–19 years	5,134	10,404	Physical health (Caries experience)	Clinical examination of DMFT
Christensen et al. (68)	2010	Denmark	CS	5–15 years	3,571	9,058	Physical health (Caries experience)	Clinical examination of DMFT
van Meijeren et al. (69) -	2019	Netherlands		9 years	611	2,510	Physical health (Caries experience)	Clinical examination of DMFT
errazzano et al. (70)	2019	Italy	CS	12–14 years	183	370	Physical health (Caries experience)	Clinical examination of DMFT
an der Tas et al. (71)	2016	Netherlands		4.96 years	1,403	2,957	Physical health (Caries experience)	Clinical examination of DMFT
Almerich-Silla and Montiel- Company 72)	2007	Spain	CS	12–15 years	54	825	Physical health (Caries experience)	Clinical examination of DMFT
Bissar et al. 73)	2014	Germany	CS	4.1 ± 0.8 years	265	698	Physical health (Caries experience)	Clinical examination of DMFT
Baggio et al. 74)	2015	Switzerland	CS	36–71 months	398	457	Physical health (Caries experience)	Clinical examination of DMFT
Bardin et al. 75)	2019	Italy	Cohort	0–14 years	21,817	191,345	Physical health (Gastroenteritis, Pneumonia, Asthma)	ICD-9
Charania et al. (76)	2020	New Zealand	CS	0–5 years	125,511	567,408	Physical health (Gastroenteritis, Pneumonia)	Hospitalization event
i et al. (77)	2019	China	CS	12–15 years	3,477	2,213	Physical health (Pneumonia, Asthma, Eczema)	Physician-diagnosed
<b>/ligliore et al.</b> 78)	2007	Italy	CS	6–7/13– 14 years	1,012	28,293	Physical health (Pneumonia, Asthma)	Self-reported questionnaire
Keet et al. 79)	2012	US	CS	11.4 years	341	3,209	Physical health (Asthma, Eczema, Food allergy)	Physician-diagnosed
Svendsen et al. (80)	2009	US	CS	9–11 years	2,026	4,370	Physical health (Asthma, Food allergy)	Physician-diagnosed
Radhakrishnan et al. (81)	2019	Canada	Cohort	0–18 years	422,305	968,256	Physical health (Asthma)	ICES (institute for clinical Evaluation Sciences) database
Apfelbacher et al. (82)	2011	Germany	CS	0–17 years	2,550	14,640	Physical health (Eczema)	Physician-diagnosed

Author [reference]	Year	Country	Design	Age	No. of migrants	No. of controls	Health outcome	Measurement/Instrument
Koplin et al. (83)	2014	Australia	Cohort	11–15 months	535	3,023	Physical health (Food allergy)	Food allergy to egg, peanut or sesame was defined as a positive oral food challenge in sensitized infants (SPT wheal $\geq 2 \text{ mm}$ or specific IgE $\geq 0.35 \text{ ku/l}$ )
Ramadhani et al. (84)	2009	US	CC	_	575	539	Physical health (Heart defects, Neural tube defect)	Surveillance registries system
Kang et al. (85)	2016	China	CS	6–13 years	325,940	214,634	Physical health (Heart defects)	Clinical cardiovascular examination
Velie et al. (86)	2006	US	CC	_	265	606	Physical health (Neural tube defect)	California Birth Defects Monitoring system
Kim et al. (87)	2018	US	CS	8–18 years	1,013	1,361	Mental health (Depression)	MFQ (Mood and Feelings Questionnaire
Fuhrmann et al. (88)	2014	US	CS	6.2 ± 0.4 years	118	535	Mental health (Depression)	PFC (Preschool Feelings Checklist)
Adriaanse et al. (89)	2014	Netherlands	CS	12.9 ± 1.8 years	576	702	Mental health	The Strengths and Difficulties Questionnaire (SDQ)
Wang et al. (90)	2017	China	CS	11.04 ± 0.04 years	731	451	Mental health	SDQ
van der Ven et al. (91)	2013	Netherlands	Cohort	,	26,599	80,354	Mental health (ASD)	DSM-IV diagnosis
Wandell et al. (92)	2020	Sweden	Cohort	<18 years	1,149,504	2,873,645	Mental health (ASD)	DSM-IV diagnosis
Magnusson et al. (93)	2012	Sweden	CC	0–17 years	9,396	34,567	Mental health (ASD)	DSM-IV diagnosis
Weiser et al. (94)	2008	Israel	CS	7.7 ± 3.7 years	639,203	22,589	Mental health (Schizophrenia)	ICD-9 and ICD-10
Hjern et al. (95)	2004	Sweden	CS	_	87,988	1,056,225	Mental health (Schizophrenia)	ICD-9/ICD-10
Pedersen et al. (96)	2012	Denmark	Cohort	-	202	1,639	Mental health (Schizophrenia)	ICD-10
Lu et al. (97)	2020	China	CS	13.67 ± 1.52 years	1,858	2,359	Mental health (Suicide attempt)	Self-injurious thoughts and behaviors (SITBs)
Vazsonyi et al. (98)	2017	Switzerland	CS	$17.85 \pm 1.21$ years	741	6,546	Mental health (Suicide attempts)	Self-reported questionnaire
Villadsen et al. (99)	2010	Northern Europe	CS	-	265,135	9,649,736	Death (Neonatal mortality, Fetal death)	Death within 0–27 days of birth
Barona-Vilar et al. (100)	2014	Spain	CS	-	40,834	162,043	Death (Perinatal death)	The number of fetal and neonatal deaths per 1,000 total births
Vang (101)	2016	Canada	CS	_	514,247	2,856,394	Death (Post-neonatal death, Neonatal death)	Neonatal death: 0 to 27 days and Post-neonatal death: 28 to 364 days
Rosenberg et al. (102)	2002	US	CS	-	72,293	130,681	Death (Infant death)	Death before first birthday
Landale et al. (103)	2006	US	CS	_	4,342	715	Death (Infant death)	Died before reaching the age of 1 year
Troe et al. (104)	2007	Netherlands	CS	_	30,331	3,838	Death (Infant death)	Died before reaching the age of 1 year
Abebe et al. (105)	2015	Norway	CS	14–17 years	2,932	8,002	Substance use (Cannabis use, Tobacco use, Alcohol use)	Self-report questionnaire

Author [reference]	Year	Country	Design	Age	No. of migrants	No. of controls	Health outcome	Measurement/Instrument
Slonim-Nevo et al. (106)	2006	Russia	CS	15–17 years	396	127	Substance use (Tobacco use, Alcohol use)	Self-report questionnaire
Donath et al. (107)	2016	Germany	CS	14.88 ± 0.74 years	2,277	7,235	Substance use (Cannabis use)	Self-report questionnaire

CS, cross-sectional; CC, case-control; LBW, low birthweight; HBW, high birthweight; ADHD, attention deficit hyperactivity disorder; ASD, autistic spectrum disorder. - represents the data cannot be obtained

Although high statistical heterogeneity across birth outcomes was observed, it was reduced after subgroup and sensitivity analysis. In the subgroup analyses by region (**Table 2**), although no significant difference of overall adverse birth outcomes was found between migrant children and native ones in European countries [OR 0.95 (95% CI 0.90–1.02)], a lower risk of low birthweight was identified. In non-European countries, migrant children had a lower risk of overall adverse birth outcome [OR 0.84 (95% CI 0.75–0.94)] and preterm birth [OR 0.81 (95% CI 0.71–0.92)]. All the studies targeting birth outcomes were performed among international migrant children and the effect of domestic migration on birth outcomes cannot be unexplored. Sensitivity analysis of excluding studies with quality score less than five did not alter the above results (**Appendix**).

#### Nutrition

Migrant children had an increased risk of malnutrition [OR 1.26 (95% CI 1.11-1.44)], including higher risk of overweight/obesity [OR 1.33 (95% CI 1.13-1.57)] and iron-deficiency anemia [OR 1.37 (95% CI 1.01-1.87)]; while no difference was identified regarding underweight [OR 0.90 (95% CI 0.77-1.04)] between migrant and non-migrant children (Figure 2B). Heterogeneity between the estimates was low for underweight and high for overweight/obesity. Subgroup analyses by region (Table 2) revealed that migrant children in European countries had a significantly increased risk of malnutrition [OR 1.51 (95% CI 1.29-1.78)] such as overweight/obesity [OR 1.62 (95% CI 1.39-1.90)], while no significant differences were found between migrant children and native ones in the non-European countries. We also explored the effect of migration way on children's nutrition, which showed that international migrant children had an increased risk of overweight/obesity than non-migrant children [OR 1.47 (95% CI 1.28-1.68)], but the result was opposite for internal migrant children [OR 0.67 (95% CI 0.60-0.74)]. When the studies with quality score less than five were excluded, the risk of malnutrition was not altered (Appendix).

### **Physical Health**

Migrant children had a significantly increased risk of poor physical health [OR 1.34 (95% CI 1.11-1.61)] compared with non-migrant children, including higher risk of oral disease [OR 2.56 (95% CI 2.11–3.11)] and gastrointestinal disease [OR 1.56 (95% CI 1.18–2.07)] (Figure 2C). Although high statistical heterogeneity was identified across the selected physical health outcomes, a reduction trend was found by using subgroup and sensitivity analysis. Subgroup analyses by region (Table 2) suggested that migrant children had poorer physical health than non-migrant children both in the European countries [OR 1.48 (95% CI 1.02–2.14)] and non-European countries [OR 1.20 (95% CI 1.03–1.41)]. The insufficient number of studies did not allow for analyses of the risk of physical health outcomes among internal migrant children. Sensitivity analyses by excluding studies of quality score less than five did not change the results related to physical health outcomes (Appendix).

### Mental Health

Migrant children had a marginally higher risk of psychological problems [OR 1.24 (95% CI 1.00–1.52)] than the controls, including higher risk of depression [OR 1.29 (95% CI 1.00– 1.65)], schizophrenia [OR 1.79 (95% CI 1.50–2.14)], and suicide attempt [OR 1.31 (95% CI 1.10–1.56)] (**Figure 2D**). Statistical heterogeneity across the mental health outcomes was moderate between estimates. Subgroup analyses by region (**Table 2**) showed that migrant children in European had an increased risk of schizophrenia; while in non-European countries had higher risk of depression. Given the limited number of studies on internal migrant children, we did not assess the effect of migration way on the risk of mental health outcomes. Sensitivity analyses by excluding studies with quality score less than five did not change the mental health outcomes (**Appendix**).

### Deaths

All the studies on mortality focused on international migrant children. Migrant children were at a higher risk of death than the controls [OR 1.11 (95% CI 1.01–1.21)], including fetal death [OR 1.24 (95% CI 1.07–1.45)], perinatal death [OR 1.25 (95% CI 1.04–1.50)], and neonatal death [OR 1.10 (95% CI 1.02–1.19)] (**Figure 2E**). Statistical heterogeneity between estimates varied substantially across death outcomes, with the exception of neonatal death. Subgroup analyses by region (**Table 2**) on fetal death [OR 1.33 (95% CI

HSW         Autor         Autor         Autor         Autor           Bethara (2017) [39]         50/259         380/1979         0.84 (0.59, 1.17)         1.22           Bethara (2017) [39]         50/259         380/1979         0.84 (0.59, 1.17)         1.22           Milexiski (2014) [21]         41/271         129/1214         0.91 (0.61, 1.33)         1.06           Milexiski (2014) [21]         41/247         129/1214         0.91 (0.60, 0.04)         241           Marcon (2011) [18]         22/641         98/298         0.94 (0.64, 1.37)         1.09           Marcon (2011) [18]         22/641         98/298         0.94 (0.64, 1.37)         1.09           Marcon (2011) [18]         22/641         98/298         1.17 (1.15, 1.76)         242           Subtrat (2014) [25]         26/386         720/7567         39/37/59660         242         1.17 (1.15, 1.76)         242           Subtrat (2014) [21]         25/386         720/7567         39/37/59660         24/3         1.17 (1.15, 1.76)         242           Subtrat (2014) [20]         22/33         139/1730         169/447033         0.66 (0.40, 0.49)         235           Besharat (2014) [21]         25/386         22/39/18         1.11 (10.91, 1.36)         1.21	A	Migrant(n/N)	Control(n/N)			OR (95% CI)	%Weigh
Final 2002 [18]       103471461       84749445       44749245       44749245         Behara (104) [12]       2374       12781	I D/M	-					
Sinda (2019) [19]       1737/257       12208/39640       4       2.14         Behara (2014) [21]       6.914       1355       6.612.51.20       6.73         Rege (2016) [21]       2.442       1355       6.612.51.20       6.73         Minek (2014) [21]       2.442       1355       6.612.51.20       6.73         Minek (2014) [21]       2.442       1355       6.612.51.20       6.73         Minek (2014) [21]       2.442       147       1355       6.612.51.20       6.72         Minek (2014) [21]       2.453       871/575       1541/577       6.612.51.20       6.72         Minek (2012) [21]       2.453/1206       1147/17757       1541/577.53       6.612.65.91       2.02         Maer (2014) [23]       2.143/1206       1147/17758       1541/577.53       6.69 (25.632)       2.41         Range (2014) [23]       2.173/780       1597/677.50       6.69 (25.632)       2.41         Mino (2015) [21]       2.075/781       1597/677.50       6.69 (25.632)       2.41         Mino (2016) [21]       2.06 (25.121)       1077/573       159 (25.110)       2.68 (25.202)       2.41         Mino (2016) [21]       1597/675.56 (5.77)       1597/675.56 (5.7)       1597/675.56 (5.7)       1597/675.56 (		1024/12462	6011/26106	▲		0 41 (0 20 0 44)	2.26
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Brage [2016][21]       066/15/26,088     158       Mickel (2014)[22]     22/47     82/12/4     05/14/25     05/16/25     05/16/25       Minardi (2004)[23]     22/47     82/12/4     05/16/25     05/16/25     05/16/25       Manardi (2014)[23]     21/57     82/12/4     05/16/25     05/16/25     05/16/25       Manardi (2014)[23]     21/57     1     06/16/25     05/16/25     05/16/25       James (2014)[27]       05/16/25     05/16/25     05/16/25       James (2014)[27]       05/16/25     05/16/25     05/16/25       James (2014)[27]       05/16/25     05/16/25     05/16/25       James (2014)[21]     20/05     10/17/316     05/16/25     05/16/25     05/16/25       James (2015)[21]     20/05     10/17/316     05/16/25     05/16/25     05/16/25       James (2015)[21]     20/05     10/17/316     05/16/25     05/16/25     05/16/25       James (2015)[21]     20/05     10/16/26     10/16/26     05/16/25     05/16/25       James (2011)[21]     20/06     10/16/26     05/16/25     05/16/25     05/16/25       James (2011)[21]     20/06     10/16/26     05/16/25     05/16/25					_		
Lehi(2113)22] Hinkesi(2014)[21] Amarg (2114)[21] 225:244672 Hangy (2114)[21] 1148/27735 Hangy (2114)[21] 227:255 Hangy (2114)[21] 427:257 Hangy (2114)[21] 427:257 Hangy (2114)[21] 427:257 Hangy (2114)[21] 427:257 Hangy (2114)[21] 427:257 Hangy (2114)[21] 427:257 Hangy (2114)[21] 427:257 Hangy (2114)[21] 427:257 427:257 Hangy (2114)[21] 427:257 Hangy (2114)[21]			01/2101				
Mileski (2014) [23]       22/27       82/1214       0.424 (4.9.4; 1.23)       0.73       0.75 (6.7.4.97)       24.8         Marseli (2014) [23]       2175 (4.47.48)       97991 (8897)       0.56 (6.7.4.97)       24.8         Marseli (2014) [23]       2175 (4.47.48)       97991 (8897)       0.80 (0.7.6.2.3)       24.2         Jaare (2114) [27]			125/5200				
Runardi (2003) [2]         2252/44724         4870/61123           Nurry (2014) [2]         2751/44744         970/818897         681 (05.70, 02)         242           Gatelio (2012) [20]         2555927         8171/575         681 (05.60, 653)         200           Jamez (2014) [21]							
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Nancy 5(2015)[21]       29/05       137/1361       0.91         Left(2016)[31]       217/20       97/47803       0.91       0.							
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Giller (1014) [9]       84807(2200)       7557/6556       100 (06.4)       112         Mile (2003) [34]       209674357       6607(100.8)       100 (06.4)       112       123         Mile (2003) [34]       209674357       6607(100.8)       113 (11.1)       123       123       113 (11.1)       224         Mager (2007) [56]       7384336       79854954       79854954       1137 (11.1)       224         Standa (2001) [77]       14971454       1686375548       1137 (11.1)       224         Mile (2001) [71]       451771454       6405435548       1177 (10.1)       223         Behara (2017) [73]       55/641       255/280       286 (07.6) 0.99       4473         Mile (2001) [71]       451771454       6405435548       840 (7.2) 0.99       880 (07.6) 0.99       4473         Behara (2017) [73]       55/641       255/280       244       99 (10.6), 1.70       128				•			
Kmai (2019) [5] Mila (2006) [3] Madar (2007) [3] Subtoal (1-squared = 80.2%, p = 0.000)       1006 (28, 14.8) 10058/3558.4 205/2580       1006 (28, 14.8) 10058/3558.4 205/2580       117 (10.6, 1.3) 224 Madar (2007) [3] Madar (2007) [3] Subtoal (1-squared = 80.2%, p = 0.000)       0406/3559.4 205/2580         HBW Beshart (2017) [3] Mila (2020) [				•	-		
Mile (2003) [24]       206(24357)       6160/110008         Madar (2006) [53]       1096(104.115)       243         Madar (2006) [53]       1096(104.15)       243         Marce (2017) [51]       1140(1154)       1096(104.15)       243         Marce (2017) [51]       1140(1154)       1096(104.15)       243         Marce (2017) [51]       55641       2557390       117(110.123)       223         Subtatal (1-squared = 80.2%, p = 0.000)       451731454       64064/359548       0.410(211)       0.410(21,17)       124         Berhard (2014) [21]       451731454       64064/359548       0.410(21,17)       123       0.480(120,17)       123         Mile (2003) [34]       64064/359548       0.410(23,17)       123       0.480(120,17)       123         Mile (2003) [43]       64064/359548       0.410(23,17)       123       0.480(120,17)       123         Mile (2003) [43]       64064/359548       0.410(23,17)       123       0.480(120,17)       123         Mile (2003) [43]       640(42,0437)       127(121,17)       0.480(120,17)       109       0.410(05,175)       109         Jamer (2014) [25]       69394/47402       1452/138687       117(115,120)       243       109(106,1,13)       100(16,1,13)       1				9			
Mdafn (2006) [5]       119952/148501       17544/3400677       113 [112,114]       243         Baroh (2001) [7]       1140/1144       1058/359548       117 (10,1,12)       235         Marcon (2011) [28]       55/641       205/2980       066 (0/9, 0.94)       4473         Baroh (2020) [37]       4517/21454       64064/350548       074 (0/2, 0/7)       241         Baroh (2020) [37]       4517/21454       64064/350548       074 (0/2, 0/7)       241         Baroh (2020) [37]       4517/21454       64064/350548       074 (0/2, 0/7)       241         Baroh (2020) [37]       4517/21454       6406/4550548       074 (0/2, 0/7)       241         Berkar (2014) [20]       452/471       219/124       091 (00,1, 133       106         Milexik (2014) [21]       42/472       129/124       091 (00,6, 133       106         Milexik (2014) [21]       4093/44/402       1452/138807       1070 (10,6, 176)       109         Amarco (2011) [31]       23/641       96/280       117 (11,6, 120)       242         Sandra (2015) [3]       4093/44/402       1452/148807       1070 (10,6, 176)       242         Sandra (2015) [3]       23/730       23/37/399660       23/37/399660       23/37/399760       23/37/399760       23/37/39 </td <td></td> <td></td> <td></td> <td></td> <td>_</td> <td></td> <td></td>					_		
Auger (2007) [56]       738(4336       798(43964         Basinal (2007) [17]       1140(11544       066(82)9584         Marcen (2011) [18]       55641       205/2390         Subtotal (1-rquared = 80.2%, p = 0.000)       4177(116, 144       205         HBW       Beshard (2017) [29]       50/239       300/1979         Beshard (2017) [29]       50/239       300/1979         Beshard (2017) [29]       50/239       300/1979         Beshard (2014) [21]       42/427       127/1164       6406/4505948         Beshard (2014) [21]       42/427       127/1171       128         Mile (2003) [18]       1226/144       116/903       031 (66, 1.33)       136         Mile (2003) [18]       1226/144       116/903       041 (66, 1.37)       109         Jaarer (2014) [27]				♠		1.09 (1.04, 1.15)	
Barba (2001) [37]       114031454       10868330548       11.77.116.125       22.5         Subtotal (Iquared = 80.2%, p = 0.000)       50       205/280       127.01.1.121       129         Barba (2001) [37]       4517/31454       64064/350548       007.05948       0.74 (0.27, 0.77)       241         Besthard (2011) [39]       50/259       3001797       0.86 (0.23, 0.94)       4433         Besthard (2014) [23]       41/4271       121201214       0.91 (0.65, 1.33)       10.66         Milexik (2014) [23]       41/4271       121201214       0.91 (0.65, 1.35)       0.97 (0.65, 1.75)       0.79         Marce (2011) [38]       23/641       98/2590       11.77 (1.16, 1.25)       24.33       11.77 (1.16, 1.25)       24.32         Marce (2011) [38]       23/641       98/2590       0.91 (0.86, 0.94)       24.14       11.99 (0.36, 1.75)       0.79         Name (2011) [38]       23/656       2300171       1456/188877       11.77 (1.16, 1.26)       24.33         Subtotal (Iquared = 79.0%, p = 0.013)       7208.96477       164/47803       24.99       11.11 (1.91, 1.36)       13.21 (44, 2.27)       12.21 (44, 2.27)       12.21 (44, 2.27)       12.21 (44, 2.27)       12.21 (44, 2.27)       12.21 (44, 2.27)       12.21 (44, 2.27)       12.21 (44, 2.27)       12.21 (44,	Madan (2006) [35]	119058/2418501					
Barbiolo (2001) [27]       114031454       106663295548       11.77 (116, 125)       2.53         Subtotal (Iquared = 60.2%, p = 0.000)       50       205/260       205/260         HBW       Barbalo (2001) [27]       417171454       60/64/359548       0.74 (0.72, 0.77)       2.41         Berhard (2011) [29]       50/259       380/1599       0.24 (0.27, 0.77)       2.41         Berhard (2011) [29]       50/259       380/1599       0.24 (0.27, 0.77)       2.41         Milexik (2014) [21]       42427       1212/114       0.81 (0.61, 1.33)       10.66         Milexik (2014) [23]       42427       1212/114       0.91 (0.61, 1.33)       10.66         Marce (2011) [38]       23/641       99/2580       0.91 (0.64, 1.30)       13.31         Marce (2011) [38]       23/656       200(17.1       142/26/188897       11.77 (1.16, 12.7)       2.42         Subtotal (Iquared = 79/9%, p = 0.013)       754/72567       32437599660       240/17.1       144/26/188897       11.17 (1.16, 12.6)       2.25         Subtotal (Iquared = 79/9%, p = 0.013)       122/134/02       126/047803       0.46 (0.42, 0.49)       2.25         Peterm birth       122/134/02       7208/9647       0.46 (0.42, 0.49)       2.25       1.11 (0.91, 1.30)       1.31 (0.91, 1.30	Auger (2007) [36]	738/43396	798/54954	<b>_</b>	-		2.24
Subtral (Iquared = 80.2%, p = 0.000) HBW Bastola (2020) [37] Besharat (2017) [39] S0/299 Besharat (2017) [39] S0/299 Besharat (2017) [39] Besharat (2014) [23] Heesks (2013) [40] Macro (2011) [38] 24/427 129/1214 Macro (2011) [38] 24/427 129/1214 Macro (2011) [38] 24/427 129/1214 Macro (2011) [38] 24/427 129/1214 Macro (2011) [38] 24/427 129/1214 Macro (2011) [38] 24/427 129/1214 Macro (2011) [39] Preterm birth Froma (2003) [14] Preterm birth Froma (2003) [14] 125/13460 129/1347 24/27 139/3287153 24/3759660 240/1771 Preterm birth Froma (2003) [18] 125/13460 122/1326 240/1773 241 139/3287153 243/359660 240/1771 241 145/26188807 111/(155, 126) 243/3759660 240/1771 241 45/26188807 111/(155, 126) 243/3759660 240/1771 244 45/26188807 111/(155, 126) 243/3759660 240/1771 244 45/26188807 111/(155, 126) 243/3759660 240/1771 244 45/26188807 111/(155, 126) 243/3759660 240/1771 244 45/26188807 111/(155, 126) 243/3759660 240/1773 243/37596 243/375960 243/375960 243/375960 244/27 156/14/2056 240/17737102 241/25566 244/07/773102 241/0774 241/0774 241/25566 244/07/773102 241/0774 2	Bastola (2020) [37]	1140/31454	10868/350548	◆	•	1.17 (1.10, 1.25)	2.35
HEW         Bardin (2020) [37]         4517/31454         606/6439548         380/1979         0.74 (072, 077)         241           Beshart (2017) [39]         50/299         380/1979         0.84 (051, 123)         122           Beshart (2017) [20]         42427         129/12/4         0.94 (052, 123)         106           Milexki (2014) [21]         42427         129/12/4         0.97 (061, 123)         106           Milexki (2014) [22]         42447         129/12/4         0.97 (061, 123)         106           Milexki (2014) [27]	Marcon (2011) [38]	55/641	205/2980		♠	1.27 (0.91, 1.74)	1.29
HEW         Bardin (2020) [37]         4517/31454         606/6439548         380/1979         0.74 (072, 077)         241           Beshart (2017) [39]         50/299         380/1979         0.84 (051, 123)         122           Beshart (2017) [20]         42427         129/12/4         0.94 (052, 123)         106           Milexki (2014) [21]         42427         129/12/4         0.97 (061, 123)         106           Milexki (2014) [22]         42447         129/12/4         0.97 (061, 123)         106           Milexki (2014) [27]				$\diamond$			44.73
Baschal (2201)[37]       4517/1344       6406/30548       0.74(072,077)       241         Besharat (2014)[20]       50/299       380/1979       0.84(05,117)       122         Besharat (2014)[21]       42/471       129/1214       0.91(08,09)       241         Milexid (2014)[23]       42/471       129/1214       0.91(08,09)       241         Milexid (2014)[23]       42/471       129/1214       0.91(08,09)       241         Milexid (2014)[24]       47/344       116/903       0.91(08,09)       241         Marcon (2011)[18]       23/641       99/2980       0.91(08,09)       241         Marcon (2011)[18]       23/641       99/2980       0.91(08,09)       242         Sanda (2015)[19]       758/71758       1379/287153       1.70(16,5,176)       242         Sanda (2015)[19]       758/71758       1379/287153       1.70(16,5,176)       242         Sanda (2015)[19]       25/3686       209/2181       0.91(08,0,09)       233         Subtotal (1-squared = 78,0%, p = 0.013)       164/47803       0.61(0.42,0.84)       1.21         Perterm birth       Forma (2003)[18]       122/573460       7208/56427       0.81(08,0,0.87)       243         Recape (2016)[29]       3514/56061       538/7746				-			
Baschard (2021) [37]       4517/11944       6406/4305648       0.74 (072, 077)       241         Beshard (2014) [20]       50/299       380/1979       0.84 (0.59, 117)       122         Beshard (2014) [21]       42/472       1291/214       0.91 (0.68, 0.96)       241         Milexid (2016) [23]       42/472       1291/214       0.91 (0.68, 0.96)       241         Milexid (2016) [24]       47/344       116/903       0.94 (0.64, 1.37)       109         Macron (2011) [28]       23/641       99/2980       0.94 (0.64, 1.37)       109         Nancy (2014) [25]       45/507 (1888077)       1.17 (115, 1.76)       242         Sandar (2015) [19]       751/47267       32437/399660       243       1.32 (146, 227)       1.12 (28)       0.33         Subtotal (1-squared =73,0%, p = 0.013)       156/297 (146, 127)       1.2 (28)       0.43       1.9 (12, 28)       0.43         Subtotal (1-squared =73,0%, p = 0.013)       166/4/7803       26/686       209/811       0.66 (0.40, 0.49)       233         Beshara (2016) [19]       251/3460       720/85427       0.61 (0.42, 0.84)       1.21         Choil (19/1)       354/540561       5383/74767       0.86 (0.62, 0.90)       239         Stein (2000) [129]       351/450661       5	HBW						
Besharat (2017) [39] S0(299 380(199) Besharat (2014) [20] S1(23) 4(24) Milex(2014) [23] 4(24) 7 1291/14 Milex(2014) [23] 4(24) 7 1291/14 Milex(2014) [23] 4(24) 7 1291/14 Milex(2014) [23] 4(24) 7 1291/14 Milex(2014) [24] 6164/14357 2123/110008 Resek (2013) [40] 47/384 116/903 Marco (2011) [38] 23/641 98/2980 Jamare (2014) [27] Nancy (2014) [25] 4053/44/402 1455/688897 11/7 (11.5, 15.0) 122 Sanda (2019) [5] 26/365 29908/171 Sobtotal (1-squared = 79,0%, p = 0.013) Preterm birth Forma (2003) [18] 125/13460 7208/36427 Lehki (2016) [33] 380/730 Besharat (2014) [25] 4592/447402 2591/188897 Choi (2012) [21] 53/14/2557 32437/599660 Zana (2019) [5] 2253/1460 7208/36427 Lehki (2016) [33] 380/730 Besharat (2014) [25] 4592/447402 22591/188897 Choi (2019) [41] 3968/601229 313191/1735724 Besharat (2014) [25] 4592/447402 22591/188897 Choi (2019) [41] 3968/6012299 313191/173724 Besharat (2014) [29] 5314/3661 5330/74577 Besharat (2014) [29] 5314/3661 57574 Hanagi (2012) [21] 5314/3661 57574 Hanagi (2012) [21] 4531454 1570/250548 Hanagi (2010) [21] 2704/1353 Besharat (2014) [21] 4697/4727 1362 Carell (0/12) [26] 5338/3659 7720/5754 Hanagi (2010) [27] 445/31454 1570/250548 Hanagi (2010) [27] 445/31454 1570/250548 Han		4517/31454	64064/350548			0.74 (0.72, 0.77)	2.41
Besharat (2014) (20)       \$68/356       41/67/181       0.88 (0.64, 1.20)       1.33         Milka (2003) (3/4)       61/8/34357       12/32/11 0008       0.91 (0.58, 0.94)       2.41         Reeske (2013) (40)       47/384       11/6/033       0.91 (0.58, 0.94)       2.41         Mika (2003) (3/4)       61/8/34357       21/32/11 0008       0.91 (0.58, 0.94)       2.41         Marcen (2011) (21)       40/59/14/44/04       14/56/08897       1.77 (1.15, 1.20)       2.43         Amary (204) (27)							
Milexiki (2014) [23]       42/47       129/12/4       0.91 (0.61, 1.33)       10.6         Mika (2003) [34]       6164/3457       2122/110008       0.91 (0.86, 0.94)       2.41         Marco (2011) [38]       23/611       98/2280       0.91 (0.86, 0.94)       2.41         Marco (2014) [27]				<u> </u>			
Nike (2003) [34]       6184/1457       2123/14008       0.91 (0.88, 0.94)       2.41         Reeske (2013) [40]       47/354       116/903       0.94 (0.64, 1.37)       10.99         Marcon (2011) [138]       221641       98/2880       1.94 (0.64, 1.37)       10.99         Juarez (2014) [27]					_		
Beesker (2013) [40]       47/384       116/903       0.94 (0.64, 1.37)       10.99         Marcon (2011) [38]       23/641       96/2980       0.94 (0.64, 1.37)       10.99         Nancy (2014) [27]         1.14 (0.83, 1.56)       1.32         Nancy (2014) [23]       40593/447402       14526/188897       1.3793/2587133       1.371/1.15, 1.20       2.43         Sandra (2015) [19]       7514/72557       32437/59960       1.32       1.32       1.32 (1.46, 2.27)       1.12         Kana (2019) [15]       2063/6427       0.64 (0.43, 0.49)       2.53       0.64 (0.43, 0.49)       2.53         Lehic (2016) [13]       38/7730       1664/47803       0.66 (0.40, 1.04)       0.83       0.66 (0.40, 1.04)       0.83         Besharat (2014) [25]       45892/44767       2259/1188877       0.64 (0.42, 0.48)       1.21       0.66 (0.40, 1.04)       0.83         Racape (2010) [29)       3514/56061       3383/7467       0.86 (0.82, 0.99)       2.39       0.84 (0.84, 0.87)       2.41         Racape (2010) [29)       3514/56061       3383/7467       0.86 (0.82, 0.99)       2.39       0.97 (0.96, 0.98)       2.43         Gillet (2016) [37]       1.86 13/0171773102       0.86 (0.82, 0.99)       2.34       0.97 (0.96, 0.98) <t< td=""><td></td><td></td><td></td><td>X</td><td></td><td></td><td></td></t<>				X			
$\begin{array}{c c c c c c c c c c c c c c c c c c c $					_		
Juære (2014) [27]							
Nancy (2014) [25]       49593/447402       14526/188897       1.17 (1.15, 1.20)       2.43         Cebolia-Boado (2016) [17]       5687/1758       3243759660       3243759660       3243759660         Subtotal (I-squared = 79.0%, p = 0.013)       751472567       290/8171       1.96 (1.24, 2.28)       0.93         Preterm birth       Forma (2003) [18]       1225/13460       7208/36427       0.46 (0.43, 0.49)       2.35         Besharat (2014) [20]       22/33       209/1811       0.66 (0.40, 1.04)       0.88       0.66 (0.40, 1.04)       0.88         Besharat (2014) [20]       22/318       209/181       0.66 (0.40, 1.04)       0.88       0.66 (0.40, 1.04)       0.88         Besharat (2014) [20]       2314/2615827       0.88 (0.84, 0.87)       2.48       0.86 (0.82, 0.80)       2.49         Starte (2014) [21]       230/1733518       240107/173102       0.84 (0.82, 0.80)       2.49       0.88 (0.87, 1.23)       2.49         Barbasit (2003) [24)       210/1733518       240107/173102       0.89 (0.97, 1.03)       2.07       0.88 (0.82, 0.80)       2.39         Gebral (2014) [9]       9890/129200       21341/261566       0.93 (0.91, 0.97)       2.42       1.81 (0.47/173102       0.91 (0.90, 0.93)       2.43         Ganstari (2003) [24]       181497/440747							
Cebolia-Boado (2016) [17]       5687/1758       13793/287153       170 (16.5, 17.6)       2.42         Sandra (2015) [19]       7514/72567       32437/599660       32437/599660       182 (14.6, 227)       1.72         Subtotal (I-squared = 79.0%, p = 0.013)       26/366       290/8171       1.70 (16.5, 17.6)       2.42         Preterm birth       106 (14.2, 227)       1.72 (16.5, 17.6)       2.42         Exhit (2016) [13]       38/1730       1694/47003       0.66 (0.40, 10.4)       0.83 (1.49, 227)         Besharat (2014) [20]       22/336       209/2181       0.66 (0.40, 10.4)       0.83 (0.48, 0.68)       2.42         Choi (2019) [41]       39666/601229       131915/1735724       0.66 (0.40, 10.4)       0.88 (0.82, 0.69)       2.39         Essen (2000) [42]       270/5211       62/10724       0.86 (0.82, 0.90)       2.39         Fare (2015) [31]       30147/23318       246107/1773102       0.99 (0.99, 0.33)       2.43         Gilet (2014) [47]       9890/172000       1341/47/2356       0.93 (0.91, 0.97)       2.44         Jarez (2014) [27]         1.03 (0.96, 1.11)       2.38         Jarez (14/127)         1.03 (0.96, 1.11)       2.38         Jarez (2014) [27]       333/5891							
Sanda (2015)[19]       7514/72567       32437/599660       182 (146, 227)       172         Kana (2015)[19]       25/386       290/8171       166 (124, 298)       0.93         Preterm birth       110 (031, 1.36)       1913         Preterm birth       0.66 (0.40, 0.49)       235         Besharat (2014) [20]       22736       209/2181       0.66 (0.40, 1.04)       0.83         Besharat (2014) [25]       45892/447402       2259/1188897       0.84 (0.82, 0.86)       242         Choi (2019) [41]       36666/01 299       131915/1735724       0.86 (0.84, 0.87)       243         Racape (2010) [29]       3514/36061       5383/74767       0.86 (0.84, 0.87)       243         Essen (2000) [42]       270/5211       621/10784       0.86 (0.84, 0.87)       243         Bracape (2010) [29]       3514/36061       5383/74767       0.86 (0.84, 0.87)       243         Essen (2000) [42]       270/5211       621/10784       0.99 (0.90, 0.93)       243         Juaree (2014) [9]       9890/129200       21341/261566       93 (0.91, 0.97)       242         Juaree (2014) [27]             0.93 (0.96, 0.88)       243         Juaree (2014) [27] <td></td> <td></td> <td></td> <td>•</td> <td>•</td> <td></td> <td></td>				•	•		
Kana (2019) [5]       26/386       290/8171       1.96 (124, 238)       0.93         Subtotal (I-squared = 79.0%, p = 0.013)       1225/13460       7208/36427       0.46 (0.43, 0.49)       2.35         Lehti (2016) [3]       38/1730       1694/47803       0.66 (0.40, 1.04)       0.83         Besharat (2017) [39]       16/299       148/1979       0.66 (0.40, 1.04)       0.83         Nancy (2014) [25]       45892/447402       22591/188977       0.86 (0.84, 0.87)       2.43         Racape (2010) [24]       3514/56061       5383/7467       0.86 (0.82, 0.90)       2.33         Essen (2000) [42]       270/5211       621/10784       0.86 (0.82, 0.90)       2.43         Gillet (2014) [9]       9800/72.202       2131/21/25166       0.99 (0.97, 1.03)       2.07         Farre (2015) [31]       30147/23518       246107/1773102       0.99 (0.97, 1.03)       2.07         Gillet (2014) [9]       9800/72.202       2131/21/261566       0.99 (0.97, 1.03)       2.07         Batasi (2003) [24]       81497/446724       11313/611233       0.97 (0.95, 0.98)       2.43         Castello (2012) [26]       363/5891       952/15754       1.01 (0.57, 1.77)       0.65         Juare (2014) [27]					₹.		
Subtotal (I-squared = 79.0%, p = 0.013)  Preterm birth Forma (2003) [18] 1225/13460 1694/47803 1694/47803 1694/47803 1694/47803 1064 (0.43, 0.49) 235 besharat (2017) [39] 16/299 148/1979 0.69 (0.38, 1.19) 0.65 0.69 (0.38, 1.19) 0.65 0.69 (0.38, 0.37) 0.69 (0.38, 0.69) 239 Essen (2000) [42] 270/5211 621/10784 Farre (2015) [31] 30147723518 246107/1773102 21341/261566 21341/2611253 2037 (0.96, 0.98) 243 Gillet (2014) [29] 9990/173200 21341/261566 21341/2611253 Costello (2012) [26] 363/3589 9217554 103 (0.97, 1.03) 097 (0.96, 0.98) 243 Auger (2007) [30] 2784/4336 3338/54954 2105 (1.10) 238 Auger (2007) [31] 485/31454 15702/350548 773/8171 24  2 5 10 029 (0.87, 0.97) 100 0  029 (0.87, 0.97) 100 0  029 (0.87, 0.97) 100 0  029 (0.87, 0.97) 100 0  099 (0.84, 0.97) 3614 0 0verall (I-squared = 80.2%, p = 0.000) 032 (0.87, 0.97) 100 0							
Preterm birth Forma (2003) [18]       1225/13460       7208/36427       ↓       ↓       0.46 (0.43, 0.49)       2.35         Besharat (2016) [33]       38/1730       1694/47803       0.67 (0.42, 0.84)       1.21         Besharat (2014) [20]       22/335       209/2181       0.66 (0.40, 1.04)       0.83         Besharat (2014) [25]       45892/447402       22591/188897       0.66 (0.84, 0.87)       2.43         Racape (2010) [29]       3514/50601       35837/4767       0.86 (0.84, 0.87)       2.43         Besharat (2014) [29]       3514/5061       35837/4767       0.86 (0.84, 0.87)       2.43         Gillet (2015) [31]       30147/233518       246107/1773102       0.99 (0.90, 0.93)       2.43         Gillet (2012) [26]       363/5891       922/15754       0.97 (0.96, 0.98)       2.43         Juarez (2014) [27]         1.03 (0.96, 1.11)       2.33         Auger (2007) [36]       278/43396       3338/5954       1.05 (1.00, 1.11)       2.38         Juarez (2014) [28]       28727/412906       67303/1090103       1.06 (1.00, 1.11)       2.83         Auger (2007) [36]       278/43396       3338/5954       1.05 (1.00, 1.11)       2.83         Juarez (2014) [29]       28727/412906       110666/1874913		26/386	290/81/1				
Forma (2003) [18]       1225/13460       7208/36427       0.46 (0.43, 0.49)       2.35         Lehti (2016) [33]       38/1730       1664/47803       0.67 (0.42, 0.84)       1.21         Besharat (2017) [39]       16/299       148/1979       0.66 (0.40, 1.04)       0.83         Nancy (2014) [25]       45892/447402       22591/188897       0.84 (0.82, 0.86)       2.42         Choi (2019) [41]       39866/601299       131915/1735724       0.86 (0.82, 0.09)       2.39         Racape (2010) [29]       3514/56061       5383/74/67       0.86 (0.82, 0.09)       2.39         Essen (2000) [42]       270/5211       621/10784       0.89 (0.77, 1.03)       2.07         Farre (2015) [31]       30147/233518       246107/173102       0.91 (0.90, 0.93)       2.43         Gallet (2014) [29]       9890/77, 1.03       2.07       2.43       0.97 (0.96, 0.98)       2.43         Castello (2012) [26]       363/5891       952/15754       0.97 (0.96, 0.98)       2.43         Juarez (2014) [27]         1.03 (0.96, 1.11)       2.38         Auger (2007) [36]       278/43396       338/54954       1.06 (1.00, 1.11)       2.38         Vik (2013) [22]       16/347       229/5300       1.07 (0.59, 1.80)       0.67	Subtotal (I-squared = 79.0%, p = 0.013)			$\sim$	>	1.11 (0.91, 1.36)	19.13
Lehti (2016) [33]       38/1730       1694/47803       0.61 (0.42, 0.84)       1.21         Besharat (2014) [20]       22/336       209/2181       0.66 (0.40, 1.04)       0.83         Besharat (2017) [39]       16/299       148/1979       0.66 (0.40, 1.04)       0.83         Nancy (2014) [21]       3568/6601299       131915/1735724       0.86 (0.84, 0.87)       2.43         Racape (2010) [29]       3514/5061       5383/4767       0.86 (0.82, 0.90)       2.39         Essen (2000) [42]       270/5211       621/10784       0.99 (0.77, 1.03)       2.07         Farre (2015) [31]       30147/23518       246107/1773102       0.91 (0.90, 0.93)       2.43         Gillet (2014) [9]       9890/129200       21341/261566       0.93 (0.91, 0.97)       2.42         Ratnasiri (2003) [24]       81497/446724       113613/611253       0.97 (0.96, 0.98)       2.43         Castello (2012) [26]       363/5891       952/1574       1.01 (0.57, 1.77)       0.65         Juarez (2014) [27]         1.03 (0.96, 1.11)       2.33         Auger (2007) [36]       278/43396       338/54954       1.06 (1.00, 1.11)       2.38         Lehti (2013) [212]       16/647       229/5300       1.06 (1.00, 1.11)       2.38			7000/04107				
Besharat (2014) [20]       22/336       209/2181       0.66 (0.40, 1.04)       0.83         Besharat (2017) [39]       16/229       148/1979       0.69 (0.38, 1.19)       0.65         Nancy (2014) [25]       45892/447402       22591/188897       0.84 (0.82, 0.86)       2.42         Choi (2019) [41]       39686/601299       131915/1735724       0.86 (0.84, 0.87)       2.43         Racape (2010) [29]       3514/56061       5383/74767       0.86 (0.82, 0.90)       2.39         Essen (2000) [42]       270/5211       621/10784       0.89 (0.77, 1.03)       0.97         Gillet (2014) [9]       9890/129200       21341/261566       0.93 (0.91, 0.97)       2.42         Ratasiri (2003) [24]       81497/44724       113613/611253       0.97 (0.96, 0.88)       2.43         Gastelio (2012) [26]       363/5891       952/15754       1.01 (0.57, 1.77)       0.65         Juarez (2014) [27]         1.03 (0.96, 1.11)       2.33         Auger (2007) [36]       278/43396       338/54954       1.05 (1.00, 1.11)       2.38         Lehti (2013) [22]       16/347       229/5300       1.06 (1.04, 1.08)       2.43         Subtotal (I-squared = 80.2%, p = 0.000)       2       5       1       2 <t< td=""><td></td><td></td><td></td><td>+</td><td></td><td></td><td></td></t<>				+			
Besharat (2017) [39]       16/299       148/1979       0.69 (0.38, 1.19)       0.65         Nancy (2014) [25]       45892/447402       22591/188897       0.84 (0.82, 0.86)       2.42         Choi (2019) [41]       39686/601299       131915/1735724       0.86 (0.84, 0.87)       2.39         Bracape (2010) [29]       3514/50601       5383/74767       0.86 (0.84, 0.87)       2.39         Essen (2000) [42]       270/5211       621/10784       0.89 (0.77, 1.03)       2.07         Farre (2015) [31]       3014/7/23518       246107/1773102       0.91 (0.90, 0.93)       2.43         Gillet (2014) [9]       9890/129200       21341/261566       0.93 (0.91, 0.97)       2.42         Castello (2012) [26]       363/5891       952/15754       1.01 (0.57, 1.77)       0.65         Juarez (2014) [27]         1.03 (0.96, 0.11)       2.38         Bastola (2020) [37]       1485/31454       15702/35048       1.05 (1.00, 1.11)       2.38         Auger (2007) [36]       278/4/3396       3338/54954       1.06 (1.00, 1.11)       2.38         Lehti (2013) [22]       16/347       229/5300       1.06 (1.00, 1.11)       2.38         Kana (2019) [5]       43/386       773/8171       0.92 (0.87, 0.97)       0.90 (0.84, 0.97) <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>							
Nancy (2014) [25]       45892/447402       22591/188897       0.84 (0.82, 0.86)       2.42         Choi (2019) [41]       39666/601299       131915/1735724       0.86 (0.84, 0.87)       2.43         Racape (2010) [29]       3514/56061       5383/74767       0.86 (0.84, 0.87)       2.43         Farre (2015) [31]       30147/233518       246107/1773102       0.89 (0.82, 0.90)       2.39         Gillet (2014) [9]       9990/129200       21341/261566       0.93 (0.91, 0.97)       2.42         Ratnasiri (2003) [24]       81497/446724       113613/611253       0.97 (0.96, 0.98)       2.43         Castello (2012) [26]       363/5891       952/15754       1.01 (0.57, 1.77)       0.65         Juarez (2014) [27]         1.03 (0.96, 1.11)       2.33         Bastola (2020) [37]       1485/31454       15702/350548       1.05 (1.00, 1.11)       2.38         Vik (2019) [43]       12426/190236       67303/1090103       1.06 (1.04, 1.08)       2.43         Auger (2007) [36]       2784/43396       3338/54954       1.06 (1.04, 1.08)       2.43         Lehti (2013) [22]       16/347       229/5300       1.07 (0.59, 1.80)       0.67         Subtotal (Isquared = 80.2%, p = 0.000)       0.92 (0.87, 0.97)       100.0       0.90				<b>•</b>			
Choi [2019] [41]       39686/601299       131915/1735724       0.86 (0.84, 0.87)       2.43         Racape [2010] [29]       3514/56061       5383/74767       0.86 (0.82, 0.90)       2.39         Essen [2000] [42]       270/5211       621/10784       0.89 (0.77, 1.03)       2.07         Farre [2015] [31]       30147/23518       0.91 (0.90, 0.93)       2.43         Gillet (2014) [9]       9890/129200       21341/261566       0.93 (0.91, 0.97)       2.42         Ratasiri (2003) [24]       81497/446724       113613/611253       0.97 (0.96, 0.98)       2.43         Castello (2012) [26]       363/5891       952/15754       1.01 (0.57, 1.77)       0.65         Juarez (2014) [27]       —       —       —       1.03 (0.96, 1.11)       2.38         Auger (2007) [36]       2784/43396       3338/54954       1.06 (1.00, 1.10)       2.38         Lehti (2013) [22]       16/347       229/5300       1.07 (0.95, 1.80)       0.67         Fuster (2014) [28]       28727/412906       11066/1874913       1.16 (1.15, 1.18)       2.43         Subtotal (I-squared = 80.2%, p = 0.000)				<b>•</b>			
$\begin{array}{c c c c c c c c c c c c c c c c c c c $				•			
Essen (2000) [42]       270/5211       621/10784       0.89 (0.77, 1.03)       2.07         Farre (2015) [31]       30147/233518       246107/1773102       0.91 (0.90, 0.93)       2.43         Gillet (2014) [9]       9890/129200       21341/261566       0.93 (0.91, 0.97)       2.42         Ratnasir (2003) [24]       81497/446724       113613/611253       0.97 (0.96, 0.98)       2.43         Castello (2012) [26]       363/5891       952/15754       1.01 (0.57, 1.77)       0.65         Juarez (2014) [27]         1.03 (0.96, 1.11)       2.33         Bastola (2020) [37]       1485/31454       15702/350548       1.06 (1.04, 1.08)       2.43         Vik (2013) [22]       16/347       229/5300       1.06 (1.00, 1.11)       2.38         Lehti (2013) [22]       16/347       229/5300       1.07 (0.59, 1.80)       0.67         Fuster (2014) [28]       28727/412906       110666/1874913       1.16 (1.15, 1.18)       2.43         Xana (2019) [5]       43/386       773/8171       0.92 (0.87, 0.97)       100.0         Overall (I-squared = 80.2%, p = 0.000)       2       5       1       2         Q       2       5       1       2       2         Q       2	Choi (2019) [41]			♦			
Farre (2015) [31]       30147/233518       246107/1773102       0.91 (0.90, 0.93)       2.43         Gillet (2014) [9]       9890/129200       21341/261566       0.93 (0.91, 0.97)       2.42         Ratnasiri (2003) [24]       81497/46724       113613/611253       0.97 (0.96, 0.98)       2.43         Gastello (2012) [26]       363/5891       952/15754       1.01 (0.57, 1.77)       0.65         Juarez (2014) [27]        1.03 (0.96, 1.11)       2.33         Bastola (2020) [37]       1485/31454       15702/350548       1.05 (1.00, 1.11)       2.38         Vik (2019) [43]       12426/190236       67303/1090103       1.06 (1.04, 1.08)       2.43         Auger (2007) [36]       2784/43396       3338/54954       1.06 (1.00, 1.11)       2.38         Lehti (2013) [22]       16/347       229/5300       1.07 (0.59, 1.80)       0.67         Fuster (2014) [28]       28727/412906       110666/1874913       1.16 (1.15, 1.18)       2.43         Subtotal (I-squared = 81.0%, p = 0.000)       0.92 (0.87, 0.97)       100.0         Querall (I-squared = 80.2%, p = 0.000)       2       5       1       2         Querall (I-squared = 80.2%, p = 0.000)       2       5       1       2	Racape (2010) [29]	3514/56061	5383/74767	◆		0.86 (0.82, 0.90)	
Farre (2015) [31]       30147/233518       246107/1773102       0.91 (0.90, 0.93)       2.43         Gillet (2014) [9]       9890/129200       21341/261566       0.93 (0.91, 0.97)       2.42         Ratnasiri (2003) [24]       81497/446724       113613/611253       0.97 (0.96, 0.98)       2.43         Gastello (2012) [26]       363/5891       952/15754       1.01 (0.57, 1.77)       0.65         Juarez (2014) [27]        1.03 (0.96, 1.11)       2.33         Bastola (2020) [37]       1485/31454       15702/350548       1.05 (1.00, 1.11)       2.38         Vik (2019) [43]       12426/190236       67030/1090103       1.06 (1.04, 1.08)       2.43         Auger (2007) [36]       2784/43396       3338/54954       1.06 (1.00, 1.11)       2.38         Lehti (2013) [22]       16/347       229/5300       1.07 (0.59, 1.80)       0.67         Fuster (2014) [28]       28727/412906       11066/1874913       1.19 (0.84, 1.66)       1.23         Subtotal (I-squared = 80.2%, p = 0.000)	Essen (2000) [42]	270/5211	621/10784	<b>-++</b>		0.89 (0.77, 1.03)	2.07
Gillet (2014) [9]       9890/129200       21341/261566       0.93 (0.91, 0.97)       2.42         Ratnasiri (2003) [24]       81497/446724       113613/611253       0.97 (0.96, 0.98)       2.43         Castello (2012) [26]       363/5891       952/15754       1.01 (0.57, 1.77)       0.65         Juarez (2014) [27]         1.03 (0.96, 1.11)       2.38         Bastola (2020) [37]       1485/31454       15702/350548       1.05 (1.00, 1.11)       2.38         Vik (2019) [43]       12426/190236       67303/1090103       1.06 (1.04, 1.08)       2.43         Auger (2007) [36]       2784/43396       3338/54954       1.06 (1.00, 1.11)       2.38         Lehti (2013) [22]       16/347       229/5300       1.07 (0.95, 1.80)       0.67         Fuster (2014) [28]       28727/412906       110666/1874913       1.16 (1.15, 1.18)       2.43         Subtotal (I-squared = 81.0%, p = 0.000)       0.90 (0.84, 0.97)       36.14         Overall (I-squared = 80.2%, p = 0.000)       0.92 (0.87, 0.97)       100.0	Farre (2015) [31]	30147/233518	246107/1773102	♦			2.43
Ratnasiri (2003) [24]       81497/446724       113613/611253       0.97 (0.96, 0.98)       2.43         Castello (2012) [26]       363/S891       952/15754       1.01 (0.57, 1.77)       0.65         Juarez (2014) [27]         1.03 (0.96, 1.11)       2.33         Bastola (2020) [37]       1445/31454       15702/350548       1.05 (1.00, 1.11)       2.38         Vik (2019) [43]       12426/190236       67303/1090103       1.06 (1.00, 1.11)       2.38         Auger (2007) [36]       2784/4336       3338/54954       1.06 (1.00, 1.11)       2.38         Lehti (2013) [22]       16/347       229/5300       1.06 (1.00, 1.11)       2.38         Kana (2019) [5]       43/386       773/8171       1.19 (0.84, 1.66)       1.23         Subtotal (I-squared = 81.0%, p = 0.000)        0.92 (0.87, 0.97)       100.0         Overall (I-squared = 80.2%, p = 0.000)        0.92 (0.87, 0.97)       100.0				۱			
Castello (2012) [26]       363/5891       952/15754       1.01 (0.57, 1.77)       0.65         Juarez (2014) [27]         1.03 (0.96, 1.11)       2.33         Bastola (2020) [37]       1485/31454       15702/35048       1.05 (1.00, 1.11)       2.38         Vik (2019) [43]       1.2426/190236       67303/1090103       1.06 (1.04, 1.08)       2.43         Auger (2007) [36]       2784/43396       3338/54954       1.06 (1.00, 1.11)       2.38         Lehti (2013) [22]       16/347       229/5300       1.07 (0.59, 1.80)       0.67         Fuster (2014) [28]       28727/412906       110666/1874913       1.16 (1.15, 1.18)       2.43         Kana (2019) [5]       43/386       773/8171        0.90 (0.84, 0.97)       36.14         Overall (I-squared = 80.2%, p = 0.000)							
Juarez (2014) [27]         1.03 (0.96, 1.11)       2.33         Bastola (2020) [37]       1485/31454       15702/350548       1.05 (1.00, 1.11)       2.38         Vik (2019) [43]       12426/190236       67303/1090103       1.06 (1.04, 1.08)       2.43         Auger (2007) [36]       2784/43396       3338/54954       1.06 (1.00, 1.11)       2.38         Lehti (2013) [22]       16/347       229/5300       1.06 (1.00, 1.11)       2.38         Kana (2019) [5]       43/386       773/8171       1.16 (1.15, 1.18)       2.43         Subtotal (I-squared = 81.0%, p = 0.000)       0.90 (0.84, 0.97)       36.14         Overall (I-squared = 80.2%, p = 0.000)       0.92 (0.87, 0.97)       100.0							
Bastola (2020) [37] Vik (2019) [43] Auger (2007) [36] Lehti (2013) [22] Lehti (2013) [22] Subtotal (I-squared = 80.2%, p = 0.000) Letti (I - squared = 80.2%, p = 0.000)				<u>k</u>			
Vik (2019) [43]       12426/190236       67303/1090103       1.06 (1.04, 1.08)       2.43         Auger (2007) [36]       2784/4336       3338/54954       1.06 (1.00, 1.11)       2.38         Lehti (2013) [22]       16/347       229/5300       1.06 (1.00, 1.11)       2.38         Kana (2019) [5]       43/386       773/8171       1.16 (1.15, 1.18)       2.43         Subtotal (I-squared = 81.0%, p = 0.000)       773/8171       0.99 (0.84, 0.97)       36.14         Overall (I-squared = 80.2%, p = 0.000)       .2       .5       1       2				K			
Auger (2007) [36]       2784/43396       3338/54954       1.06 (1.00, 1.11)       2.38         Lehti [2013] [22]       16/347       229/5300       1.07 (0.59, 1.80)       0.67         Fuster (2014) [28]       28727/412906       110666/1874913       1.16 (1.15, 1.18)       2.43         Subtotal (I-squared = 81.0%, p = 0.000)       43/386       773/8171				X			
Lefit (2013) [22]       16/347       229/5300       1.07 (0.59, 1.80)       0.67         Fuster (2014) [28]       28727/412906       110666/1874913       1.16 (1.15, 1.18)       2.43         Subtotal (I-squared = 81.0%, p = 0.000)       43/386       773/8171 <ul> <li>(I-squared = 80.2%, p = 0.000)</li> <li>0.92 (0.87, 0.97)</li> <li>100.0</li> <li>2</li> <li>2</li> <li>5</li> <li>2</li> <li>5</li> <li>2</li> </ul>							
Fuster (2014) [28]       28727/412906       110666/1874913       1.16 (1.15, 1.18)       2.43         Kana (2019) [5]       43/386       773/8171       1.19 (0.84, 1.66)       1.23         Subtotal (I-squared = 80.2%, p = 0.000)       0.90 (0.84, 0.97)       36.14         Overall (I-squared = 80.2%, p = 0.000)       0.92 (0.87, 0.97)       100.0         Image: Comparison of the squared = 80.2%, p = 0.000)       Image: Comparison of the squared = 80.2%, p = 0.000)       0.92 (0.87, 0.97)       100.0         Image: Comparison of the squared = 80.2%, p = 0.000)       Image: Comparison of the squared = 80.2%, p = 0.000)       0.92 (0.87, 0.97)       100.0				T			
Kana (2019) [5]       43/386       773/8171       1.19 (0.84, 1.66)       1.23         Subtotal (I-squared = 81.0%, p = 0.000)       0.90 (0.84, 0.97)       36.14         Overall (I-squared = 80.2%, p = 0.000)       0.92 (0.87, 0.97)       100.0         Image: Rel of the squared = 80.2%, p = 0.000)       Image: Rel of the squared = 80.2%, p = 0.000)       0.92 (0.87, 0.97)       100.0         Image: Rel of the squared = 80.2%, p = 0.000)       Image: Rel of							
Subtotal (I-squared = 81.0%, p = 0.000)       ◇       0.90 (0.84, 0.97)       36.14         Overall (I-squared = 80.2%, p = 0.000)       ◇       0.92 (0.87, 0.97)       100.0         I       I       I       I       I         .2       .5       1       2         .4       .4       .4       .4				🕈			
Overall (I-squared = 80.2%, p = 0.000)         Output         Output <th< td=""><td></td><td>43/386</td><td>7/3/8171</td><td>•</td><td></td><td></td><td></td></th<>		43/386	7/3/8171	•			
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Subtotal (I-squared = 81.0%, p = 0.000)			$\diamond$		0.90 (0.84, 0.97)	36.14
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$						0.00 (0.07 0.07)	100.00
$\leftarrow  \rightarrow$	Overall (I-squared = 80.2%, p = 0.000)			$\diamond$		0.92 (0.87, 0.97)	100.00
$\leftarrow  \rightarrow$				<u> </u>			
$\leftarrow  \rightarrow$			.2	.5 1	2		
				←	$\rightarrow$		
Better outcome Worse outcome				Better outcome	Worse outcome		
					noise outcome		

	Migrant (n/N)	Control(n/N)		OR (95% CI)	%Weight
Overweight/obesity					
Kumar (2016) [44]	85/11327	32/2488	▶	0.58 (0.38, 0.90)	2.98
Liu (2016) [45]	436/3057	1370/6860	←	0.66 (0.59, 0.75)	4.23
Ji (2016) [14]	241/991	198/650	<b>→</b>	0.73 (0.58, 0.92)	
Lin (2011) [46]	56/157	223/519 -	<b>→</b>	0.73 (0.49, 1.08)	3.14
De (2018) [47]	174/353	459/847	<b>—•–†</b>	0.82 (0.63, 1.06)	
Zulfiqar (2018) [48]	416/1799	571/2434	-	0.98 (0.84, 1.13)	
Maximova (2011) [13]	1618/5261	326/1131		1.09 (0.94, 1.26)	
Lindstrom (2014) [49]	412/2423	1061/7195	<b>-</b>	1.18 (1.04, 1.34)	
Esteban–Gonzalo (2014) [50]	66/335	296/1742	<b></b>	1.19 (0.87, 1.62)	
Besharat (2014) [51]			<b>→</b>	1.33 (1.07, 1.66)	
Furthner (2017) [52]	223/827	437/2103	<b>↓</b>	1.40 (1.16, 1.70)	
Burgi (2010) [53]	39/391	11/151		- 1.41 (0.68, 3.14)	
Iguacel (2018) [54]	329/1156	1597/7427		1.45 (1.26, 1.67)	
Khanolkar (2013) [55]				1.52 (1.08, 2.14)	
Thi (2018) [56]	147/1080	203/2623	· · ·	1.75 (1.39, 2.21)	
Will (2005) [57]	46/258	29/265		- 1.76 (1.04, 3.02)	
Zhou (2018) [58]	2452/19245	2154/31441		1.78 (1.26, 2.51)	
Meroc (2019) [15]	2452/15245	2134/31441		1.84 (1.46, 2.32)	
Labree (2015) [59]	114/397	205/1546	<b>_</b>	2.17 (1.22, 3.87)	
Brettschneider (2011) [60]		203/1340		2.36 (1.28, 4.34)	
Vorwieger (2018) [61]				2.30 (1.28, 4.54)	
Nagel (2009) [62]	88/287	104/689			
•	44/183			2.48 (1.76, 3.48)	
Beyerlein (2014) [63]		219/2096		2.71 (1.83, 3.95)	
Subtotal (I–squared = 78.0%, p	= 0.015)			1.33 (1.13, 1.57)	/9.50
Underweight					
De (2018) [47]	58/353	181/847 -	<b></b>	0.72 (0.51, 1.01)	3.38
Labree (2015) [59]	22/397	100/1546 -		0.85 (0.50, 1.39)	
Prusty (2015) [64]			<b>.</b>	0.95 (0.85, 1.05)	
Subtotal (I-squared = 17.2%, p	= 0.299)		$\diamond$	0.90 (0.77, 1.04)	
			-		
Anaemia	22/1244	26/1260		0.00/0.51.4.20	2.40
Saunders (2017) [65]	22/1244	26/1268		0.93 (0.54, 1.62)	
(umar (2016) [44]	8032/11327	1628/2488	<b>→</b>	1.28 (1.17, 1.41)	
Hu (2014) [66]	244/667	60/321		1.86 (1.40, 2.47)	
Subtotal (I-squared = 63.6%, p	= 0.033)		$\sim$	1.37 (1.01, 1.87)	10.42
Overall (I–squared = 80.0%, p =	0.000)		$\diamond$	1.26 (1.11, 1.44)	100.00
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FIGURE

	Suboutcome	Migrant(n/N)	Control(n/N)			OR (95% CI)	%Weight
Oral diseases							
Julihn (2010) [67]	Caries	2396/5134	3610/10404		<b>•</b>	1.64 (1.53, 1.76)	3.16
Christensen (2010) [68]	Caries	2590/5154	5010/10404		<b>T</b> _		
			75/650		<b>—</b>	2.00 (1.80, 2.10)	3.15
Ji (2016) [14]	Caries	235/991				2.38 (1.78, 3.20)	2.94
Van Meijeren (2019) [69]	Caries	179/611	370/2510		<b>—</b>	2.39 (1.93, 2.95)	3.04
Ferrazzano (2019) [70]	Caries	142/183	207/370			- 2.72 (1.79, 4.18)	2.72
Van der (2016) [71]	Caries	642/1403	674/2957		<b></b>	2.85 (2.48, 3.28)	3.11
Almerich (2007) [72]	Caries	40/54	387/825			3.23 (1.68, 6.52)	2.23
Bissar (2014) [73]	Caries	48/265	40/698			3.63 (2.27, 5.83)	2.63
Baggio (2015) [74]	Caries	154/398	55/457		~ _	4.61 (3.22, 6.64)	2.83
Subtotal (I-squared = 61.1%, p	o = 0.043)				$\diamond$	2.56 (2.11, 3.11)	25.81
Gastrointestinal disease							
Kumar (2016) [44]	Diarrhea	974/11327	182/2488	<b>▲</b>	_	1.19 (1.01, 1.41)	3.09
Bardin (2019) [75]	Gastroenteritis	462/21817	4056/191345		+	1.74 (1.57, 1.94)	3.14
Ji (2016) [14]	Diarrhea	209/991	80/650			1.90 (1.42, 2.55)	2.94
Subtotal (I–squared = 67.3%, p					$\sim$	1.56 (1.18, 2.07)	9.17
	) = 0.024)				$\checkmark$	1.50 (1.10, 2.07)	2.17
Respiratory diseases							
Charania (2019) [76]	Pneumonia	1683/125511	17793/567408 🔶			0.41 (0.39, 0.44)	3.16
Li (2019) [77]	Pneumonia	567/3477	595/2213	←		0.52 (0.46, 0.60)	3.12
Migliore (2007) [78]	Asthma	55/1012	2764/28293	✦── │		0.53 (0.40, 0.70)	2.96
Lindstrom (2014) [69]	Asthma	200/2423	932/7195	<b>→</b>		0.60 (0.51, 0.71)	3.09
Keet (2011) [79]	Asthma			<b></b>		0.73 (0.44, 1.22)	2.56
Li (2019) [77]	Asthma	263/3477	294/2213	<b>—</b>		0.77 (0.52, 1.13)	2.78
Bardin (2019) [75]	pneumonia	202/21817	2659/191345	· · •	-	1.18 (1.01, 1.37)	3.10
Svendsen (2009) [80]	Asthma	399/2026	1008/4370	<b>i</b>	_	1.20 (1.04, 1.39)	3.11
Radhakrishnan (2018) [81]	Asthma	88818/422305	191451/968256			1.21 (1.18, 1.25)	3.17
Marcon (2011) [38]	Pneumonia	23/641	74/2980		<b></b>	1.46 (0.86, 2.38)	2.56
Bardin (2019) [75]	Asthma	54/21817	665/191345		<u> </u>	1.53 (1.12, 2.06)	2.92
Migliore (2007) [78]	Pneumonia	69/1012	1026/28293		<b>*</b>	1.94 (1.48, 2.50)	2.98
Subtotal (I–squared = 79.1%, p		09/1012	1020/20275	>	•	0.90 (0.63, 1.28)	35.52
Allergic disease				.			
Marcon (2011) [38]	Eczema					0.61 (0.43, 0.86)	2.85
Apfelbacher (2011) [82]	Eczema			<b>→</b>		0.63 (0.49, 0.80)	3.00
Li (2019) [77]	Eczema	527/3477	509/2213	<b>-+</b> <u>+</u> <u>+</u>		0.82 (0.67, 1.01)	3.05
Keet (2011) [79]	Eczema				•	0.91 (0.64, 1.31)	2.84
Svendsen (2009) [80]	Food allergy	235/1055	499/2495		<b></b>	1.53 (1.05, 2.24)	2.80
Koplin (2014) [83]	Food allergy				<b>—</b>	2.60 (1.80, 3.80)	2.81
Subtotal (I-squared = 70.4%, p	o = 0.002)				>	1.01 (0.68, 1.50)	17.36
Congenital disease							
Ramadhani (2009) [84]	Heart defects			<b>_</b>		0.89 (0.76, 1.06)	3.09
Kang (2015) [85]	Heart defects	735/325940	422/214634			1.14 (1.10, 1.29)	3.15
Ramadhani (2009) [84]	Neural tube defect			<b>_</b>	♠	1.38 (1.06, 1.80)	2.98
Velie (2006) [86]	Neural tube defect		213/484			2.40 (1.80, 3.30)	2.90
Subtotal (I–squared = 61.1%, p		1/4/203	213/404			1.32 (0.98, 1.78)	12.15
subtotal (i-squared = 61.1%), p	)=0.051)					1.32 (0.96, 1.76)	
Overall (I–squared = 78.5%, p	= 0.024)			<	>	1.34 (1.11, 1.61)	100.00
				<u> </u>			
			1				
			.2	5 1	2		
				$\leftarrow$	$\rightarrow$		
			Better	utcome	Worse outcome		
			Detter		worse outcome		

FIGURE 2 | Continued

D	Migrant(n/N)	Control(n/N)			OR (95% CI)	%Weigl
Depression						
Kim (2018) [87]				+	1.17 (1.09, 1.27)	7.33
Lin (2011) [46]	32/157	89/519	-	<b>→</b>	1.23 (0.76, 1.97)	5.35
Fuhrmann (2014) [88]	8/118	29/535		•	1.26 (0.48, 2.94)	3.09
Esteban–Gonzalo (2014)[50]	14/335	30/1742		↓	2.48 (1.20, 4.90)	4.02
Subtotal (I–squared = 31.5%, p	= 0.223)			$\diamond$	1.29 (1.00, 1.65)	19.79
ADHD						
Adriaanse (2014)[89]	68/576	199/702	_		0.33 (0.24, 0.46)	6.28
Lehti (2016) [33]	507/1730	9902/47803		-	1.58 (1.42, 1.76)	7.26
Wang (2017) [90]	58/731	17/451		↓	2.20 (1.24, 4.08)	4.62
Subtotal (I–squared = 87.6%, p	= 0.000)	_			1.03 (0.33, 3.20)	18.16
ASD						
Van der(2013)[91]	98/26599	420/80354	-+	-	0.70 (0.55, 0.87)	6.80
Wandell (2020) [92]	12965/1149504	39451/2873645	•		0.81 (0.80, 0.84)	7.39
Magnusson (2012) [93]	796/9396	3122/34567		<b>→</b>	0.93 (0.85, 1.01)	7.31
Lehti (2013) [22]	97/347	1035/5300			1.59 (1.23, 2.05)	6.66
Subtotal (I–squared = 71.8%, p	= 0.001)		<	$\Rightarrow$	0.93 (0.78, 1.12)	28.16
Schizophrenia						
Weiser (2008) [94]	284/104638	46/557154		-	1.50 (1.25, 1.80)	7.01
Hjern (2004) [95]	635/87988	4049/1056225		+	1.88 (1.73, 2.05)	7.31
Pedersen (2012) [96]	129/202	739/1639			2.15 (1.57, 2.95)	6.33
Subtotal (I–squared = 66.4%, p	= 0.051)				1.79 (1.50, 2.14)	20.65
Suicide attempt						
Lu (2018) [97]	189/1805	193/2284		<b></b>	1.26 (1.02, 1.57)	6.86
Vazsonyi (2017) [98]	54/741	344/6546			1.41 (1.03, 1.91)	6.37
Subtotal (I–squared = 0.0%, p =	= 0.558)			$\langle \rangle$	1.31 (1.10, 1.56)	13.23
Querell /L coursed - 77.70( p -	0.000)			$\sim$	1 24 (1 00 1 52)	100.00
Overall (I–squared = 77.7%, p =	= 0.000)			$\sim$	1.24 (1.00, 1.52)	100.00
		.2	.5	1 2		
			← Better outcome			
				Worse outcome		

1	Migrant(n/N)	Control(n/N)		OR (95% CI)	%Weigh
Fetal death					
Ratnasiri (2003) [24]	2037/446724	2720/611253	+	1.02 (0.96, 1.08)	4.18
Mika (2003) [34]	124/34357	363/110008	_ <b>_</b>	1.09 (0.88, 1.34)	3.47
Choi (2019) [41]	124/5455/		<b>•</b>	1.14 (1.02, 1.27)	4.01
	1100/100520				
Vik (2019) [43]	1108/198520	5585/1156444	<b>₩</b>	1.15 (1.08, 1.23)	4.16
Bastola (2020) [37]	63/31454	496/350548		1.41 (1.07, 1.84)	3.10
Villadsen (2010)[99]			♣	1.42 (1.31, 1.54)	4.11
Fuster (2014) [28]	1647/412906	4698/1874913	◆	1.59 (1.50, 1.68)	4.18
Subtotal (I-squared = 73.6%,	p = 0.002)		$\diamond$	1.24 (1.07, 1.45)	27.21
Perinatal death					
				0.07 (0.74, 1.26)	2 1 2
Racape (2010) [29]				0.97 (0.74, 1.26)	3.13
Mika (2003) [34]	203/34357	627/110008	<b>—</b> —.	1.03 (0.88, 1.21)	3.77
Farr"¦ (2013) [31]	187/233518	1064/1773102	-+-	1.33 (1.13, 1.56)	3.76
Essen (2000) [42]	53/5211	65/10784	──✦──	- 1.50 (1.10, 2.20)	2.64
Barona–Vilar (2012) [100]	399/40834	1053/162043		1.51 (1.34, 1.69)	3.98
Subtotal (I-squared = 65.0%,			$\diamond$	1.25 (1.04, 1.50)	17.27
Neonatal death					
				0.00 (0.07, 1.11)	2.05
Choi (2019) [41]			<b>—</b>	0.98 (0.87, 1.11)	3.95
Mika (2003)[34]	82/34357	264/110008	<b>_</b>	0.99 (0.76, 1.27)	3.19
Madan (2006) [35]	3333/2418501	5127/4005671	♦	1.07 (1.03, 1.12)	4.21
Vang (2016) [101]			♦	1.07 (0.86, 1.33)	3.43
Villadsen (2010) [99]			<b>→</b>	1.17 (1.03, 1.32)	3.94
Gillet (2014) [9]	210/64600	566/261566	<b></b>	1.28 (1.07, 1.53)	3.66
Bastola (2020) [37]	38/31454	282/350548	<b>_</b>	- 1.50 (1.04, 2.11)	2.60
Subtotal (I-squared = 47.7%,		202, 3303 10	$\diamond$	1.10 (1.02, 1.19)	24.98
Post-neonatal death					
Ratnasiri (2003) [24]	711/446724	1434/611253 -	┡─	0.67 (0.61, 0.74)	4.06
Gillet (2014) [9]	107/64600	310/261566		0.97 (0.76, 1.24)	3.26
Madan (2006) [35]	4036/2418501	6689/4005671	•	0.99 (0.96, 1.03)	4.22
Vang (2016) [101]			_ <b>_</b>	1.02 (0.85, 1.22)	3.65
Bastola (2020) [37]	16/31454	151/350548	ľ	1.18 (0.65, 1.98)	1.65
Subtotal (I-squared = 68.9%,		131/330340	~	0.92 (0.74, 1.14)	16.84
	p = 0.003)		$\checkmark$	0.72 (0.74, 1.14)	10.04
Infant death					
Rosenberg (2002) [102]	1109/72293	2938/130681	▶	0.67 (0.63, 0.72)	4.16
Landale (2006) [103]	973/4342	154/715	<b></b>	1.05 (0.86, 1.28)	3.54
Troe (2006) [104]	178/30331	26/3838		0.86 (0.57, 1.36)	2.17
Gillet (2014) [9]	317/64600	876/261566	·	1.17 (1.01, 1.35)	3.84
Subtotal (I-squared = 74.8%,		0/0/201500		0.92 (0.65, 1.30)	13.71
	p = 0.000)			0.92 (0.05, 1.50)	15./1
Overall (I-squared = 75.5%, p	o = 0.000)		$\diamond$	1.11 (1.01, 1.21)	100.00
		2	1	2	
		←			
		Better outcor	ne Worse	outcome	



1.12–1.34)], perinatal death [OR 1.25 (95% CI 1.04– 1.50)], and neonatal death [OR 1.20 (95% CI 1.06–1.35)] indicated a higher risk for migrant children in European countries than for non-migrant children, but not in the non-European countries, with the exception of neonatal death. The insufficient number of studies did not allow for analyses of the risk of death among internal migrant children. Sensitivity analyses did not change the above results (**Appendix**).

### Substance Use

No significant differences were found in the risk of substance use [OR 0.83 (95% CI 0.54–1.27)], including alcohol, tobacco, and cannabis use among migrant children compared with non-migrant children (**Figure 2F**). The above results did not change after sensitivity analyses (**Appendix**). Given the studies included in substance use were all conducted in the European countries, subgroup analyses by region did not performed. Also, the effect of migration type

TABLE 2   The subgi	roup analyses by	/ study region.
---------------------	------------------	-----------------

Health outcomes	European country		Non-European country	
	Pooled OR (95%CI)	Heterogeneity (I2)	Pooled OR (95%CI)	Heterogeneity (I2)
Birth outcome	0.95(0.90, 1.02)	68.5%	0.84 (0.75, 0.94)	76.7
LBW	0.89 (0.84, 0.94)	73.2%	0.83 (0.65, 1.05)	79.8
HBW	1.11 (0.85,1.45)	69.3%	_	
Preterm birth	0.96 (0.88, 1.04)	75.0%	0.81 (0.71, 0.92)	80.4
Nutrition	1.51 (1.29, 1.78)	71.1%	0.98 (0.81, 1.17)	81.7%
Overweight/obesity	1.62 (1.39, 1.90)	68.8%	0.86 (0.68, 1.09)	80.3%
Underweight	0.76 (0.57, 1.01)	0%	_	
Anemia	_		1.37 (1.01, 1.87)	73.6%
Physical health	1.48 (1.02, 2.14)	79.1%	1.20 (1.03, 1.41)	74.1%
Oral disease	2.59 (2.10, 3.20)	62.1%	_	
Gastrointestinal disease	_		1.48 (0.94, 2.34)	86.5%
Respiratory disease	0.93 (0.57, 1.54)	78.2%	0.85 (0.57, 1.27)	77.4%
Allergic disease	0.62 (0.51, 0.76)	0%	1.30 (0.77, 2.19)	80.7%
Congenital disease	_		1.32 (0.98, 1.78)	81.1%
Mental health	1.17 (0.88, 1.57)	68.4%	1.32 (1.14, 1.52)	49.5%
Depression	_		1.17 (1.09, 1.26)	0%
ADHD	0.73 (0.16, 3.38)	78.8%	_	
ASD	0.93 (0.78, 1.12)	71.8%	_	
Schizophrenia	1.90 (1.75, 2.06)	0%	_	
Suicide attempt	_		_	
Death	1.23 (1.13, 1.34)	70.2%	0.97 (0.87, 1.09)	75.9%
Fetal death	1.33 (1.12, 1.34)	67.3%	1.07 (0.96, 1.19)	67.45
Perinatal death	1.25 (1.04, 1.50)	60.0%	_	
Neonatal death	1.20 (1.06, 1.35)	30.7%	1.06 (1.02, 1.10)	0%
Post-neonatal death	1.00 (0.80, 1.25)	0%	0.88 (0.66, 1.16)	66.4%
Infant death	1.08 (0.82, 1.41)	42.3%	0.83 (0.53, 1.29)	74.3%
Substance use	0.83 (0.54, 1.27)	78.5%	_	

LBW, low birth weight; HBW, high birth weight; ADHD, attention deficit hyperactivity disorder; ASD, autistic spectrum disorder: "-" indicate the studies included in the specific outcome no more than one. The pooled OR with 95%CI for the risk of health outcome among subgroup using random-effects model.

on substance use did not conducted due to the limited available studies.

The Begg's and Egger's tests indicated no significant publication bias among the included studies in six health outcomes (all  $P_{\text{Begg'sTest}} > 0.05$  and  $P_{\text{Egger'sTest}} > 0.05$ ).

Meta-regression analyses showed that the sample size, study design, publish year, and study region had effects on physical health outcome ( $\beta = 0.557$ , SE = 0.254, P = 0.043;  $\beta = 0.821$ , SE = 0.281, P = 0.010;  $\beta = 0.430$ , SE = 0.159, P = 0.015;  $\beta = 0.498$ , SE = 0.157, P = 0.006; respectively), while had no effects on birth outcome and physical health outcome (all P > 0.05). Additionally, the effect of study region on nutrition outcome ( $\beta = 0.597$ , SE = 0.209, P = 0.008) and publish year on mental health outcome ( $\beta = -0.557$ , SE = 0.228, P = 0.027) were also observed.

#### DISCUSSION

Our findings demonstrated that migrant children tend to have overall worse health outcomes than non-migrant children. Compared with the controls, migrant children had an increased risk of malnutrition (e.g., overweight/obesity and anemia), poor physical health (oral diseases and gastrointestinal diseases), mental disorder (e.g., depression, schizophrenia, and suicide attempt), and death (fetal death, perinatal death, and neonatal death). The beneficial health effects were observed in birth outcomes such as lower risk of LBW and preterm birth.

### The Healthy Migration Effect Does Not Necessarily Exist in Migrant Children Although Superior Birth Outcome Was Observed

"The immigrant paradox" has been reported in studies targeting the adult migration population. Despite the average lower socio-economic status of migrants and their inferior access to healthcare, adult migrants in advanced societies are generally healthier than the natives in the host country (17). The healthy immigrant effect was also reported in some health outcomes in children upon their birth or arrival. A review on international migrants in Spain suggested that children with migrant mothers have superior birth outcomes, such as a lower incidence of LBW

and preterm birth than the natives (108), which is consistent with the finding of our meta-analysis. Specific factors such as mother's healthier migrant lifestyles and the cultural heritages of the migrant countries (e.g., lower rates of smoking and alcohol consumption) may partially explain the phenomenon (109). Another explanation is the selective migration hypothesis that healthier and/or wealthier women may choose to migrate to richer countries where they can have better birth outcomes (31). However, the notion that the health effect does not apply to all migrants is a subject of debate. Due to the limited generalizability, the immigrant paradox may be better conceptualized as outcome-specific with consideration of such relevant factors as immigrants' ethnicity, length of residence (10), nativity, and age at arrival (110). This meta-analysis suggests that the immigrant paradox does not necessarily exist among children in multiple outcomes. Migrant children have an overall poorer health status, especially in overweight/obesity, mental disorder, poorly physical health, and mortality.

# Migrant Children Have Higher Risk of Developing Malnutrition, Especially Being Overweight/Obesity

As reported, migrant children adhered poorly to health diet recommendations for vegetable consumption and more likely to consume sweet and soft drinks than did the native residents, which is a driver factor for obesity (111). Our meta-analysis indicated an increased risk of overweight/obesity in migrant children, especially in those who migrated to European countries with high incomes, which were consistent with the concept that migration to developed countries may develop to be overweight and obesity (112). The increased risk of obesity among migrant children can be caused by alterations in dietary intake and adopting "unhealthier" practices of the host nations (113), including increased saturated fat and carbohydrate consumption. Eating disorder among migrants may be associated with stress during acculturation compounded by pressure to adapt to new cultural body shape norms (114). Additionally, children within lower income migrant families may easily exposed to more processed and energy-dense foods because they are cheaper and quicker to prepare (111). Moreover, alterations in physical activity, a more sedentary way of life, and lower sleep duration among migrant children (115), are also important drivers for overweight and obesity (116). Our study also suggested that international migrant children had a higher risk of overweight/obesity, but the opposite result was observed among children migrating within the country. As we known, international migrants from low-middle income countries to high income countries were more likely to adopt the abovementioned westernized lifestyle and unhealthy dietary habits (e.g., high energy, sugar, and fat intake) which were the key risk of overweight/obesity. While the rural-to-urban migrant children in India and China usually live in lower socioeconomic families and may less likely to access to more other foods compared to urban children. Yet, the prevalence of overweight/obesity of rural-tourban migrant children is increasing gradually in recent year, which need to be of concern.

# Psychological Wellbeing Is Also One of Concerns in the Broader Population of Migrant Children

Our study found that migrant children have poorer mental health than their indigenous peers, including higher risk of depression, suicide attempt, and schizophrenia. In general, stress, anxiety and depression in migrant children are strongly influenced by psychological adaption within the host country (117). Acculturation stress which refers to the potential challenges migrants face when they negotiate differences between their home and host cultures (118) increases the risks of various mental health problems among immigrant adolescents, including withdrawn, somatic, and anxious/depressed symptoms (119). Such stress arises from multiple aspects of the acculturation process, including learning new and sometimes confusing cultural rules and expectations, dealing with prejudice and discrimination, and managing the overarching conflict between maintaining elements of the old culture while incorporating those of the new (120). By the way, the publication year of the included studies had effect on migrant children's mental health in our meta-regression analysis, this may be connected with the phenomenon that increasing number of researches focused on mental health were appeared in a decade year with the progress of globalization.

# Poorly Experience of Health Is Not Uncommon Among Migrant Children

As reported that migrant children have high levels of ill health and unmet healthcare needs (121). In our study, migrant children have increased risk of mortality such as fetal death, perinatal death, and neonatal death, as well as worse physical health such as oral diseases and gastrointestinal diseases including diarrhea. The limited access to health service and insurance are the most challenging barriers for this situations (122). Experiences of health services are often unsatisfactory for migrant children, such as difficulties and delay in registering with the General medical Practitioners, difficulties securing medical appointments and missed follow-up appointments (121). Studies suggests that migrant children are four times as likely to be uninsured as native children (7). Moreover, access to health care may also be limited by their parents' knowledge and healthcare awareness, and language and cultural barriers (123-125). Additionally, the effects of poverty on access to health insurance and healthcare appear to be the strongest (7). Children from a migrant household are more likely to live in poverty than children from a non-migrant household. For US migrant families, children in poorer families were nearly twice as likely to have not visited a dentist and to lack a usual source of sick care, and 50% were more likely not to have visited a doctor in the previous year (7).

# Actions Are Required to Address the Health Inequity Among These Populations

To date, monitoring migrant health is among the key priorities of the International Organization for Migration, and a set of actions have been taken to monitor migrants' health-seeking behaviors, access to and utilization of health services, and

to increase the collection of data related to health status and outcomes of migrants (1). However, strategies specially designed to improve the birth and health status of migrant children remain insufficient. Through the United Nations 2030 Agenda for Sustainable Development, countries worldwide have pledged to take actions to achieve the Sustainable Development Goals, including Goal 3 of good health and wellbeing and Goal 10 of reduced inequalities. Yet, the health inequalities are still prevalent. Poor health outcomes are secondary to system (e.g., long wait times between making appointments and seeing health professionals, and the long wait times at health facilities), financial, and language and cultural barriers (126). Addressing those barriers should be prioritized if the health status of migrants is to be improved. First, developing migrantsensitive health systems and ensuring that health services are delivered to migrant children in a culturally and linguistically appropriate way, and enforce laws and regulations that prohibit discrimination. Second, adopting measures to improve the ability of health systems to deliver migrant inclusive services and programmes in a comprehensive, coordinated and financially sustainable way. Third, identifying good practices in monitoring migrant children's health and mapping policy models that facilitate equitable access to health care (1).

### **Strength and Limitations**

The comprehensive scope of this meta-analysis is a strength since evidence across multiple health outcomes and with low publication bias. However, our study has several limitations. First, our original systematic search included literature published up to January 30, 2021, and thus newer studies may draw different conclusions. Second, statistical heterogeneity was moderate high in this meta-analysis, which did not significantly decrease after subgroup-analyses. Yet, meta-regression indicated that the sample size, study design, publish year, or study region had effects on multiple health outcomes, which may partly explain the source of high heterogeneity. Similarly, high heterogeneity was identified in a systematic review and meta-analyses of the health impacts of parental migration on left-behind children (127). Third, most of the included studies in our meta-analysis were from European countries, focused on international migration and were cross-sectional, which means temporal causal inference is limited and might not generalized. Fourth, the studies with forced migrant and unaccompanied children were excluded, which might have underestimated the health status of the migrant children. Fifth, we only included studies published in English language, the non-English studies with internal migrant children especially in Chinese publications might have been excluded. Last but not the least, we were unable to explore the effect of

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socioeconomic status, origin country, migrant generation (e.g., the first-generation and second-generation migration) and length of residence in the host country on the health outcomes of migrant children due to the unavailability of this information, which might contribute to the migration paradox.

# CONCLUSION

Children migrating with parents have higher risk of poor health outcomes such as malnutrition, physical diseases, mental disorder, and death than the host populations. The healthy migrant paradox does not necessary exist among children in multiple outcomes. Interventions that support migrants are urgently needed to prevent long-term negative effects on their health and development.

# DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

# **AUTHOR CONTRIBUTIONS**

RC developed the study and oversaw its implementation, analyzed the data, and wrote the manuscript. RC, CL, HQ, and YZ did review activities, consisting of searches, study selection, data extraction, and quality assessment. JZ conceptualized and designed the study, coordinated, supervised data collection, and critically reviewed the manuscript for important intellectual content. All authors reviewed the study findings, read, and approved the final version before submission.

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### SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fped. 2022.810150/full#supplementary-material

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