Prevalence and determinants of constipation in children in Asia: a systematic review and meta-analysis

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Summary

Background Constipation is prevalent worldwide, significantly increasing healthcare costs and diminishing the quality of life in children affected. Current studies have yielded mixed results regarding the factors associated with constipation, and mainly focusing on patients outside of Asia. Moreover, most of these studies lack focus on the paediatric population. This study aimed to identify the prevalence and associated factors of constipation among children in Asia.

Methods In this systematic review and meta-analysis, we systematically searched PubMed, Scopus, and Cochrane for cohort and cross-sectional studies published from database inception up to October 12, 2022, and continued with manual searching until September 2, 2023. Eligible studies were those that included children in Asia aged 0–18 years old suffering from idiopathic constipation, with prevalence value provided in the English abstract. The analysis included clinical and general population. Children with organic constipation, who had undergone gastrointestinal surgery, or with congenital defects were excluded, as these factors affect the incidence of constipation. Data included in the analysis were extracted from published reports only. The extracted data were pooled using random-effects model to analyse the prevalence of constipation in children in Asia. This study is registered with PROSPERO, CRD42022367122.

Findings Out of 4410 systematically searched studies and 36 manually searched ones, a total of 50 studies were included in the final analysis, encompassing data from 311,660 children residing in Asia. The pooled prevalence of constipation was 12.0% (95% CI 9.3–14.6%, I^2 = 99.8%). There was no significant difference in constipation prevalence observed by sex and geographical location. Nonetheless, adolescents and children aged 1–9 years exhibited a significantly higher prevalence constipation compared to infants ($p < 0.0001$) Additionally, significant differences in constipation rates were observed across various diagnostic methods, population sources, and mental health conditions.

Interpretation Despite the high heterogeneity resulting from varying diagnostic tools or definitions used among studies, our review adds to the literature on constipation among children in Asia. It reveals a notably high prevalence of constipation in this demographic. Diagnostic methods, age, and compromised mental health emerged as significant influencers of constipation among children in Asia, highlighting potential strategies to mitigate constipation prevalence in children in Asia.

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Research in context

Evidence before this study

Upon conducting a search at Scopus, Google Scholars, and PROSPERO with keywords such as "children", "adolescent", and "constipation", "childhood constipation" from database inception up to September 2, 2022, we found that previous studies regarding paediatric constipation were scarce and predominantly conducted outside of Asia. The recent meta-analysis by Chu et al. reported a constipation rate of 18.8% among children solely in China, exceeding the range of constipation in population in Asia, reported by Koppen et al. (6.3%), which included studies utilizing Rome III and IV diagnostic criteria exclusively.

Added value of this study

The previous studies focus on prevalence of worldwide or a specific country, and lacks focus on paediatric population in Asia. This study provides a deeper understanding of constipation prevalence and the associated factors in children in Asia. Results of the study can be used as a consideration for policy makers and health care professionals in tackling childhood constipation in both individual and population level.

Implications of all the available evidence

The key limitation of this study lies in the high heterogeneity, likely stemming from different definitions of constipation and diagnosis method employed across studies, thereby resulting in a wide range of 95% confidence intervals. Notably, this systematic review and meta-analysis revealed a relatively high constipation prevalence in children in Asia, but it was still inside the range of worldwide functional constipation prevalence. Sex did not affect the prevalence, as with previous studies, but diagnosis method, population source, age, and compromised mental health were significantly associated with constipation prevalence in children in Asia.

Introduction

Functional constipation (FC) is characterised by hard or dry stools, infrequent bowel movements, and incomplete bowel evacuation.[1] More than 95% of constipation cases are considered to be of functional origin and require frequent consultation in paediatric gastroenterology clinics, which increases healthcare expenditures.[2] Until now, the pathophysiology of childhood FC is not completely understood; the stool withholding behaviour that often occurs after a negative experience associated with stooling—e.g. a hard, painful, or frightening bowel movement has been considered an important etiological factor,[3] causing the child to voluntarily or involuntarily withhold bowel movements.[4] Though constipation is mainly associated with symptoms in the gastrointestinal tract, it can also cause other somatic symptoms, induce specific behavioural problems and impose negative psychological effects.[5] Various therapies have been developed to manage childhood constipation, including non-pharmacological approaches and pharmacological interventions.[1] Treatment typically aims to remove existing faecal masses in the bowel or soften stool in the gastrointestinal tract.[6] Despite treatment efforts, a significant percentage of children (30%–52%) continue to experience constipation symptoms upon entering adulthood.[7]

The Rome Paediatric Diagnostic Questionnaire, RPDQ for short (Rome I, II, III, and IV) has been developed and modified over the years to diagnose Functional Gastrointestinal Disorders (FGIDs),[8] including FC, and can be administered to all ages.[9] According to diagnosis with the Rome IV criteria, FC is the most common disorder among FGIDs in children, ranging from 9% to 12%.[10,11] While numerous efforts have been made to report the global prevalence of FC among older children and adults,[12] no relevant study has been conducted on children living in Asia. Healthcare in Asia once heavily relied on traditional medicine. However, the Asian Economic Miracle led to significant progress in the healthcare sector. Increased wealth enabled governments to invest in health research and expand insurance coverage. Thus, more epidemiological data have been published, and these data further emphasised the need to understand paediatric health issues in Asia.

This systematic review and meta-analysis aimed to estimate the prevalence of constipation in children and adolescents in Asia and to identify the factors associated with constipation. In recent years, constipation with a non-organic origin has been redefined as 'functional constipation'.[12] As a result, we will continue to use the term "constipation" to encompass past literature that still refers to FC as such. These findings can be utilised to reduce the prevalence of constipation among children in Asia from an epidemiological perspective.

Methods

Search strategy and selection criteria

The systematic searching followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guideline. In this systematic review and meta-analysis, we conducted a search for cohort studies and cross-sectional studies in PubMed, Scopus, and

Cochrane that reported the prevalence of FC or constipation among children across Asia. We used medical literature terms such as "Colic," "Constipation," "Regurgitation," and "FGID," in combination with "toddler," "children," "infant," "junior," and "pediatrics," with an emphasis on "prevalence" or "incidence" and "risk" or "risk factor" (Table S1). The studies included in the search were published from the inception of the 3 databases up to October 12, 2022, and manual searching was continued until September 2, 2023. This analysis included studies that provided the prevalence value in the English abstract, and that recruited participants from clinics, the general population, or from a certain community.

To be eligible, study participants had to be children living in Asia and confirmed to have idiopathic constipation by caregivers, healthcare professionals, or a diagnostic tool. We included articles that labelled the condition as 'constipation' or 'functional constipation', including diagnosis with specific criteria (e.g. RPDQ, constipation defined by bowel movement frequency, stool consistency, or other criteria) or self-reported constipation. We excluded studies involving populations with organic causes of constipation, congenital defects, or gastrointestinal surgery, as these factors are associated with constipation occurrence.[6,13] The term 'constipation' will refer to constipation of non-organic origin.

Two authors independently screened titles, abstracts, and full texts of records retrieved from systematic database and manual searches. Potentially eligible articles underwent further assessment for final inclusion in the analysis.

Risk of bias were independently assessed by two of the authors using Hoy Risk-of-Bias tool for prevalence studies.[14] This tool consists of 10 items, each with a minimum score of 0 and a maximum score of 1 for assessing four bias domains, along with a summary risk assessment. The overall scores 0–4 denote low risk, 5–7 moderate, and 8–10 high bias. Disagreements regarding study inclusion were resolved through discussion and consensus with a third reviewer. Demographic information relevant to the individuals (authors and year, country, geographic region, referral source, study population, sex, mean age of participants) and information relevant to the prevalence of constipation (diagnosis method, constipation prevalence, and the associated factors) were manually collected during the data extraction phase.

Data analysis

Data were pooled using fixed-effects and random-effects models to estimate constipation prevalence. Duplicate data from two different papers analysing the same population at the same time were excluded. Sex of the individuals in studies were determined by the definition of each author. The time period of the studies was defined as the duration of data collection for each study. If the data collection period was unspecified, the publication year was used. When the data collection period could be divided into two groups, the longer duration was chosen. Population referral sources were classified as clinic-based if recruited from hospitals or clinics, and community-based if recruited from the community (e.g., schools, census). Urban and rural areas were defined according to the author's delineation of urban and rural settings. Country income (high, upper-middle, and lower-middle income categories) was based on the Gross Domestic Product-GDP data from the World Bank for the relevant time period in each country in every study. Age groups were defined as per WHO guidelines - infants (<1 year), children (1–9 years), adolescents (10–18 years)).[15] Abnormal or normal body weight was categorised using body mass index (BMI) cut off points defined by the WHO. If BMI was not provided, the author's definition of abnormal body weight was used. Sedentary behaviour was primarily based on the frequency of physical activity during a specified period, as defined by the author. Poor sleep was determined by the nightly duration of sleep or according to the author's specified criteria. Compromised mental health was defined by exposure to stress-inducing events in children; in the absence of such information, events related to compromised mental health (e.g., depression) were considered in the analyses, irrespective of the data collection method. Adequacy of water intake was defined based on the recommendations of the Children's Hospital of Orange County, rounded to the nearest value. Fibre intake (gram/day) was assessed through a 3-day food records, and then inputted in a computerised database for calculation,[16] or manually calculated by a nutritionist.[17]

Data pooling and effect size calculation were conducted using the "*metaprop*" function from the "*metafor*" package in R, version 4.1.1 (The R Foundation for Statistical Computing). This function offers methods for meta-analysis of single proportions to calculate an overall proportion. To address high heterogeneity and publication bias, meta-regression analysis was performed to examine the moderating factors. To assess the robustness of the results, we conducted a sensitivity analysis by utilising the *"dmetar"* package, which includes a function called *"find.outliers"* for outlier removal. After raw data analysis, outliers were identified and removed; outliers were defined as studies whose CI did not overlap with the CI of the pooled effect. The *"find.outliers"* function was then used to detect and remove these outliers. Subsequently, the remaining data were recalculated to obtain the new prevalence value and tested for changes using the Chi-square test. All statistical tests used the *p*-value of $p < 0.05$ being statistically significant.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. All the authors have access to the dataset and had the final responsibility for the decision to submit for publication.

Results

In total, 4410 studies were identified using similar search strategies across multiple databases, supplemented by the discovery of 36 additional studies through manual searching. Following the screening process, 50 studies that met the criteria were included (Fig. 1). Among these studies, only 47 studies were included in the pooled prevalence analysis to prevent duplications. Some studies were used to complete missing data on moderating factors (Table 1).[31,34,39]

The risk of bias assessment identified five studies with a moderate risk, and all were incorporated into the final analysis. None of the studies were categorised as high risk (Fig. 2 and Table S2). Quality assessment could not be performed for Zhang et al.[28] and Li et al.[63] as their full texts were not accessible. As we obtained prevalence values from these studies, they were included in the final analysis. The agreement between investigators for risk of bias assessment results were rated as 'substantial agreement' ($\kappa = 0.72$).

Among the 311,660 children, the pooled prevalence of constipation was 12.0% (95% CI 9.3–14.6%, $I^2 = 99.8$) (Fig. 3). Due to a high heterogeneity and publication bias by Egger's test (*bias* = 14.9 [SE: 3.8], $p = 0.0003$), meta-regression analysis was applied. The analysis of various characteristics in the patients revealed that diagnosis method, population source, age, and compromised mental health were identified as significant factors influencing the constipation rates. Classification according to geographic region showed a marginal difference between the prevalence of South Asia and East Asia, with a constipation rate of 6.9% (95% CI 3.0–10.8%) and 14.1% (95% CI 10.1–18.1%), respectively (Figure S5A and B and Table 2). Grouping according to abnormal body weight based on BMI, as well as mean difference in BMI, did not reveal any significant difference in the prevalence of constipation (Figures S6 and S7 and Table 2).

Diagnosis criteria

The prevalence of constipation in three community-based studies using constipation scales was 8.0% (95% CI 0.4–15.5%).[23,25,60] Among the eight studies conducted in the community, the pooled prevalence of constipation, defined as having less than three defecations per week,[20,29,35,44,57] defecating less than once every two days,[38,53] or less than once a day,[19] was 9.5% (95% CI 5.5–13.5%). Three community-based studies that applied Rome II revealed 27.4% (95% CI 24.8–30.1%) suffered from constipation (Figure S1 and Fig. 4).[17,22,25] Notably, the prevalence of constipation was 11.8% (95% CI 8.7–14.8%) with Rome-based criteria and 12.4% (95% CI 7.1–17.6%) with non-Rome-based criteria (Figure S2). Upon closer examination of the different versions of studies using the Rome criteria, we found that the prevalence of constipation was not significantly different, as shown in the two studies comparing the diagnosis of patients using Rome II and Rome III (Figure S3).[30,37] Of the 20 studies that used the Rome III, the constipation rate was much lower (12.3%,

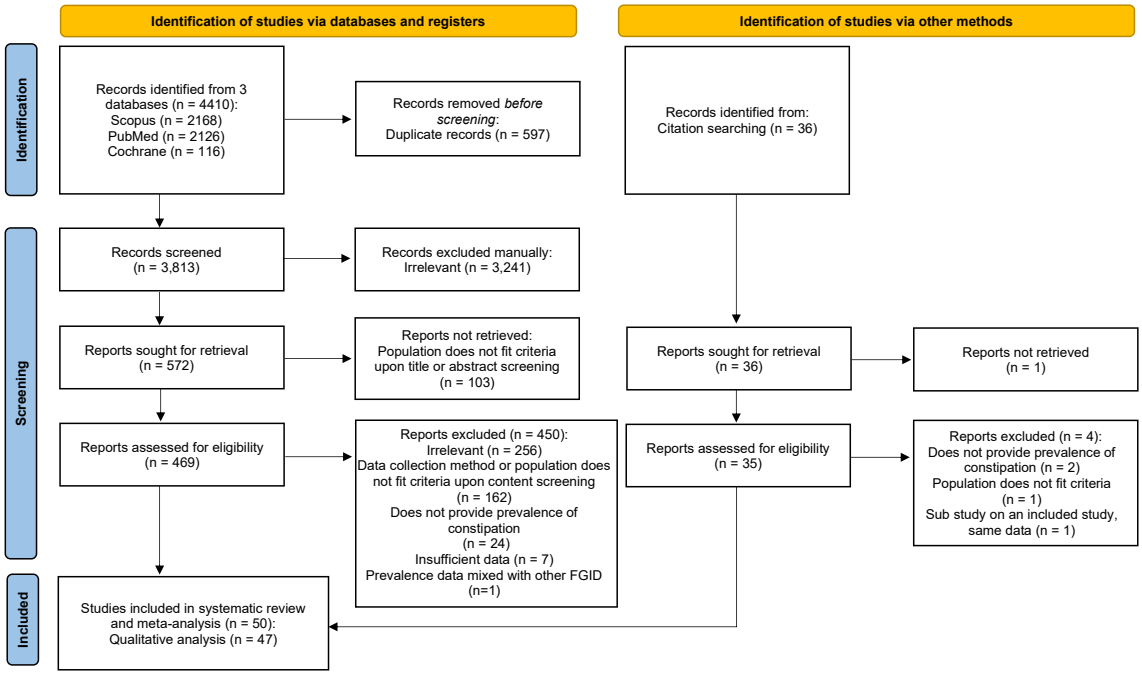

***Fig. 1:* PRISMA flowchart summarizing the study selection process.** *n, number of the included studies; FGID, Functional Gastrointestinal Disorder.*

No	Author, year	Country	Geographic region	Referral source	Study population (n)	Sex (Male %)	Age range (Mean ± SD)	Diagnosis method	Constipation prevalence (%)	Related factors to constipation
1	Kalo et al., 1996[18]	Saudi Arabia	West Asia	Community-Based	640	50%	6–16 years (9.9 ± 2.3 years)	Self-reported constipation	9.1%	- NA
2	Uguralp et al., 2003[19]	Turkey	West Asia	Community-Based	1377	51%	5–9 years (7.4 ± 0.9 years)	Defecation frequency (<1 time/d) OR passage of hard, dry, large or difficult to pass stools for ≥2 wks	12.4%	- NA
3	Kajiwara et al., 2004[20]	Japan	East Asia	Community-Based	5282	51%	7–12 years (9.3 ± 1.7 years)	Bowel movement (<3 times/wk)	18.5%	- Daytime urinary incontinence
4	Ip et al., 2005[16]	Hong Kong	East Asia	Community-Based	561	68%	3–5 years (4.12 ± 0.89 years)	Passage of hard, dry, large or difficult to pass stools for ≥2 wks OR defecation frequency (≤2 times/wk)	29.6%	- Family history of constipation
5	Inan et al., 2007[21]	Turkey	West Asia	Community-Based	1689	49%	7–12 years (9.23 ± 1.2 years)	NASPGHAN Criteria	7.2% –7.3%/boys –7.2%/girls	- Family history of constipation - Sports-related activity
6	Zhou et al., 2007[22]	China	East Asia	Community-Based	51,956	51%	10–18 years (16.5 ± 1.3 years)	Rome II	25.9%	- Females
7	Lee et al., 2008[17]	Hong Kong	East Asia	Community-Based	368	–	3–5 years (4.1 ± 0.9 years)	Rome II	28.8%	- Lower fibre intake - Total fluid intake
8	Devanarayana et al., 2008[23]	Sri Lanka	South Asia	Community-Based	734	47%	5–15 years (10.5 ± 2.7 years)	Questionnaire for Recurrent Abdominal Pain	3.9%	- NA
9	Liu et al., 2009[24]	China	East Asia	Community-Based	5030	50%	0–24 months	Defecation frequency (<3 times/wk) OR history of difficulty passing stool for ≥2 wks	13.7%	- Age
10	Chan et al., 2010[25]	Hong Kong	East Asia	Community-Based	383	21%	8–10 years	Constipation Assessment Scale (CAS)	7.3%	- Aged <10 years old - Daily fluid intake >3–4 cups - Fruit and vegetables intake
11	Chung et al., 2010[26]	South Korea	East Asia	Community-Based	16,516	50%	5–13 years	Defecation frequency (<3 times/wk) OR Bristol Stool Form Scale (Type 1 or 2) (evaluation done by caregivers)	6.7% 11.8%	- Double-income family - Low level of education
12	Devanarayana et al., 2010[27]	Sri Lanka	South Asia	Community-Based	2699	51%	10–16 years (12.7 ± 1.7 years)	Rome III	15.4%	- Stressful event exposure
13	Zhang et al., 2010[28]	China	East Asia	Community-Based	19,286	56%	4–14 years	Rome III	4.7%	- Urban areas
14	Chien et al., 2011[29]	Taiwan	East Asia	Community-Based	14,626 (grade 7–12)	54%	12–17 years	Defecation frequency (<3 times/wk)	9.3%	- Females - Body weight - Sedentary activity - Fluid intake
15	Devanarayana et al., 2011[30]	Sri Lanka	South Asia	Community-Based	427	50%	12–16 years (14.4 ± 1.3 years)	Rome III	4.2%	- NA
16	Rajindrajith et al., 2011[31]	Sri Lanka	South Asia	Community-Based	Phase I: 2770 Phase II: 2164	Phase I (50.8%) Phase II (55%)	10–16 years Phase I:13.2 ± 1.7 years Phase II: 13.5 ± 1.7 years	Rome III	15.0% (Phase I) 10.8% (Phase II)	- Eastern province post-war
17	Wu et al., 2011[32]	Taiwan	East Asia	Community-Based	2375	54%	7–12 years (9.3 ± 2.2 years)	Iowa Criteria	32.3%	- Females - Age
18	Zhou et al., 2011[33]	China	East Asia	Community-Based	3671	54%	12–18 years	Rome III	24.9%	- Males - Depression
19	Zhou et al., 2012[34]	China	East Asia	Community-Based	1362	51%	12–18 years[a]	Rome III	20.2%	- Poor sleep
20	Rajindrajith et al., 2012[b,35]	Sri Lanka	South Asia	Community-Based	2694	51%	10–16 years (13.2 ± 1.7 years)	Rome III	15.4%	- Family history of constipation - War-affected area - Urban school
21	Tam et al., 2012[36]	Hong Kong	East Asia	Community-Based	2318	51%	6–15 years (9 ± 1.9 years)	Rome III	12.2%	- Children aged 6–7 - Inadequate sleep (night time sleep <7 h)

(Table 1 continues on next page)

No	Author, year	Country	Geographic region	Referral source	Study population (n)	Sex (Male %)	Age range (Mean ± SD)	Diagnosis method	Constipation prevalence (%)	Related factors to constipation
(Continued from previous page)										
22	Osatakul et al., 2013[37]	Thailand	Southeast Asia	Clinic-Based	3010	51%	4 months-5 years	Rome III	1.9% (Rome II) 1.6% (Rome III)	- NA
23	Huang et al., 2014[38]	Hong Kong	East Asia	Community-Based	32,371	44%	11–18 years	Bowel movement (<once/2 d)	15.6%	- Insufficient exercise - Sedentary behaviour
24	Rajindrajith et al., 2014[39]	Sri Lanka	South Asia	Community-Based	1792	54%	13–18 years (14.4 ± 1.3 years)	Rome III	7.7%	- Sexual exposure - Emotional exposure - Physical abuse
25	Bhatia et al., 2016[40]	India	South Asia	Community-Based	1115	–	10–17 years 12.8 ± 1.9 years (male); 14.6 ± 2.1 years (female)	Rome III	0.5%	- Males
26	Park et al., 2016[41]	South Korea	East Asia	Community-Based	212	53%	25–84 months (54.5 ± 15.1 months)	Rome III	8.5%	- Maternal constipation - Outdoor activities - Water intake ≤500 mL
27	Shau et al., 2016[42]	Taiwan	East Asia	Community-Based	2034	52%	12–19 years	Rome III	17.9%	- NA
28	AlGhamdi et al., 2017[43]	Saudi Arabia	West Asia	Clinic-Based	80	48%	1 month-5 years (20 ± 17.7 months)	Rome III	22.5%	- NA
29	Asakura et al., 2017[44]	Japan	East Asia	Community-Based	5309	53%	5–6 years (2349 ± 105 days)	Bowel movement (≤3 times/wk)	8.4%	- Dietary fibre intake - Physical activity
30	Rajindrajith et al., 2017[c,45]	Sri Lanka	South Asia	Community-Based	1792	54%	13–17 years	Rome III	7.7%	- Sexual trauma exposure - Emotional exposure - Physical abuse
31	Froon-Torenstra et al., 2018[46]	Palestine	West Asia	Clinic-Based	862	50%	7–12 months	Rome III	12.0%	- Trauma exposure
32	Oswari et al., 2018[47]	Indonesia	Southeast Asia	Community-Based	1796	41%	10–16 years (13.5 ± 0.9 years)	Rome III	18.3%	- Stressful life events (father's alcoholism; severe illness of a close family member, hospitalisation, being bullied at school, loss of a parent's job)
33	Yoshida et al., 2018[48]	Japan	East Asia	Community-Based	83,019	51%	1 year	Defecation frequency (≤3 times/wk)	1.4%	- NA
34	Yuwanita et al., 2018[49]	Indonesia	Southeast Asia	Community-Based	150	42%	12–17 years (14.7 years)	Rome III	32.6%	- Obesity
35	Ji et al., 2018[50]	China	East Asia	Clinic-Based	20,932	53%	0 month-5 years	Rome IV	8.4%	- Age
36	Çaglar et al., 2019[51]	Turkey	West Asia	Community-Based	203	53%	0–12 months (4.8 months)	Rome III + Bristol Stool Form Scale (evaluation done by caregivers)	17.7%	- Constipated mothers
37	Walter et al., 2019[52]	Sri Lanka	South Asia	Clinic-Based	1113	50%	6.5–47.4 months (20.7 ± 11.2 months)	Rome III	8.0%	- Urban areas - Violent exposure
38	Yamada et al., 2019[53]	Japan	East Asia	Community-Based	7998	52%	9–10 years (9.76 ± 0.29 years)	Bowel movement (<1 times/2 d)	3.9%	- Female - Physical inactivity - Fruit and vegetable intake - Being overweight
39	Okuda et al., 2019[54]	Japan	East Asia	Community-Based	2194	52%	10–14 years 10.6 ± 0.3 years (5th grader) 13.6 ± 0.3 years (8th grader)	Rome III	6.6%	- Fibre, fruit, and vegetable intake
40	Altamimi et al., 2020[55]	Jordan	West Asia	Community-Based	1587	53%	4–18 years (10.2 years)	Rome III	16.0%	- Age

(Table 1 continues on next page)

No	Author, year	Country	Geographic region	Referral source	Study population (n)	Sex (Male %)	Age range (Mean ± SD)	Diagnosis method	Constipation prevalence (%)	Related factors to constipation
(Continued from previous page)										
41	Beser et al., 2021[56]	Turkey	West Asia	Clinic-Based	2383	52%	1–12 months (4.9 ± 3.3 months)	Rome IV	4.0%	- NA
42	Chew et al., 2021[57]	Malaysia	Southeast Asia	Clinic-Based	534	54%	1–12 months (6.8 ± 3.4 months)	Rome IV	1.1%	- NA
43	Huang et al., 2021[58]	China	East Asia	Clinic-Based	2604	51%	0–48 months (14 ± 14.1 months)	Rome IV	27.3%	- Age 1–4 years old
44	Khayat et al., 2021[59]	Saudi Arabia	West Asia	Community-Based	317	49%	3–18 years	Rome IV	4.7%	- NA
45	Kim et al., 2021[60]	South Korea	East Asia	Community-Based	819	53%	16–18 years	Bristol Stool Form Scale (evaluation done by individuals)	15.0%	- Depression or anxiety
46	Fang et al., 2021[61]	China	East Asia	Community-Based	294	50%	7–11 years (8.8 years)	Self-reported constipation	39.1%	- Age - Males - Water intake ≤1000 mL
47	Chia et al., 2022[62]	Vietnam	Southeast Asia	Clinic-Based	1511	55%	0–48 months 3.17 ± 1.73 months (0–6 months) 24.40 ± 12.99 months (6.1–48 months)	Rome IV	4.7%	- Age 7–48 months old - Male - No sibling
48	Li et al., 2022[63]	China	East Asia	Community-Based	2615	51%	0–4 years	Rome IV	10.7%	- Age - Sex - Parental history of childhood constipation - Ea ting vegetables <3/wk
49	Siajunboriboon et al., 2022[64]	Thailand	Southeast Asia	Community-Based	1700	–	14–18 years (16.1 ± 0.9 years)	Rome IV	8.1%	- NA
50	Huang et al., 2022[65]	China	East Asia	Clinic-Based	1006	–	1–12 months	Rome IV	3.1%	- Younger father age - Parents history of FGIDs - Mother history of FGIDs

SD, standard deviation. Abbreviation: d, day; wk/wks, week/weeks; FGIDs, Functional Gastrointestinal Disorders. Used information from Zhou et al., 2012 to complete missing data of related factors of FC as it is the substudy of Zhou et al., 2011. [a]Age range was based on the education system in China, the author stated the age range of the participants was Junior High School students and Senior High School students. [b]Used information from Rajindrajith et al., 2012 to complete missing data of related factors of FC as it is the substudy of Devanarayana et al., 2010. [c]Used information from Rajindrajith et al., 2014, Sri Lanka to complete missing data; study is the primary analysis of the study used for this study.

Table 1: **Characteristics of the included studies (n = 50).**

95% CI 9.0–15.7%). Nine studies reported the constipation prevalence according to the Rome IV,[50,56–59,62–65] with a prevalence of 5.2% (95% CI 3.2–7.1%) (Table 3).

Population referral source

The prevalence of constipation for the community-based study population was 13.5%, which was significantly higher than the constipation prevalence of the clinic-based population at 6.0% (Figure S4 and Table 3).

Age

The infants had the lowest constipation prevalence at 6.2%, whereas children and adolescents had significantly higher prevalence rates at 13.4% and 14.0%, respectively (Table 3).

Fibre intake

Children with constipation consumed lower amounts of fibre compared to those without (mean difference = –0.41 g/day, 95% CI –0.56 to –0.26 g/day, $I^2 = 0\%$, $p < 0.0001$) without the existence of heterogeneity. However, these findings were based on only two studies with a small sample size (Fig. 5).[16,17]

Sensitivity analysis

The use of the outlier removal method revealed a significant difference in the overall pooled prevalence of constipation. Individuals diagnosed based on their defecation frequency or adherence to Rome IV criteria, with a clinic-based population source, exhibited a notable shift in the prevalence of constipation during sensitivity analyses. Both children who are in mentally

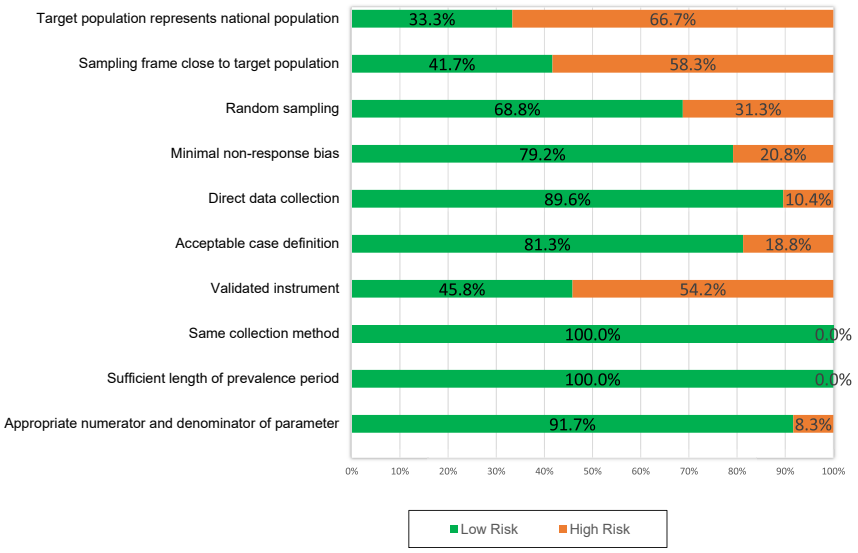

Fig. 2: **Risk of bias plot**. A total of 48 studies were assessed for risk of bias using the Risk of Bias Assessment Checklist for Prevalence Studies, adapted from Hoy et al. For every question, a score of 0 was defined as 'low risk', whereas score of 1 was defined as 'high risk'.

and non-mentally compromised groups, as well as all age groups, experienced a reduction in prevalence rates following the removal of outliers (Table 4).

The present study included a greater number of studies and participants compared to previous reviews and meta-analyses. Using the Chi-squared test, our prevalence of constipation was significantly higher than that reported in previous studies, except for the finding for constipation prevalence in China (12.0% vs. 18.8%) (Table 5).

Discussion

For this systematic review and meta-analysis, we gathered the most extensive and up-to-date prevalence data regarding constipation among 50 paediatric studies conducted in 15 countries and regions across Asia. The prevalence of constipation among children in Asia was 12.0%, with rates ranging from less than 1% to more than 39%. When examining studies applying the Rome II criteria, the constipation prevalence was higher at 27.4%, in contrast to the 5.2% prevalence observed in studies utilising the Rome IV. Studies with community-based population sources had a higher prevalence rate of 13.5%, compared to clinic-based population prevalence at 6.0%. What's even more crucial, an association was discovered between increased constipation prevalence among children in Asia and factors such as age, compromised mental health, and lower dietary fibre intake. However, further research is needed to explore the potential of dietary fibre in mitigating constipation in children, given the limited data available for analysis in this study.

The constipation prevalence of among children in Asia fell within the range of worldwide constipation prevalence, which varied from 0.7% to 29.6%.[10–12] A systematic review published in 2011 by Mugie et al.[66] revealed that children and adults residing in Asian countries had a lower constipation rate (median 10.8%), compared with those in North America (16%), Europe (19.2%), and Oceania (19.7%); this study utilised Rome III, Bristol scale, and defecation frequency as the diagnosis method. The authors suggested that diagnostic methods and regional disparities, including cultural, dietary, genetic, environmental, socioeconomic, and healthcare systems, were factors that contributed to the observed variation. This does not align with our findings regarding geographical location, which did not show significant association with constipation. The present study revealed a notably higher constipation rate among children in Asia compared to the global prevalence of constipation (12.0% vs. 9.5%) and the Asian prevalence (12.0% vs. 6.3%) reported by Koppen et al.,[67] which utilised Rome III/IV criteria. Despite the focus on paediatric populations, the lower prevalence rates in the mentioned study were likely caused by the limited dataset, consisting of 16 studies in the Asian population. Notably, our constipation rate was lower than that of Chinese children (12.0% vs. 18.8%), as reported by Chu et al.[68] This difference could be attributed to the diverse diagnostic methods employed in our research, which encompassed a broader population representing various races, ethnicities, and cultures.

While the broader inclusion criteria of studies enable a more extensive analysis, the diversity in the diagnosis

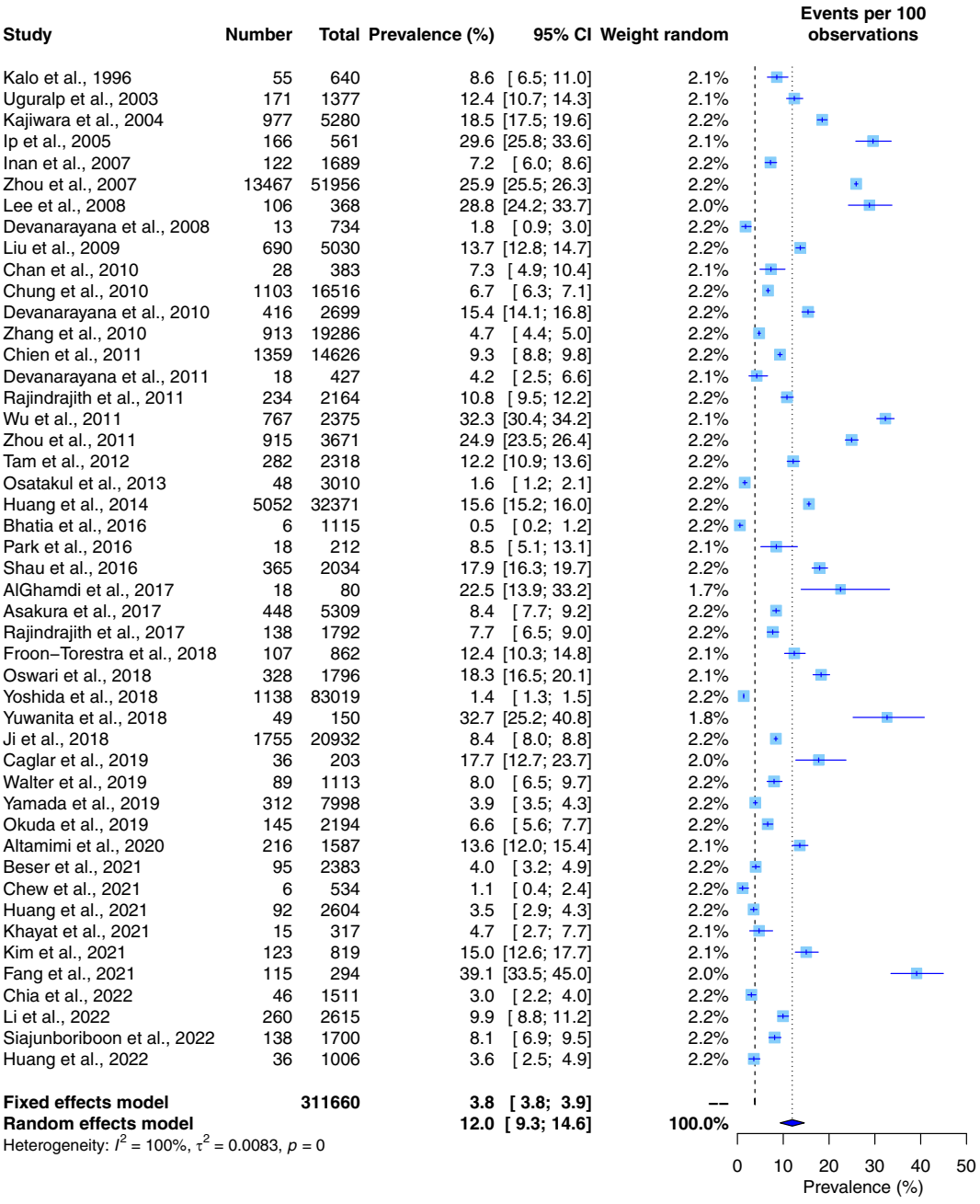

***Fig. 3*: Forest plot of the prevalence of constipation among children in 15 Asian countries and regions.** Horizontal bar at each study indicates the 95% confidence interval. *CI, confidence interval.*

criteria across different studies may contribute to significant heterogeneity in the constipation prevalence. Diagnoses relying on factors like defecation frequency or stool consistency might be less stringent compared to those based on criteria like the Rome criteria, potentially resulting in a higher prevalence rate. However, no significant difference in the constipation rate was observed between Rome-based and non-Rome-based criteria (11.8% vs. 12.4%, $p = 0.85$). Therefore, it is essential to interpret these rates in accordance with the diagnostic methods employed, as it serves as a significant moderating factor. We identified that studies using Rome II criteria reported the highest constipation rate, reaching 27.4% in children from three community-based studies in East Asia.[17,22,25] Upon analysing 20 studies using Rome III criteria, the constipation rate was 12.3%; these

Characteristics/Related events	k	n	Estimate	SE	*p*-value
Time period					
Up to 2000	2	8638	Ref		
2000–2005	7	63,972	0.119	0.065	0.34
2006–2010	11	100,124	0.063	0.070	0.37
2011–2015	9	15,522	0.049	0.072	0.50
2016–2020	14	36,634	0.048	0.069	0.49
2020 ~	4	86,770	0.015	0.079	0.85
Diagnosis method					
Constipation scale	3	1936		Ref	
Defecation frequency	8	166,496	0.015	0.050	0.76
Rome II	3	52,885	0.201	0.061	0.0012*
Rome III	20	51,743	0.043	0.046	0.34
Rome IV	9	33,602	−0.028	0.049	0.570
Others	4	4998	0.133	0.057	0.019*
Population referral source					
Community-Based	37	277,625	0.070	0.032	0.027*
Geographic region					
East Asia	25	283,777	Ref		
West Asia	9	9138	−0.029	0.036	0.41
South Asia	7	10,044	−0.072	0.039	0.065
Southeast Asia	6	8701	−0.039	0.042	0.35
Region (Urban)	3	3297	0.006	0.022	0.77
Country income classification					
High income	18	176,780	Ref		
Upper-middle income	15	60,065	−0.047	0.032	0.14
Lower-middle income	14	74,815	−0.006	0.033	0.85
Family characteristics					
Have siblings	8	10,134	−0.071	0.134	0.55
Birth order					
Youngest	3	1787	−0.022	0.063	0.72
Oldest	4	2643	−0.068	0.061	0.26
Mother is employed	6	14,824	−0.014	0.1675	0.93
Mother's highest education degree: Primary school and below	2	1088	−0.017	0.107	0.87
Father is employed	4	6529	0.031	0.245	0.90
Has a family history of constipation	4	5156	0.151	0.105	0.15
Income meets need	5	22,688	−0.017	0.070	0.81
Children characteristics					
Age (years)	29	103,159	0.004	0.004	0.30
Infants (<1 yrs)	12	25,980	Ref		
Children (1–9 yrs)	22	144,165	0.070	0.033	0.034*
Adolescent (10–19 yrs)	23	141,277	0.077	0.033	0.019*
Male	26	77,278	−0.015	0.028	0.60
BMI (kg/m^2)[a]	4	6039	0.024	0.017	0.16
Abnormal body weight	4	4362	−0.056	0.125	0.66
Being sedentary	6	17,558	0.052	0.06	0.39
Poor sleep	3	149	−0.026	0.068	0.70
Compromised mental health	6	4186	0.106	0.041	0.010*
History of sexual abuse	3	2166	−0.079	0.288	0.79
Unwilling to use school toilet	3	4346	0.065	0.042	0.12
Inadequate liquid intake	5	10,571	0.069	0.088	0.43
Energy intake (kcal)[a]	3	6049	1.186	23.691	0.96

Abbreviation: yrs, years old; kcal, kilocalorie(s). *p-value <0.05. k, number of the included studies. n, number of participants. SE, standard error. [a]Adjusted by age.

Table 2: **Meta-regression analysis on potentially moderating factors.**

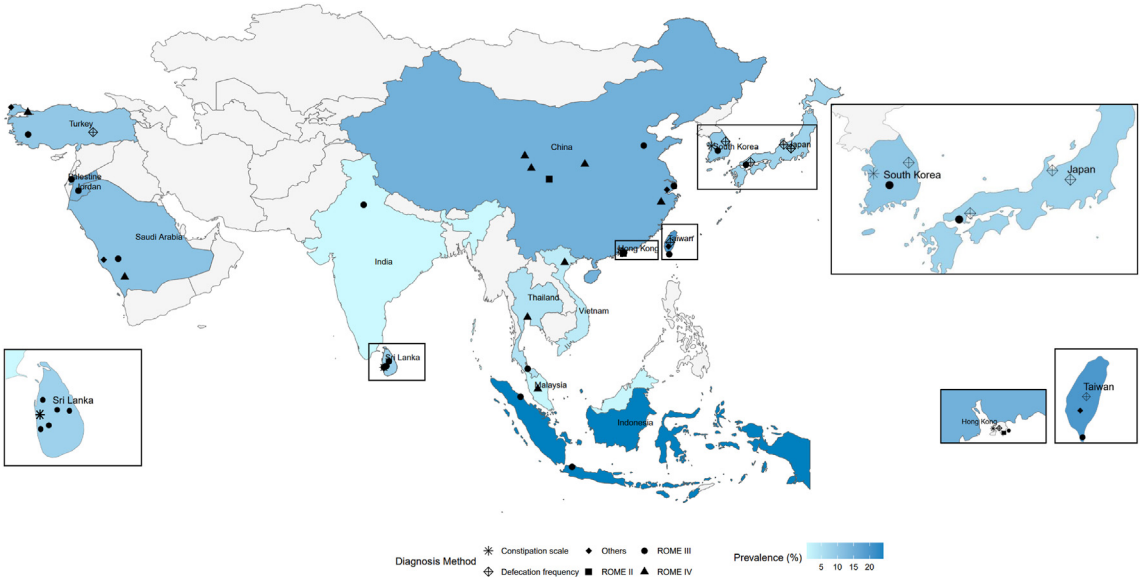

Fig. 4: **The prevalence and the diagnosis methods of constipation across 15 different countries regions.** Color gradient depicts different prevalence of constipation in each country; the darker the color, the higher the prevalence of constipation. Different markers represent the different diagnosis methods used where the study was done. If study was done in two cities, the marker is placed in between the two cities, if study was done in 3 or more cities, marker is placed in the center of the country.

studies included data obtained from 16 community-based studies,[24,27,28,30,33,35,36,40–42,45,47,49,51,54,55] and four clinical studies.[37,43,46,52] Meanwhile, the constipation rate diagnosed with the Rome IV was the lowest, at 4.4%, based on data analysed from five clinic-based studies,[50,56–58,62] and four community-based studies.[59,61,63,64] We revealed inconsistent results of constipation rates between Rome II and III. Although the only change from Rome II to Rome III was a shortened duration of symptoms (decreased from 3 to 2 months),[9] this discrepancy can be explained by Rome II being appropriate for the diagnosis of constipation in young children,[37] whereas Rome III were more suitable for school-age children and adolescents.[30] Indeed, age

Characteristics/Related events	k	n	Constipation prevalence % (95% CI)	I^2	*p*-value[a]
Diagnosis method/criteria					
Constipation scale	3	1936	8.0% (0.4–15.5%)	98.1%*	Ref
Defecation frequency	8	166,496	9.5% (5.5–13.5%)	99.9%*	0.025
Rome II	3	52,885	27.4% (24.8–30.1%)	60.3%	<0.0001
Rome III	20	51,743	12.3% (9.0–15.7%)	99.3%*	<0.0001
Rome IV	9	33,602	5.2% (3.2–7.1%)	98.3%*	<0.0001
Others	4	4998	21.7% (5.8%–37.6%)	99.5%*	<0.0001
Population Referral Source					
Community-Based	37	277,625	13.5% (10.4–16.5%)	99.9%*	Ref
Clinic-Based	10	34,035	6.0% (3.0%–8.9%)	98.8%*	<0.0001
Age groups					
Infants (<1 yrs)	12	25,980	6.2% (3.2–9.2%)	99.4%*	Ref
Children (1–9 yrs)	22	144,165	13.4% (8.9–17.9%)	99.5%*	<0.0001
Adolescent (10–19 yrs)	23	141,277	14.0% (10.3%–17.8%)	99.8%*	<0.0001
Compromised mental health					
Yes	6	4186	22.6% (14.6–30.5%)	94.7%*	Ref
No	7	36,773	11.9% (8.3–15.5%)	98.2%*	<0.0001

k, number of the included studies. n, number of participants. CI, confidence interval. *p-value <0.05. [a]N-1 Chi-squared test.

Table 3: **Pooled prevalence of FC stratified by moderating factors.**

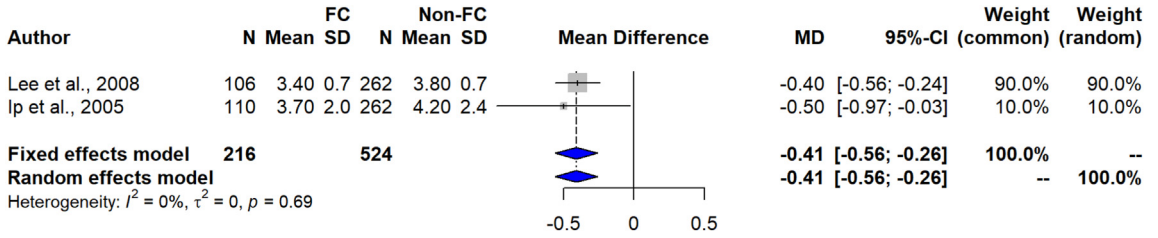

Fig. 5: **Forest plot of fiber intake per day (g/day) between children with and without constipation.** *FC, Functional Constipation; SD, standard deviation; CI, confidence interval.*

was identified as a significant risk factor for constipation among Chinese children according to a study done by Chu et al.,[68] and our study yielded similar results. In 2016, Rome IV replaced Rome III for the early diagnosis of FC in paediatric populations.[69] Rome IV introduced two separate diagnostic criteria for children who had or had not undergone toilet-training, and shortened the time frame for diagnosing FC to within one month. However, the prevalence of constipation diagnosed by Rome III was significantly higher than that diagnosed by Rome IV in this meta-analysis. This contrasts with the study conducted by Russo M et al.,[70] in which no difference in FC prevalence was found using Rome III and IV criteria among Italian children aged 77.4 ± 59.5 months (18.2% vs. 17.3%; p = 0.83), without information available regarding other diagnostic methods. Additionally, the source of study population was found to be a significant factor influencing the rate of constipation. The prevalence observed in community-based studies (13.5%) was higher than that in clinic-based studies (6.0%). This difference may be attributed to variations in the screening tools employed and the individuals responsible for the diagnosis, potentially impacting accuracy. This finding underscores the importance of distinguishing between diagnoses based on Rome III and Rome IV. Out of the nine studies in the Rome IV subgroup analysis, only three originated from community sources.[17,59,64] Obtaining the population from clinics could lead to a more precise diagnosis of constipation. Additionally, infants make up more than half of the population in the Rome IV analysis. As age is one of the moderating factors in constipation prevalence, a lower pooled prevalence for the Rome IV can be anticipated. Because early identification of constipation could enhance outcomes for children affected and prevent recurrence in adulthood, additional research should explore the effective utilisation of the latest Rome IV in children in Asia, both in community and clinical settings.

Understanding factors that affect the constipation prevalence discloses the aetiology of constipation among children in Asia. Geographic region did not significantly affect the constipation prevalence, but individuals living in South Asia had a marginally lower constipation prevalence when compared to East Asia (p = 0.065). The prevalence findings across different parts of Asia are

Factors	Main meta-analysis		Sensitivity analysis		
	Prevalence, 95% CI	I^2	Prevalence, 95% CI	I^2	p-value[a]
Total pooled prevalence	12.0% (9.3–14.6%)	99.8%	11.5% (10.1–12.9%)	92.2%	0.0005*
Constipation scale	8.0% (0.4–15.5%)	98.1%	8.0% (0.4–15.5%)	98.1%	1.00
Defecation frequency	9.5% (5.5–13.5%)	99.9%	9.1% (6.9–11.4%)	97.0%	0.016*
Rome II	27.4% (24.8–30.1%)	60.3%	27.4% (24.8–30.1%)	60.3%	1.00
Rome III	12.3% (9.0–15.7%)	99.3%	12.6% (10.8–14.5%)	88.1%	0.31
Rome IV	5.2% (3.2–7.1%)	98.3%	4.5% (3.0–5.9%)	89.1%	0.0059*
Others	21.7% (5.8%–37.6%)	99.5%	21.7% (5.8%–37.6%)	99.5%	1.00
Community-Based	13.5% (10.4–16.5%)	99.9%	13.5% (11.9%–15.2%)	94.0%	1.00
Clinic-Based	6.0% (3.0%–8.9%)	98.8%	5.1% (3.1%–7.0%)	98.3%	<0.0001*
Infants (<1 yrs)	6.2% (3.2–9.2%)	99.4%	5.1% (3.4%–6.7%)	96.0%	<0.0001*
Children (1–10 yrs)	13.4% (8.9–17.9%)	99.5%	10.3% (8.9%–11.7%)	84.7%	<0.0001*
Adolescent (10–19 yrs)	14.0% (10.3%–17.8%)	99.8%	15.5% (13.4%–17.6%)	90.6%	<0.0001*
Compromised mental health	22.6% (14.6–30.5%)	94.7%*	16.0% (14.8–17.3%)	65.0%	<0.0001*
Non-compromised mental health	11.9% (8.3–15.5%)	98.2%*	13.5% (9.9–17.4%)	96.4%	<0.0001*

CI, confidence interval. I^2, heterogeneity. Abbreviation: yrs, years old. *p-value <0.05. [a]Comparison of constipation prevalence (%) before vs. after removing outliers.

Table 4: **Sensitivity analysis based on the significant moderating factors.**

Studies	Diagnosed methods	General population			Asian population		
		k	n	Prevalence, 95% CI	k	n	Prevalence, 95% CI
Van Den Berg et al. (2006)[62]	Defecation frequency<3/wk Rome II	18	34,008	8.9 (5.3–17.4)[a]	2	5843	18.5–29.0%[b]
Mugie et al. (2011)[63]	Bristol scale/BM per wk Rome II Rome III	19	82,275	12% (0.7–29.6%)[a]	6	24,984	10.8% (1.4–32.9%)[c]
Chu et al. (2014)[64]	BM	–	–	–	14	90,091	18.8%[c]
Koppen et al. (2018)[65]	Rome III Rome IV	33	65,147	9.5% (7.5–12.1%)	16	49,148	6.3% (4.0–9.6%)[c]
The present study	Self-reported Constipation scale Defecation frequency Rome II Rome III Rome IV	–	–	–	47	311,660	12.0% (9.3–14.6%)

Abbreviation: wk, week; BM, bowel movement. k, number of the included studies. n, number of participants. CI, confidence interval. [a]Median and interquatile. [b]No data of pooled prevalence. [c]Significant difference in constipation prevalence between our finding and the previous study, as indicated by the Chi-squared test (*p*-value < 0.05).

Table 5: **Comparison with previous meta-analyses on prevalence of constipation in children.**

limited, indicating future studies should delve deeper into this disparity.

As mentioned, age was identified as a risk factor for constipation among Chinese children, with a higher prevalence observed among children aged greater than 6 years.[68] This supports our finding of children and adolescents having higher prevalence rates compared to infants. Interestingly, no significant effects of sex on constipation were found among Asian children. This discovery aligns with the conclusions drawn in a systematic review conducted by Van den Berg et al.,[71] which included children from various parts of the world, and the study by Chu et al.[68] involving Chinese children. In the adult-based study, by contrast, it was observed that females had a higher constipation prevalence. This phenomenon was attributed to differences in sex hormones and colonic transit rates.[66] However, in healthy children, there were no notable impacts of sex and age on colonic transit time. Regarding age groups, Kim et al.[60] discovered that among the three age groups analysed, adolescents exhibited the highest prevalence of constipation, potentially attributed to heightened stress in Korean high school students. Meanwhile, it appears that sex may not significantly influence the constipation prevalence in children in Asia. Having said that, additional research should investigate colonic transit time and its association with constipation to better understand the pathophysiology of constipation in children in Asia in different age groups.

Mounting evidence indicated a potential link between obesity and constipation explained by disturbances in neural centres, imbalances in the intestinal flora, and impaired intestinal mucosal permeability.[72] Recent study showed that BMI was inversely related to constipation.[73] This signifies that abnormal body weight in both ends may be related to the constipation prevalence. However, we did not find a significant association between BMI and abnormal weight in relation to constipation, although children with abnormal body weight had a higher constipation prevalence than those without (18.4% vs. 12.9%). This finding contrasts with a previous report in adulthood,[74] and a recent meta-analysis[75] of nine studies (including one study in Asia[49]) explored overweight/obesity was a risk factor for constipation in children residing in developed countries, but this effect was not observed in developing countries.

Sedentary activity was considered a contributing factor to alterations in defecation patterns, heightened propulsive large intestine movements, and hormonal shifts.[66] However, we did not unveil a significant relationship between constipation and sedentary activity, based on seven included studies,[21,29,38,41,44,53,61] possibly due to the existence of heterogeneity.

Recent studies have linked sleep disorders with FGID, but most of them were conducted in adults.[76] A meta-analysis done in adults with constipation showed that poor sleep quality increased the constipation prevalence,[7] but we found sleep quality was not related with constipation in children. The discrepancy may be caused by the limited number of studies available in children. (n = 3).[22,36,53] The mechanism connecting sleep disorders and constipation may involve disruptions in circadian rhythms leading to abnormal basal colonic motility.[77] Hosseinzadeh ST et al.[78] found a relatively high prevalence of anxiety and depression in adults with chronic constipation, but evidence among children has been scarce. Importantly, this study found that children with compromised mental health had a higher constipation prevalence at 22.6%, compared to those without at 11.9%, based on seven studies.[21,27,38,45,47,52,60] Notably, a recent study conducted on Italian children aged 0–18 months, who were the only children in the

family had a lower constipation prevalence. This phenomenon was possibly attributed to reduced sibling rivalry and competition, leading to lower stress levels, and increased individual attention from parents.[79] Though we showed that the presence of siblings had no impact on constipation prevalence, it did identify an association between compromised mental health and an increased constipation prevalence in children in Asia. Therefore, further research is needed to understand the precise mechanisms underlying the relationship between constipation and mental health in children.

Contrary to what is commonly acknowledged, we did not confirm that inadequate liquid intake was significantly related to a higher constipation prevalence. This was not in line with a review done by Arnaud MJ,[80] who stated that adequate liquid intake may be effective in improving constipation when fluid consumption was lower-than-normal in children. Another common factor contributing to constipation was dietary behaviour patterns and a low-fibre diet.[67] We noted that children with constipation had a lower daily fibre intake than those without constipation, based on limited available findings.[16,17] Dietary fibre stimulates the growth of beneficial gut bacteria, promotes smoother bowel movements by enhancing motility, and reduces colonic transit time, thereby lowering the risk of constipation. The gut microbiome selectively metabolised different fibre structures to effectively transform indigestible dietary fibre into short-chain fatty acids, a valuable by product to attenuate constipation symptoms.[81] Future studies should aim to understand the mechanism and the role of fibre in attenuating childhood constipation.

This study provided the latest prevalence data on constipation among children in Asia, along with a comprehensive analysis to address the heterogeneity across the region. We emphasised the importance of age, fibre intake, and compromised mental health on constipation rate that have been relatively limited in evidence in children in Asia. Research on constipation in children should note that population source and diagnostic methods may affect prevalence and should be considered. The study also has several limitations. First, the inclusion of different diagnostic tools contributed to the high heterogeneity. We conducted a sensitivity analysis to mitigate the impact of heterogeneity and strengthen the results. Second, despite efforts to group data and remove outliers, the varying definitions and ranges of moderating variables made achieving statistical significance challenging. Third, we acknowledge the high risk of missing non-English literature in Asia. Therefore, we attempted to extract constipation rates from available abstracts in preferred electronic databases, even without access to full-text articles.[28,63] Lastly, we did not examine the adequacy of fibre intake and constipation rate due to insufficient data. The fibre consumption of children in the included studies[16,17] was lower than the suggested amount according to the guidelines for fibre intake of 'age of the child in years +5 g'.[82] Further studies address this issue.

In conclusion, our systematic review and meta-analysis that included studies published in 3 databases up to September 2, 2023, revealed a relatively high constipation prevalence in children in Asia. We pinpointed diagnostic methods, population source, age, and compromised mental health as major factors impacting constipation in children in Asia. The pathogenesis of constipation and its connection to age and mental health in children remain not fully understood, indicating that further mechanistic investigation is necessary. Additionally, research efforts should aim to elucidate appropriate nutritional interventions as potential strategies to reduce the relatively high prevalence of constipation in children in Asia, particularly interventions regarding fibre intake, overweight and obesity issues.

Contributors

Author FD, SHL, ANH, NPV, and NTKN formulated the objectives of this research. FD and SHL identified the studies and screening process, following with data extraction and statistical analysis by author FD, SHL, NQKL, SCS, and CHW. FD wrote the first draft of the report with input from SHL, NPV, JYC, and NTKN. All authors had access to the underlying study data. FD and NTKN had verified the study data. All authors had full access to the final report and had final responsibility for the decision to submit for publication.

Data sharing statement

Applications for requests to access forest plots of each subgroup data included in this study and statistical analysis code is available upon publication by contacting the first author for educational and research purposes.

Declaration of interests

All authors declare no competing interests.

Acknowledgements

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.eclinm.2024.102578.

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