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Prevalence of developmental dysplasia of the hip (DDH) in infants: a systematic review and meta-analysis

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ABSTRACT

Objective To estimate the prevalence of developmental dysplasia of the hip (DDH) in infants with a systematic review and meta-analysis.

Method A literature search was conducted in April 2023, using databases such as Cochrane Library, PubMed, MEDLINE, CNKI, and SinoMed, without language restrictions. Eligible studies included cross-sectional studies reporting the prevalence of DDH among infants aged 0–12 months. Two independent reviewers manually selected and coded the studies, with any disagreements resolved by a third reviewer. Meta-analysis was performed using a random-effects model to calculate the prevalence of DDH. Regression analysis examined the trend of DDH prevalence, and stratification analysis explored heterogeneity between studies.

Results A total of 65 studies involving 3 451 682 infants were included in the meta-analysis. None of the studies were classified as high quality, four were medium-to-high quality, 50 were low-to-medium quality, and eight were low quality. The pooled prevalence of DDH was 1.40% (95% CI: 0.86 to 2.28, I^2=100%), and prevalence of dysplasia, subluxation, and dislocation was 1.45% (95% CI: 0.93 to 2.24, I^2=97%), 0.37% (95% CI: 0.22 to 0.60, I^2=94%), and 0.21% (95% CI: 0.13 to 0.34, I^2=92%), respectively. Notably, the overall prevalence has a slight upward trend in the last three decades (β=0.24, p=0.35), but the dysplasia was downward trend (β=−0.48, p<0.01). Girls have higher risk of DDH than boys (1.46% vs 0.66%; Q=5.83, df=1, p=0.02). There were no significant differences based on gender, country, setting, or screening technique.

Conclusion The prevalence of DDH among infants is approximately one in a 100, with girls being at higher risk. Though the prevalence of dysplasia has decreased, there is a slight upward trend in overall DDH. Therefore, routine screening for DDH in infants is recommended to prevent more serious developmental problems.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Developmental dysplasia of the hip (DDH) is a developmental disorder that can cause a variety of abnormalities in the structure of the hip joint, and if left untreated, DDH can cause pain or difficulty in walking. Early diagnosis of DDH makes treatment easier and reduces complications. The incidence of DDH varies according to geography and ethnicity, and the prevalence of DDH is still unclear. Therefore, it is necessary to evaluate the prevalence of DDH in infants by meta-analysis to provide high-quality evidence for clinical decision-makers and parents.

WHAT THIS STUDY ADDS

⇒ DDH affects almost one in 100 infants, with girls at higher risk than boys.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The high prevalence of DDH supports the introduction of a screening programme.

BACKGROUND

Developmental dysplasia of the hip (DDH) is a developmental disorder that can lead to various abnormalities in the hip joint architecture, resulting in abnormal femoral head fossa, and loose surrounding ligaments. According to Graf classification, DDH is classified with I–IV types. Type I is considered as normal hip joint (α>60°, β<55), type II is classified as dysplasia or delayed ossification (43°α<60°, 55°<β<77°), type III is described as subluxation (α<43°, β>77), and type IV is regarded as dislocation (α<43°, β is unmeasurable). The α-angle refers to the angle between the femoral head–neck junction and the intersection point with the acetabular surface. It is an indicator of the degree of femoral head coverage by the acetabulum. The β-angle is the angle between the femoral head–neck junction and a line connecting the intersection point with the posterior rim of the acetabulum. It is primarily used to evaluate acetabular flatness and the prominence of the acetabular roof.[1] According to the Graf classification, the diagnosis of any type of DDH typically requires abnormalities in both the α-angle and β-angle.

The incidence of DDH varies from 0.5% to 30% according to geographical and ethnic

origin.[2] If untreated, DDH can lead to pain or problems with walking.[3] Studies have shown that 25% children walked at 12 months and 75% of the children walked at 14 months.[4] Therefore, early intervention has positive significance for the normal development of children. In addition, early diagnosis of DDH makes treatment easier and complications less likely.[5] Therefore, it is essential to evaluate the prevalence of DDH in infants with meta-analysis, which can provide a high quality of evidence for clinical decision-makers and parents.

OBJECTIVE

An accurate estimation of the prevalence of DDH in infants is crucial for informing efforts towards the development of children. The present study aimed to systematically review publications on DDH in infants in order to address the following questions:

a. What is the actual prevalence of DDH in newborns to 12-month-old infants?
b. How has the prevalence of DDH changed from 1980 to 2020?
c. Does the prevalence of DDH vary depending on factors such as gender, country, setting, or measurement?

By answering these questions, we can enhance our understanding of DDH prevalence in infants, track changes over time, and identify potential variations based on different factors. Such knowledge is essential for guiding clinical decision-making, resource allocation, and public health initiatives related to DDH in infants.

METHODS

This study have been registered in PROSPERO international prospective register of systematic reviews (CRD42023415879). And the whole process was based on the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) guideline.[6 7]

Inclusion/exclusion criteria

The objective of the present review is to estimate the prevalence of DDH in infants. To achieve this, studies meeting the following criteria were included in the meta-analysis: (a) The articles were written in English or Chinese. (b) The participants involved in the study were aged between 0 and 12 months. Infants with other physical diseases were not considered for inclusion. (c) The prevalence of DDH, including dysplasia, subluxation, and dislocation, was reported in the study, or sufficient information was provided to calculate the prevalence. (d) The study design was a cross-sectional research.

Literature retrieval

Two reviewers systematically searched electronic databases of the Cochrane Library, PubMed, MEDLINE, CNKI and SinoMed before the end of April in 2023. It is worth noting that most of the Chinese studies included in the analysis were sourced from the CNKI and SinoMed databases, and there was no restriction of the publication year. Furthermore, the reference lists of eligible studies and relevant review articles were searched manually.[2 8–12] The selection of primary studies was carried out by the same authors, and any conflicts were resolved by the third author in the process. The results of the literature search and the selection of articles were based on the PRISMA flow diagram, as shown in figure 1.[6 7]

Data extraction

Data extraction table was created with Excel software. Two pilot extractions were initially performed on 15 selected studies to test and refine the extraction process. The extraction process was revised and refined through multiple iterations until a final vision was determined. Information extraction and coding consisted of four parts: general information (including the title, author, year of publication, and survey), the characteristics of the sample (including the sampling methods, sample size, number of boys, age, and their nationality), methods information (including the screening technique and clinical criteria), and outcomes (including the rate of DDH, dysplasia, subluxation, and dislocation). This process was conducted by the two authors, and conflicts were resolved by the third author.

Quality assessment

A 10-point quality assessment tool devised by Matcham *et al* was used to assess the quality of the studies included in the meta-analyses.[13] The five domains of assessment included the sampling method, sample size, participation rate, measurement tools, and clinical criteria of DDH. Studies were rated as low quality (0–3 points), low

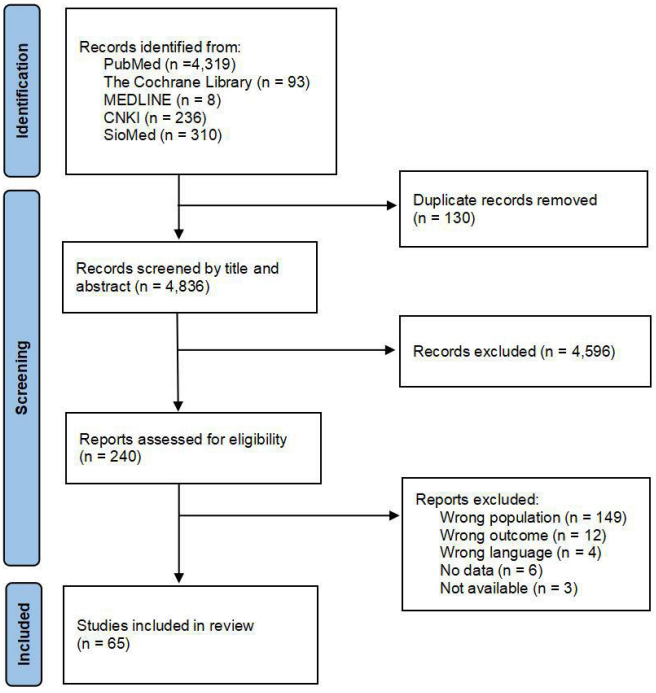

Figure 1 PRISMA flow of selection.

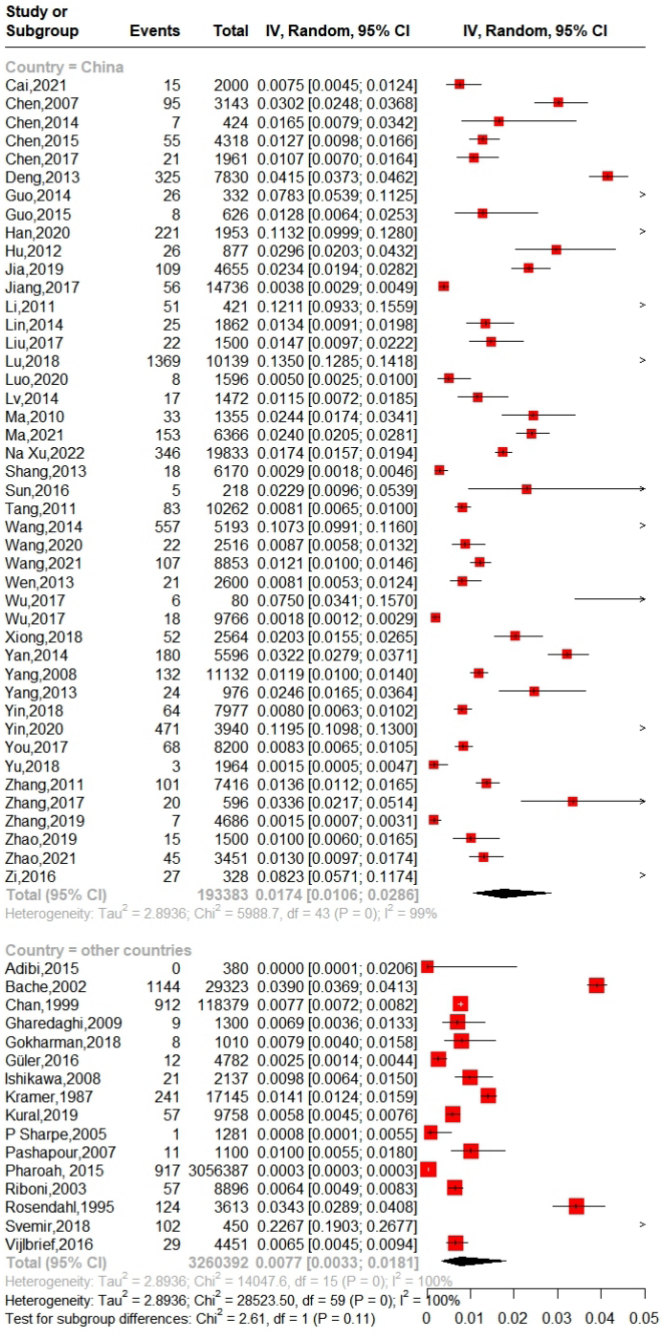

Figure 2 Prevalence of DDH.

to medium quality (4–6 points), medium to high quality (7–8 points), and high quality (9–10 points).

Data synthesis and analysis

A random-effect meta-analysis was conducted to calculate the pooled prevalence of DDH due to the various setting of participants. Q statistics and the I^2 index were used to evaluate heterogeneity among studies, and I^2 values of 25%, 50%, and 75% indicate low, medium, and high heterogeneity, respectively.[14] A funnel plot was used to check the publication bias visually. If the studies are symmetrically distributed, this suggested no publication bias. Otherwise, trim-and-fill method was adopted to compare the differences between the results before and after the trim and fill.[15] In addition, a fail–safe N test was done to calculate the number of excluded studies with null results (ie, zero effect size) that would need to be included to lower the average effect size to a non-significant level.[15]

Regression analysis was used to examine the trend of DDH prevalence, and stratification analysis was adopted to explore the heterogeneity between studies. All data synthesis and analysis were performed in R V.3.6.3 with the 'metafor' and 'meta' package.

Patient and public involvement

Ethical approval was not necessary for this study, as the study did not involve patients and included RCTs can be traced from databases. All data generated or analysed during this study are included in this article and its supplementary material files.

RESULTS

Characteristics of included studies

Out of the 4966 records identified, 4836 titles and abstracts were screened, 240 full-text were located. Ultimately, 65 studies published between 1995 and 2022 were included in the meta-analysis (figure 1). Majority studies were conducted in hospital (62, 95%) from China (50, 77%), America (2, 3%), Australia (3, 5%), England (2, 3%), Iran (2, 3%), Turkey (2, 3%), and other seven countries (6, 9%). The number of infants included in the primary studies were ranging from 80 to 3 056 387, totally 3 451 682. Most of studies (58, 89%) used Graf classification to identify the type of DDH. The detail of characteristics of included studies were shown in online supplemental table S1.

Quality assessment

The quality of the included studies was assessed across five domains, including sampling method, sample size, participation rate, measurement tools, and clinical criteria of DDH, were assessed. Out of 65 studies, none of studies were rated as high quality, 8 studies were rated as low quality, 53 were rated as low-to-medium quality, and four were rated as medium-to-high quality. The details were shown in online supplemental table S2.

Prevalence of DDH in infants

Prevalence of DDH in infants was ranging from 0.00% to 22.66% across 60 studies. The China pooled prevalence estimate was 1.74% (193 383 individuals; 95% CI: 1.06 to 2.86), with significant heterogeneity among studies (Q=5988.7, df=43, p=0; I^2=99%). The other countries pooled prevalence estimate was 0.77% (3 260 392 individuals; 95% CI: 0.33 to 1.81), with significant heterogeneity among studies (Q=28 523.50, df=59, p=0; I^2=100%). The details were shown in figure 2. Funnel plots after trim-and-fill performance indicated no potential publication bias (online supplemental figure S1). The fail–safe number

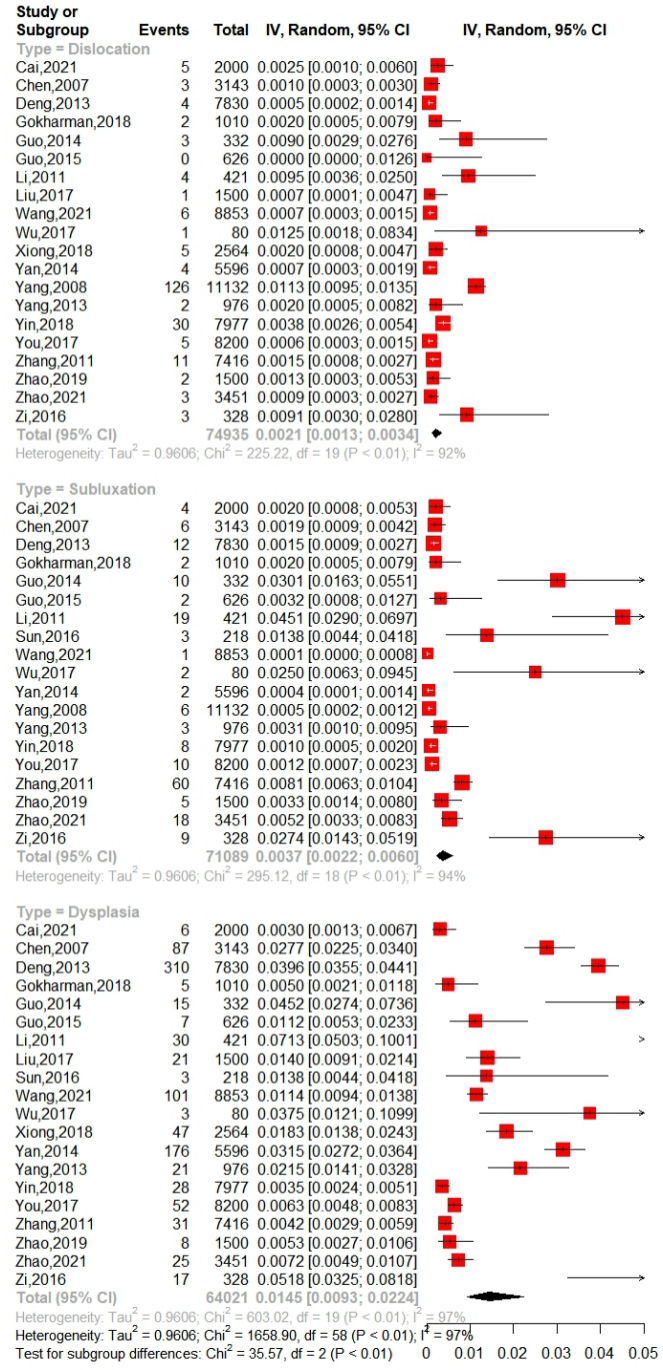

Figure 3 Prevalence of different type of DDH.

was larger than the recommended criterion (5K+10) for the prevalence of DD (N_{fs}=19,13,319>335), which is supported the visual estimate. Specifically, the aggregated prevalence of dysplasia was 1.45% (64 021 individuals; 95% CI: 0.93 to 2.24; Q=603.02, df=19, p<0.01; τ^2=0.96, I^2=97%), subluxation was 0.37% (71 089 individuals; 95% CI: 0.22 to 0.60; Q=295.18, df=19, p<0.01; τ^2=0.96, I^2=94%), and dislocation was 0.21% (74 935 individuals; 95% CI: 0.13 to 0.34; Q=225.22, df=19, p<0.01; τ^2=0.96, I^2=92%). The details were shown in figure 3.

In addition, nine studies screening the DDH based on the bones, and the results showed that there was no

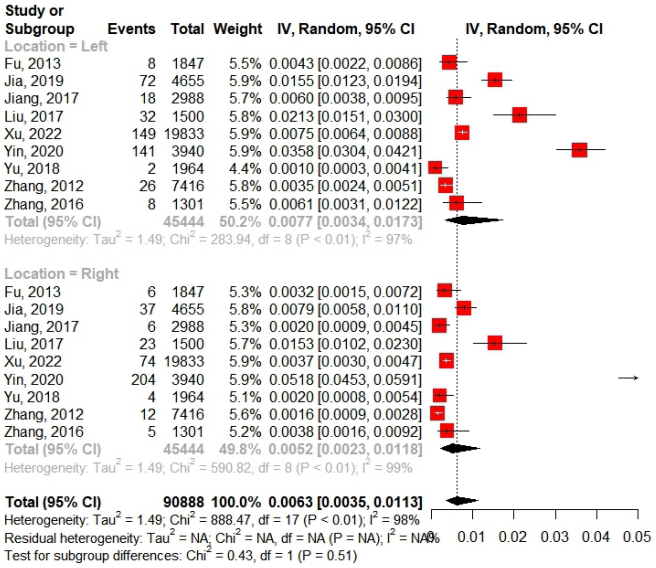

Figure 4 Prevalence of different location of DDH.

difference between left and right bones (0.77% vs 0.52%; Q=0.43, df=1, p=0.51; figure 4).

Changes of DDH prevalence

As shown in figure 5, the prevalence of DDH in infants had a slight upward trend between 1980 and 2020 but this change had no statistic significant (β=0.24, p=0.35; Q=0.87, p=0.35). The prevalence of dysplasia and dislocation had obviously decreased (β=–0.48, p<0.01; Q=7.40, p<0.01), but the prevalence of subluxation and dislocation remained relatively constant (subluxation: β=–0.26, p=0.76; Q=0.58, p=0.76; dislocation: β=–0.04, p=0.85; Q=0.03, p=0.85).

Prevalence of DDH in girls versus boys

Twenty-eight studies reported the prevalence of DDH for girls and boys separately, involving 141 259 infants. The results of subgroup analysis showed that girls had a higher risk of DDH than boys (1.46% vs 0.66%; Q=5.83, df=1, p=0.02). The details were shown in figure 6.

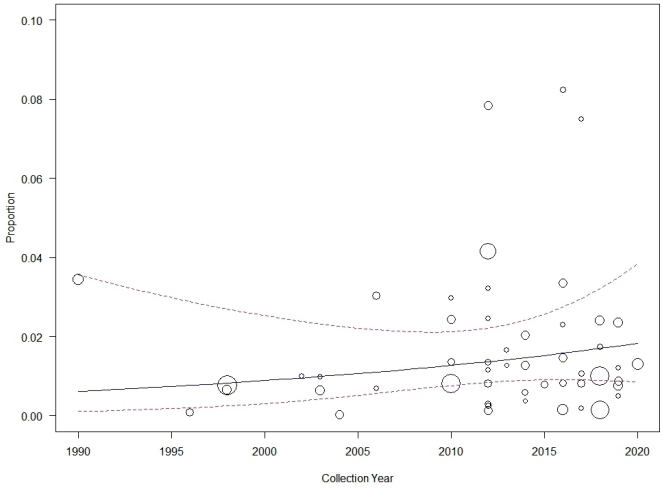

Figure 5 The change of DDH between 1980 to 2022.

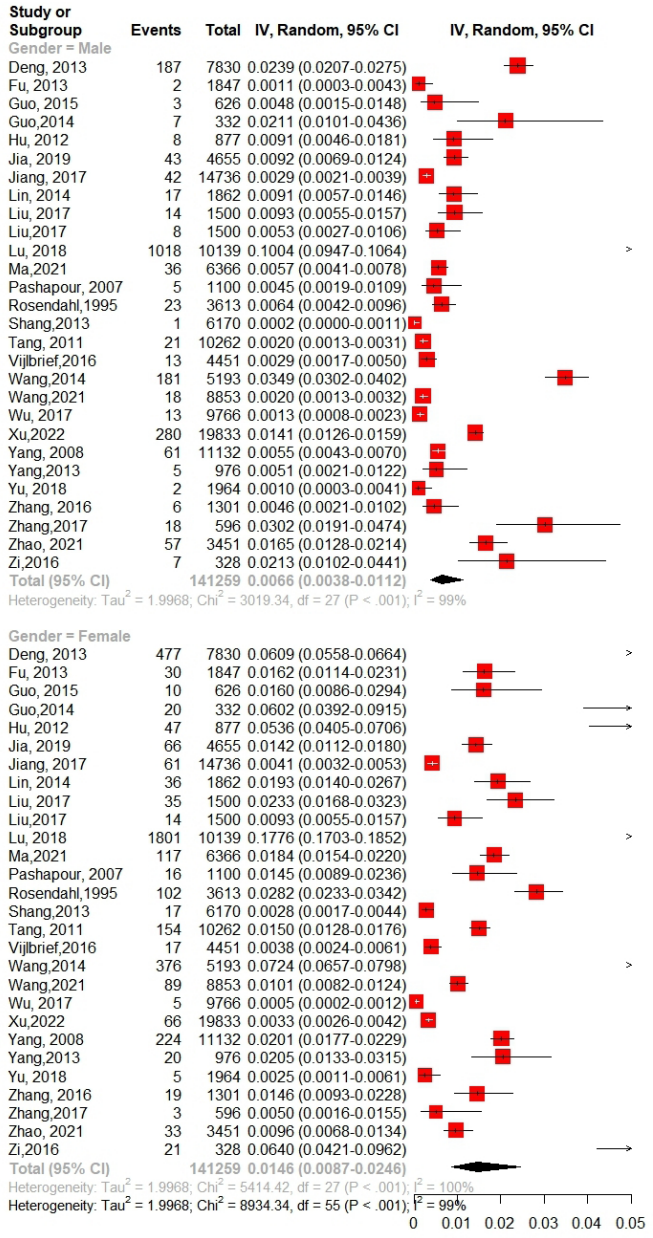

Figure 6 Prevalence of DDH moderated by gender.

Prevalence of DDH across countries

Although the participants were mainly from 10 countries, the prevalence of DDH was similar between them (Q=9.96, df=9, p=0.35). Respectively, Chinese was 1.76% (193 383 infants; 95% CI: 1.24 to 2.48), the studies that were from outside of China shown in table 1.

Prevalence of DDH in different settings

Out of 65 studies, 55 were conducted in hospital, and three in community. The results showed that there was no significant difference depend on the setting (1.62% vs 0.83%; Q=0.90, df=1, p=0.34). The details were shown in online supplemental figure S2.

Prevalence of DDH with different measurements

Four screening techniques were mainly used to identify the overall prevalence of DDH, including ultrasound (40, 62%), colour ultrasound (13, 20%), high frequency ultrasound (1, 2%), and X-ray (2, 3%). The result indicates no obviously difference among them (Q=3.86, df=3, p=0.43; ultrasound: 1.33%, 95% CI: 0.93 to 1.89; colour ultrasound: 2.76%, 95% CI: 1.51 to 4.98; high frequency ultrasound: 1.00%, 95% CI: 0.11 to 8.68; X-ray:0.98%, 95% CI: 0.11 to 8.42). The details were shown in online supplemental figure S3.

DISCUSSION

The present review aimed to estimate the prevalence of DDH in infants based on data from 65 primary studies, which included a total of 3 451 682 participants. The results showed that the pooled prevalence of DDH was 1.40% (95% CI: 0.86 to 2.28, I^2=100%), and prevalence of dysplasia, subluxation, and dislocation was 1.45% (95% CI: 0.93 to 2.24, I^2=97%), 0.37% (95% CI: 0.22 to 0.60, I^2=94%), and 0.21% (95% CI: 0.13 to 0.34, I^2=92%), respectively. These results were higher than the previous reports. Harsanyi *et al* indicated that the global incidence can roughly be estimated to 0.1–6.6 cases per 1000 live births.[16] The present review focused on infants aged 0–12 months, which may account for this discrepancy. Moreover, it was observed that the overall prevalence of DDH has slightly increased over the past 30 years, despite a decline in the prevalence of hip dysplasia.

Moreover, girls have a higher risk of DDH than boys (1.46% vs 0.66), which was supported by the report from Johns Hopkins.[3] In addition, there was no difference across regions (Q=9.96, df=9, p=0.35) and setting (Q=0.90, df=1, p=0.34). The ultrasound (including colour ultrasound and high frequently ultrasound) and X-ray can be used to screen the potential DDH among infants, which is corresponding to the existing reviews.[9 17 18]

This review utilised a meta-analysis to pool the prevalence of DDH, but there are several limitations in this process. First, the Chinese and English studies were included due to the restriction of the team members, which may lead to potential selection bias. Therefore, the overall results should be explained cautiously. Second, the number of studies included in the subgroup analysis is extremely unbalanced, especially across countries. In the further research, the difference among regions should be compared with more studies in each group. Finally, it is noteworthy that none of the studies included in the analysis were rated as high quality, emphasising the need for higher quality research in subsequent studies.

CONCLUSION

It has been observed that approximately one in every 100 infants is affected by DDH, with girls being at a higher risk. Given this prevalence, it is crucial to implement routine screening for DDH in infants. By detecting and intervening early, it is possible to prevent the development of more severe developmental problems associated with DDH.

Table 1 Studies conducted from outside of China

Study ID	Year*	Country	Setting	Screening technique	Sample	Case	Prevalence with 95% CI
Gharedaghi, 2009	2006	Iran	Hospital	Ultrasound	1300	9	0.69% (0.36 to 1.33)
Rosendahl, 1995	1990	Norway	Hospital	Ultrasound	3613	124	3.43% (2.89 to 4.08)
Sharpe, 2005	1996	Australia	Hospital	Ultrasound	1281	1	0.08% (0.01 to 0.55)
Chan, 1999	1998	Australia	Hospital	Ultrasound	118379	912	0.77% (0.72 to 0.82)
Vijlbrief, 2016	1998	Netherlands	Hospital	NR	4451	29	0.65% (0.45 to 0.94)
Gokharman, 2018	2015	America	Hospital	Ultrasound	1010	8	0.79% (0.40 to 1.58)
Pharoah, 2015	2004	England and Wales	NR	NR	3056387	917	0.03% (0.03 to 0.03)
Adibi, 2015	2012	America	Hospital	Ultrasound	380	0	0.00% (0.00 to 2.06)
Güler, 2016	2012	Turkey	Hospital	Ultrasound	4782	12	0.25% (0.14 to 0.44)
Kural, 2019	2014	Turkey	Hospital	Ultrasound	9758	57	0.58% (0.45 to 0.76)
Bache, 2002	NR	England	Hospital	Ultrasound	29323	1144	3.90% (3.69 to 4.13)
Pashapour, 2007	2002	Iran	Hospital	Ultrasound	1100	11	1.00% (0.55 to 1.80)
Kramer, 1987	NR	Norway	Community	NR	17145	241	1.41% (1.24 to 1.59)
Svemir, 2018	2012	Bosnia and Herzegovina	Hospital	Ultrasound	450	102	22.67% (19.03 to 26.77)
Ishikawa, 2008	2003	Japan	Hospital	X-ray	2137	21	0.98% (0.64 to 1.50)
Riboni, 2003	2003	Italy	Hospital	Ultrasound	8896	57	

*Data collection year.
NR, not report.

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Contributors All the authors conceived the work. ZT and JW wrote the article and drew the drawings. YZ, XY, JY, HL, and BL searched the data and literature. JL, YP, JZ, and YL were responsible for revising the article. YL was responsible for finalising the manuscript. All the authors reviewed the paper.

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Patient consent for publication Not required.

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