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Hypertension prevalence and coverage and intellectual disability: a systematic review and meta-analysis

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ABSTRACT

Background: People with intellectual disabilities (ID) frequently experience poorer health and lower treatment coverage compared to those without ID, yet differences in hypertension prevalence and treatment coverage remain unclear.
Objective: To estimate the pooled prevalence ratio (PR) of hypertension and hypertension treatment coverage comparing adults with and without ID.
Methods: We searched MEDLINE, Embase, PsychINFO, Global Health and Global Index Medicus on June 6, 2024. We included observational and intervention studies that estimated the prevalence of hypertension and/or treatment coverage. The risk of bias was assessed using the Newcastle-Ottawa Scale tool. We undertook a random-effects meta-analysis to estimate the pooled PR with 95 % confidence intervals (CI). Sources of heterogeneity were explored through sensitivity and subgroup analyses, and meta-regression.
Results: 21 studies from 10 countries across three regions were included. The pooled PR were 0.71 (95 % CI: 0.47–1.05) for hypertension and 0.61 (95 % CI: 0.47–0.81) for hypertension treatment coverage. Only one study adjusted for age; most reported unadjusted estimates, making them prone to confounding. 14 studies were rated as high risk of bias. Subgroup analysis and meta-regression revealed variability in the methods used to diagnose ID, with sample size emerging as the primary source of variability in the effect estimates.
Conclusions: This systematic review showed that adults with ID have a similar prevalence of hypertension, but lower hypertension treatment coverage compared to those without disabilities. However, these results should be interpreted with caution due to the lack of adjustment for confounding in the association and variability in the diagnosis of ID.

1. Introduction

Hypertension is one of the leading preventable risk factors for ischemic heart disease, stroke, other cardiovascular diseases, and chronic kidney disease,[1] responsible for over 10 million deaths and 230 million disability-adjusted life years in 2019.[2] Reducing its burden is a critical target in efforts to decrease premature mortality from non-communicable diseases (NCDs).[3] However, limited access to diagnosis, treatment, and effective control poses a public health challenge, particularly for high-risk groups,[4] which may include people with intellectual disabilities (ID). ID is a condition that affects intellectual and adaptive functioning[5] and is frequently caused by chromosomal disorders, genetic syndromes, infections, brain injuries, and childbirth complications.[6,7] ID affects approximately 1 % of the population, with higher prevalence in LMIC and among children and adolescents.[8,9] People with ID frequently experience poor health status, including higher rates of mortality,[10] hospital admissions,[11] and a higher prevalence of chronic health conditions.[12–15]

People with ID may face a higher risk of hypertension due to a greater prevalence of risk factors such as obesity, low physical activity, tobacco use, inadequate nutrition, and poor cardiorespiratory fitness.[16–22] Moreover, lower socioeconomic status, less accessible health information, and fewer opportunities for physical activity contribute to their increased risk.[19,23] Certain types of ID, such as Fragile

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X premutation, may also involve biological factors that further increase hypertension risk.[24] The association of ID and hypertension prevalence requires careful consideration, however, as hypertension risk increases with age,[25] yet adults with ID are frequently younger due to shorter life expectancy, and so unadjusted analyses may underestimate the true association between ID and hypertension.

People with ID may also exhibit lower adherence to antihypertensive treatment and reduced access to chronic care management compared to those without ID.[26–28] Low adherence may be attributed to lower detection (e.g., difficulties in symptom recognition), informational barriers, lack of social support, and higher levels of poverty.

There has not been a systematic review or meta-analysis of the association of ID and hypertension prevalence or treatment coverage, nor consideration of which factors influence this relationship. In fact, studies report contradictory results, suggesting that the prevalence of hypertension could be higher,[17] similar,[28,29] or lower[30] compared to the general population. Therefore, our study aimed to estimate the pooled prevalence ratio (PR) of hypertension and hypertension treatment coverage between adults with and without ID through a systematic review and meta-analysis.

2. Materials and methods

2.1. Search strategy and selection criteria

This study was conducted in accordance with PRISMA[31] (Appendix S1) and MOOSE checklist[32] (Appendix S2), and was registered in the Prospective Register of Systematic Reviews (PROSPERO; number: CRD42024574521). We searched MEDLINE, Embase, PsychINFO, Global Health and Global Index Medicus for studies published in English, Spanish or Portuguese from database inception to June 6, 2024. The search strategies can be found in Appendix S3.

The inclusion criteria were:

i) Study design: cross-sectional, baseline characteristics of cohort and case-control studies or randomized controlled trials (RCT) if the intervention did not influence the ID-hypertension relationship;
ii) Population: Adults aged ≥18 years, living in community settings;
iii) Exposure: ID either alone or in combination with other disabilities or limitations (e.g., autism spectrum disorders), and ID-related diseases (e.g. Down Syndrome), diagnosed through genetic/molecular testing, physician diagnosis, health records (ICD-9, ICD-10, and Read codes) (Appendix S4), self-reports, or administrative data linked to legal definitions or social/health support;
iv) Outcome:
   a. Hypertension: systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg, or antihypertensive medication use per international guidelines,[4,33,34] diagnosed using blood pressure monitoring devices, health records (ICD-9, ICD-10, and Read codes) (Appendix S5), self-reports, or physician diagnosis;
   b. Hypertension treatment: reported medication use for hypertension.

Review articles, qualitative studies, book chapters, editorials, commentaries, conference abstracts, letters to the editor, study protocols and grey literature were excluded. Studies in which all participants have a specific condition or disease (e.g., Human Immunodeficiency Virus [HIV] infection, obesity, COVID-19, type 1 diabetes, etc.) were also excluded, as it is difficult to distinguish the potential association of ID on hypertension prevalence from the effect of these conditions or diseases. Furthermore, studies that included adults with and without ID from specific settings (such as inpatient facilities, correctional facilities, care homes, etc.) were excluded.

2.2. Data search and extraction

Rayyan screening tool was used to screen titles and abstracts, and assess full-text articles. References of eligible studies were then examined for additional relevant sources. Specifically, the references of studies that met the eligibility criteria were examined to capture any studies that may not have appeared in the electronic search due to missing hypertension-related terms in their titles or abstracts. This process was independently conducted by two authors (RVF and AHV), with a third author (HK) resolving any discrepancies.

RVF and AHV extracted data from all articles that met the eligibility criteria using a data extraction spreadsheet. When multiple publications contained data from the same data source, data were extracted from the publication with the largest sample size or the most recent data. Information extracted included: i) publication characteristics (author, publication year and country or region); ii) study characteristics (design, sample size and response rate); and iii) participant characteristics (population description, selection criteria, age, sex, and other relevant descriptive data); iv) outcome data (definition and measurement); and v) measures of effect (unadjusted, age-adjusted and multivariable-adjusted PR). To calculate the prevalence and PR of interest, four key values were collected: number of exposed people with events, total number of participants in the exposed group, number of unexposed people with events, and total number of participants in the unexposed group.

2.3. Risk of bias

The risk of bias was measured by RVF and AHV using Newcastle-Ottawa Scale tool.[35] An adapted version of this tool for cross-sectional, case-control and cohort studies was designed to assess the key characteristics that each article included in this systematic review should encompass[36] (Appendices S6-S8). The maximum score in each version was 9, and lower scores represent high risk of bias. A high risk of bias was indicated by a score of 0 or 1 in the selection domain, 0 in comparability, or 0 or 1 in the outcome domain. Disagreements on risk of bias ratings were discussed and resolved by a third reviewer (HK).

Publication bias was measured in meta-analyses that included 10 or more studies through the inspection of Funnel Plot and Egger's test, using a significance threshold of <0.05. A contour-enhanced funnel plot was performed to inspect how the patterns of asymmetry relate to statistical significance.[37]

2.4. Statistical analysis

We undertook a meta-analysis using the Dersimonian and Laird random-effect model, which applies the inverse-variance method to determine the weight assigned to each study, to generate a pooled PR and 95 % confidence interval (CI) for the association of ID with hypertension and coverage. The minimum number of studies required for a meta-analysis was two.[38] The extent and impact of between-study heterogeneity were assessed with I^2 and τ^2 statistics, respectively.[38] We investigated the sources of heterogeneity using.

1. Subgroup analysis: studies were stratified according to study design, type of ID, setting of exposed group, method of disability and hypertension assessment, region according to WHO,[39] and risk of bias.
2. Sensitivity analysis: i) excluding studies with high risk of bias, ii) including only those focused on adults with ID as opposed to adults with ID alongside with other limitations and (iii) comparing pooled estimates from age-matched studies to those from unadjusted studies.
3. Meta-regression using a random-effects-model to assess whether the effect estimates varied by the following explanatory variables: study design (cross-sectional, retrospective cohort), type of ID (ID, ID with other limitations), disability (health record, diagnostic tool or

clinical and from register or database) and hypertension assessment method (blood pressure monitoring devices, health record, and self-report), region (Europe, Americas, Western Pacific), risk of bias (low, medium, high), year of publication and study sample size. Since the effect estimate is a ratio measure, the model was adapted using a log-transformed relative measure (log PR). To improve interpretability, β coefficients were exponentiated to estimate the average PR for each study-level variable.[38] Finally, bubble plots were generated to illustrate the relationship between the pooled log PR and the numerical explanatory variable.[40]

All analyses were conducted using the R version 4.0.2 and Rstudio through the metafor[41] and meta[42] packages.

3. Results

3.1. Study selection

We identified 10,438 records through electronic search. After duplicates removal, we reviewed 8130 records by title and abstract. Of these, 34 records were selected for full-text review of which 14 were deemed eligible. The references of the articles that met the eligibility criteria were reviewed, resulting in the retrieval of 11 additional articles, of which 7 were eligible for inclusion.[27,43–48] The reasons for the exclusion of the 24 articles are provided in Appendix S9. Finally, 21 articles were included in this systematic review[16,17,27,28,30,43–58] (Fig. 1).

3.2. Study characteristics

The 21 included studies comprised 43,283 adults with ID and 257,758,253 without ID from 10 countries across three regions. Over half were conducted since 2016, ten (47.6 %) were conducted in Europe and all but one were undertaken in high-income countries (Table 1; Table 2). Most studies identified adults with ID (42.9 %) and hypertension (76.2 %) through health records. 14 were identified as studies at high risk of bias. In most of the studies, the setting for the unexposed (n = 12) and exposed (n = 16) groups was outpatient. Moreover, 15 studies included adults with ID alongside another condition or disability. Of these, six studies included adults with Down syndrome,[28,45,48,50,56,58] eight studies focused on people with intellectual and developmental disabilities,[30,44,47,49,53,55,57,58] two studies included people with Prader-Willi syndrome,[48,54] one study focused on people with Williams syndrome,[48] and one study included people with Fragile X syndrome.[46] The sample size of adults with ID ranged from 49 to 14,751.

Six studies reported a lower mean age for adults with ID compared to those without ID.[43,45,49,51,53,56] The mean age of adults with ID ranged from 34.5 to 72.6 years, whereas for those without ID, it ranged from 42 to 74.2 years. Seven studies employed a matching process based on age and sex.[28,30,46,52,54,57,58] Five studies did not report a p-value to assess differences between the groups,[16,27,47,48,50] while three found no age differences between them[17,44,55] (Table 2).

Most of the studies (n = 20) provided the required data to calculate the PR of hypertension in both groups. One study was excluded from the meta-analysis because it lacked data on overall hypertension prevalence, providing only age and sex specific estimates.[16] Finally, 20 of the 21 studies were included in the meta-analysis (9 cross-sectional studies, 2 case-control studies and 9 retrospective cohort studies).[17,27,28,30,43–58]

3.3. Risk of bias in studies

Six cohorts[16,17,27,45,50,53] and eight cross-sectional studies[28,43,47–49,51,55,56] were identified as having a high risk of bias (Fig. 2; Appendix S11). In contrast, both case-control studies were classified as low risk of bias.[46,57]

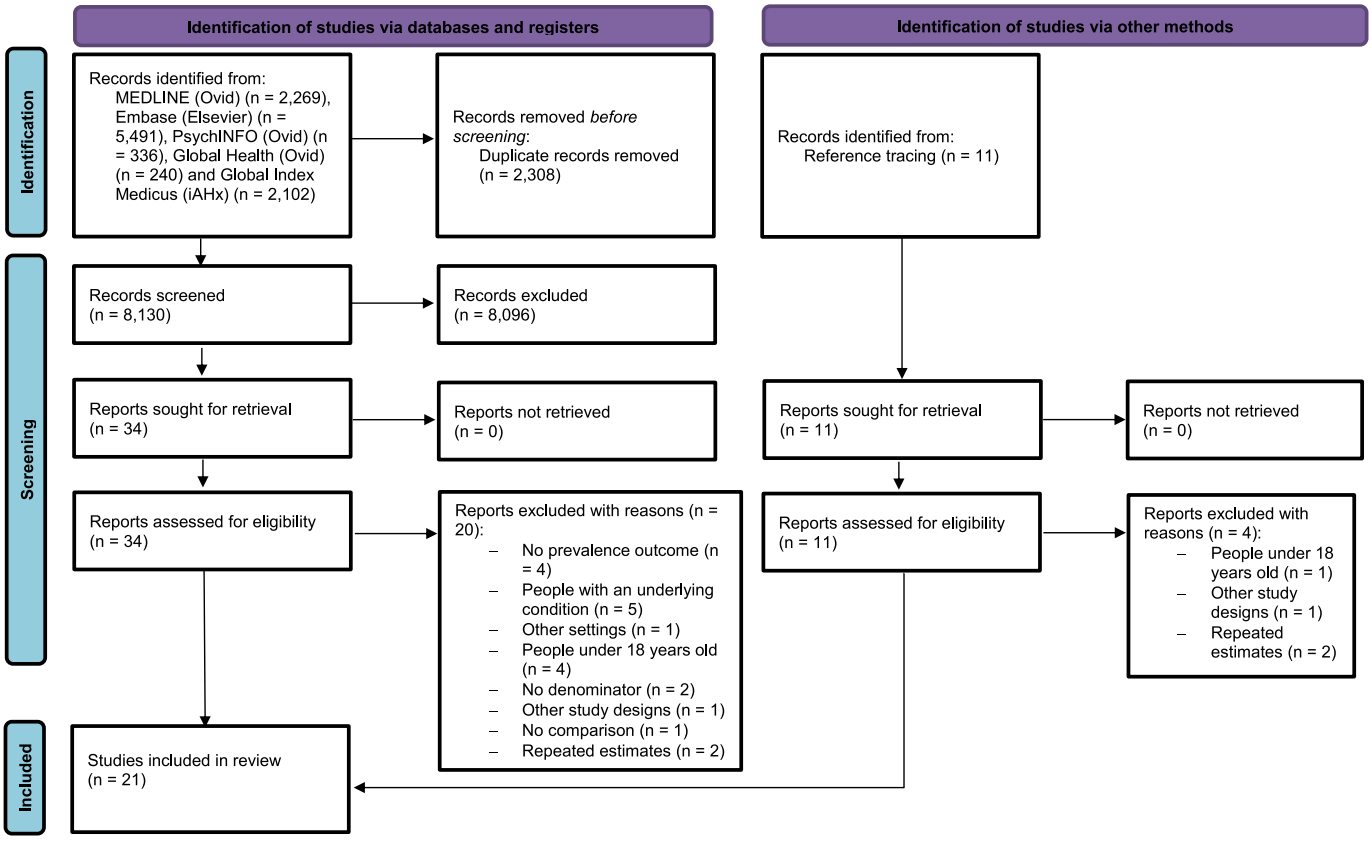

Fig. 1. Flowchart of the process of selection of studies.
Source: Page MJ et al. BMJ 2021; 372:n71. doi: 10.1136/bmj.n71.

Table 1
Summary characteristics of included studies.

Characteristic	Number of studies	Proportion of studies
Overall	21	100
Year of publication		
2004–2007	2	9.5
2008–2011	2	9.5
2012–2015	6	28.6
2016–2019	7	33.3
2020–2022	4	19.0
Study design		
Cross-sectional	9	42.9
Retrospective cohort	10	47.6
Case-control[a]	2	9.5
WHO Region		
Europe	10	47.6
Americas	8	38.1
Western Pacific	3	14.3
Eastern Mediterranean	0	0
Africa	0	0
Country income status[b]		
Low income	0	0
Lower middle income	0	0
Upper middle income	1	4.8
High income	20	95.2
Setting of exposed group		
Population	5	23.8
Outpatient	16	76.2
Setting of unexposed group		
Population	9	42.9
Outpatient	12	57.1
Type of disability		
Intellectual disabilities	6	28.6
Intellectual disabilities with other limitations	15	71.4
Down Syndrome	6	28.6
Prader-Willi Syndrome	2	9.5
Intellectual and developmental disabilities	8	38.1
Williams Syndrome	1	4.8
Fragile X syndrome	1	4.8
Disability assessment method		
Health record	9	42.9
Diagnostic tool or clinical	5	23.8
From register or database	7	33.3
Hypertension assessment method		
Blood pressure monitoring device or physical examination	2	9.5
Health record	16	76.2
Self-report	3	14.3
Sample size (adults with intellectual disabilities)		
<100	1	4.8
≥100	20	95.2
Mean age of exposed group		
18-29	1	4.8
30-79	12	57.1
80 or older	0	0
Not reported	8	38.1
Risk of bias		
Low	14	66.7
Medium	1	4.8
High	6	28.6

WHO: World Health Organization.
[a] includes matched case-control and nested case-control studies.
[b] According to the World Bank classification.

3.4. Hypertension

The pooled unadjusted PR for hypertension in people with ID compared with those without ID was 0.71 (95 % CI: 0.47–1.05; p = 0.088) and heterogeneity between studies was considerable (I^2: 98 %; τ^2: 0.76) (Fig. 3). A contour-enhanced funnel plot revealed no evidence of publication bias (Egger's test: p = 0.749) (Appendix 12). It is crucial to highlight that only one study included in the meta-analysis reported a sex- and age-adjusted PR (aPR) in addition to an unadjusted estimate.[44] The unadjusted PR showed no difference in hypertension prevalence between people with and without ID (PR: 0.97, 95 % CI: 0.88–1.06). However, after adjusting for sex and age, the study found that people with ID had a 42 % higher prevalence of hypertension compared to those without ID (aPR: 1.42, 95 % CI: 1.29–1.55).

3.5. Sensitivity analysis

Three sensitivity analyses were conducted to explore heterogeneity. Two approaches were used: (i) excluding studies with a high risk of bias, (ii) including only studies that focused exclusively on adults with ID, rather than those that also included people with other limitations, and (iii) comparing pooled estimates from age-matched studies to those from unadjusted studies. These analyses were based on the main meta-analysis and aimed to assess whether the exclusion or stratification of specific studies could influence the pooled effect estimate. In the first two meta-analyses, the effect estimate shows the same direction, but the confidence interval includes 1, indicating that both populations have similar prevalence. In addition, there is strong evidence of considerable heterogeneity (I^2: 97.2 % [p < 0.01] and I^2: 87 % [p < 0.01]) (Appendices S13 and S14). In the third meta-analysis, stratification by age adjustment did not change the pooled effect estimate. In both age-matched and unadjusted studies, the confidence intervals of the pooled effect estimates included 1, indicating similar prevalence between people with and without ID. Moreover, there is again strong evidence of considerable heterogeneity (I^2: 98.1 % [p < 0.01]) (Appendix S15).

3.6. Subgroup analysis

The pooled PR of hypertension in adults with ID compared to those without ID according to different characteristics of the studies are shown in Appendices S16-S23.

The pooled unadjusted PR of hypertension varied depending on the method used to assess ID. In studies using health records, adults with ID had a 42 % lower prevalence of hypertension compared to those without ID (pooled unadjusted PR: 0.58, 95 % CI: 0.30–1.13). Similarly, in studies using registers or databases, the prevalence was 40 % lower (pooled unadjusted PR: 0.60, 95 % CI: 0.38–0.95). In contrast, studies that identified ID through a diagnostic tool or clinical assessment reported a 62 % higher prevalence of hypertension in adults with ID (pooled unadjusted PR: 1.62, 95 % CI: 1.03–2.54). These differences in pooled estimates and confidence intervals across assessment methods reflect substantial between-study heterogeneity (I^2 > 75 % in all subgroups; p < 0.01 for subgroup differences).

Subgroup analyses based on study design, type of ID, WHO region, and risk of bias indicate that the confidence interval of effect estimates of each category cross 1, which demonstrates that there was no difference in the prevalence of hypertension by disability status. However, in the subgroup where hypertension was assessed using health records, there was statistical evidence suggesting that adults with ID had a 41 % lower prevalence (pooled unadjusted PR: 0.59; 95 % CI: 0.36–0.95) compared to those without ID. High heterogeneity persisted across most categories (I^2 > 75 %), indicating varying effects within subgroups. However, no significant differences were found between subgroups in the explanatory variables (p = 0.13), suggesting no evidence of a difference in pooled effect estimates.

3.7. Meta-regression

Meta-regression analysis found no evidence that the estimated PR for hypertension varied by study design, WHO region, type of ID, hypertension assessment method, risk of bias, or publication year.

However, studies using health records and registries or databases reported that adults with ID had a 67 % lower prevalence of hypertension compared to those without (average PR: 0.33; 95 % CI: 0.13–0.85

Table 2
Descriptive characteristics of included studies.

Study ID (author and year)	Country	Study design	Setting of unexposed group	Setting of exposed group	Type of disability	ID definition	Disability assessment method	Severity of ID	Response rate (%)	Sample size (people with intellectual disabilities)	Sample size (people without intellectual disabilities)	Age of exposed group (mean [SD], percentage, or range)	Age of unexposed group (mean [SD], percentage or range)	p-value of the difference between age	Female (%)	Hypertension assessment method
Axmon et al., 2017[30]	Sweden	Retrospective cohort	Population	Population	People with ID or ASD	People with ID diagnosis from National Board of Health and Welfare's register	From register or database	NR	NR	7936	7936	64 (range: 55–96)	64 (range: 55–96)	Age- and sex-matched	45.50 %	Health record
Carey et al., 2016[58]	United Kingdom	Cross-sectional	Outpatient	Outpatient	People with ID (10 % DS and 10 % ASD)	Read codes associated with ID	Health record	NR	NR	14,751	86,221	42.1 (SD: 15.7)	42.1 (SD: 15.7)	Age- and sex-matched	42.10 %	Health record
Cooper et al., 2018[27]	Scotland	Retrospective cohort	Population	Outpatient	People with ID	Primary health care register of people with ID	From register or database	Mild: 35.4 %, Moderate: 26.9 %, Severe: 17.8 %, Profound: 19.9 %	87 %	721	764,672	44.3 (range: 18–92)	Not reported	NR	44.80 %	Health record
Cooper et al., 2015[43]	Scotland	Cross-sectional	Outpatient	Outpatient	People with ID	Read codes associated with ID	Health record	Not reported	NR	8014	1,416,364	43.1 (SD: 15.8)	48.0 (SD: 18.3)	$p < 0.001$	43.6 % in ID; 52.0 % in no ID	Health record
de Winter et al., 2012[28]	Netherlands	Cross-sectional	Population	Population served by care-provider organizations	People with ID (including DS)	General practitioner and specialised physician diagnosis	Diagnostic tool or clinical	Borderline: 3.1 %, Mild: 21.4 %, Moderate: 48.6 %, Severe: 16.0 %, Profound: 8.7 %, Unknown: 2.2 %	NR	685	2264	50–70	50–70	Age- and sex-matched	51.30 %	Blood pressure monitoring device or physical examiation
Durbin et al., 2019[44]	Canada	Retrospective cohort	Outpatient	Outpatient	People with IDD	Diagnostic codes recorded in health administrative data	Health record	Not reported	NR	2830	1,646,803	19-25: 29.8 % 26–49: 56.3 % 50–65: 13.9 %	19-25: 10.6 % 26–49: 67.1 % 50–65: 22.3 %	$p = 0.10$ (15–29), $p = 0.10$ (26–49), $p = 0.09$ (50–65)	51.8 % in no IDD group; 47.3 % in IDD group	Health record
Erickson et al., 2016[49]	United States	Cross-sectional	Outpatient	Outpatient	People with IDD	People with ICD-9 (317, 318.0, 318.1, 318.2, or 319) codes	Health record	Not reported	NR	183	497	49.4 (SD: 11.5)	52.8 (SD: 18.0)	$p < 0.001$	63.6 % in no IDD group; 47.5 % in IDD group	Health record
Fitzpatrick et al., 2020[50]	United States	Retrospective cohort	Population	Outpatient	People with DS	People with ICD-9 (758.0) or ICD-10 (Q90.9) codes	Health record	NR	NR	2342	253,043,478	18-29: 7.84 % 30–39: 7.34 % 40–49: 8.66 % 50–59: 3.61 % 60–69: 11.44 %	18-29: 21.74 % 30–39: 16.93 % 40–49: 16.93 % 50–59: 17.84 %	NR	53.67 % in DS sample; 51.4 % in general population estimates	Health record

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Table 2 (*continued*)

Study ID (author and year)	Country	Study design	Setting of unexposed group	Setting of exposed group	Type of disability	ID definition	Disability assessment method	Severity of ID	Response rate (%)	Sample size (people with intellectual disabilities)	Sample size (people without intellectual disabilities)	Age of exposed group (mean [SD], percentage, or range)	Age of unexposed group (mean [SD], percentage or range)	p-value of the difference between age	Female (%)	Hypertension assessment method
												70–79: 1.11 % 80 or older: 0 %	60–69: 13.93 % 70–79: 7.81 % 80 or older: 4.82 %			
Flygare et al., 2018[16]	Sweden	Retrospective cohort	Population	Outpatient	People with ID non-DS	People with ICD-10 (F70; F71; F72; F73; F78; F79; F89; Q90; Q91; Q92.1; Q92.2; Q92.3; Q92.6; Q93.4; Q93.5; Q99.2 (males only); Q87.1C; Q87.1F; Q87.8; Q87.2D; F84.2 and F84.4.) codes	Health record	NR	NR	973	374,575	Women: 19-49: 0.54 % 50–64: 0.25 % 65–74: 0.18 % 75.84: 0.10 % 85 or older: 0.05 % Men: 19-49: 0.67 % 50–64: 0.30 % 65–74: 0.20 % 75.84: 0.14 % 85 or older: 0.07 %	Women: 19-49: 444,100 50–64: 178,612 65–74: 90,687 75.84: 54,199 85 or older: 35,473 Men: 19-49: 449,017 50–64: 176,802 65–74: 84,060 75.84: 39,001 85 or older: 16,298	NR	0.48 % in ID group	Health record
Gonzalo-Calvo et al., 2020[45]	Spain	Retrospective cohort	Outpatient	Outpatient	People with DS	Data from Down Medical Center	From register or database	NR	NR	248	248	43.0 (33.0–50.8)	55.0 (47.3–59.8)	$p < 0.001$	DS group: 46.8 %; Control: 75.0 %	Health record
Hamlin et al., 2012[46]	United States	Matched case-control	Population	Population	People with fragile X premutation carriers with FXTAS	Molecular diagnosis: CGG repeat numbers between 55 and 200 at the FMR1 gene.	Diagnostic tool or clinical	NR	NR	100	117	67 (SD: 7.58)	56.26 (SD: 12.18)	Age-matched	Only males	Self-report
Havercamp et al., 2004[47]	United States	Cross-sectional	Outpatient	Population	People with DD (91.3 % MR)	Data from from the North Carolina Developmental Disability Service registry	From register or database	Mild: 39.4 %, Moderate: 26.6 %, Severe: 14.7 %, Profound: 10.6 %	NR	477	4358	18-34: 47.5 % 35–54: 43.1 % 55 or older: 9.4 %	18-34: 36.0 % 35–54: 40.4 % 55 or older: 23.6 %	NR	No disability group: 51.5 %; Developmental disability group: 43.9 %	Self-report
Henderson et al., 2008[17]	United States	Retrospective cohort	Population	Outpatient	People with ID	People with ID from community residences with	From register or database	NR	NR	100	2526	NS	NS	$p > 0.05$	Not reported	Health record in ID group and Self-

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Table 2 (*continued*)

Study ID (author and year)	Country	Study design	Setting of unexposed group	Setting of exposed group	Type of disability	ID definition	Disability assessment method	Severity of ID	Response rate (%)	Sample size (people with intellectual disabilities)	Sample size (people without intellectual disabilities)	Age of exposed group (mean [SD], percentage, or range)	Age of unexposed group (mean [SD], percentage or range)	p-value of the difference between age	Female (%)	Hypertension assessment method
						12 or fewer residents										report in no ID group
Hsu et al., 2012[51]	China	Cross-sectional	Outpatient	Outpatient	People with ID	People with ICD-9 (317–318) codes	Health record	NR	NR	90	8677	72.6 (SD: 6.6)	74.2 (SD: 6.8)	$p < 0.05$	51.37 % in general population; 53.78 % in ID group	Health record
McDermott et al., 2006[53]	United States	Retrospective cohort	Population	Outpatient	People with DD (autism, CP, MR)	People with ICD-9 (299, 343, 317, 318, 319) codes	Health record	Only severe disabilities	NR	692	2084	34.5	43.5	$p < 0.01$	58 %	Health record
Peklar et al., 2017[52]	Ireland	Retrospective cohort	Outpatient	Population	People with ID	Data from Intellectual Disability Supplement to the Irish Longitudinal Study on Ageing	From register or database	IDS TILDA: Mild: 35.8 %, Moderate: 51.4 %, Severe/ Profound: 12.8 %	IDS-TILDA: 97.7 %; TILDA: 98.9 %	238	8081	50-59: 63.9 % 60–69: 28.2 % 70 or older: 8.0 %	50-59: 40.3 % 60–69: 31.7 % 70 or older: 28.0 %	Age and living status matched	TILDA: 39.7 %; IDS-TILDA: 42.5 %	Self-report
Noh et al., 2022[54]	Korea	Retrospective cohort	Outpatient	Outpatient	People wiith PWS	People diagnosed wiith Prader-Willi syndrome using methylation PCR	Diagnostic tool or clinical	NR	NR	68	204	24.5 (SD: 4.2)	24.5 (SD: 4.2)	Age-, sex- and BMI-matched	In PWS: 42.7 %	Health record
Nordstrøm et al., 2016[48]	Norway	Cross-sectional	Population	Outpatient	People with WS, PWS, DS	People diagnosed using molecular testing	Diagnostic tool or clinical	NR	NR	71	14,000	WS: 34.2 (SD: 5.4) PWS: 29.3 (SD: 5.3) DS: 29.4 (SD: 6.6)	20–43	NR	Williams syndrome: 67 %; Prader-Willi syndrome: 55 %; Down syndrome: 61 %	Blood pressure monitoring device or physical examiation
Oh Jong et al., 2020[55]	Korea	Cross-sectional	Outpatient	Outpatient	People with IMD	People registered as disabled in the local governments	From register or database	NR	NR	1448	372,565	30-49: 53.3 % 50–59: 29.9 % 60–69: 11.7 % 70–79: 5.1 %	30-49: 51.7 % 50–59: 27.3 % 60–69: 14.5 % 70–79: 6.5 %	$p = 0.302$	49.40 %	Health record
Real de Asua et al., 2014[56]	Spain	Cross-sectional	Outpatient	Outpatient	People with DS	People diagnosed by karyotype	Diagnostic tool or clinical	NR	NR	49	49	36 (SD: 11)	42 (SD: 13)	$p < 0.01$	Down: 43 %; Control: 61 %	Health record
Tyler et al., 2010[57]	United States	Nested case-control	outpatient	outpatient	People with IDD	People with ICD-9 (317–319, 343, 758, 299, 315.8, 315.9 and 742.4 [cerebral anomalies]) codes	Health record	Mild: 7.4 %, Moderate: 6.9 %, Severe: 3.3 %, Profound: 2.4 %	NR	1267	2534	38.8 (SD: 14.3)	38.9 (SD: 14.5)	Age-, sex-, race- and health insurance status-matched	IDD cohort: 46.3 %; control cohort: 46.5 %	Health record

ID: intellectual disabilities, NR: not reported, NS: not specified, ASD: autism spectrum disorder, DD: developmental disabilities, IMD: intellectual and mental disabilities, SD: standard deviation, DS: Down Syndrome, IDD: intellectual and developmental disabilities, MR: mental retardation, CP: cerebral palsy, PWS: Prader-Willi Syndrome, WS: Williams Syndrome, BMI: body mass index, ICD: International Statistical Classification of Diseases and Related Health Problems, PCR: polymerase chain reaction, FXTAS: Fragile X-associated tremor ataxia syndrome, FMR1: fragile X mental retardation 1.

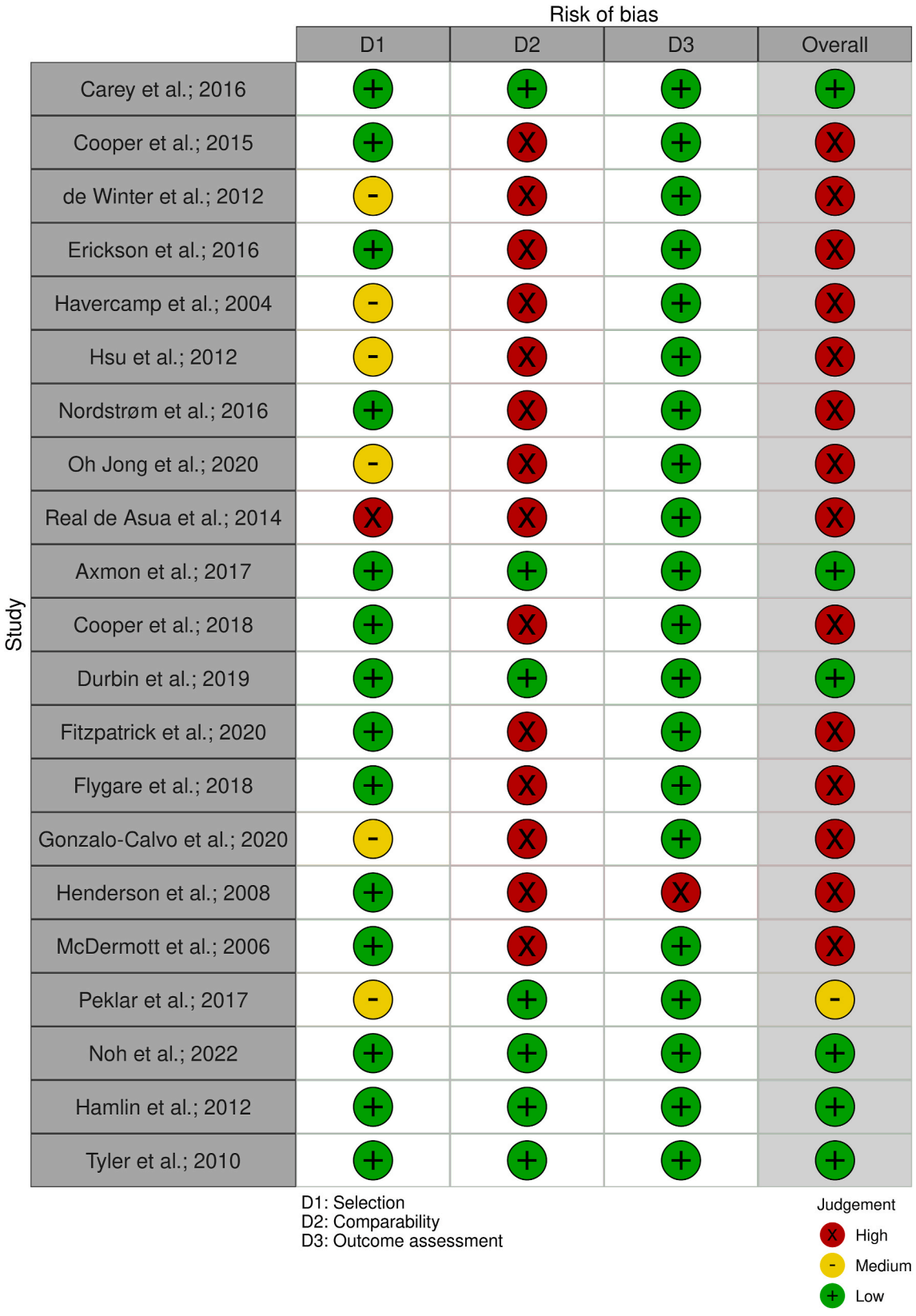

Fig. 2. Risk-of-bias assessment summary.

and 0.12–0.87, respectively). As opposed to studies that used a diagnostic tool or clinical assessment, which reported a 77 % higher prevalence of hypertension in adults with ID (average PR: 1.77; 95 % CI: 0.81–3.86). The high I^2 (99.2 %) for this explanatory variable indicates that nearly all variance in the true average PR is due to residual heterogeneity rather than sampling error. The test for moderators ($p = 0.04$) suggests significant differences in PRs across subgroups, with this variable accounting for 20.2 % of the variability (Appendix S24).

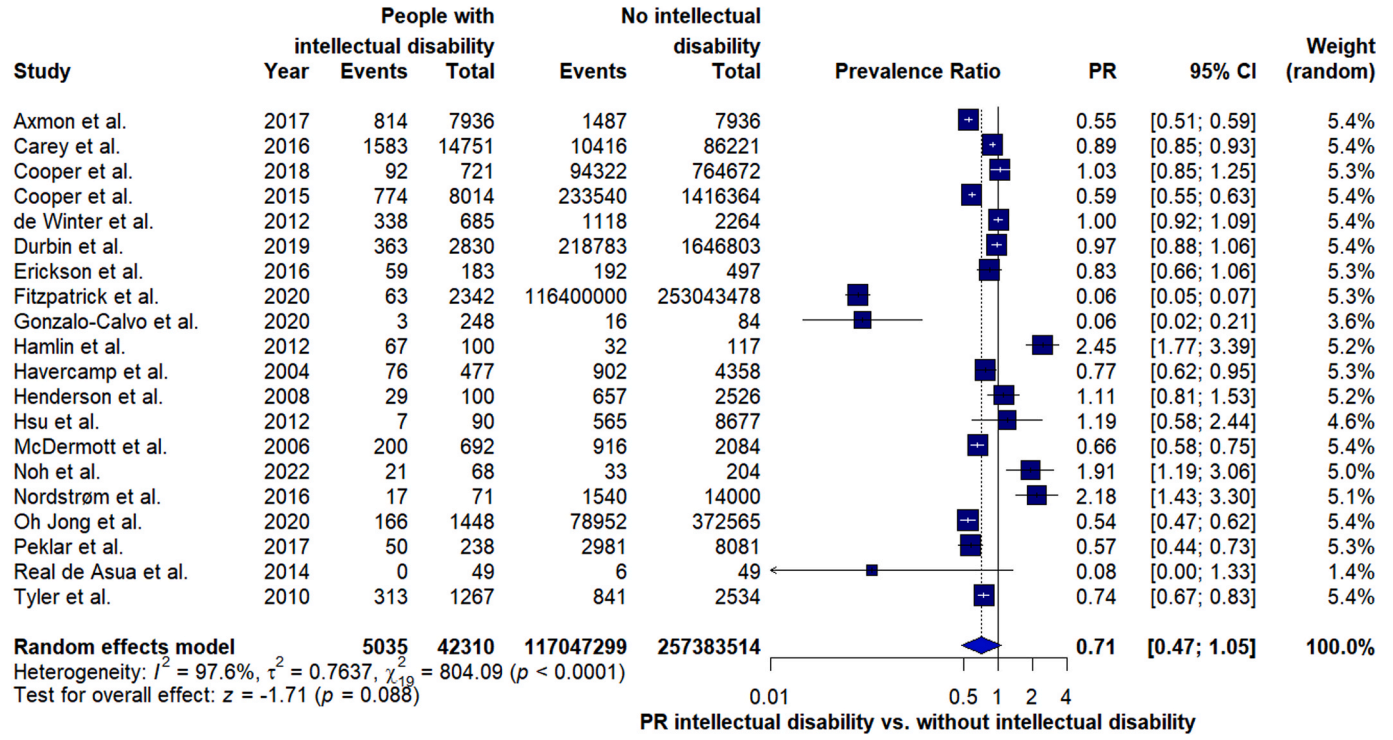

Fig. 3. Forest plot of hypertension prevalence in adults with intellectual disability compared to adults without intellectual disabilities. PR: prevalence ratio, CI: confidence interval.

A random-effects univariate meta-regression using 20 effect estimates found that sample size explained 64.8 % of the variation in PR between adults with and without ID. The model estimated that for each additional participant, the log PR decreased by 0.010 (95 % CI: −0.010 to −0.009; p < 0.001), indicating a strong inverse association (Appendix S24). A bubble plot (Appendix S25) shows a downward trend, reinforcing this relationship. Additionally, the I^2 (98.5 %) suggests that most variance in the true average PR stems from residual heterogeneity rather than sampling error.

3.8. Hypertension treatment coverage

The meta-analysis of hypertension treatment coverage included two studies[30,52] which comprised 7986 adults with ID and 10,917 adults without ID. The pooled unadjusted PR of hypertension treatment coverage in adults with ID compared to adults without ID indicates that the former group had 39 % lower treatment coverage (pooled unadjusted PR: 0.61, 95 % CI: 0.47–0.81; p < 0.001) compared to adults without ID. Despite the substantial heterogeneity of the studies (I^2 = 77 %; p = 0.04), a subgroup analysis or meta-regression for this outcome were not conducted due to the limited number of included studies (n = 2), which may not allow for an adequate estimation of the source of heterogeneity (Fig. 4).

4. Discussion

This systematic review and meta-analysis synthesised evidence on hypertension prevalence and treatment coverage among adults with and without ID across 10 countries in three regions. The findings suggest that hypertension prevalence appears lower in adults with ID; however, this may be due to the lack of age adjustment in most studies. In contrast, adults with ID have lower treatment coverage. Although this finding is based on a meta-analysis of two studies with considerable heterogeneity, it highlights a public health concern in a vulnerable population and highlights the need for further research that accounts for age differences. This reinforces the importance of Sustainable Development Goal 3.4, which aims to reduce premature mortality from noncommunicable diseases through prevention and treatment,[3] and aligns with the Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013–2020.[59]

The first meta-analyses in this study quantified the association between ID and hypertension prevalence. The confidence interval including the null value suggests weak statistical evidence, likely due to chance. However, this estimate is meaningless as there was no age adjustment. Age is crucial in chronic diseases and both populations.[60–62] Since age meets the three criteria for being a confounder, the lack of adjustment for it would lead to inconclusive results. This pattern aligns with the findings of Durbin *et al.*[44] The unadjusted PR showed no difference in hypertension prevalence between people with and without ID (PR: 0.97, 95 % CI: 0.88–1.06). In contrast, the age- and sex-adjusted PR indicated that adults with ID had a 42 % higher prevalence of hypertension compared to those without ID aged 19–65 years. Notably, the highest proportion of participants in this study were aged 26–49 years, emphasizing the impact of age adjustment on the estimated association. Also, in six of the included studies,[43,45,49,51,53,55,56] there were clear differences in mean age between adults with and without ID, with those with ID being younger. This age difference may lead to a lower prevalence of hypertension among adults with ID, potentially underestimating the true association of interest and emphasizing that age is a crucial confounder in this association. To further explore this issue, a sensitivity analysis was conducted comparing pooled estimates from age-adjusted studies to those from unadjusted studies. The results were consistent across both groups, with pooled estimates indicating no statistically significant difference in hypertension prevalence. While this suggests that age matching alone may not substantially alter the observed association, it does not rule out the presence of residual confounding, particularly in studies where age balance may have been partial or insufficiently reported.

As a secondary objective, the meta-analysis on hypertension treatment coverage showed that adults with ID had lower coverage than

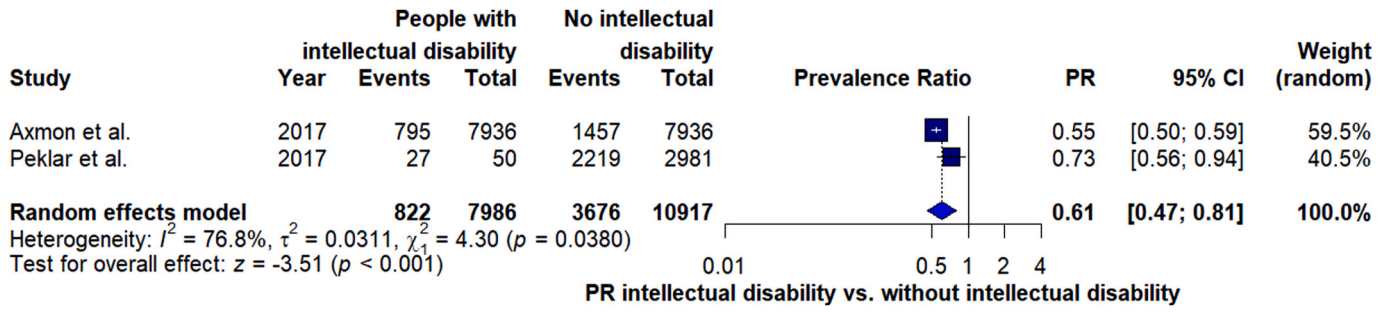

Fig. 4. Forest plot of hypertension treatment coverage prevalence in adults with intellectual disability compared to adults without intellectual disabilities. PR: prevalence ratio, CI: confidence interval.

those without disabilities. The confidence interval excluding the null value suggests statistical evidence for this association. However, with only two included studies and high heterogeneity, the robustness of these findings is limited. The small number of studies also prevents the identification of heterogeneity sources, as at least 10 studies are typically required for post-hoc analyses.[38] Similar to hypertension prevalence, this result should be interpreted cautiously due to the lack of adjustment for confounders. Nevertheless, this finding may serve as an initial step toward evaluating treatment access in a vulnerable population and addressing the personal, service delivery, and systemic barriers that people with ID encounter in achieving appropriate treatment and adherence.[63] The results of this meta-analysis underscore the urgent need for targeted interventions, as less than half of the global population currently has hypertension treatment coverage.[4]

Notably, the included studies varied in their methods for diagnosing and reporting ID, affecting result interpretation. Subgroup analysis showed that the pooled PR of hypertension differed depending on the ID diagnostic method. Meta-regression analysis revealed that nearly 20 % of the variability in effect estimates was due to diagnostic criteria. Some studies in the diagnostic tool or clinical judgment category included adults with ID alongside other conditions (e.g., chromosomal abnormalities, autism spectrum disorder), potentially increasing hypertension risk compared to adults with ID alone.[64] These contradictory results highlight the need for standardized, validated diagnostic approaches to ensure comparability across studies. Several guidelines recommend assessing both intellectual and adaptive function using standardized methods.[5,65–67]

Most included studies were from high-income countries, with only one from an upper-middle-income country. To strengthen policy-making and improve understanding, more research from underrepresented regions, such as low- and middle-income countries, is needed. ID prevalence is nearly twice as high in LMICs compared to high-income countries, and hypertension treatment coverage is significantly lower.[4,9] People with ID in LMICs face greater barriers to accessing healthcare for physical and mental comorbidities, leading to higher mortality rates than the general population.[68] Screening tools with adequate sensitivity and specificity are essential for accurate identification and to avoid misclassification bias.[69] However, stigma, social exclusion, discrimination, human rights violations, and cultural barriers pose additional challenges that future policies must address to improve healthcare access.[70] Furthermore, studies should include data disaggregated by age, sex, and ID severity to determine the direction and strength of the association with hypertension prevalence in both populations. Only two of the included studies conducted sex-specific analyses,[28,30] preventing subgroup analysis, and only five reported severity measures,[27,28,47,52,57] limiting the ability to assess dose-response relationships. Finally, future research should also incorporate outcomes relevant to hypertension control programs, such as uncontrolled hypertension prevalence, treatment coverage, and effective treatment coverage.[4] These measures enable comparisons between populations and provide a comprehensive perspective on a condition with a high global burden, informing targeted policies to mitigate its impact.

This systematic review and meta-analysis has several strengths and limitations. It is the first to address a major research gap concerning a chronic disease with inconsistent findings in the literature. Comprehensive searches were conducted using major bibliographic databases, including Global Index Medicus, which enhances the identification of studies from underrepresented regions.[71] Additionally, reference tracing identified seven studies that met eligibility criteria but were not retrieved in the initial search due to the absence of hypertension-related terms in titles and abstracts. This underscores the importance of reference screening in systematic reviews. Moreover, risk of bias assessment was performed using an adapted Newcastle-Ottawa Scale. Although only six of 20 studies were classified as having a low risk of bias, meta-regression analysis showed that bias classification did not affect the effect estimate. Furthermore, three studies that diagnosed hypertension based on self-reported data were included, which could have introduced misclassification bias of the outcome. However, similar to the risk of bias, the meta-regression analysis showed that the method of hypertension diagnosis did not affect the effect estimate. Finally, although 21 studies were eligible for the review, only two contributed to the meta-analysis of hypertension treatment coverage. Consequently, the robustness of these findings is limited, and heterogeneity could not be explored, so results should be interpreted with caution.

5. Conclusion

This systematic review and meta-analysis showed that adults with ID have a similar prevalence of hypertension, but lower hypertension treatment coverage compared to those without disabilities. However, these results should be interpreted with caution due to the lack of adjustment for confounding in the association and variability in the diagnosis of ID. Moreover, this study focused exclusively on adults and the association in children may be quite different. Strategies focused on the diagnosis and treatment of hypertension and ID should be prioritised in national agendas.

CRediT authorship contribution statement

Rodrigo Vargas-Fernández: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Akram Hernández-Vásquez:** Writing – review & editing, Investigation. **Hannah Kuper:** Writing – review & editing, Writing – original draft, Validation, Supervision, Conceptualization.

Data availability disclosure

No additional data are available.

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Conflicts of interest disclosure

We declare no competing interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dhjo.2025.101965.

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