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Global health inequalities of chronic kidney disease: a meta-analysis

Rachael Duff[1], Omodolapo Awofala[1], Muhammad Tahir Arshad[1], Emilie Lambourg[1], Peter Gallacher[2], Neeraj Dhaun[2] and Samira Bell[1]

[1]Division of Population Health and Genomics, School of Medicine, University of Dundee, Dundee, UK
[2]BHF/University Centre for Cardiovascular Science, University of Edinburgh, Edinburgh, UK
Correspondence to: Samira Bell; E-mail: s.t.bell@dundee.ac.uk

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ABSTRACT

Background. Chronic kidney disease (CKD) is a significant contributor to global morbidity and mortality. This study investigated disparities in age, sex and socio-economic status in CKD and updated global prevalence estimates through systematic review and meta-analysis.

Methods. Five databases were searched from 2014 to 2022, with 14 871 articles screened, 119 papers included and data analysed on 29 159 948 participants. Random effects meta-analyses were conducted to determine overall prevalence, prevalence of stages 3–5 and prevalence in males and females. Influences of age, sex and socio-economic status were assessed in subgroup analyses and risk of bias assessment and meta-regressions were conducted to explore heterogeneity.

Results. The overall prevalence of CKD was 13.0% [95% confidence interval (CI) 11.3–14.8] and 6.6% (95% CI 5.6–7.8) for stages 3–5. The prevalence was higher in studies of older populations (19.3% for stages 1–5, 15.0% for stages 3–5) and meta-regression demonstrated an association of age, body mass index, diabetes and hypertension with prevalence of stages 3–5. The prevalence of CKD stages 1–5 was similar in males and females (13.1% versus 13.2%), but the prevalence of stages 3–5 was higher in females (6.4% versus 7.5%). Overall prevalence was 11.4%, 15.0% and 10.8% in low-, middle- and high-income countries, respectively; for stages 3–5, prevalence was 4.0%, 6.7% and 6.8%, respectively. Included studies were at moderate–high risk of bias in the majority of cases (92%) and heterogeneity was high.

Conclusion. This study provides a comprehensive assessment of CKD prevalence, highlighting important disparities related to age, sex and socio-economic status. Future research should focus on targeted screening and treatment approaches, improving access to care and more effective data monitoring, particularly in low- and middle-income countries.

Keywords: CKD, global health, prevalence, systematic review

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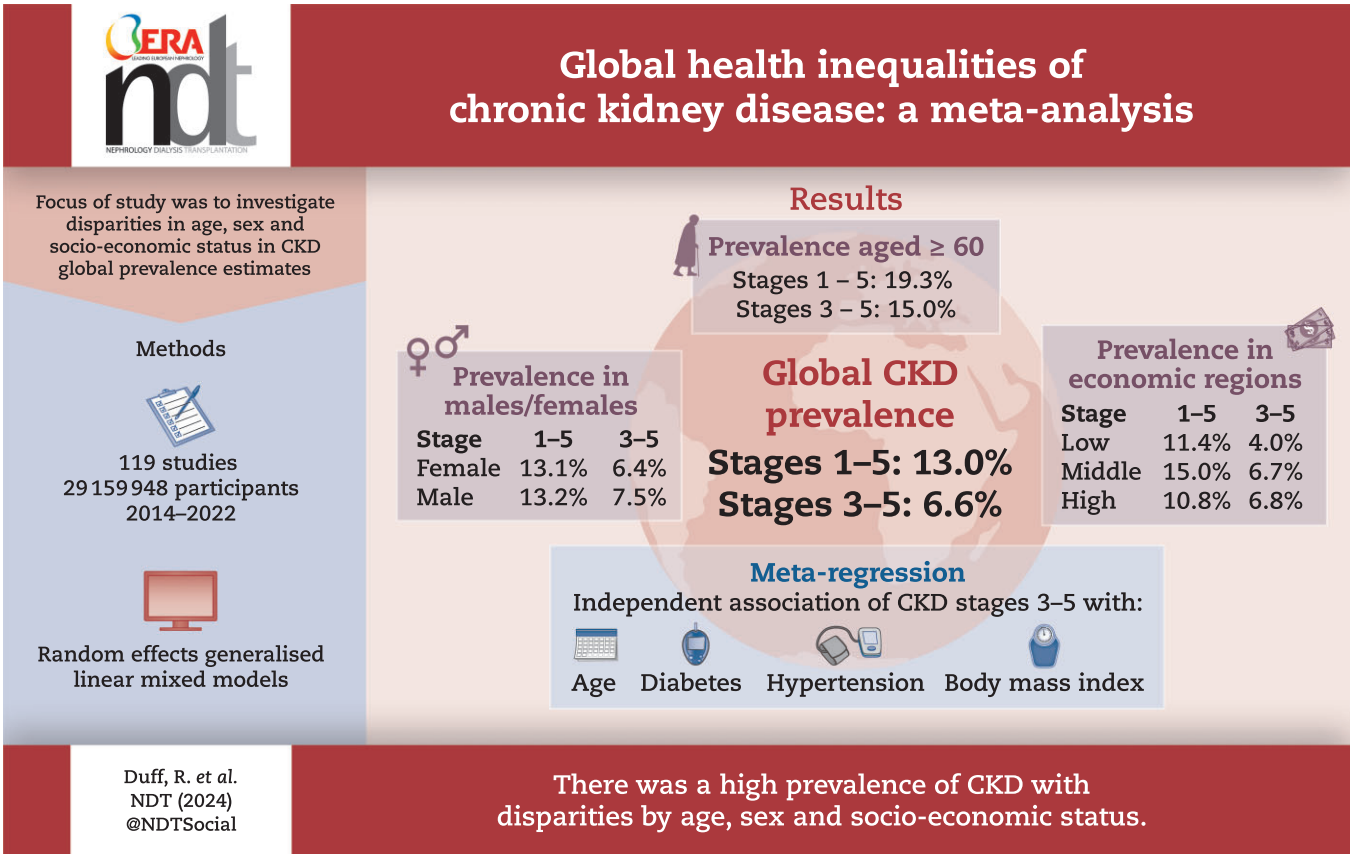
GRAPHICAL ABSTRACT



KEY LEARNING POINTS

What was known:

- The burden of CKD is increasing.
- Concerns about disparities in age, sex and socio-economic status exist.
- A clearer understanding of these elements is crucial for targeted research and interventions.

This study adds:

- This is the largest systematic review of CKD prevalence.
- Females and older age groups had a higher prevalence, with disparities across countries of differing socio-economic status.
- Compared with a previous systematic review, this study has a greater number of participants, with most included studies using the Chronic Kidney Disease Epidemiology Collaboration estimate.

Potential impact:

- Demonstration of significant disparities in age, sex and socio-economic status should encourage further research into understanding what is driving these differences.
- Research that considers these elements along with examining important outcomes such as mortality and quality of life will be instrumental in driving positive changes in global health.

INTRODUCTION

Chronic kidney disease (CKD) is a significant contributor to the healthcare burden globally. The Global Burden of Disease Study (2017) demonstrated a CKD prevalence of 9.1%, accounting for 35.8 million disability-adjusted life years (DALYs), with all-age mortality increasing by 41.5% from 1990 to 2017 and much of the burden concentrated in areas of lower socio-economic status [1]. Research shows healthcare costs of cardio-renal events are higher than those for atherosclerotic events and that CKD costs in excess of $114 billion in the USA and £1.45 billion in the UK annually [2, 3].

Age, sex and socio-economic status are considered influential in the development, progression and outcomes of CKD. Age is a well-established risk factor for developing CKD, but understanding the extent of the burden associated with an ageing population is crucial for effective screening and management. The influence of sex is less clear, with research indicating a higher prevalence of CKD in females but a greater prevalence of end-stage kidney

disease (ESKD) in males. Defining whether this is reflected globally is important to further understand gender gaps in CKD care. Lower socio-economic countries are also thought to have a greater burden of CKD, although there are challenges in assessing this due to limited access to data sources. Obtaining a comprehensive understanding of prevalence in countries of varying economic status would provide valuable insights into the level of work needed to bridge any disparities that exist.

The aim of this study was to update systematic review data [4] to determine current global prevalence estimates for CKD. A primary focus was to examine disparities associated with CKD, focusing on age, sex and socio-economic status. A better understanding of these factors will play a crucial role in guiding healthcare professionals, policymakers and the public in identifying priorities for intervention and research. By focusing efforts in these areas, the overall burden imposed by CKD can be reduced and the quality of life of patients can be improved.

MATERIALS AND METHODS

This study was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [5]. The protocol was registered on PROSPERO (CRD42022311032) [6].

Searches were carried out using MEDLINE, PubMed, Embase, Cochrane Controlled Register of Trials (CENTRAL), CINAHL and Web of Science, with search strategy developed with the assistance of a librarian. The search was carried out on 28 September 2022, limited to studies published since 2014 to avoid duplicating papers in a previous systematic review [4]. The search strategy consisted of free-text words and Medical Subject Headings terms (Supplementary Table S1). References of associated systematic reviews and included studies were searched, along with grey literature. Contact was made with authors if there was difficulty sourcing the full text or if details required clarification. References were screened using title and abstract by three reviewers (R.D., O.A. and M.A.) using Rayyan (Rayyan, Boston, MA, USA) [7]. Conflict was resolved by a fourth reviewer (S.B.). Following initial review, full-text assessment of all potentially suitable studies was carried out against pre-determined inclusion/exclusion criteria (Supplementary Table S2).

Studies in English or French that reported the prevalence of CKD or allowed prevalence to be calculated in participants ≥18 years of age and carried out in the general population were included. CKD was defined as the presence of albuminuria/proteinuria and/or an estimated glomerular filtration rate (eGFR) <60 ml/min/1.73 m^2. Definitions of CKD stages are provided in Supplementary Table S3. Studies were excluded if they only described CKD stages 1 and 2, were performed in a specialist population, included participants <18 years of age or did not describe CKD prevalence. Qualitative papers, case reports, case series and opinion pieces were excluded.

Data analysis

Data were fully extracted by three reviewers (R.D., O.A. and M.A.). Studies reported in French were translated and the data extracted by E.L. Key elements of the PICO (patient/population/problem, intervention, comparison and outcome) criteria are given in Supplementary Table S4. Conflict was resolved by a fourth reviewer (S.B.).

Risk of bias was assessed using criteria published by Stanifer *et al.* [8]. This tool was designed for assessing risk of bias in studies of CKD prevalence. It considers subject sampling, sampling technique, response and exclusion rates and the determination of kidney disease, enabling an overall assessment (Supplementary Methods). Assessment was carried out by three reviewers (R.D., O.A. and M.A.) and conflicts were resolved by a fourth reviewer (S.B.). All studies were included irrespective of their risk of bias.

Small-study effect was assessed using funnel plots. Logit-transformed prevalence was used against the standard error. Asymmetry was tested using Egger's [9] linear regression and Begg's [10] rank correlation tests. If there was evidence of publication bias, the trim and fill method [11] was used to calculate a corrected estimate.

Meta-analyses were conducted to determine overall CKD prevalence, prevalence of CKD stages 3–5, overall CKD prevalence in men/women and prevalence of CKD stages 3–5 in men/women. Meta-regressions were carried out to determine the association between the prevalence of CKD and population characteristics [age, sex, year, body mass index (BMI), diabetes, hypertension, smoking and obesity]. All meta-regressions were planned a priori.

For articles reporting multiple different prevalences of CKD using different methods of GFR estimation, Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) estimates were used if available. For articles reporting crude and adjusted prevalence, crude prevalence was used. If an article reported CKD prevalence in multiple populations, the populations were considered as separate estimates. Between-study heterogeneity was assessed by the Higgins and Thompson [12] I^2, with a value >75% representing a high level of heterogeneity.

Sensitivity analyses looked at the impact of outliers, influential articles and studies with a high risk of bias. Subgroup analyses were planned a priori, examining differences between regions, studies that looked at a limited age group, the difference in prevalence depending on a country's income status according to the World Bank [13] and studies of different quality. Subgroup analyses that assessed differences between articles that tested for chronicity, different methodologies, different definitions and crude versus adjusted prevalence were data driven. A sensitivity analysis looking at the prevalence of kidney replacement therapy (KRT) was planned but was not carried out due to insufficient data.

Statistical analyses were carried out using R (version 4.2.2; R Foundation for Statistical Computing, Vienna, Austria). Details of the R packages used are provided in Supplementary Methods. A random effects model was used for all meta-analyses. Models were built using a generalised linear mixed model (GLMM) [14]. A maximum likelihood estimator was used and a Q profile estimated tau and its confidence interval (CI) [15]. The Hartung–Knapp [16] method was used to adjust the CI of the overall estimate. Heterogeneity was explored with sensitivity analyses that used a basic outlier removal defined by Viechtbauer and Cheung [17], as well as the leave-one-out method sorted by effect size and I^2.

RESULTS

The search yielded 14 871 studies (Fig. 1) and 119 [2, 18–135] met the inclusion criteria. Of these, 12 studies [18, 21, 27, 41, 45, 48, 50, 69, 94, 101, 107, 112] used the same sources of data (National Health and Nutrition Examination Survey, Korea National Health and Nutrition Examination Survey, German Health Interview and

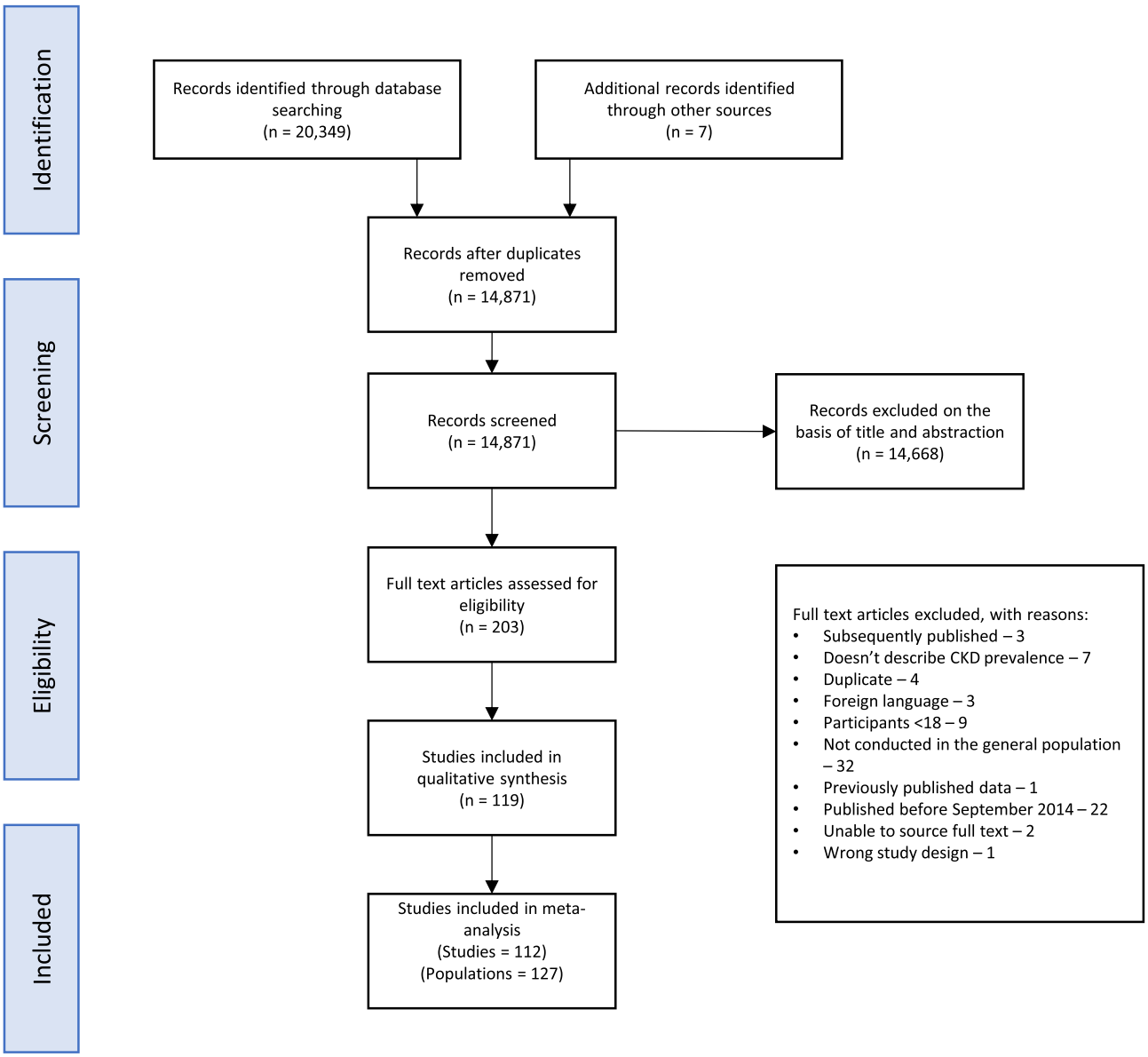


Figure 1: PRISMA flow chart.

Examination Survey for Adults 1 and Age, Gene/Environment Susceptibility Reykjavik Study) and subsequently one study covering each source of data was included [27, 48, 69, 101]. These studies were selected as they had already covered the data presented in the other studies [27, 101], had a larger sample size [48] or had presented the same data with a more comprehensive analysis [69]. The study by Bragg-Gresham *et al.* [94] was included, but only data from the Punjab survey was used within the meta-analysis. Five studies [2, 24, 39, 109, 122] had divided their population, and the separate populations were included as separate estimates, resulting in 127 estimates, comprising 29 159 948 participants. A total of 54 different countries provided data, with China providing the largest number of included studies (n = 14, number of participants 916 825) and low- and middle-income countries (LMICs) comprising a significant proportion of included studies but a small number of participants overall (n = 77, number of participants 1 141 602). The total number of studies and data obtained are detailed in Supplementary Table S5. Risk of bias was high across the included studies.

The prevalence of CKD stages 1–5 was 13.0% (95% CI 11.3–15.0) (Fig. 2). Prevalence estimates ranged from 2.3 to 47.7%, and heterogeneity was high (I^2 = 100%). The prevalence of CKD stages 3–5 was 6.6% (95% CI 5.6–7.8) (Fig. 3). The prevalence of specific CKD stages was also calculated where possible: stage 1, 3.0% (95% CI 2.1–4.3); stage 2, 2.9% (95% CI 2.2–3.8), stage 3A, 4.1% (95% CI 3.0–5.5); stage 3B, 1.3% (95% CI 1.0–1.8); stage 4, 0.4% (95% CI 0.3–0.5) and stage 5, 0.1% (95% CI 0.1–0.2).

The prevalence of CKD (stages 1–5) in males and females was 13.1% (95% CI 11.2–15.3) and 13.2% (95% CI 11.4–15.2), respectively (Fig. 4), whereas the prevalence of stages 3–5 was 6.4% (95% CI 4.9–8.3) and 7.5% (95% CI 5.8–9.8) in males and females, respectively (Fig. 5). Within a multivariable analysis for CKD stages 1–5, a higher proportion of females within the population was associated with an increased prevalence of CKD (Table 1).

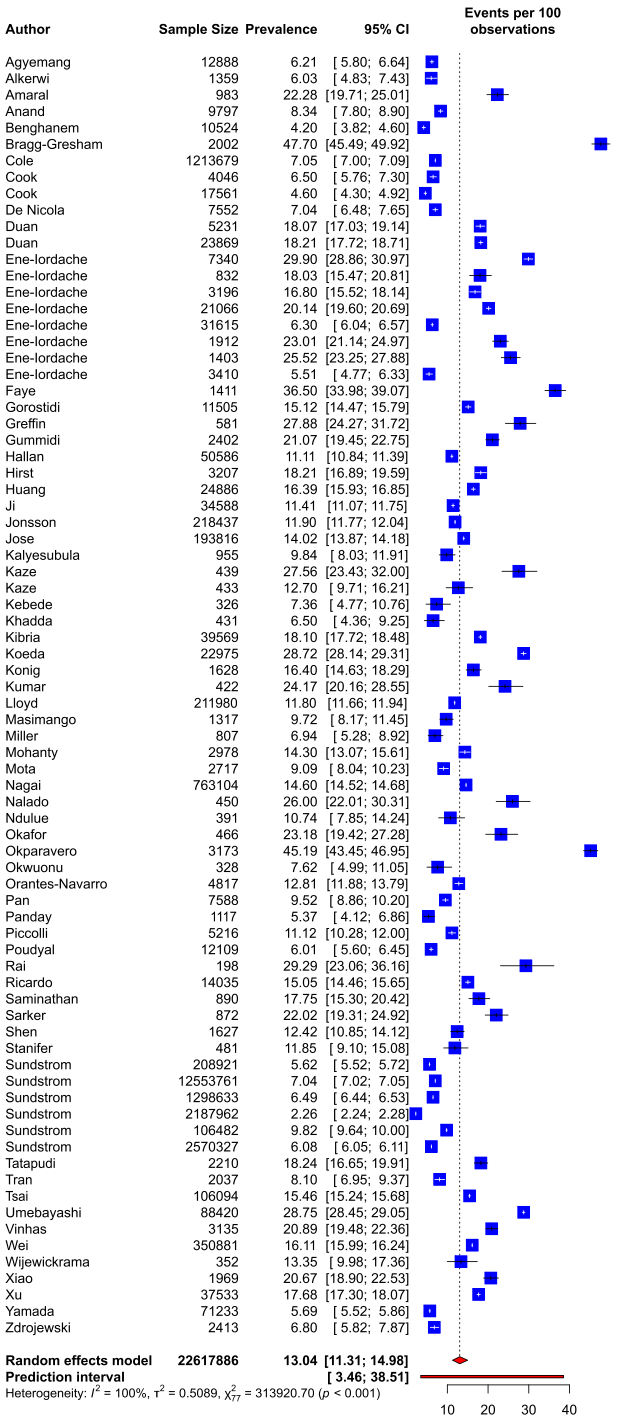


Figure 2: Pooled prevalence of CKD stages 1–5. GLMM.

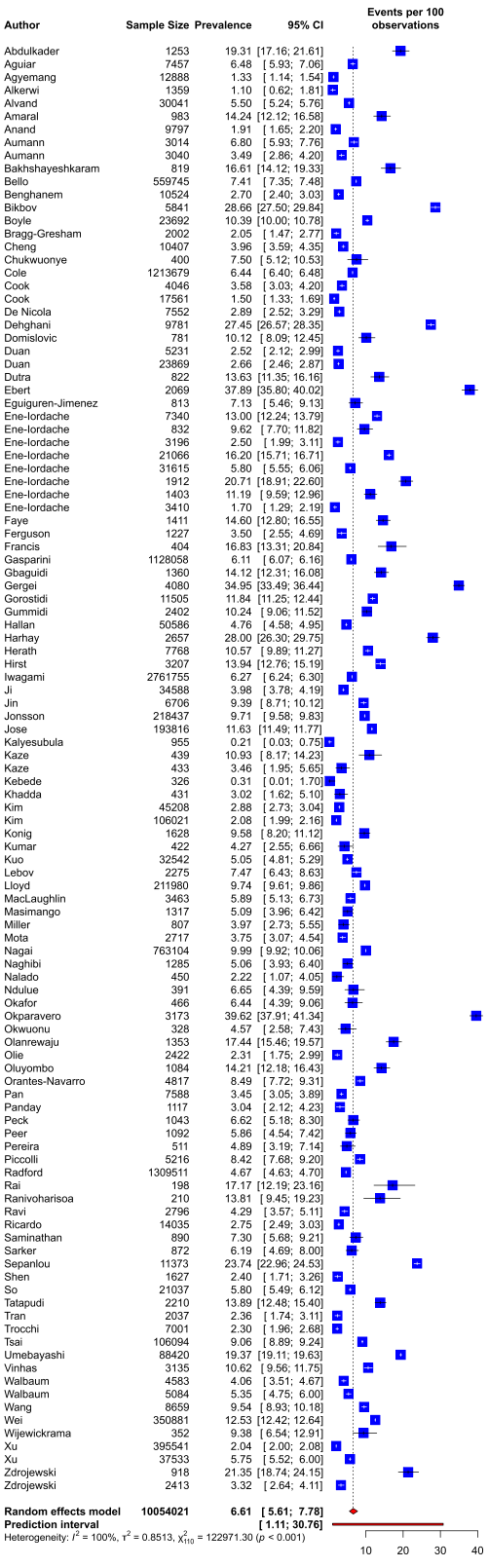


Figure 3: Pooled prevalence of CKD stages 3–5. GLMM.

There was a significant difference in studies that looked at an older population versus studies within the general population (Tables 2 and 3). For CKD stages 1–5, prevalence in studies carried out in the general population was 12.4% (95% CI 10.7–14.4), compared with 19.3% (95% CI 13.5–26.8) in studies carried out in participants ≥60 years of age (Table 2). Similarly, for stages 3–5, prevalence in studies carried out in the general population was 5.9% (95% CI 5.0–7.0), compared with 15.0% (95% CI 9.9–22.2) in those ≥60 years of age (Table 3). The mean age was significant in the multivariable analysis for stages 1–5 and the univariable analysis for stages 3–5 (Table 1). Subgroup analyses were also carried out looking at differences in the prevalence of specific CKD stages in general and older populations, with findings presented in Table 4.

There was a variation in prevalence for both stages 1–5 and stages 3–5 in countries of differing socio-economic status. For

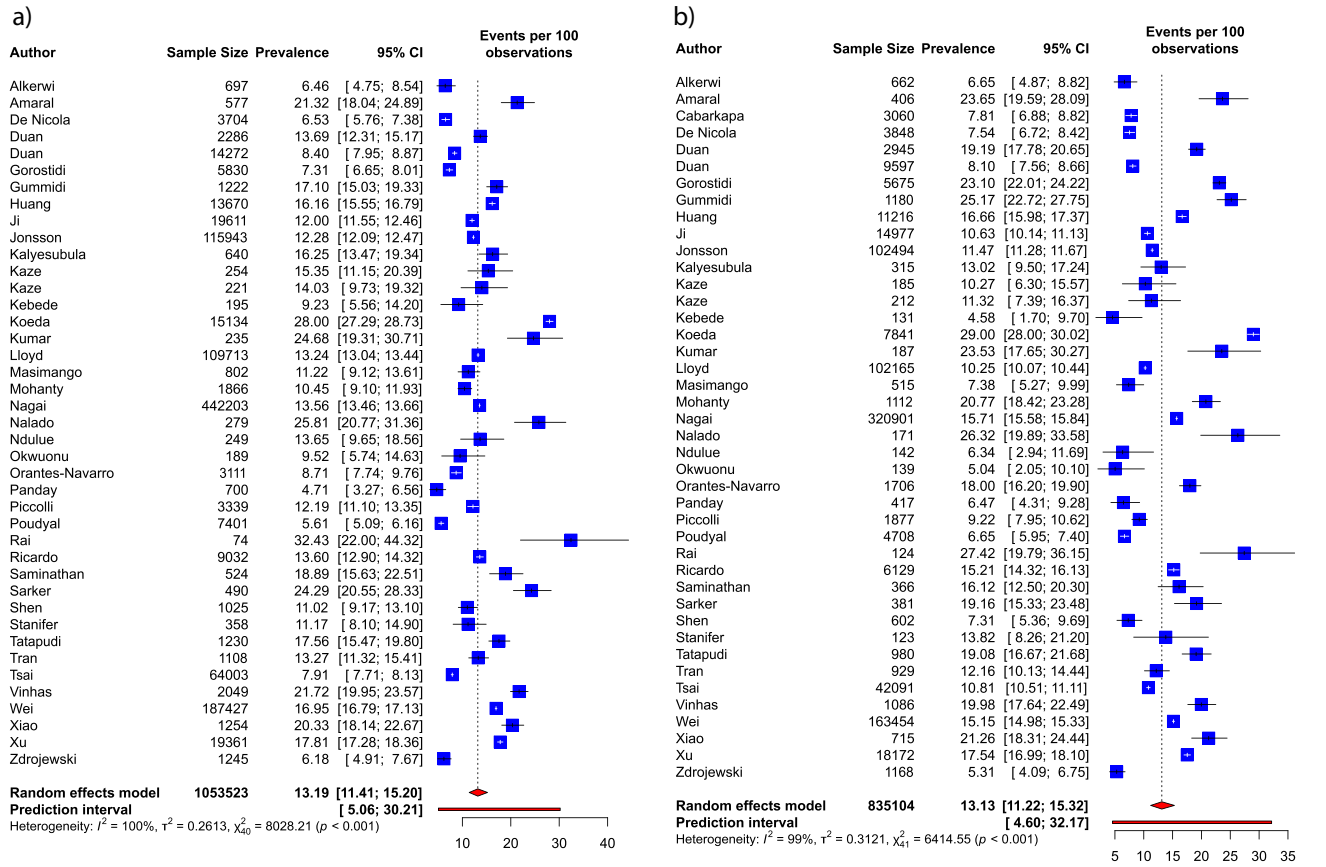


Figure 4: Pooled prevalence of CKD stages 1–5 in (a) females and (b) males.

stages 1–5, the prevalence was 10.8% (95% CI 8.3–13.8) in high-income countries, 15.0% (95% CI 12.6–17.9) in middle-income countries and 11.4% (95% CI 7.3–17.5) in low-income countries. For stages 3–5, the prevalence was 6.8% (95% CI 5.1–9.1) in high-income countries, 6.7% (95% CI 5.6–8.1) in middle-income countries and 4.0% (95% CI 0.8–17.2) in low-income countries (Fig. 6). The prevalence in different regions was also determined, as shown in Fig. 7. The results of full subgroup and sensitivity analyses are provided in Tables 2 and 3.

A total of 8% of studies had a low risk of bias, 48% had a high risk and 44% had a moderate risk. The response rate was not reported in 56% of the studies, 32% did not state their exclusion rate, 53% were not considered to be a representative sample, 36% were not recruited at random (Supplementary Figs. S2 and S3) and 20% tested for chronicity of kidney impairment. Subgroup and sensitivity analysis looked at the risk of bias and chronicity assessment. There was no difference between low, moderate and high risk of bias for either stages 1–5 or 3–5 (P = .48 and P = .76), although there was a difference between studies that tested for chronicity when looking at stages 1–5 (P = .01) (Fig. 8). For CKD stages 1–5, removing articles with a high risk of bias had little effect on the overall pooled prevalence [13.1% (95% CI 10.8–15.8)]. Similar results were also noted for CKD stages 3–5 when excluding studies with a high risk of bias [6.3% (95% CI 5.0–8.3)] (Supplementary Table S7). Chronicity assessment did not change the prevalence estimates for CKD stages 3–5 (Fig. 8).

Funnel plots assessing publication bias are shown in Supplementary Figs. S8 and S9. There was asymmetry when examining stages 1–5 using both the Egger's test (P = .005) and Begg's test (P = .001). There was no evidence of publication bias in the analysis for stages 3–5. Trim and fill results for stages 1–5 are detailed in Supplementary Table S8.

DISCUSSION

The burden of CKD is significant, with a prevalence of 13.0% for stages 1–5 and 6.6% for stages 3–5. Females had a higher prevalence of later-stage CKD compared with males (7.5% versus 6.4%), and studies that only investigated older participants (≥60 years) found a significantly higher prevalence of CKD. This was as high as 19.3% for CKD stages 1–5 and 15.0% for CKD stages 3–5. The highest prevalence of CKD stages 1–5 was in Asia (15.5%), whereas the highest prevalence of CKD stages 3–5 was in Australia and Oceania (8.1%). Europe has the lowest prevalence of CKD stages 1–5 (10.0%), while Africa had the lowest prevalence of CKD stages 3–5 (5.7%). High-income countries had the lowest prevalence of CKD stages 1–5 (10.8%), whereas low-income countries had the lowest prevalence of CKD stages 3–5 (4.0%). The risk of bias was significant and heterogeneity was high and there was evidence of publication bias. However, traditional methods to determine publication bias are not designed for observational studies of single proportions [136, 137].

CKD prevalence is similar between males and females, but later stage CKD is more common in females. Pre-dialysis CKD is more prevalent in females, but males make up a greater proportion of dialysis patients [138, 139]. Although a lower eGFR was previously considered less of a risk factor for CKD progression in females than in males, a meta-analysis found the risk of ESKD to be

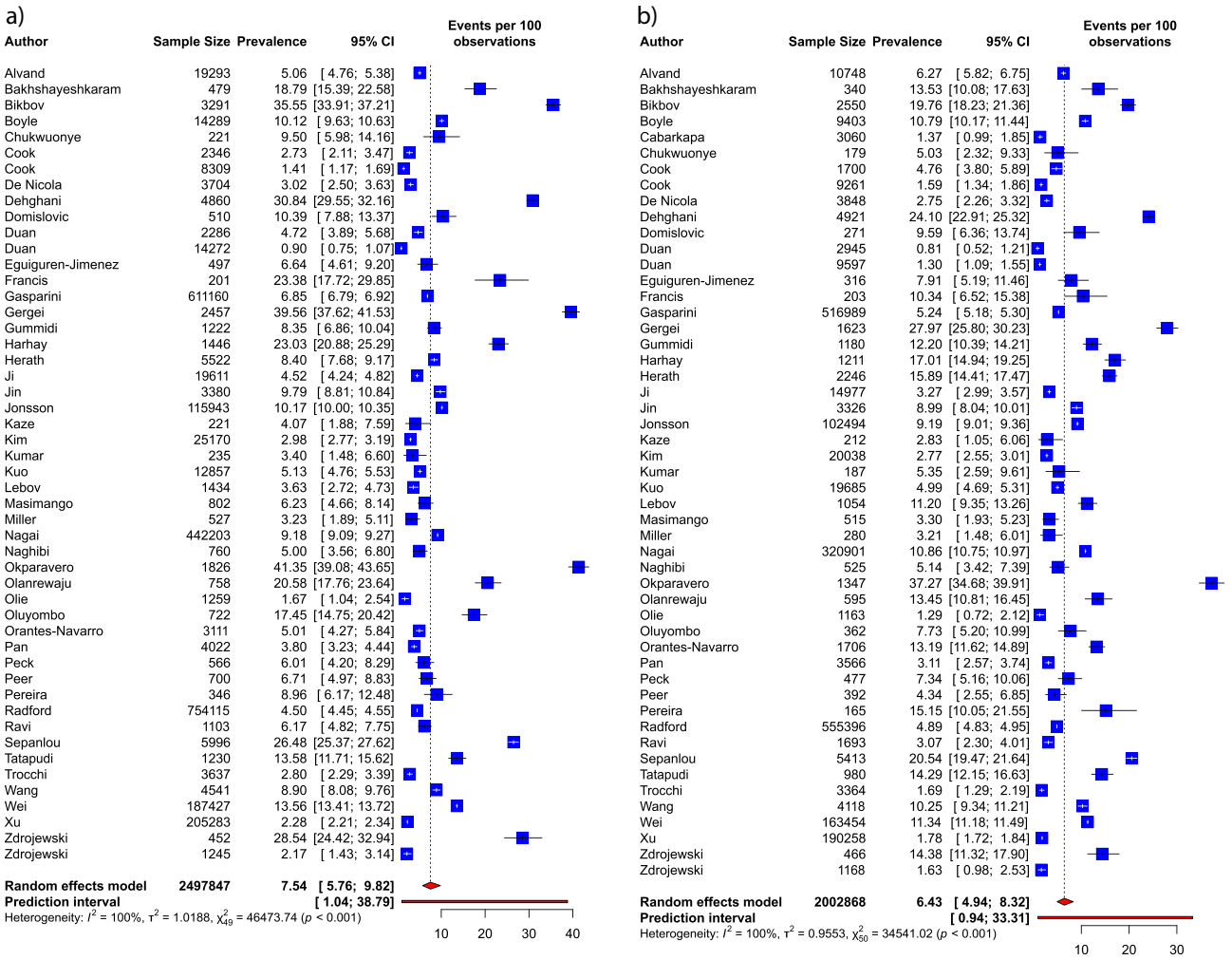


Figure 5: Pooled prevalence of CKD stages 3–5 in (a) females and (b) males.

Table 1: Meta-regression results.

Predictors	Age	Sex	Study period	Mean BMI	Diabetes	HTN	Smoking	Obesity
Stages 1–5								
Univariable	$P = .12$	$P = .14$	$P = .24$	$P = .96$	$P = .49$	$P = .15$	$P = .35$	$P = .78$
Multivariable	$P = .02$	$P = .04$	$P = .34$	$P = .69$	$P = .44$	$P = .64$	$P = .91$	$P = .89$
Stages 3–5								
Univariable	$P < .0001$	$P = .86$	$P = .37$	$P = .02$	$P = .003$	$P = .004$	$P = .94$	$P = .63$
Multivariable	$P = .0002$	$P = .46$	$P = .07$	$P = .09$	$P = .87$	$P = .88$	$P = .99$	$P = .56$

HTN: hypertension.
Multivariable analysis adjusted for age and sex.
Bubble plots for significant findings are shown in Supplementary Fig. S1.

equal [140]. There were insufficient data to define the prevalence of males and females on KRT, but the fact that females have a higher prevalence of CKD stages 3–5 demonstrates there may be a disparity between a higher risk of CKD and treatment in females. However, GFR estimating equations may overdiagnosis CKD in females, and the fact that they have a longer life expectancy may also explain these findings [138]. CKD is thought to progress faster in men, but women are less likely to be screened for CKD, have less access to specialist care and are more likely to choose conservative management [139, 141]. Addressing differences in mortality, overall comorbidities and discrepancies in access to KRT for males and females would help quantify whether this represents a greater burden of disease in females, and further research into psychosocial and behavioural elements that may be driving differences will guide what should be done to reduce this gap.

CKD prevalence was higher in older age groups. There was a higher prevalence of stages 3A and 3B in older populations, with no significant difference in stages 4 and 5. These findings are important given the greater risk of poorer outcomes in older patients with CKD stage 3B in particular [142]. The fact that stages 4 and 5 are similar in both general and older populations may also suggest a greater risk of poorer outcomes in older people at earlier stages

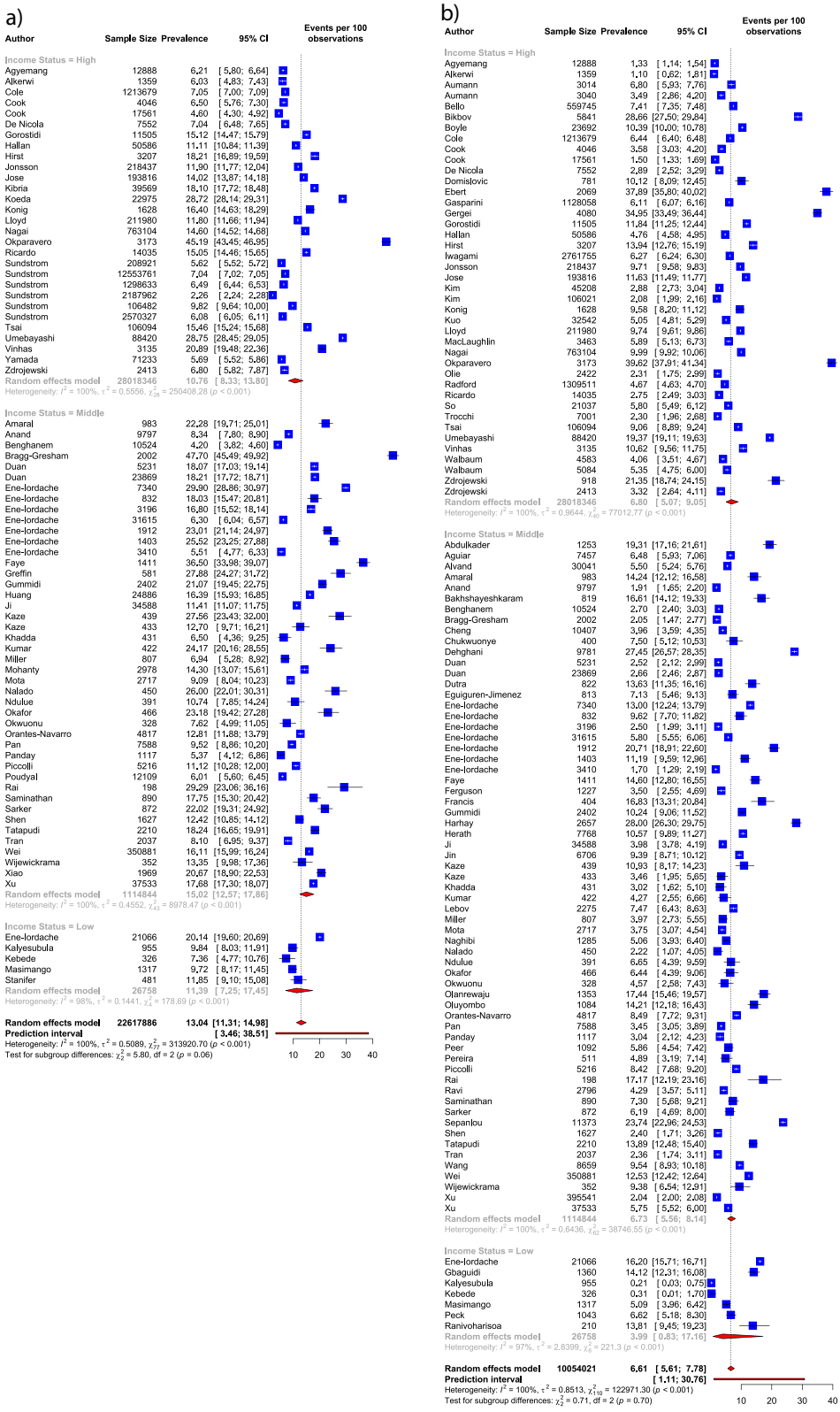


Figure 6: Pooled prevalence of CKD according to income status for (a) stages 1–5 and (b) stages 3–5.

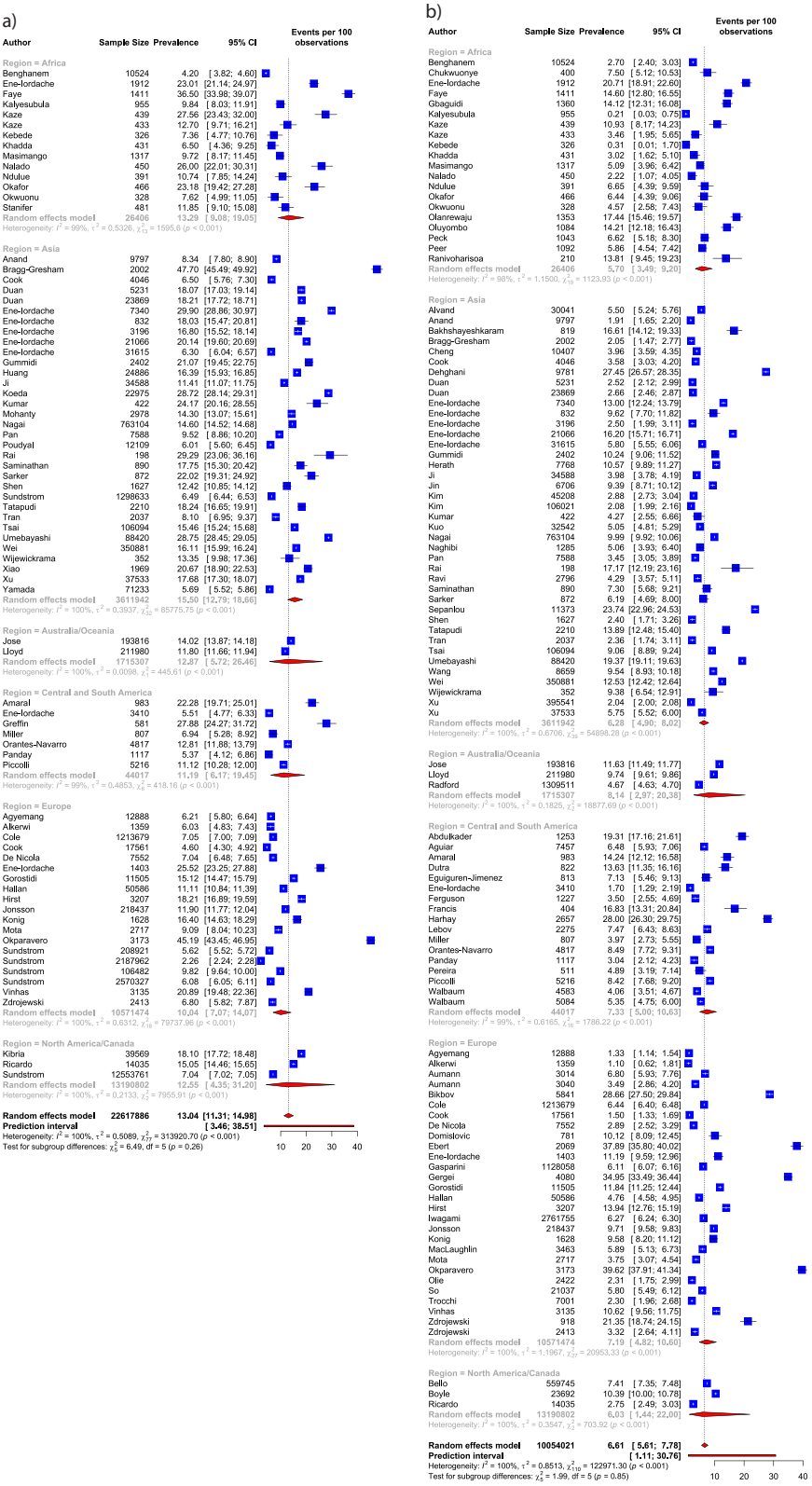


Figure 7: Pooled prevalence of CKD according to region for (a) stages 1–5 and (b) stages 3–5.

Table 2: CKD stages 1–5 subgroup analyses.

Analysis	Subgroup	Prevalence	95% CI	I^2 (%)	Subgroup difference
Region	Africa	13.4	9.1–19.1	99.2	Q = 6.5 P = .26
	Asia	15.5	12.8–18.7	100	
	Australia/Oceania	12.9	5.7–26.3	99.8	
	Central/South America	11.2	6.2–19.5	98.6	
	Europe	10.0	7.1–14.1	100	
	North America and Canada	12.6	4.4–31.2	100	
Risk of bias	High	13.0	10.5–16.0	100	Q = 1.5 P = .48
	Moderate	13.5	10.9–16.6	99.7	
	Low	10.5	6.3–17.1	99.6	
Test for chronicity	No	14.4	12.3–16.8	99.8	Q = 6.1 P = .01
	Yes	9.9	7.5–13.0	100	
Population income status	High	10.8	8.3–13.8	100	Q = 5.8 P = .06
	Middle	15.0	12.6–17.9	99.5	
	Low	11.4	7.3–17.5	97.8	
Methodology used	Random sampling	13.4	11.3–15.7	99.7	Q = 36.3 P < .0001 Q = 2.2 P = .33
	Routine dataset	10.6	7.3–15.1	100	
	Health camp recruitment[a]	25.2	7.3–59.1	63.8	
	Other	14.6	9.1–22.8	99.5	
Population age	General	12.4	10.7–14.4	100	Q = 6.7 P = .01
	≥60 years	19.3	13.5–26.8	99.7	
Adjusted prevalence	No	12.6	10.8–14.7	100	Q = 0.7 P = .40
	Yes	14.8	10.2–20.9	99.8	
eGFR estimating equation	MDRD	13.1	9.4–17.8	99.5	Q = 3.6 P = .16
	CKD-EPI	14.0	11.9–16.4	99.9	
	Other	8.8	5.0–14.8	100	

[a]This subgroup analysis was repeated by excluding health camp recruitment papers ($n = 2$) due to the significant difference in prevalence and subsequent influence on subgroup analysis.

of CKD. It is also possible that these findings could reflect overdiagnosis, and it is important to interpret these findings in the context of concerns regarding the validity of eGFR thresholds in older people [143]. A decreasing GFR occurs during the normal ageing process, and consensus on whether eGFR thresholds and their interpretation should be adapted for older people is important for differentiating normal ageing from true kidney damage [143, 144]. Changing thresholds may result in different prevalence estimates of CKD in older populations, which is important for optimising management and helping identify those at greatest risk. Mortality data are important, but increased screening in older populations and exploration of age-specific interventions to delay and ideally prevent the development and progression of CKD should also be considered.

There were geographical variations and disparities between low-, middle- and high-income countries. Low-income countries had the lowest overall prevalence of CKD stages 3–5 (4%), whereas high-income countries had the lowest prevalence of CKD overall (11%). Notably, the ages of these populations differed, with a mean age of 56.4 years in high-income countries, 49.3 years in middle-income countries and 38.3 years in low-income countries. The highest prevalence of CKD overall was in Asia, with Australia/Oceania having the highest prevalence of later-stage CKD. Australian data suggest that the high prevalence of CKD is likely due to an ageing population and increased survival of patients with ESKD receiving KRT [145]. Similarly, a lower prevalence of elderly people, as well as lower rates of testing, in low-income countries could explain the lower prevalence of CKD stages 3–5. It may also reflect the fact that people with advanced CKD in LMICs have a greater mortality, as they are unable to access KRT and other forms of treatment. Future work assessing differences in CKD mortality between high-income countries and LMICs would help quantify this further. Certain environmental factors may also contribute to CKD prevalence, but these are poorly understood [146].

A limitation of this review is the risk of bias within included studies. There was no difference in prevalence noted between studies at low-, moderate- and high-risk of bias, but the predominance of a moderate–high risk of bias within studies means that results must be interpreted with caution. The studies included were designed to represent the general population, but only half were considered truly representative, and there were concerns regarding reporting of the sampling techniques. CKD prevalence estimates at a population level are also influenced by variations in screening methods, eGFR measurement, CKD definitions and limitations of resources in some areas, thus pooled estimates and reported differences according to demographic factors should be interpreted with this in mind.

Despite attempts to standardise defining CKD, there continues to be variation. There were nine different GFR estimating equations used within the included studies (Supplementary Table S5), and even in studies using the CKD-EPI estimate, there were multiple variations of this, making comparability challenging. Standardising GFR estimating equations and any modifications used within published research is crucial for ensuring consistency, and this would be an important element to include within core outcomes expected to be reported in CKD prevalence

Table 3: CKD stages 3–5 subgroup analyses.

Analysis	Subgroup	Prevalence	95% CI	I^2 (%)	Subgroup difference
Region	Africa	5.7	3.5–9.2	98.3	Q = 2.0 P = .85
	Asia	6.3	4.9–8.0	99.9	
	Australia/Oceania	8.1	3.0–20.4	100	
	Central/South America	7.3	5.0–10.6	99.1	
	Europe	7.2	4.8–10.6	99.9	
	North America and Canada	6.0	1.4–22.0	99.7	
Risk of bias	High	7.0	5.6–8.8	100	Q = 0.6 P = .76
	Moderate	6.4	5.0–8.2	99.8	
	Low	5.8	3.0–11.1	99.8	
Test for chronicity	No	6.6	5.2–8.0	99.9	Q = 0 P = .99
	Yes	6.6	5.2–8.3	99.9	
Population income status	High	6.8	5.1–9.1	99.9	Q = 0.7 P = .70
	Middle	6.7	5.6–8.1	99.8	
	Low	4.0	0.8–17.2	97.3	
Methodology used	Random sampling	6.1	5.1–7.4	99.7	Q = 4.8 P = .19
	Routine dataset	7.7	5.4–10.9	100	
	Health camp recruitment	10.5	0.01–94.4	94.2	
	Other	10.4	4.4–22.4	99.9	
Population age	General	5.9	5.0–7.0	99.8	Q = 19.4 P < .0001
	≥60 years	15.0	9.9–22.2	99.9	
Adjusted prevalence	No	6.6	5.5–7.9	99.9	Q = 0.6 P = .43
	Yes	5.4	2.9–9.6	99.0	
eGFR estimating equation	MDRD	6.9	4.8–9.9	99.8	Q = 0.1 P = .96
	CKD-EPI	6.5	5.4–7.9	99.9	
	Other	6.7	2.9–14.4	99.9	

Table 4: Subgroup analyses determining differences in prevalence in all CKD stages in general versus older (≥60 years) populations.

CKD stage	Population	Prevalence (%)	95% CI	I^2 (%)	Subgroup difference
1	General	3.2	2.2–4.5	99.8	Q = 0.6
	Older	2.0	0.3–11.4	99.4	P = .44
2	General	2.8	2.0–3.8	99.8	Q = 4.6
	Older	4.1	3.0–5.5	97.1	P = .03
3A	General	3.7	2.7–5.0	99.9	Q = 8.0
	Older	10.7	3.6–28.2	99.8	P = .0047
3B	General	1.2	0.9–1.6	99.7	Q = 7.1
	Older	3.9	1.0–13.6	99.7	P = .0076
3	General	4.7	3.7–6.0	99.9	Q = 8.9
	Older	11.8	5.9–22.1	99.9	P = .0029
4	General	0.4	0.3–0.5	99.0	Q = 0.4
	Older	0.5	0.2–1.2	98.1	P = .518
5	General	0.1	0.1–0.2	95.7	Q = 4.2
	Older	0.1	0.1–0.1	61.6	P = .0397

studies. Other important outcomes should include reporting of key demographic data such as race and standardised reporting of prevalence by age. Race and ethnicity are associated with differences in measured and estimated GFR, but only 22 studies provided data on the race of participants, and there was no consistency in the reporting of CKD prevalence by age, which meant that a more accurate assessment in this review was not possible.

Only 20% of articles assessed chronicity, and there was a notable difference in prevalence when comparing CKD stages 1–5 in studies that considered this versus those that did not. An expectation that researchers include a chronicity assessment is crucial. The vast majority of studies were cross-sectional, which can limit understanding of the chronic nature of CKD. Routine datasets such as primary care databases, laboratory databases and renal registries provide valuable sources of data that are capable of generating large sample sizes and should be utilised to allow researchers to distinguish CKD from acute kidney injury. Enhancing funding for national screening programs that are designed to ensure chronicity is assessed would also be valuable. Improved collaboration on an international scale and consideration of how these methods of data monitoring can be extended to areas with more limited resources is crucial. Greater investment in training of healthcare professionals, researchers and community workers in LMICs to understand the risks of CKD and the value of accurate monitoring in their population is needed, along with improved public health campaigns, better integration with primary care and consideration of low-cost point-of-care testing to enable monitoring in areas that are harder to engage. This would improve the quality of global surveillance networks and enable a greater focus on longitudinal assessment of CKD.

The prevalence of CKD overall was not different from that in a previous systematic review [4], although the prevalence of stages 3–5 was notably lower in the current study. This may be due to the higher proportion of CKD-EPI eGFRs used. Sensitivity analysis did not demonstrate a difference between studies using Modification of Diet in renal Disease (MDRD) estimates of GFR

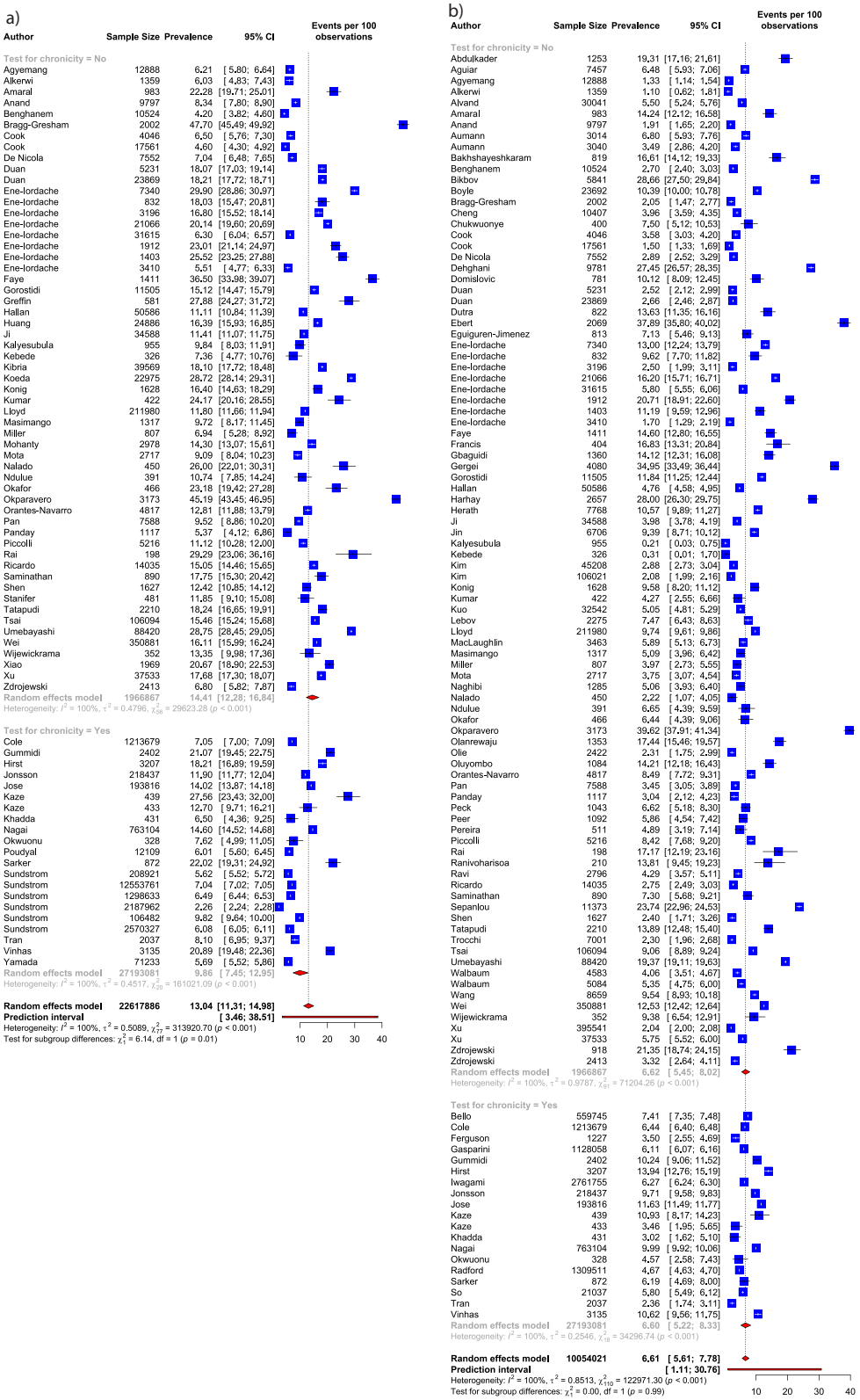


Figure 8: Pooled prevalence of CKD according to chronicity assessment for (a) stages 1–5 and (b) stages 3–5.

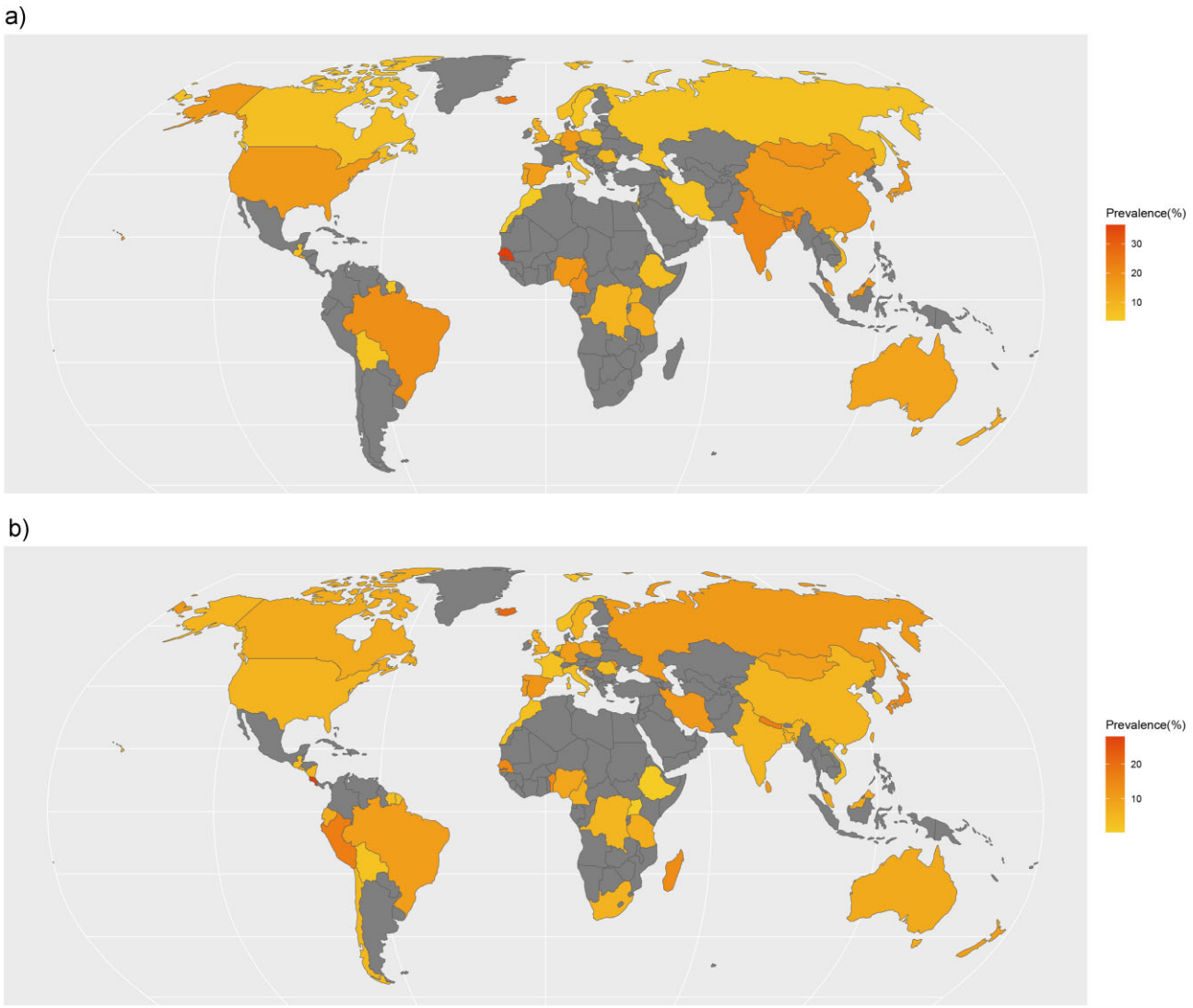


Figure 9: Heatmap of global CKD prevalence for (a) stages 1–5 and (b) stages 3–5. Grey: no data available.

and those using CKD-EPI. However, this analysis is limited by only 29 of the 127 population estimates included having used the MDRD definition. Of note, the previous review showed a higher prevalence of CKD in females, and it is concerning that in the almost 10 years between these reviews, this discrepancy remains.

This review extends previous work in several ways. It provides the most up-to-date global prevalence estimate for CKD, with most studies making use of the CKD-EPI estimate of GFR. It demonstrated significant health inequalities affecting CKD prevalence, and addressing these concerns should be a priority for policymakers. A large number of studies were included, covering prevalence across all worldwide regions. Compared with a previous systematic review [4], this review was able to demonstrate the prevalence of all CKD stages, including separate estimates for 3A and 3B, which are important to differentiate given the greater risk associated with stage 3B [142]. The search strategy was comprehensive and articles published in both English and French were included to reduce bias caused by including only studies reported in English.

CONCLUSION

Global CKD prevalence remains high, with significant gaps across age, sex and socio-economic status. Future research that focuses on understanding the reasons for these disparities and considers interventions that are needed to drive improvements will be important in reducing the overall burden from this condition.

SUPPLEMENTARY DATA

Supplementary data are available at *ndt* online.

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AUTHORS' CONTRIBUTIONS

S.B. conceived and supervised the study. R.D., O.A. and M.A. screened the studies, extracted data and completed the risk of

bias assessment. E.L. translated articles in French. R.D. carried out the statistical analysis and wrote the first draft of the manuscript. R.D., S.B., E.L., P.G. and N.D. interpreted the findings. All authors critically reviewed the manuscript and approved the final version.

DATA AVAILABILITY STATEMENT

All data were extracted from published studies and most data used are supplied in Supplementary Table S5. Access to the full set of data will be made available upon request.

CONFLICT OF INTEREST STATEMENT

R.D., O.A., M.A., E.L., P.D. and N.D. report no conflicts of interest. S.B. reports consultancy fees from AstraZeneca, Bayer and GSK.

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