Nephrol Dial Transplant (2012) 27: 1812–1821
doi: 10.1093/ndt/gfr547
Advance Access publication 29 September 2011

Original Articles

NDT
Nephrology Dialysis Transplantation

Measuring the population burden of chronic kidney disease: a systematic literature review of the estimated prevalence of impaired kidney function

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Abstract

Background. Internationally, there have been substantial efforts to improve the early identification of chronic kidney disease (CKD), with a view to improving survival, reducing progression and minimizing cardiovascular morbidity and mortality. In 2002, a new and globally adopted definition of CKD was introduced. The burden of kidney function impairment in the population is unclear and widely ranging prevalence estimates have been reported.

Methods. We conducted a systematic literature review, searching databases to June 2009. We included all adult population screening studies and studies based on laboratory or clinical datasets where the denominator was clear. Studies reporting prevalence estimates based on at least one eGFR <60 mL/min/1.73m^2 or elevated creatinine above a stated threshold were included. Study design and quality were explored as potential factors leading to heterogeneity.

Results. We identified 43 eligible studies (57 published reports) for inclusion. Substantial heterogeneity was observed with estimated prevalence (0.6–42.6%). The included studies demonstrated significant variation in methodology and quality that impacted on the comparability of their findings. From the higher quality studies, the six studies measuring impaired kidney function (iKF) using estimated glomerular filtration rate in community screening samples reported a prevalence ranging from 1.7% in a Chinese study to 8.1% in a US study, with four reporting an estimated prevalence of 3.2–5.6%. Heterogeneity was driven by the measure used, study design and study population.

Conclusion. In the general population, estimated iKF, particularly eGFR 30–59 mL/min/1.73m^2 was common with prevalence similar to diabetes mellitus. Appropriate care of patients poses a substantial global health care challenge.

Keywords: chronic kidney disease; population health; prevalence; systematic literature review

Introduction

The prevalence of treated end-stage renal disease has increased globally over the last two decades [1]. A continued increase in disease burden is predicted; a consequence of rising diabetes and an ageing population. Internationally, efforts have been made to improve early identification, with a view to improving survival, reducing progression and minimizing cardiovascular morbidity [2].

Traditionally, practice relied on measurement of serum creatinine as a marker for kidney function but limitations in the test, along with the lack of a consistent definition for chronic kidney disease (CKD), limited its usefulness for describing the population burden of disease. Guidelines in 2002 included a classification system for CKD based on impaired kidney function (iKF) determined by glomerular filtration rate (GFR) and evidence of kidney damage (Table 1) [3]. Stages 3–5 CKD was defined by blood test estimation of GFR alone (eGFR). The classification system has become widely accepted internationally.

A large US population health survey reported in excess of 4% of the general population may have iKF (eGFR <60 mL/min/1.73m^2) [4]. Despite the introduction of a clear definition, a wide range of estimates of prevalence have been reported with some reporting as high as 42% [5].

The uncertainty around the burden of CKD, in terms of prevalence of iKF, presents a major challenge for planning health services. Understanding why such diversity of prevalence estimates has been reported is critical for understanding the condition. Here, we report the findings of a systematic literature review exploring the prevalence of iKF.

Materials and methods

Data sources and searches

The electronic databases MEDLINE (1960) and EMBASE (1980) were searched through to June 2009 and limited to English language. A sensitive search strategy was constructed using a combination of Medical Subject Heading terms and keywords for CKD combined with terms for

Table 1. Kidney Disease Outcomes Quality Initiative (KDOQI) definition of CKD stages[a]

CKD stages	Definition
Stage 1	Kidney damage[b] with normal or raised GFR (90 mL/min/1.73m^2)
Stage 2	Kidney damage[b] with mildly impaired GFR (60–89 mL/min/1.73m^2)
Stage 3	Moderately impaired GFR (30–59 mL/min/1.73m^2)
Stage 4	Severely impaired GFR (15–29 mL/min/1.73m^2)
Stage 5	End-stage renal failure or GFR < 15 mL/min/1.73m^2

[a]Classification requires the sustained impairment in GFR for at least 3 months.
[b]Kidney damage: persistent proteinuria; persistent haematuria (after exclusion of other causes, e.g. urological disease); structural abnormalities of the kidneys demonstrated on ultrasound scanning or other radiological tests or biopsy-proven chronic glomerulonephritis.
Classification requires the sustained impairment in GFR for at least 3 months.

Box 1. Example search strategy for MEDLINE (modified for EMBASE)

MEDLINE
1. Kidney Disease.mp. or exp Kidney Diseases/
2. Chronic Disease.mp. or exp Chronic Disease/
3. 1 and 2
4. Kidney failure, chronic.mp. or exp Kidney Failure, Chronic/
5. Renal insufficiency,chronic.mp. or exp Renal Insufficiency, Chronic/
6. Uremia.mp. or exp Uremia/
7. Kidney Failure/
8. Chronic kidney disease .mp.
9. 3 or 4 or 5 or 6 or 7 or 8
10. exp Morbidity/*
11. 9 and 10

Restricted to: published in English.

*MeSH term 'Morbidity' includes: incidence, prevalence as sub-headings.

prevalence (Box 1). The reference lists of included studies and systematic reviews were searched.

Study selection

Titles and abstracts were screened for inclusion by an experienced nephrologist. Two researchers independently reviewed each full paper to determine inclusion based on predefined criteria. We included population-screening studies estimating the community prevalence of CKD. Studies estimating the size of the CKD population in clinical practice, from laboratory or other data (provided there was clarity on the nature of the population tested), were also included. All age ranges were included except exclusively paediatric populations. Studies that excluded subjects with particular medical conditions or studies restricted to high-risk groups were excluded.

We defined 'iKF' as the demonstration of reduced GFR or estimated GFR (<60 mL/min/1.73m^2), creatinine clearance (<60 mL/min) or raised serum creatinine (above a predefined threshold as specified by the authors of included studies) on one or more occasion. CKD and CKD stage were only used in relation to studies measuring at least two eGFRs at least 3 months apart. Studies restricted to end-stage kidney disease (including those using a serum creatinine threshold of 200 μmol/L or more) were excluded. Studies were also excluded if they considered only proteinuria or other markers of kidney damage, without reference to creatinine or GFR, or if they identified cases using only diagnostic clinical codes.

Data extraction and quality assessment

One researcher extracted information from the included studies using a specifically designed data extraction template. Where a study reported prevalence estimates for >1 year, the most recent data were reported. Where multiple estimates based on different methods of measuring GFR were reported, data related to one method were extracted; in these cases estimating equations were used in preference to creatinine thresholds and the Modification of Diet in Renal Disease (MDRD) formula in preference to the Cockcroft-Gault (C-G) formula. Data extraction was checked for accuracy by a second researcher and any discrepancies were resolved by referral to the original text.

We assessed the quality of each of the included studies, reporting descriptively but not using quality to exclude studies. There were three quality issues of particular importance:

Representativeness of sampling. For community screening studies, a priori, we pragmatically set a response rate (including acceptance of a blood test) of at least 55% of those originally invited as an indicator of good quality. We knew that two many-cited population surveys had reported response rates of 56 and 65% and so took the lower threshold to be our cut-off [4, 6]. Data collected as part of routine practice were deemed of good quality where it was clear that all routine data were accessible for a well-defined community population. In addition, for all studies, the time period for screening or data collection had to be clear and reasonable; again in a large representative US population survey, screening took place over a 6-year period and we took this as an upper limit for good quality [4].

Chronicity. Where studies determined chronicity by applying a definition of CKD based on greater than one sample (at least 3 months apart), this was considered to be an indicator of higher quality.

Minimizing potential serum creatinine assay biases. Direct measurement of GFR by inulin clearance or isotope methods, while accurate, is not practical in population studies or routine practice. GFR can be estimated (eGFR) from serum creatinine by a variety of formulae; the two most commonly used being the C-G equation for estimating creatinine clearance and the four-variable MDRD equation.

Traditional uncompensated Jaffe creatinine assays systematically overestimate serum creatinine to varying degrees compared with the gold standard isotope dilution mass spectrometry (IDMS) method. When the C-G equation is applied in prevalence studies, regardless of the assay type used, there is no method of accounting for between-assay biases. The MDRD equation was derived more recently using an uncompensated Jaffe assay [7] and calibration directly to the MDRD laboratory has been possible to minimize assay bias effect. Alternatively, researchers can use minimally biased assay (i.e. wet enzymic assays, a compensated Jaffe assay or IDMS) or calibration to such in combination with the correct version of the MDRD equation to account for assay bias [8, 9].

Where studies performed well on at least two of the three criteria above, they were considered to be of higher quality.

Analysis

The results from data extraction were tabulated and summarized graphically. We have reported the data descriptively providing a general overview of prevalence and reporting by age group, race and gender, where available. In order to explore heterogeneity in reported prevalence, a scatter plot of prevalence against standard error of the prevalence was plotted and the findings were then explored by the sub-groups below.

Sub-groups

(1) Representativeness: population versus restricted samples; community screening versus routine clinical laboratory testing; other sampling issues.
(2) Chronicity: single versus at least two samples 3 months apart.
(3) Laboratory technique: estimating equations versus creatinine threshold; bias minimized versus high potential for bias.

Finally, the results, restricted only to high quality studies, were presented. All tabulations and graphs were created in MS Office Excel 2007.

Results

We identified 58 reports, from 43 studies, for inclusion (Figure 1) and two systematic reviews [10, 11]. Checking the reference lists of the systematic reviews and included studies did not yield additional studies.

The 43 studies are summarized in Supplementary Table S1 (available online) along with methodological quality. Duplicates are noted.

Nine studies were from the USA [4, 6, 17, 29, 41, 42, 62, 65, 66] and the remainder represents a wide range of countries across Europe, Asia, Central America and Australia. No studies were published prior to 1998.

Thirty-three studies concerned screening tests performed in the community and 10 were based on laboratory results recorded as routine health care data [56, 58–66]. Eleven studies were considered to be of high quality in relation to representativeness, chronicity and minimization of assay biases [4, 17, 27, 30, 37, 45, 55, 59, 61, 65, 66].

Prevalence: a general overview

The prevalence results are summarized in Figure 2 (and Supplementary Table S2 online). Thirty-seven studies provided a single overall estimate of the prevalence of iKF in their adult populations. Substantial heterogeneity was observed with 11 studies reporting prevalence of >10%. Where the prevalence was presented in eGFR bands reflecting Kidney Disease Outcomes Quality Initiative (KDOQI) stages, eGFR 30–59 mL/min/1.73m^2 was the most prevalent range accounting for >90% of people with iKF (Supplementary Table S2).

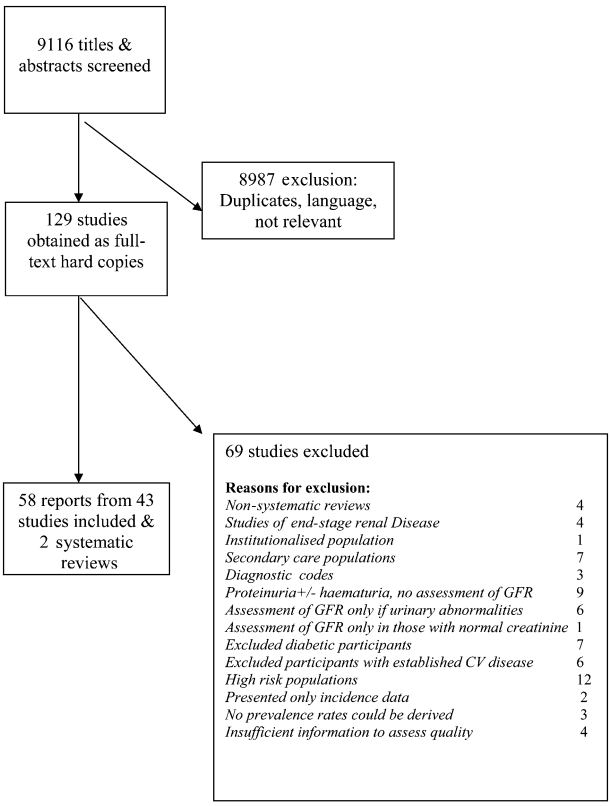

Fig. 1. Flow diagram of study selection process.

Twenty-seven studies reported sex-specific prevalence. Sixteen studies reported that CKD was more prevalent in women than in men with the pattern reversed in 11 studies [6, 25, 27–29, 39, 42, 43, 52, 65, 66].

In 18 studies, where sufficient sub-group data were available, a steep rise in prevalence with increasing age was consistently reported. Four of these studies presented their findings by age and sex and the rise in prevalence with age was observed in both men and women [44, 49, 61, 63]. Four US studies [4, 17, 42, 62] presented detailed ethnicity sub-group data. Stage 3 CKD tended to be more common among white participants and Stages 4–5 CKD tended to be more common among black participants.

Given the heterogeneity in the prevalence estimates, we explored prevalence estimates by the sub-groups defined a priori in the methods.

Sub-group analysis exploring heterogeneity

The size of the study was not an important explanatory factor for heterogeneity (Figure 3).

Representativeness of the sampling. Age restriction.—Twenty-five studies reported an overall population estimate for a minimally restricted adult population (lower age cut-off <25 years) but restricting to these studies did not reduce heterogeneity (range 0.6% [59] to 42.6% [5]).

Community screening versus routine testing from laboratory data.—The 33 community screening prevalence estimates ranged from 0.8% [26] to 42.6% [5]. Prevalence estimates based on five routine health care data studies and using the total general population estimate for a health service catchment area as the denominator, ranged from 0.6 to 7.3% [56, 58–61, 63]. The proportpgoto "tion with iKF, using only those who had at least one blood test as the denominator, ranged from 9.3 to 30.5% [62–65].

Other sampling issues.—Five community-screening studies experienced response rates that were <55% [38, 39, 42, 43, 53]. The prevalence estimates ranged from 1.7 to 5.2%. In seven other community-screening studies where the sample self selected for participation, estimates ranged from 5.0 to 42.6% [5, 33, 39, 40, 48, 52].

Chronicity. Only one of the community screening studies used more than a single blood sample to categorize patients as having CKD (prevalence 0.8%) [26].

Two studies that were based on routine health care data and used the general population as a denominator addressed chronicity by looking for abnormal test results at least 3 months after the first sample [58, 59]. The prevalence estimates for CKD were 7.2% (eGFR) and 0.6% (creatinine threshold). In two further studies, in which the prevalence was expressed as the proportion of the tested population with eGFR <60 mL/min/1.73m^2, separate estimates were reported based on the availability of at least one blood test and two blood tests 3 months apart [65, 66]. The prevalence estimate fell from 3.7 to 1.7% [66] and from 30.5 to 24.0% [65] when the study populations were restricted to at least two measures.

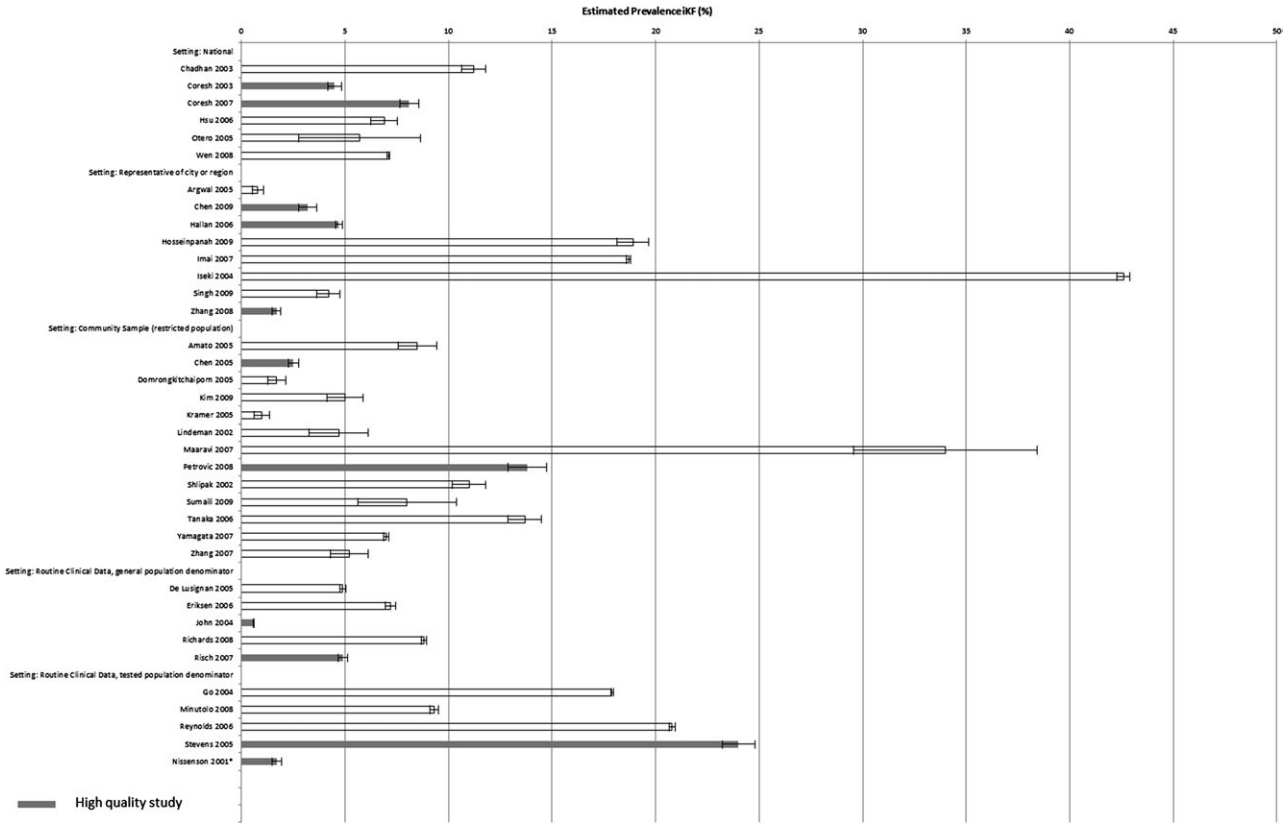

Fig. 2. Estimated prevalence (95% confidence intervals) of iKF for 37 studies reporting a single overall estimate of prevalence in adult populations.

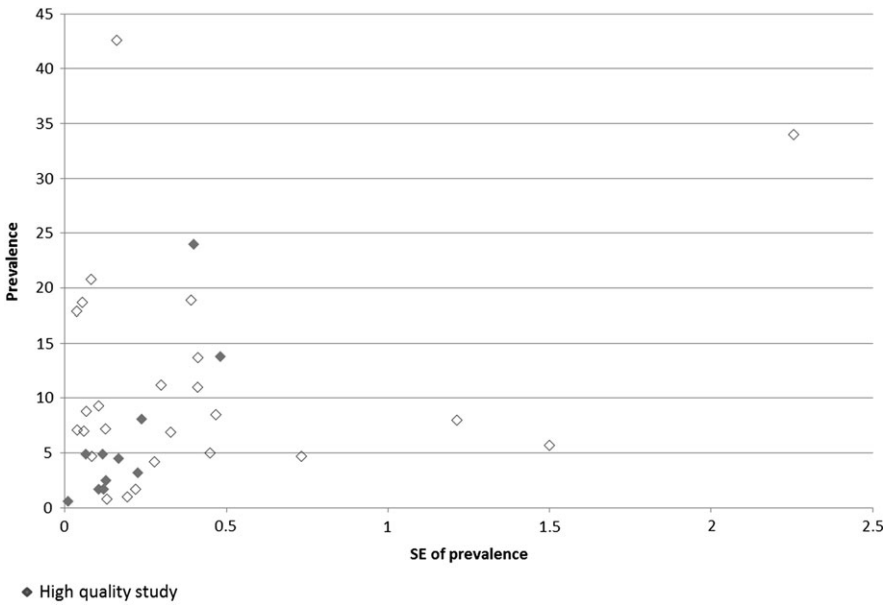

Fig. 3. Scatted plot of prevalence of estimated iKF against the standard error of the prevalence for 37 studies reporting a single overall estimate of prevalence in adult populations.

Laboratory assay and measurement issues. Measures of glomerular function. —Prevalence estimates based on creatinine thresholds varied from 0.6 to 1.7% in studies without age restriction, with higher thresholds generally producing lower prevalence estimates [26, 58, 59, 66]. In the two studies limited to people >65 years old, the prevalence was estimated as 4.7 and 11.1% [6, 42]. Even where lower thresholds were used for females, the prevalence of

CKD was, with one exception [59], generally reported to be higher in men than women [6, 29, 42, 66].

Three screening studies used the C-G equation as the measure of renal function. Prevalence estimates varied from 8.5 to 42.6% [5, 12, 36]. In eight other studies, prevalence estimates based on both the C-G and MDRD equations were reported [4, 37, 43–45, 47, 49]. In all, the estimates based on C-G equation were substantially higher, particularly in the elderly [4].

Forty studies used the MDRD equation; prevalence estimates from eight studies with no age restrictions (six community-screening studies and two based on routine data with population denominators) varied from 3.2% [27] to 18.9% [32].

Where reported, the prevalence based on the MDRD equation for females was higher than for males, with the difference accounted for by a higher prevalence of eGFR range 30–59 mL/min/1.73m^2 among women (with one exception where a modified version of the formula was used in women [28]).

Minimizing assay bias. —Fourteen studies took appropriate steps to minimize assay bias in relation to the use of the MDRD equation. Six of these were in unrestricted population samples [4, 17, 27, 30, 33, 55] and prevalence estimates ranged from 1.7% [55] to 18.7% [33]; one study used general population catchment as the denominator and gave a prevalence estimate of 4.9% [61].

Impact of quality issues on estimate of prevalence. Eleven studies were of higher quality based on the criteria set out in the methods section (Table 2 and Figure 4). No studies fulfilled all three of the quality criteria. Seven studies were based on community samples [4, 17, 27, 30, 37, 45, 55] of which five were large screening samples [4, 17, 30, 37, 55]. The samples in the USA [4, 17] and Norwegian [30] studies were representative of the general population over the age of 20; the sample in one Chinese study was representative of the general population over the age of 18 [55], while the other was representative of the population aged between 35 and 74 years [37]. All used the MDRD equation, with appropriate assay standardization, to estimate the prevalence of iKF. None demonstrated chronicity. The Chinese study estimates ranged from 1.7 to 3.2% [27, 37, 55] and the estimates for Norway and the USA ranged from 3.8 to 8.1% [4, 17, 30]. The prevalence from Thailand was higher: 13.8% [45, 55]. Prevalence increased with age in all studies (Figure 5) with heterogeneity evident at all age groups. Estimated GFR 30–59ml/min/1.73m^2 accounted for >90% of all study participants detected as having iKF (Figure 2).

Four studies utilized data collected as part of routine health care [59, 61, 65, 66] and three demonstrated chronicity based on opportunistic samples at least 3 months later [59, 65, 66]. Two were representative studies that used creatinine thresholds to identify cases (prevalence 0.6–1.7%) [59, 66]. One study 61 did not demonstrate chronicity and estimated the prevalence to be 4.9%. One study [26], from the US, was the only study in the review using the MDRD equation which both adequately standardized the study assay and demonstrated chronicity; however, the study lacked representativeness and the very high prevalence estimate of 24% may reflect the selected nature of the tested population in terms of demographic and comorbidity profile.

Discussion

This systematic review provides a comprehensive overview of the current literature estimating the population burden from iKF and taking into account issues of quality and factors contributing to heterogeneity. From the higher quality studies, the six studies measuring iKF using eGFR in community-screening samples reported a prevalence ranging from 1.7% in a Chinese study to 8.1% in a US study, with four reporting an estimated prevalence of 3.2–5.6%. Thus eGFR <60 mL/min/1.73m^2 was as common as diabetes mellitus, for example, in the community; with >90% in the range of 30–59 mL/min/1.73m^2.

Studies using creatinine thresholds produced lower prevalence estimates than other methods; even where different thresholds were adopted for men and women, these studies generally found the prevalence to be higher in men. This situation was reversed with the introduction of eGFR, with a very high prevalence of eGFR 30–59 mL/min/1.73m^2 in elderly women.

The international adoption of a standard classification system has been associated with a rapid proliferation of epidemiological studies of iKF. We identified studies from 14 different countries, economically developed and developing and covering a wide range of different ethnic groups. Although the original MDRD equation included an adjustment factor for race, there was no adjustment for Oriental or Asian ethnicities. Studies from Japan and Thailand, which used the original MDRD equation reported relatively high prevalence estimates, but the Japanese modified MDRD equation estimates were higher still. Estimates from other East Asian countries (China, Taiwan) were lower. Only one of these studies was a high quality study.

There was substantial heterogeneity in the reported prevalence (0.6–42.6%), particularly in relation to the range 30–59 mL/min/1.73m^2. The proportion of people with eGFR <30 mL/min/1.73m^2 was markedly lower and consistent between studies. Six studies [5, 32, 33, 43, 62, 64] reported a prevalence in excess of 15%. Multiple methodological factors potentially contributed to the high prevalence. Iseki *et al.* [5], reporting a prevalence of 42.6%, relied on self-selection and may, therefore, have included a higher risk sub-group. Only 11% of the total population of the region participated. Indeed, studies of self-selecting populations generally reported higher prevalence. Studies using people tested as part of routine practice as the denominator, a selected population who were likely to be at higher risk of CKD, also reported higher prevalence. Sub-classification into eGFR 45–59 mL/min/1.73m^2 and eGFR 30–44 mL/min/1.73m^2 was only reported in two studies; both reporting the majority of individuals to be in the 30–59 mL/min/1.73m^2 range [25]. We noted a consistent finding of increased prevalence with age.

The 11 high quality studies still showed substantial variation in the estimated prevalence. None of the studies had resolved all three major quality issues. Differences in the definition of iKF and age of study populations accounted for some of the variability. The main differences in prevalence

Table 2. Summary of the prevalence of CKD reported in high quality studies (%; 95% confidence interval)

Study ID	Measure of CKD	Prevalence (all)	Prevalence (male)	Prevalence (female)	Comment
Community-screening studies					
Chen *et al.* [27], China	Chinese 4v eGFR single sample	eGFR < 60: 3.2 (2.8–3.7) eGFR 30–59: 2.8e GFR 1–29: 0.3 eGFR < 15: 0.1	eGFR < 60: 4.1	eGFR < 60: 2.2	Stratified, multistage sampling, representative of the city of Guangzhou population (adults 20 years)
Coresh *et al.* [4], USA NHANES III	4v eGFR single sample	eGFR 15–59: 4.5 (4.1–4.9) eGFR 30–59: 4.3 (3.9–4.7) eGFR 15–29: 0.2 (0.14–0.26)	eGFR 15–59: 3.6 (3.0–4.3) eGFR 30–59: 3.4 (2.8–4.0) eGFR 15–29: 0.2 (0.10–0.30)	eGFR 15–59: 5.3 (4.4–6.2) eGFR 30–59: 5.1 (4.3–5.9) eGFR 15–29: 0.2 (0.10–0.30)	Standardized to US census population by age, sex and race (adults 20 years)
Coresh *et al.* [17], USA, NHANES III.	4v eGFR1999–2004 single sample.	eGFR 15–59: 8.1 (7.3–8.9) eGFR 30–59: 7.7 (7.0–8.4) eGFR 15–29: 0.35 (0.25–0.45)			Standardized to US census population by age, sex and race (adults 20 years)
Hallan *et al.* [31], Norway, HUNTII	4v eGFR single sample	eGFR < 60: 4.7			Standardized to Norwegian census population by age (adults 20 years)
Zhang *et al.* [55], China.	4v eGFR single sample	eGFR < 60: 1.7(1.2–2.1)	eGFR < 60: 1.4	eGFR < 60: 2.0	Representative sample of Beijing city (adults 18 years)
Community-screening studies: age restricted					
Chen *et al.* [37], China, InterAsia	4v eGFR single sample	eGFR < 60: 2.5 (2.1–2.9) eGFR 30–59: 2.4 (2.0–2.8) eGFR < 30: 0.1 (0.09–0.11)	eGFR < 60: 1.4 (0.9–1.9) eGFR 30–59: 1.2 (0.8–1.6); eGFR < 30: 0.2 (0.08–0.32)	eGFR < 60: 3.8 (3.1–4.5) eGFR 30–59: 3.7 (3.1–4.3) eGFR < 30: 0.1 (0.0–0.22)	Standardized to Chinese population by age, sex and geography (adults aged 35–74 years)
Perkovic *et al.* [45], Thailand, InterAsia	4v eGFR single sample	eGFR 15–59: 13.8 (10.9–16.7) eGFR 30–59: 13.2 (10.6–15.8) eGFR 15–29: 0.61 (0.29–0.93)	Stages 3–5: 11.6 (8.7–15.7) eGFR 30–59: 11.5 (8.6–14.4) eGFR < 30: 0.7 (0.11–1.3)	Stages 3–5: 15.7 (11.2–20.2) eGFR 30–59: 15.1 (11.0–19.2) eGFR < 30: 0.6 (0.21–0.99)	Standardized to the census population (adults 35 years)
Routine health care data					
John *et al.* [59], UK	Creatinine thresholds two samples	Creatinine threshold: 0.6	Creatinine > 180: 0.5	Creatinine > 135: 0.6	Percentage of the catchment area population identified by routine testing (adults 18 years)
Nissenson *et al.* [66], USA	Creatinine thresholds two samples	Creatinine threshold: 1.7	Creatinine > 124: 1.9	Creatinine > 106: 1.5	Based on percentage of those with two or more tests performed as part of routine practice, standardized by age and sex to US population (all ages)
Risch *et al.* [61], Liechtenstein	4veGFR single sample	eGFR < 60: 4.9 eGFR 30–59: 4.4 eGFR 15–29: 0.5 eGFR < 15: 0.1			Catchment area population denominator, proportions standardized to census demographics (adults ≥ 25 years)
Stevens *et al.* [65], USA	4veGFR two samples	Stages 3–5: 24.0			Percentage of those with two or more tests performed as part of routine practice (adults ≥ 40 years with high comorbidity)

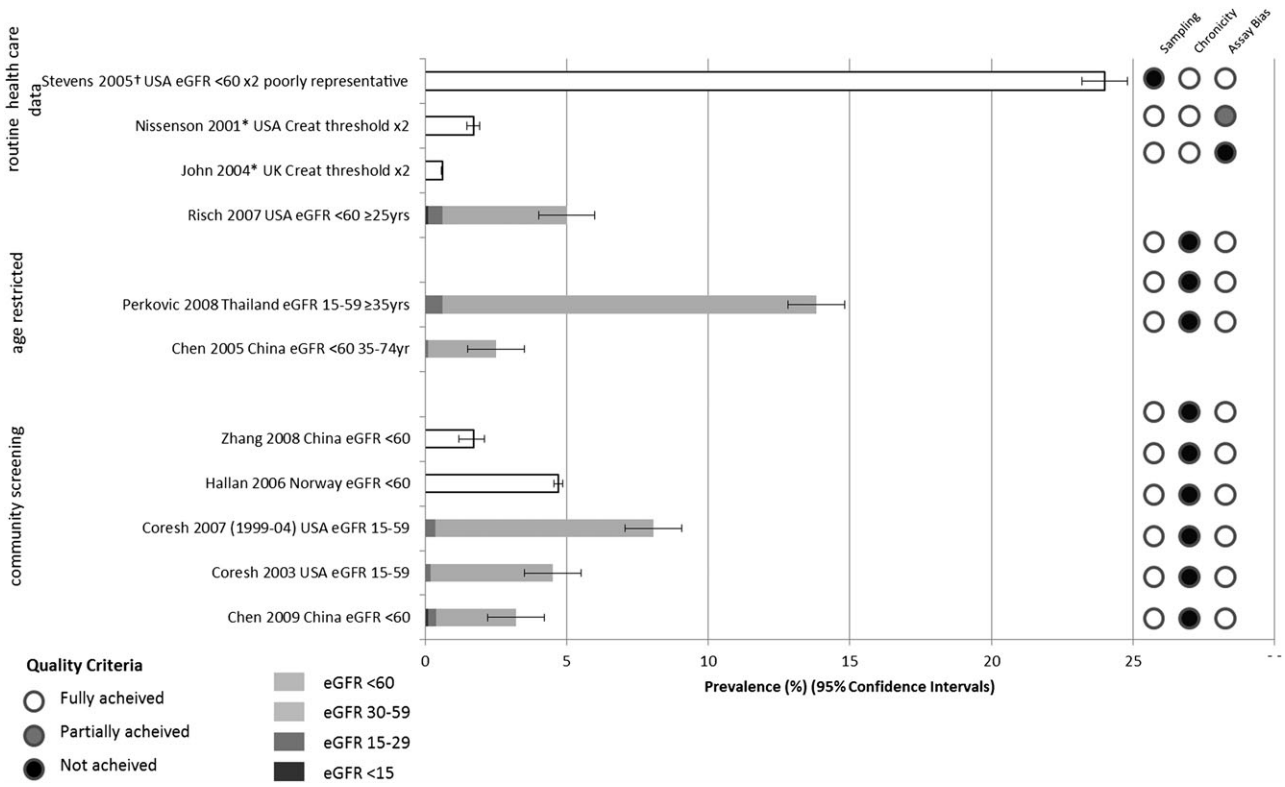

Fig. 4. Prevalence (95% confidence interval) of iKF reported in high quality studies.

were in the estimated prevalence of eGFR 30–59 mL/min/1.73m^2 and may reflect differences in the performance of the equations and assay factors. GFR estimates are normally distributed in a random community sample and therefore, a small shift in the distribution in one direction can result in a change of classification for large numbers of individuals who are close to the <60 mL/min/1.73m^2 threshold. In the community-screening studies, there was, for practical reasons, a reliance on a single measure of renal function. While a single measure of kidney function fails to exclude people with acute kidney disease, this is probably less of an issue in a relatively healthy community sample compared with a laboratory database. However, the high quality community samples, which used the MDRD equation with appropriate assay standardization, may remain open to over-diagnosis for two reasons. Firstly, the formula is based on serum creatinine, which varies in healthy individuals due to a variety of non-renal factors: hydration status, dietary intake and thus eGFR is similarly influenced. Secondly, the equation was developed in a clinical trial population with known kidney disease (GFR measured by isotopic methods between 13 and 55 mL/min/1.73m^2) recruited from secondary care [7]. The equation has subsequently been demonstrated to systematically under-estimate kidney function in healthy individuals [67, 68]. In data from health care settings, there is the additional consideration that certain medicines can impact on serum creatinine without changing actual GFRs.

Our review provides a systematic comprehensive overview of studies reporting the population prevalence of iKF based on blood testing and considers the methodological issues that impact on our interpretation of these estimates. We add to the previous reviews by searching multiple reference database, updating the latest search from January 2007 to June 2009 and identifying an additional nine studies. In using quality criteria, we have been able to provide a more robust estimate of population prevalence based on high quality studies and address confusion around CKD prevalence by applying strict definitions of iKF and CKD. We had to limit our review to English language publications for reasons of resources and, while finding a diverse range of countries represented among our included studies, will have under-represented the published literature from non-English speaking countries. The impact of a single person undertaking the data extraction was mitigated by the use of a specifically designed data extraction form and checking by a second reviewer. We have only reported the data as presented in the original publications, deducing prevalence estimates where possible if none were given. We did not contact authors to supplement gaps. A major international collaboration to pool individual patient data from CKD cohort studies is underway and will address some of the issues of consistency of reporting of findings that we encountered [35]. We did not include urinary protein as a measure of kidney function impairment in this review. There is substantial evidence that it is an important and independent factor when determining risk of future outcomes such as progression of kidney disease or cardiovascular disease.

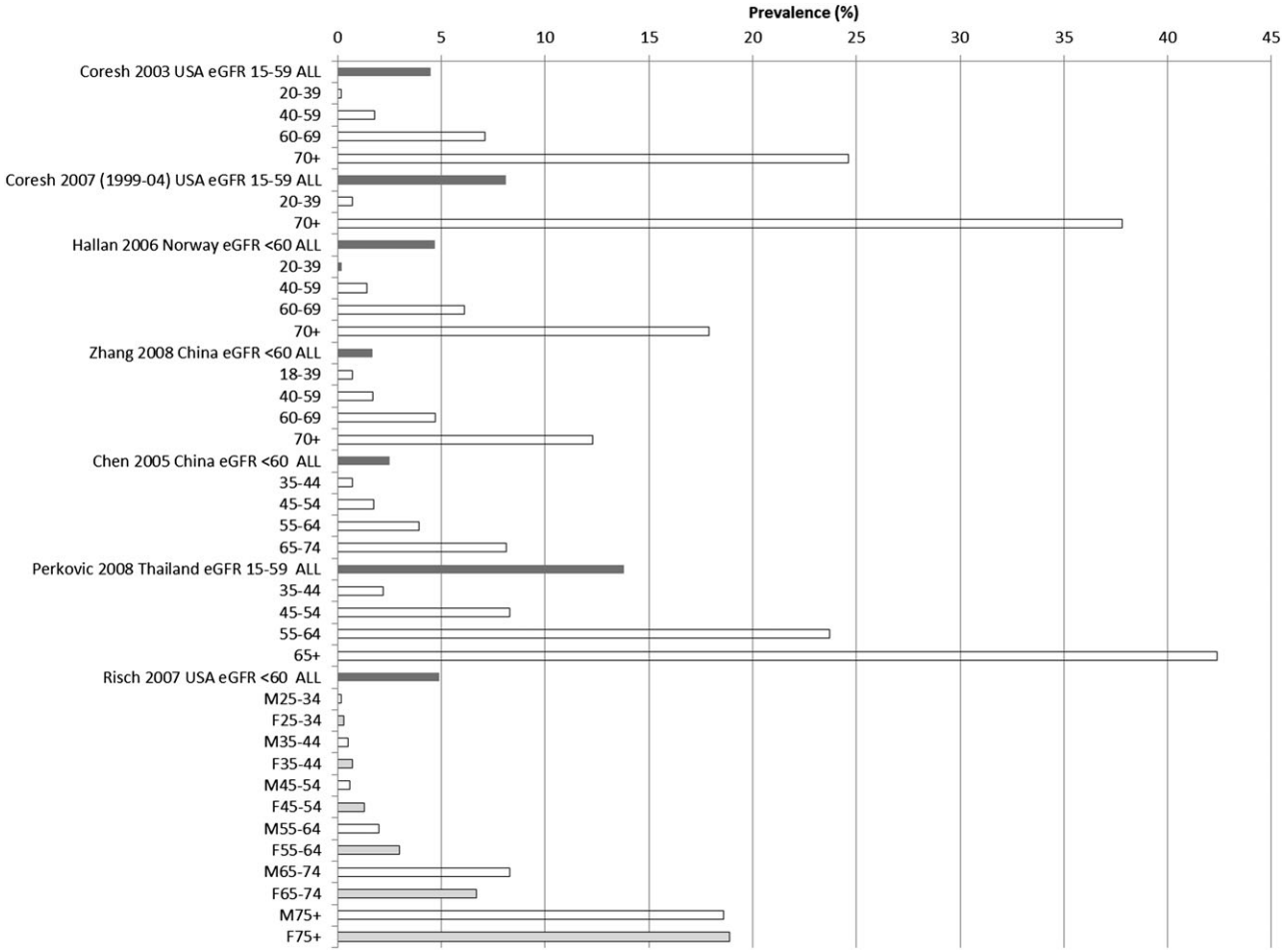

Fig. 5. Prevalence (%) by age band of iKF reported in high quality studies.

Conclusions

Our findings confirm that iKF, particularly in the eGFR range of 30–59 mL/min/1.73m^2 is at least as common as, for example, diabetes mellitus in the general population. From the higher quality studies, the six studies measuring iKF using eGFR in community-screening samples reported a prevalence ranging from 1.7% in a Chinese study to 8.1% in a US study, with four reporting an estimated prevalence of 3.2–5.6%. Heterogeneity between study estimates was driven by the measure used, study design and differences in study population. Following the introduction of routine reporting of eGFR values by laboratories, a large proportion of cases will be detected by routine practice due to targeted testing towards those at higher risk. With the growing evidence base for early intervention in the management of CKD, the role of angiotensin–renin system blockade, early intervention to manage anaemia and cardiovascular risk factor modification, the high prevalence of iKF identified by eGFR will pose substantial challenges to health care systems globally. The most urgent challenge is to develop evidence-based algorithms, taking into account other markers of kidney damage such as proteinuria, which allow health professionals to risk-stratify patients and enable service planners to develop the most cost-effective models of care.

Supplementary data

Supplementary Tables are available online at http://ndt.oxfordjournals.org.

Acknowledgements. Funding. This work was undertaken with the support of funding from the Chief Scientist Office, Scotland and NHS Grampian Research and Development Endowment funding (CZG/2/239).

Conflict of interest statement. None declared.

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Received for publication: 19.4.11; Accepted in revised form: 17.8.11