UNIVERSITY OF AMSTERDAM

# UvA-DARE (Digital Academic Repository)

## Epidemiology of chronic kidney disease in Europe

Brück, K.

**Publication date**
2016
**Document Version**
Final published version

Link to publication

**Citation for published version (APA):**
Brück, K. (2016). *Epidemiology of chronic kidney disease in Europe*. [Thesis, fully internal, Universiteit van Amsterdam].

**General rights**
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

**Disclaimer/Complaints regulations**
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: https://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

*UvA-DARE is a service provided by the library of the University of Amsterdam (https://dare.uva.nl)*

Download date:22 Jan 2025

**CHAPTER 2:**

# Methodology used in studies reporting chronic kidney disease prevalence: a systematic literature review

Katharina Brück, Kitty J. Jager, Evangelia Dounousi, Alexander Kainz, Dorothea Nitsch, Johan Ärnlöv, Dietrich Rothenbacher, Gemma Browne, Vincenzo Capuano, Pietro Manuel Ferraro, Jean Ferrieres, Giovanni Gambaro, Idris Guessous, Stein Hallan, Mika Kastarinen, Gerjan Navis, Alfonso Otero Gonzalez, Luigi Palmieri, Solfrid Romundstad, Belinda Spoto, Benedicte Stengel, Charles Tomson, Giovanni Tripepi, Henry Völzke, Andrzej Wieçek, Ron Gansevoort, Ben Schöttker, Christoph Wanner, Jose Vinhas, Carmine Zoccali, Wim Van Biesen and Vianda S. Stel
on behalf of the European CKD Burden Consortium

*Nephrology Dialysis and Transplantation. 2015 August; 30(4): iv6-16.*
*http://ndt.oxfordjournals.org/content/30/suppl_4/iv6.long*

## ABSTRACT

**Background**

Many publications report chronic kidney disease (CKD) prevalence in the general population. Comparisons across studies are hampered as CKD prevalence estimations are influenced by study population characteristics and laboratory methods.

**Methods**

For this systematic review, two researchers independently searched PubMed, MEDLINE and EMBASE to identify all original research articles reporting the prevalence of CKD in the European adult general population, which were published between January first 2003 and November first 2014. Data on study methodology and reporting of CKD prevalence results were independently extracted by two researchers.

**Results**

We identified 82 eligible publications and included 48 publications of individual studies for the data extraction. There was considerable variation in population sample selection. The majority of studies did not report the sampling frame used, and the response ranged from 10% to 87%. With regard to the assessment of kidney function, 67% used a Jaffe assay, whereas 13% used the enzymatic assay for creatinine determination. Isotope dilute mass spectrometry calibration was used in 29%. The CKD-EPI (52%) and MDRD (75%) equation were most often used to estimate Glomerular Filtration Rate (eGFR). CKD was defined as eGFR <60 ml/min/1.73m2 in 92% of studies. Urinary markers of CKD were assessed in 60% of studies. CKD prevalence was reported by sex and age strata in 54% and 50% of studies, respectively. In publications with a primary objective of reporting CKD prevalence, 39% reported a 95% confidence interval.

**Conclusions**

The findings from this systematic review showed considerable variation in methods for sampling the general population and assessment of kidney function across studies reporting CKD prevalence. These results are utilized to provide recommendations to help optimize both the design and the reporting of future CKD prevalence studies, which will enhance comparability of study results.








## INTRODUCTION

Chronic kidney disease (CKD) is considered to be a major public health problem (1). CKD has an important impact both at the patient level, by decreasing the quality of life and life-expectancy, and at the population level by increasing health care costs and the demand for health care services.

Since CKD prevalence estimation is central to CKD management and prevention planning at the population level (2), it is not surprising that many publications report CKD prevalence in the general population. It is common research practice to put study results into context by comparing them with previous publications to identify the regional CKD burden, assessing the impact on regional health-care systems and for tailoring preventive strategies to communities. In case of CKD prevalence, such comparisons are likely hampered as CKD prevalence estimations are influenced by study population characteristics and by the methods used to assess kidney function (3, 4). To realistically compare CKD prevalence across different population-based studies, methodological factors should be taken into account.

The purpose of this systematic literature review was to 1) identify all studies reporting on CKD prevalence in the European adult general population and 2) to describe the methodology used in these studies. The findings from this review are utilized to provide recommendations that may help investigators to optimize both the design and the reporting of future CKD prevalence studies, which will enhance comparability of results across studies.

## METHODS

*Search strategy*

A systematic literature search was performed in PubMed, MEDLINE and EMBASE to identify all original research articles reporting the prevalence of CKD in the adult general population. As KDOQI published a guideline on CKD definition (5) in 2002, we included articles published since January 1st 2003 which is one year after the publication of the KDOQI guideline. Our search was last updated on November 1st 2014. The database-specific search queries are presented in appendix 1. Additionally, the representatives of national kidney foundations, renal registries and expert nephrologists in 39 European countries were asked to provide information on any relevant studies.

*Study selection*

Publications were included that presented original research, were designed to select a representative sample of a European adult general population and reported a CKD prevalence estimate. We excluded studies which ended subject recruitment prior to 1996 and studies lacking GFR estimation based on serum creatinine. Cystatin C-based eGFR will

lead to higher CKD prevalence estimates than creatinine-based eGFR (6). For the sake of comparability we chose not to include publications which solely reported Cystatin C-based prevalence estimates. No language restrictions were applied. The literature search was done by two investigators (KB, ED). Any study that was judged relevant on the basis of its title was retrieved in abstract form, and if relevant, in full-text form. Any doubt about eligibility was resolved by discussion with another investigator (VS).

*Data extraction*

All publications were initially seen by one investigator (KB) and then independently reassessed by two additional investigators (ED for the first half and AK for the second half). For studies with multiple eligible publications, we selected the publication with a primary objective of reporting CKD prevalence or the most recent publication. Publications were assessed on method of population selection, which included the sampling frame (i.e. source used to identify subjects) and the sample design (i.e. the method of sample selection). Additionally we extracted information on the assessment of kidney function.

The extracted data were categorized as follows:

1. Creatinine assay was categorized as enzymatic, Jaffe, modified Jaffe, compensated Jaffe or unclear. The Jaffe method is known to suffer from interference by other substances (7) and multiple adaptations have been implemented to improve method specificity (7). The compensated and modified Jaffe assays were developed to improve method specificity and minimize susceptibility of interfering substances (7). The compensated Jaffe method is the use of a manufacturer-specific mathematical compensation (8). The modified Jaffe assays are modifications of the method such as deproteinization of the sample prior to analysis or the addition of potassium ferricyanide (9).
2. Calibration was categorized as calibrated to the standardized isotope dilution mass spectrometry (IDMS) or calibrated by another method or calibrator.
3. Urinary albumin assay was categorized as dipstick, immunoassay (including both nephelometric and turbidometric immunoassays) or other.
4. The CKD definition was categorized as use of the KDOQI 2002 definitions (5) or use of other definitions. Use of chronicity criterion, i.e. persistence of albuminuria or decreased eGFR for at least 3 months, was assessed.
5. Ethnicity reporting was categorized as “yes” if publication reported collection of ethnicity data and as “no” if ‘ethnicity’ data was not collected or if this was not reported.

Finally we extracted the following data on presentation of CKD prevalence results: the use of 95% confidence intervals (95%CI), the use of standardization of the prevalence estimate to a reference population, and the presentation of results by age group and sex. If CKD prevalence was not the main focus of the publication, the use of 95%CI was rated as not





applicable (n/a). The data extraction form is shown in appendix 2.

## RESULTS

*Study selection*

Figure 1 shows the selection process of in- and ex-clusion of publications in a flow chart. We retrieved 2000 individual publications of which only one study was solely identified through contacting national representatives. 1842 publications were excluded based on title or abstract. Twenty-five publications were excluded as the study was not designed to select a representative sample of the general population, nine studies were excluded as they ended recruitment prior to 1996 and forty-two publications were excluded for not presenting a CKD prevalence estimate. Eighty-two publications fulfilled the inclusion criteria. Eighteen studies had multiple publications, highlighting various aspects of CKD (overall 34 publications). Finally, we included forty-eight publications of individual studies for the data extraction.

*Data extraction*

Table 1 describes the method of general population sample selection including the response per study. Details on the laboratory assessment of kidney function, the CKD definition used and on the reporting of CKD prevalence are presented in table 2.

*Population selection*

All studies combined described a total of 247,342 subjects. The size of the study population ranged from 328 to 65,181 subjects. Twenty-three studies (48%) included virtually the entire age range of the adult population. The remaining (n=25; 52%) studies restricted the recruitment of subjects to a higher age range. Four studies (8%) used census data as the sampling frame to identify eligible study subjects. More than half of the studies (n=26; 54%) did not report the sampling frame used. Fourteen studies (29%) were designed to select their population by age and sex stratification and twelve studies (25%) selected a random sample. Ten studies (21%) did not provide details on the sample design, six of which referred to previous publications for more details.

The response was given in 31 studies (65%), and ranged from 10% to 87%. Of the 17 studies which did not report a response, two studies referred to a previous publication for details regarding responders and non-responders.

*Assessment of kidney function*

Serum creatinine was determined by Jaffe assay in the majority of studies (n=32; 67%) and by enzymatic assay in six (13%) studies. Only few creatinine assays were calibrated to IDMS (n=14; 29%). Urinary markers for kidney disease were assessed in 29 studies (60%), 15 of which (31%) used immunoassay to detect albuminuria. Seven studies (15%) used dipsticks

to identify proteinuria, with confirmation of albuminuria by immunoassay in four studies (8%).

*CKD definition*

Almost all studies (n=44; 92%) defined CKD as an eGFR below 60 ml/min/1.73m$^2$. Eighteen studies (38%) reported CKD prevalence defined as eGFR below 60 ml/min/1.73m$^2$ and/or the presence of albuminuria >30mg/g and 15 studies (32%) reported CKD prevalence defined as albuminuria >30mg/g. Although ten studies (21%) additionally reported CKD according to another definition, only one study exclusively reported a CKD prevalence not defined by KDOQI.

The Modification of Diet in Renal Disease (MDRD) equation for unstandardized creatinine was used to estimate GFR in 22 studies (46%), and the MDRD equation for standardized creatinine was used in 14 studies (29%). Twenty-five studies (52%) used the CKD Epidemiology Collaboration (CKD-EPI) equation and nine studies (19%) used the Cockcroft & Gault equation. Even though both the CKD-EPI and MDRD equation include an ethnicity variable, only 18 studies (38%) reported collecting ethnicity data. Eleven studies (23%) did not indicate whether ethnicity data were collected.

*Reporting results*

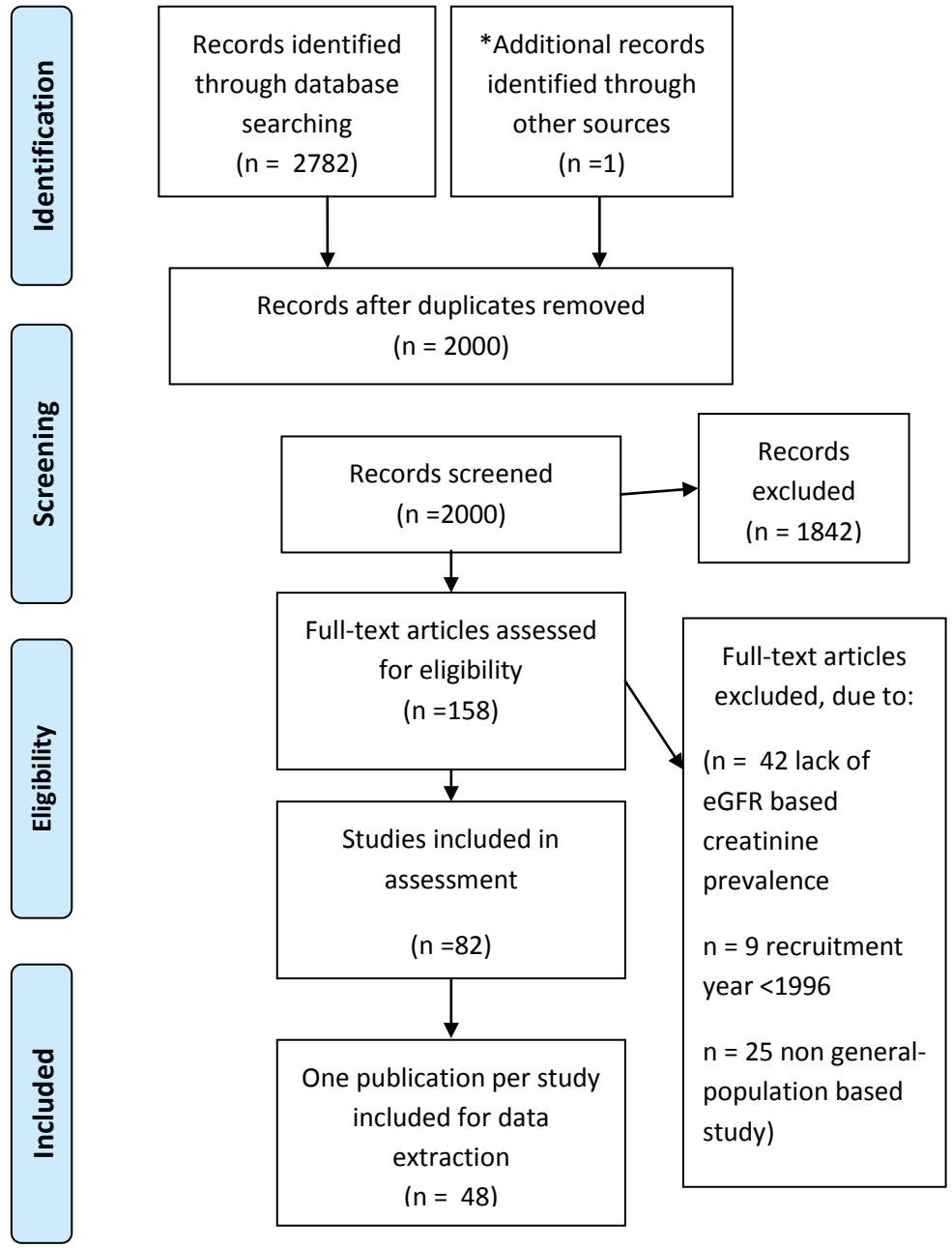
CKD prevalence reporting was the main objective in 36 publications, of which 39% reported a 95%CI. An age and sex standardized prevalence was reported in 12 studies (25%), of which nine standardized to their national population. Although two studies standardized their population to the US population, only one study standardized to the European population. The presentation of CKD prevalence by strata was done by 31 studies, these studies presented the CKD prevalence stratified per risk factor, mostly by age (n=24; 50%) and by sex (n=26; 54%).







**Figure 1: Flow chart of publication selection.**




*Only one study was solely identified through contacting national representatives and not by the database query.

**Table 1: Description of the method of general population sample selection per study. ( Part 1)**

| First author, (ref) | Study | Country | Time period | N | Age range | Sample frame | Sample design | Response |
|---|---|---|---|---|---|---|---|---|
| Aumann, (17) | SHIP | Germany | 2001-06 | 2830 | 25-88 | ns | multistage sampling | 69% |
| Bongard, (18) | MONA LISA | France | 2006-07 | 4727 | 35-75 | electoral rolls | age and sex stratified | ns |
| Browne, (19) | SLAN | Ireland | 2007 | 1098 | 45+ | other (Geo-directory) | multi-stage random sample: by area & region | 66% |
| Capuano, (20) | VIP | Italy | 1998-99 2008-09 | 2400 | 25-74 | electoral rolls | age and sex stratified | ns |
| Christensson, (21) | GAS | Sweden | 2001-04 | 2815 | 60-93 | census | stratified, age, sex & urban/rural location | 60% |
| Chudek, (22) | PolSenior | Poland | 2007-11 | 3793 | 65+ | ns* | ns* | 32% |
| Cirillo, (23) | Gubbio Pop. | Italy | ns | 4574 | 18-95 | ns* | ns* | ns |
| Codreanu, (24) | ** | Moldova | 2006-07 | 973 | 18-77 | ns | ns | ns |
| De Nicola, (25) | CARHES | Italy | 2008 | 4077 | 35-79 | electoral rolls | age and sex stratified | 45% |
| Delanaye, (26) | | Belgium | 2008-09 | 1992 | 45-75 | ns | voluntary nature | ns |
| Donfrancesco,(27) | MATISS | Italy | 1993-96 | 2924 | 20-79 | random sample | age and sex stratified | 60% |
| Formiga, (28) | Octabaix | Spain | 2009 | 328 | 85 | ns* | | ns |
| Fraser, (29) | HSE | England | 2009-10 | 5799 | 16+ | random 2 stage sample | | ns* |
| Gambaro, (30) | INCIPE | Italy | 2006 | 3629 | 40+ | GP list | random sample | 62% |

N= Number of subjects with creatinine measurement, ns= not specified. Gubbio Pop.=Gubbio population Study. *authors refer to previous publication.**Early Detection and Intervention Program for Chronic Renal and Cardiovascular Disease in Rep Moldova.

**Table 1: (continued).**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Gianelli, (31) | InChianti | Italy | 1998-2000 | 676 | 65+ | ns | multistage stratified random sample | ns |
| Goek, (32) | KORA | Germany | 1999-2001 | 1104 | 54-75 | ns | ns | ns |
| Gu, (33) | FLEMENGHO | Belgium | 2005-10 | 797 | 18-89 | ns | ns | 78% |
| Guessous, (34) | Swiss Study on | Switzer-land | 2010-11 | 1145 | 15+ | other | age and sex stratified random sample | 10% |
| Hallan, (35) | HUNT 2 | Norway | 1995-97 | 65181 | 20+ | ns | | 70% |
| Hernandez, (36) | IMAP | Spain | 2007 | 2270 | 18-80 | ns* | | ns |
| Juutilainen, (37) | FINRISK | Finland | 2002 & 2007 | 11277 | 25-74 | census | age and sex stratified random sample | 74% women 71% men |
| Lieb, (38) | MONICA/KORA | Germany | ns | 1187 | 25-74 | ns | age and sex stratified random sample | 71% |
| Meuwese, (39) | Leiden 85+ study | Nether-lands | 1997-99 | 558 | 85 | ns | all in birth cohort | 87% |
| Nitsch, (40) | BWHH | UK | 1999-2001 | 3851 | 60-79 | ns* | random sample | 60% |
| Nitsch, (41) | SAPALDIA 2 | Switzer-land | 1991 & 2002 | 6317 | 18+ | ns* | rom sample | 73% |
| Otero, (42) | EPIRCE | Spain | 2004-08 | 2746 | 20+ | census | age, sex & region strati-fied random sample | 43% |
| Pani, (43) | SardiNIA study | Italy | 2001- | 4471 | 14-102 | ns* | ns* | 56% |
| Pattaro, (44) | MICROS | Italy | 2002-03 | 1199 | 18+ | ns* | ns* | ns |

N= Number of subjects with creatinine measurement, ns= not specified. *authors refer to previous publication.

**Table 1: Description of the method of general population sample selection per study. ( Part 2)**

| First author, (ref) | Study | Country | Time period | N | Age range | Sample frame | Sample design | Response |
|---|---|---|---|---|---|---|---|---|
| Ponte, (45) | CoLaus | Switzer-land | 2003-06 | 5921 | 35-75 | population registry | random sample | 41% |
| Redon, (46) | PREV-ICTUS | Spain | 2005 | 6419 | 60- | GP lists | random sample | 72% |
| Robles, (47) | HERMEX | Spain | ns | 2813 | 25-79 | other | age and sex stratified random sample | 83% |
| Roderick, (48) | MRC | United Kingdom | 1994-99 | 13179 | 75+ | GP list | practices stratified by mortality score & deprivation score | 73% |
| Rothenbacher, (49) | ActiFE Ulm | Germany | 2009-10 | 1471 | 65+ | census | random sample | 20% |
| Rutkowski, (50) | PolNef | Poland | 2004-05 | 2476 | ns | other | random sample | 26% |
| Sahin, (51) | | Turkey | 2005 | 1079 | 18-95 | ns | age, sex & region stratified | ns |
| Schaeffner, (52) | BIS | Germany | 2011 | 2072° | 70+ | ns* | ns* | ns |
| Scheven, (53) | PREVEND | NL | 1997-98 | 8121 | 28-75 | ns | all inhabitants | 48% |
| Stasevic, (54) | | Kosovo & Metohia | 2006 | 423 | 18+ | ns | all inhabitants | 43% |
| Stengel, (55) | 3C | France | 1991-2001 | 8705 | 65 + | electoral rolls | random sample | 37% |
| Suleymanlar, (56) | CREDIT | Turkey | ns | 10056 | 18+ | ns | age, sex & region stratified | ns |

N= Number of subjects with creatinine measurement, ns= not specified. *authors refer to previous publication.°CKD prevalence was only reported for subgroup (N=570).

**Table 1: (continued).**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Tavira, (57) | RENASTUR | Spain | 2010-12 | 592 | 55-85 | ns | random sample | ns |
| Van Pottelbergh, (58) | Crystal | Russia | 2009 | 611 | 65-91 | GP list | all registered on list | 66% |
| Viktorsdottir, (59) | RHS | Iceland | 1967-96 | 19256 | 33-85 | ns | all in birth cohort | ns |
| Vinhas, (60) | PREVADIAB | Portugal | 2008-09 | 5167 | 20-79 | other | age, sex and region stratified | 84% |
| Wasen, (61) | | Finland | 1998-99 | 1246 | 64-100 | ns | all residents born <= 1933 | 83% |
| Wetmore, (62) | | Iceland | 2001-03 | 1630 | 18 + | ns | random sample | 71% |
| Zambon, (63) | ProV.A. | Italy | 1995-97 | 3063 | 65+ | other | age & sex stratified random sample | 64% women 77% men |
| Zhang, (64) | ESTHER | Germany | 2000-02 | 9806 | 50-74 | GP list | not specified | ns |

N= Number of subjects with creatinine measurement, ns= not specified. *authors refer to previous publication. RHS=Reykjavik Heart Study.

## DISCUSSION

We assessed 48 publications, published between 1st of January 2003 and 1st of November 2014, reporting CKD prevalence for the adult general population in 20 European countries. The results of this systematic literature review revealed considerable variation in general population sample selection methods and assessment of kidney function across studies. Moreover, often a clear description of the methods used was lacking and the reporting of CKD prevalence was heterogeneous. These factors may have considerable influence on the prevalence estimates of CKD and need to be taken into account to allow comparison of CKD prevalence across studies.

*Population sample selection*

Although we restricted our search to studies which were designed to be representative of the general population, we observed great heterogeneity in population sample selection methods. Part of this variation was found in the sampling frame used to identify contact details of eligible subjects. The sampling frame should ideally include the entire target population (10) which in this case is the entire general population. National census or population registry data are ideal for sampling the general population, for in principal these should include all inhabitants of a country or region. However, general population surveys are typically limited to community dwelling subjects who are physically and mentally capable to participate in such studies. At old age, a substantial proportion of those with age related chronic diseases such as CKD may no longer fulfill these inclusion criteria, which may lead to substantial underestimation of the true prevalence of such diseases. In such circumstances, depending on the health system or country, general practitioner list or registry based approaches might be required to provide more valid estimates of true prevalence.

Additionally, there existed great variation in sample design. For example, some studies first performed stratification of population by age and sex whereas others invited all inhabitants in the selected region. Both the sampling frame and sample design influence the response and non-response bias (10), which in turn may influence the representativeness of the resulting sample for the general population and consequently of the CKD prevalence estimate. Collecting information on non-responders may help to assess the possibility and likely direction of non-response bias (10).

*Assessment of kidney function*

*Serum creatinine and albuminuria measurements*

There was great variation in the laboratory methods used in studies which reported details of those methods, especially in the calibration of serum creatinine. Differences in creatinine assays are important to take into account in CKD prevalence comparisons, as Jaffe methods overestimate serum creatinine and therefore overestimate CKD prevalence







(11). In 2006 IDMS standardization has been implemented to reduce the systematic bias in creatinine determination and to increase inter-laboratory comparability (7). The publications which clearly reported the use of IDMS standardization were only published in 2010 or later.

*Ethnicity*

In equations used to estimate GFR, like MDRD and CKD-EPI, the variable “ethnicity” is included to adjust for ethnicity-specific differences. Ethnicity may therefore influence CKD prevalence estimates; even so less than half of the publications reported collection of ethnicity data. Since in most European countries the vast majority of the European population is Caucasian, the lack of ethnicity data is unlikely to influence the CKD prevalence of most countries. In the future, however, the proportion of Caucasian subjects in the European population may change, making the collection of ethnicity data more important.

*CKD definition*

Despite the KDOQI guideline on CKD which was published in 2002 (5) and updated by KDIGO in 2012 (12), we observed great variation in the definition of CKD, both in eGFR equations used and in cut-off values for both eGFR and albuminuria. For future studies it is advisable to report CKD as recommended in the updated KDIGO guideline, including six eGFR categories and three albuminuria categories, as this classification allows presentation by mortality and progression risk (13). The chronicity criterion was never used, mainly because follow-up data on serum creatinine were not collected. In more recent studies, CKD was most commonly defined using the CKD-EPI equation, as recommended by KDOQI (5).

*Reporting methods*

A clear description of the population sample selection methods and assessment of kidney function may facilitate a more fair comparison of CKD prevalence across studies. Studies should therefore preferably report this in detail in the method section of their publication. Unfortunately, many studies did not report the sampling frame used. In addition, information about biological sample collection (e.g. nature of collecting procedure, participants conditions, time between sampling and further processing), sample storage conditions (duration of storage, thawing cycles, etc.) should also be reported (14).

*Reporting results*

Another observed difference was the presentation of the results on CKD prevalence estimates. Part of this variation is likely explained by the fact that CKD prevalence was not the main focus of 12 publications. However, even in publications with the main focus on CKD prevalence there was great variation in reporting. All studies did report unadjusted prevalence estimates, yet they were mostly reported without a 95%CI. The reporting of

the 95%CI is necessary as it provides an indication of how much uncertainty there is in the prevalence estimate.

Future studies should preferably report CKD prevalence standardized to the European population to enable international comparison, at least across Europe. In case of regional prevalence estimates, additionally standardization to the national population is required for within-country comparison. This standardization is essential when comparing CKD prevalence estimates from different countries or regions to avoid the influence of differences in national or regional age and sex distributions.

*European CKD Burden Consortium*

In 2012, the European CKD Burden Consortium was established, including both nephrologists and epidemiologists, to enhance comparability of CKD prevalence across European regions and countries.

Box 1 provides an overview of the methodology used by the European CKD Burden Consortium to compare CKD prevalence results across different general population based studies in Europe. This methodology facilitates comparability by providing a detailed description of the population selection method and the response of each study to help assess representativeness of the study population sample. Additionally, the figures and tables clearly show the serum creatinine method used (i.e. Jaffe vs enzymatic) and whether IDMS calibration standardization was used.

Furthermore, a uniform definition of CKD, based on the KDIGO guideline was established (12). CKD was defined as the presence of albuminuria >30mg/g and/or an eGFR <60 ml/min/1.73 $m^2$ as calculated by the CKD-EPI equation. The chronicity criterion was not applied, for none of the assessed general population based studies had this available.

The Consortium will additionally harmonize reporting of results in their publications. All CKD prevalence estimates will be presented as unadjusted rates and standardized to the EU27 population of 2005 (15), and include a 95%CI. As the occurrence of CKD is associated with age and not all study populations cover the entire range of the adult population, the CKD prevalence will also be presented for different age ranges, i.e. 20-44, 45-64, 65-74 and 75-84 years. Additionally the prevalence estimates will be presented with stratification for the presence of the following risk factors: diabetes, hypertension and obesity. This stratification is useful to determine if differences in CKD prevalence are caused by differences in risk factor presence or differences in overall health status of the general population. Whether disparities in CKD prevalence are explained by important risk factors for CKD will guide policy makers to focus on secondary or primary prevention.







**Box 1: Recommended methodology for comparison of CKD prevalence results across general population-based studies as used by the European CKD Burden Consortium.**

| Recommended tools | Details |
|---|---|
| **1.General population sampling** | |
| Sampling methods | Describe:<br>- sampling frame, i.e. source used to identify subjects<br>- sample design, i.e. method of subject selection (e.g. age stratified, random etc.) |
| Response | Report the response in percentages |
| **2.Assessment of kidney function** | |
| Serum creatinine assay | Describe assay used, i.e. Jaffe or enzymatic |
| Albuminuria assay | Describe assay used, e.g. immunoassay, dipstick etc. |
| IDMS calibration standardization | Describe if IDMS calibration standardization was used (yes/ no) |
| CKD definition | Use of the same definition of CKD:<br><u>CKD stage 1-5:</u><br>eGFR <60ml/min/1·73m² calculated by the CKD-EPI equation and /or ACR > 30mg/g<br><u>CKD stage 3-5:</u><br>eGFR <60ml/min/1·73m² calculated by the CKD- EPI equation |
| **3.Presentation of results** | |
| CKD prevalence estimate | Report:<br>- unadjusted and adjusted CKD prevalence (e.g. standardized to the EU27 population)<br>- 95% confidence interval |
| CKD prevalence estimate by strata | Report:<br>- stratified by age group: 20-44, 45-64, 65-74 & 75-84 years<br>- stratified by diabetic, hypertension, and obesity status |
| Serum creatinine determination | Indicate in tables & figures which studies use:<br>- Jaffe or enzymatic assay<br>- IDMS calibration standardization |

**Table 2: Laboratory assessment of kidney function, CKD definition used and details on the reporting of CKD prevalence per study.**

| First author | Creatinine method | IDMS | Albuminuria method | CKD def. | eGFR equation | Ethnicity | CI | Age & sex stand. prevalence | Stratified prevalence |
|---|---|---|---|---|---|---|---|---|---|
| Aumann | Jaffe | Other | n/a | 2 | CKD-EPI + Other | Yes | n/a | | Yes: Other |
| Bongard | Jaffe | No | n/a | 2 | MDRD (old) | No | Yes | Yes to national pop. | No |
| Browne | Modified Jaffe | Yes | Other | 1 + 2 | CKD-EPI + new MDRD | Unclear | Yes | Yes to national pop. | Yes:age, sex, & other |
| Capuano | Modified Jaffe | No | n/a | 2 | CG | No | No | Yes to national pop. | Yes:age,sex & other |
| Christensson | Unclear | Other | n/a | Other | CKD-EPI, MDRD (old) & CG | Yes | No | No | Yes: age & sex |
| Chudek | Jaffe | Unclear | Dipstick - → Immunoassay | 1+2+3 | CKD-EPI | No | No | No | Yes: age, sex & other |
| Cirillo | Modified Jaffe | No | Immunoassay | 2 | MDRD (old) | Yes | N;Yes %;No | Yes to national pop. | Yes: age & sex |
| Codreanu | Unclear | No | Other | 2 + 3 | MDRD (old) | No | No | No | Yes: age, sex & other |
| De Nicola | Enzymatic | Yes | Immunoassay | 1+2+3 | CKD-EPI | No | Yes | No | No |
| Delanaye | Compensated Jaffe | Yes | n/a | 2 | CKD-EPI + new MDRD | Unclear | No | No | Yes: sex |
| Donfrancesco | Enzymatic | Yes | n/a | 2 | CKD-EPI | No | No | No | Yes: sex |
| Formiga | Compensated Jaffe | No | n/a | 2 | MDRD (old) | No | No | No | No |
| Fraser | Enzymatic | Yes | ns | 1+2+3 +other | CKD-EPI + new MDRD | Yes | No | Unclear | Yes: Other |
| Gambaro | Modified Jaffe | Other | if Dipstick + → Immunoassay | 1+2+3 | CKD-EPI | Yes | Yes | Yes to US pop | Yes: age, sex & other |

**Table 2: (continued).**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Gianelli | Modified Jaffe | No | n/a | 2 | MDRD (old) and CG | No | No | No | No |
| Goek | Comp Jaffe | Unclear | n/a | 2 | CKD-EPI | Unclear | n/a | No | No |
| Gu | Modified Jaffe | Unclear | ns | 2 | CKD-EPI + MDRD (old) | No | No | No | No |
| Guessous | Comp Jaffe | Unclear | Unclear | 1 | CKD-EPI | Yes | n/a | No | No |
| Hallan | Jaffe | Other | Immunoassay | 1+2+3 | new MDRD | Yes | Yes | Yes to national pop & US pop | Yes: age, sex & other |
| Hernandez | ns | Unclear | ns | 1&other | CKD-EPI | Yes | n/a | No | Yes: Other |
| Juutilainen | Enzymatic | Yes | n/a | 2&other | CKD-EPI + new MDRD | Unclear | No | No | Yes: age &sex |
| Lieb | Enzymatic | No | Immunoassay | 3 | MDRD (old) | Unclear | n/a | No | No |
| Meuwes | Jaffe | No | n/a | 2 | CKD-EPI + MDRD (old) | No | n/a | No | No |
| Nitsch | Modified Jaffe | Other | n/a | 2 | MDRD (old) | Yes | n/a | No | Yes: Other |
| Nitsch | Jaffe | Other | n/a | 2 | MDRD (old) and CG | Yes | Yes | No | Yes: age & sex |
| Otero | Unclear | Unclear | Unclear | 1 + 2 | MDRD (old) | Yes | Yes | Yes to national pop. | Yes: age, sex & other |
| Pani | ns | Other | ns | 1+2+3 | CKD-EPI + new MDRD | No | Yes | No | Yes: age & sex |
| Pattaro | Enzymatic | Yes | n/a | 2 | CKD-EPI, new MDRD + Other | Unclear | Yes | No | Yes: age |
| Ponte | Comp Jaffe | Yes | Immunoassay | 1+2+3 | CKD-EPI + new MDRD | Yes | Yes | No | Yes: age & sex |

CKD def.= CKD definition 1= CKD stage 1-5; 2= eGFR < 60 ml/min/1.73m$^2$; 3= albuminuria >30mg/g. Ethnicity= 'yes' if collection is reported; 'no' if not reported or not collected. CI= confidence interval given for prevalence estimate, stand.=standardized, CG= Cockcroft and Gault equation, n/a= not applicable.

**Table 2: (continued).**

| First author | Creatinine method | IDMS | Albuminuria method | CKD def. | eGFR equation | Ethnicity | CI | Age & sex stand. prevalence | Stratified prevalence |
|---|---|---|---|---|---|---|---|---|---|
| Redon | ns | Unclear | n/a | 2 | CG | No | n/a | No | No |
| Robles | Jaffe | Yes | Immunoassay | 2 + Other | CKD-EPI + new MDRD | Yes | Yes | Yest to EU pop | Yes: age & sex |
| Roderick | Modified Jaffe & Enzymatic | No | Dipstick | 2 + Other | MDRD (old) | No | Yes | No | Yes: age & sex |
| Rothenbacher | Modified Jaffe | Yes | Immunoassay | 1+2+3 | CKD-EPI + new MDRD | Unclear | No | No | Yes: age and sex |
| Rutkowski | Modified Jaffe | No | if Dipstick + → Immunoassay | 1+2+3 | MDRD (old) | No | No | No | No |
| Sahin | Modified Jaffe | Unclear | n/a | 2 | new MDRD | No | No | No | Yes: age, sex & other |
| Schaeffner | Enzymatic | Yes | ns | 2 | CKD-EPI + Other | Yes | n/a | No | No |
| Scheven | Unclear | Unclear | Immunoassay | 1+2+3 | CKD-EPI | Unclear | n/a | No* | No |
| Stasevic | Modified Jaffe | Unclear | if Dipstick + → Immunoassay | 2 + 3 + Other | MDRD (old) | No | No | No | No |
| Stengel | Jaffe | Yes[1] | Unclear | 1 + 2 | CKD-EPI + new MDRD | No | No | No | Yes: age and sex |
| Suleymanlar | Jaffe | No | Immunoassay | 1+2+3 | MDRD (old) | Yes | No | Yes to national pop. | Yes: age and sex |
| Tavira | ns | No | ns | 2 | MDRD (old) | Yes | n/a | No | No |
| Van Pottelbergh | Modified Jaffe | No | n/a | 2 | MDRD (old) and CG | Unclear | No | No | Yes: age and sex |
| Viktorsdottir | Modified Jaffe | No | Dipstick | 1+2+3 | MDRD (old) and CG | Yes | No | Yes to global pop | Yes: age and sex |

**Table 2. (continued).**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Vinhas | Modified Jaffe | No | n/a | 2 | MDRD (old) | Unclear | Yes | Yes to national pop. | Yes: age, sex & other |
| Wasen | Jaffe | Unclear | Immunoassay | 2 + Other | new MDRD and CG | No | No | No | Yes per sex |
| Wetmore | Unclear | Yes | n/a | 2 | new MDRD and CG | Yes | No | No | No |
| Zambon | Jaffe | Other | Dipstick | 2 + Other | CKD-EPI and MDRD (old) | Yes | n/a | Yes to national pop. | No |
| Zhang | Modified Jaffe | No | Immunoassay | 2 + Other | MDRD (old) | Unclear | No | No | Yes: age, sex & other |

CKD def.= CKD definition 1= CKD stage 1-5; 2= eGFR < 60 ml/min/1.73m2; 3= albuminuria >30mg/g. Ethnicity= 'yes' if collection is reported; 'no' if not reported or not collected. CI= confidence interval given for prevalence estimate, stand.=standardized, CG= Cockcroft and Gault equation, n/a= not applicable.[1] In order to standardize creatinine values, 1720 frozen serum samples were remeasured in a single laboratory with an isotope dilution mass spectrometry (IDMS) traceable enzymatic assay. Hereafter equations relating the Jaffe and IDMS-traceable creatinine were developed to standardized all baseline values as follows: ScrIDMS= 0.86 x ScrJaffe + 4.40. *Population corrected for sampling design (i.e. oversampling of albuminuria).

*Implications*

This systematic literature review revealed considerable variation in general population sample selection methods and assessment of kidney function across studies. In addition, a clear description of the methods used was often lacking and the reporting of CKD prevalence was heterogeneous. The approach of The European CKD Burden Consortium will not eliminate the differences in population selection methods and laboratory assessment of kidney function. However, the recommendations regarding the reporting of both methods and results of CKD prevalence studies, may enhance comparability of CKD prevalence results across Europe and even worldwide (16). Our recommendations may be used by investigators to optimize both the design and the reporting of future CKD prevalence studies.







**REFERENCES**


1. Levey AS, Atkins R, Coresh J, Cohen EP, Collins AJ, Eckardt KU, et al. Chronic kidney disease as a global public health problem: approaches and initiatives - a position statement from Kidney Disease Improving Global Outcomes. Kidney international. 2007;72(3):247-59.
2. Coresh J, Selvin E, Stevens LA, Manzi J, Kusek JW, Eggers P, et al. Prevalence of chronic kidney disease in the United States. JAMA. 2007;298(17):2038-47.
3. Boutten A, Bargnoux AS, Carlier MC, Delanaye P, Rozet E, Delatour V, et al. Enzymatic but not compensated Jaffe methods reach the desirable specifications of NKDEP at normal levels of creatinine. Results of the French multicentric evaluation. ClinChimActa. 2013;419:132-5.
4. Van Biesen W, Vanholder R, Veys N, Verbeke F, Delanghe J, De Bacquer D, et al. The importance of standardization of creatinine in the implementation of guidelines and recommendations for CKD: implications for CKD management programmes. Nephrology, dialysis, transplantation : official publication of the European Dialysis and Transplant Association - European Renal Association. 2006;21(1):77-83.
5. K/DOQI Clinical Practice Guidelines for Chronic Kidney Disease: Evaluation, Classification, and Stratification. American journal of kidney diseases : the official journal of the National Kidney Foundation. 2002;39(February Supplement 1).
6. Shlipak MG, Matsushita K, Arnlov J, Inker LA, Katz R, Polkinghorne KR, et al. Cystatin C versus creatinine in determining risk based on kidney function. The New England journal of medicine. 2013;369(10):932-43.
7. Myers GL, Miller WG, Coresh J, Fleming J, Greenberg N, Greene T, et al. Recommendations for improving serum creatinine measurement: a report from the Laboratory Working Group of the National Kidney Disease Education Program. ClinChem. 2006;52(1):5-18.
8. Delanaye P, Cavalier E, Cristol JP, Delanghe JR. Calibration and precision of serum creatinine and plasma cystatin C measurement: impact on the estimation of glomerular filtration rate. JNephrol. 2014.
9. Cholongitas E, Marelli L, Kerry A, Senzolo M, Goodier DW, Nair D, et al. Different methods of creatinine measurement significantly affect MELD scores. Liver transplantation : official publication of the American Association for the Study of Liver Diseases and the International Liver Transplantation Society. 2007;13(4): 523-9.
10. Groves R, Fowler F, Couper M, Lepkowski J, Singer E, Tourangeau R. Survey Methodology. 2nd ed: Wiley; 2009.
11. Drion I, Cobbaert C, Groenier KH, Weykamp C, Bilo HJ, Wetzels JF, et al. Clinical evaluation of analytical variations in serum creatinine measurements: why laboratories should abandon Jaffe techniques. BMC Nephrol. 2012;13:133.

12. Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group. KDIGO 2012 Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease. Kidney IntSuppl. 2012;3.
13. Levey AS, de Jong PE, Coresh J, El Nahas M, Astor BC, Matsushita K, et al. The definition, classification, and prognosis of chronic kidney disease: a KDIGO Controversies Conference report. Kidney Int. 2011;80(1):17-28.
14. Gallo V, Egger M, McCormack V, Farmer PB, Ioannidis JP, Kirsch-Volders M, et al. STrengthening the Reporting of OBservational studies in Epidemiology-Molecular Epidemiology (STROBE-ME): an extension of the STROBE Statement. PLoS medicine. 2011;8(10):e1001117.
15. Eurostat: http://epp.eurostat.ec.europa.eu/portal/page/portal/population/data/database Table: Average population by sex and five-year age groups. [Internet]. [cited 2013 August 15].
16. Bikbov B, Perico N, Remuzzi G. Mortality landscape in the global burden of diseases, injuries and risk factors study. Eur J Intern Med. 2014;25(1):1-5.
17. Aumann N, Baumeister SE, Werner A, Wallaschofski H, Hannemann A, Nauck M, et al. Inverse association of estimated cystatin C- and creatinine-based glomerular filtration rate with left ventricular mass: Results from the Study of Health in Pomerania. Int J Cardiol. 2013;167(6):2786-91.
18. Bongard V, Dallongeville J, Arveiler D, Ruidavets JB, Cottel D, Wagner A, et al. Assessment and characteristics of chronic kidney disease in France. [French]. Annales de Cardiologie et d'Angeiologie. 2012;61(4):239-44.
19. Browne GM, Eustace JA, Fitzgerald AP, Lutomski JE, Perry IJ. Prevalence of diminished kidney function in a representative sample of middle and older age adults in the Irish population. BMC Nephrology. 2012;13(1).
20. Capuano V, Lamaida N, Borrelli MI, Capuano E, Fasolino A, Capuano E, et al. Chronic kidney disease prevalence and trends (1998-2008) in an area of southern Italy. The data of the VIP project. G. 2012;29(4):445-51.
21. Christensson A, Elmstahl S. Estimation of the age-dependent decline of glomerular filtration rate from formulas based on creatinine and cystatin C in the general elderly population. Nephron - Clinical Practice. 2011;117(1):c40-c50.
22. Chudek J, Wieczorowska-Tobis K, Zejda J, Broczek K, Skalska A, Zdrojewski T, et al. The prevalence of chronic kidney disease and its relation to socioeconomic conditions in an elderly Polish population: Results from the national population-based study PolSenior. Nephrology Dialysis Transplantation. 2014;29(5):1073-82.
23. Cirillo M, Laurenzi M, Mancini M, Zanchetti A, Lombardi C, De Santo NG. Low glomerular filtration in the population: Prevalence, associated disorders, and awareness. Kidney international. 2006;70(4):800-6.
24. Codreanu I, Sali V, Gaibu S, Suveica L, Popa S, Perico N, et al. Prevalence of hypertension and diabetes and coexistence of chronic kidney disease and





cardiovascular risk in the population of the Republic of Moldova. International Journal of Hypertension. 2012;2012(951734).
25. De Nicola L, Donfrancesco C, Minutolo R, Lo Noce C, De Curtis A, Palmieri L, et al. [Epidemiology of chronic kidney disease in Italy: current state and contribution of the CARHES study]. Giornale italiano di nefrologia : organo ufficiale della Societa italiana di nefrologia. 2011;28(4):401-7.
26. Delanaye P, Cavalier E, Mariat C, Maillard N, Krzesinski JM. MDRD or CKD-EPI study equations for estimating prevalence of stage 3 CKD in epidemiological studies: Which difference? Is this difference relevant? BMC Nephrology. 2010;11(1).
27. Donfrancesco C, Palleschi S, Palmieri L, Rossi B, Lo Noce C, Pannozzo F, et al. Estimated glomerular filtration rate, all-cause mortality and cardiovascular diseases incidence in a low risk population: the MATISS study.[Erratum appears in PLoS One. 2014;9(1). doi:10.1371/annotation/1f5e18af-4a68-4419-9f3f-7e8bff410b48]. PLoS ONE. 2013;8(10):e78475.
28. Formiga F, Ferrer A, Cruzado JM, Padros G, Fanlo M, Roson B, et al. Geriatric assessment and chronic kidney disease in the oldest old: The Octabaix study. European Journal of Internal Medicine. 2012;23(6):534-8.
29. Fraser SD, Roderick PJ, Aitken G, Roth M, Mindell JS, Moon G, et al. Chronic kidney disease, albuminuria and socioeconomic status in the Health Surveys for England 2009 and 2010. Journal of public health (Oxford, England). 2014;36(4):577-86.
30. Gambaro G, Yabarek T, Graziani MS, Gemelli A, Abaterusso C, Frigo AC, et al. Prevalence of CKD in northeastern Italy: results of the INCIPE study and comparison with NHANES. Clin J Am Soc Nephrol. 2010;5(11):1946-53.
31. Giannelli SV, Graf CE, Herrmann FR, Michel JP, Patel KV, Pizzarelli F, et al. Natural history of older adults with impaired kidney function: The InCHIANTI study. Rejuvenation Research. 2011;14(5):513-23.
32. Goek ON, Prehn C, Sekula P, Romisch-Margl W, Doring A, Gieger C, et al. Metabolites associate with kidney function decline and incident chronic kidney disease in the general population. Nephrology Dialysis Transplantation. 2013;28(8):2131-8.
33. Gu YM, Thijs L, Liu YP, Zhang Z, Jacobs L, Koeck T, et al. The urinary proteome as correlate and predictor of renal function in a population study. Nephrology, dialysis, transplantation : official publication of the European Dialysis and Transplant Association - European Renal Association. 2014;29(12):2260-8.
34. Guessous I, McClellan W, Kleinbaum D, Vaccarino V, Zoller O, Theler JM, et al. Comparisons of serum vitamin D levels, status, and determinants in populations with and without chronic kidney disease not requiring renal dialysis: a 24-hour urine collection population-based study. J Ren Nutr. 2014;24(5):303-12.
35. Hallan SI, Coresh J, Astor BC, Asberg A, Powe NR, Romundstad S, et al. Inter-

national comparison of the relationship of chronic kidney disease prevalence and ESRD risk. Journal of the American Society of Nephrology. 2006;17(8):2275-84.
36. Hernandez D, Espejo-Gil A, Bernal-Lopez MR, Mancera-Romero J, Baca-Osorio AJ, Tinahones FJ, et al. Association of HbA1c and cardiovascular and renal disease in an adult Mediterranean population. BMC Nephrology. 2013;14(1).
37. Juutilainen A, Kastarinen H, Antikainen R, Peltonen M, Salomaa V, Tuomilehto J, et al. Comparison of the MDRD Study and the CKD-EPI Study equations in evaluating trends of estimated kidney function at population level: Findings from the National FINRISK Study. Nephrology Dialysis Transplantation. 2012;27(8):3210-7.
38. Lieb W, Mayer B, Stritzke J, Doering A, Hense HW, Loewel H, et al. Association of low-grade urinary albumin excretion with left ventricular hypertrophy in the general population: the MONICA/KORA Augsburg Echocardiographic Substudy. Nephrology Dialysis Transplantation. 2006;21(10):2780-7.
39. Meuwese CL, Gussekloo J, de Craen AJ, Dekker FW, den Elzen WP. Thyroid status and renal function in older persons in the general population. The Journal of clinical endocrinology and metabolism. 2014;99(8):2689-96.
40. Nitsch D, Lawlor DA, Patel R, Carson C, Ebrahim S. The association of renal impairment with all-cause and cardiovascular disease mortality. Nephrology Dialysis Transplantation. 2010;25(4):1191-9.
41. Nitsch D, Felber Dietrich D, von Eckardstein A, Gaspoz JM, Downs SH, Leuenberger P, et al. Prevalence of renal impairment and its association with cardiovascular risk factors in a general population: results of the Swiss SAPALDIA study. Nephrology Dialysis Transplantation. 2006;21(4):935-44.
42. Otero A, de Francisco A, Gayoso P, Garcia F, Group ES. Prevalence of chronic renal disease in Spain: results of the EPIRCE study. Nefrologia. 2010;30(1):78-86.
43. Pani A, Bragg-Gresham J, Masala M, Piras D, Atzeni A, Pilia MG, et al. Prevalence of CKD and its relationship to eGFR-related genetic loci and clinical risk factors in the SardiNIA study cohort. Journal of the American Society of Nephrology: JASN. 2014;25(7):1533-44.
44. Pattaro C, Riegler P, Stifter G, Modenese M, Minelli C, Pramstaller PP. Estimating the glomerular filtration rate in the general population using different equations: effects on classification and association. Nephron. 2013;123(1-2):102-11.
45. Ponte B, Pruijm M, Marques-Vidal P, Martin PY, Burnier M, Paccaud F, et al. Determinants and burden of chronic kidney disease in the population-based CoLaus study: A cross-sectional analysis. Nephrology Dialysis Transplantation. 2013;28(9):2329-39.
46. Redon J, Gil V, Cea-Calvo L, Lozano JV, Marti-Canales JC, Llisterri JL, et al. The impact of occult renal failure on the cardiovascular risk stratification in an elderly population: the PREV-ICTUS study. Blood Press. 2008;17(4):212-9.
47. Robles NR, Felix FJ, Fernandez-Berges D, Perez-Castan JF, Zaro MJ, Lozano L, et al. Cross-sectional survey of the prevalence of reduced estimated glomerular filtration rate, albuminuria and cardiovascular risk in a native Spanish population. Journal of Nephrology. 2013;26(4):675-82.
48. Roderick PJ, Atkins RJ, Smeeth L, Nitsch DM, Hubbard RB, Fletcher AE, et al. Detecting chronic kidney disease in older people; what are the implications?. [Erratum appears in Age Ageing. 2009 Sep;38(5):638 Note: Flectcher, Astrid E [corrected to Fletcher, Astrid E]]. Age Ageing. 2008;37(2):179-86.
49. Rothenbacher D, Klenk J, Denkinger M, Karakas M, Nikolaus T, Peter R, et al. Prevalence and determinants of chronic kidney disease in community-dwelling elderly by various estimating equations. BMC public health. 2012;12:343.
50. Rutkowski B, Krol E. Epidemiology of chronic kidney disease in Central and Eastern Europe. Blood Purification. 2008;26(4):381-5.
51. Sahin I, Yildirim B, Cetin I, Etikan I, Ozturk B, Ozyurt H, et al. Prevalence of chronic kidney disease in the black sea region, Turkey, and investigation of the related factors with chronic kidney disease. Renal Failure. 2009;31(10):920-7.
52. Schaeffner ES, Ebert N, Delanaye P, Frei U, Gaedeke J, Jakob O, et al. Two novel equations to estimate kidney function in persons aged 70 years or older. Ann Intern Med. 2012;157(7):471-81.
53. Scheven L, de Jong PE, Hillege HL, Lambers Heerspink HJ, van Pelt LJ, Kootstra JE, et al. High-sensitive troponin T and N-terminal pro-B type natriuretic peptide are associated with cardiovascular events despite the cross-sectional association with albuminuria and glomerular filtration rate. European heart journal. 2012;33(18):2272-81.
54. Stasevic Z, Gorgieva GS, Vasic S, Ristic S, Djukanovic L, Lezaic V. High prevalence of kidney disease in two rural communities in Kosovo and Metohia. Renal Failure. 2010;32(5):541-6.
55. Stengel B, Metzger M, Froissart M, Rainfray M, Berr C, Tzourio C, et al. Epidemiology and prognostic significance of chronic kidney disease in the elderly--the Three-City prospective cohort study. Nephrology, dialysis, transplantation : official publication of the European Dialysis and Transplant Association - European Renal Association. 2011;26(10):3286-95.
56. Suleymanlar G, Uta C, Arinsoy T, Ate K, Altun B, Altiparmak MR, et al. A population-based survey of Chronic REnal Disease in Turkey-the CREDIT study. Nephrology Dialysis Transplantation. 2011;26(6):1862-71.
57. Tavira B, Coto E, Gomez J, Tranche S, Miguelez K, Ortega F, et al. Association between a MYH9 polymorphism (rs3752462) and renal function in the Spanish RENASTUR cohort. Gene. 2013;520(1):73-6.
58. Van Pottelbergh C, Gurina N, Degryse J, Frolova E. Prevalence of impaired renal function in the elderly in the St. Petersburg District: results of the Crystal study. Advances in gerontology = Uspekhi gerontologii / Rossiiskaia akademiia nauk,

Gerontologicheskoe obshchestvo. 2011;24(1):108-13.
59. Viktorsdottir O, Palsson R, Andresdottir MB, Aspelund T, Gudnason V, Indridason OS. Prevalence of chronic kidney disease based on estimated glomerular filtration rate and proteinuria in Icelandic adults. Nephrology Dialysis Transplantation. 2005;20(9):1799-807.
60. Vinhas J, Gardete-Correia L, Boavida JM, Raposo JF, Mesquita A, Fona MC, et al. Prevalence of chronic kidney disease and associated risk factors, and risk of end-stage renal disease: Data from the PREVADIAB study. Nephron Clinical Practice. 2011;119(1):c35-c40.
61. Wasen E, Isoaho R, Mattila K, Vahlberg T, Kivela SL, Irjala K. Estimation of glomerular filtration rate in the elderly: A comparison of creatinine-based formulae with serum cystatin C. Journal of Internal Medicine. 2004;256(1):70-8.
62. Wetmore JB, Palsson R, Belmont JM, Sigurdsson G, Franzson L, Indridason OS. Discrepancies between creatinine- and cystatin C-based equations: implications for identification of chronic kidney disease in the general population. Scand J Urol Nephrol. 2010;44(4):242-50.
63. Zambon S, Maggi S, Zanoni S, Romanato G, Noale M, Corti MC, et al. Association of single measurement of estimated glomerular filtration rate and non-quantitative dipstick proteinuria with all-cause and cardiovascular mortality in the elderly. Results from the Progetto Veneto Anziani (Pro.V.A.) Study. Atherosclerosis. 2012;220(1):201-7.
64. Zhang QL, Koenig W, Raum E, Stegmaier C, Brenner H, Rothenbacher D. Epidemiology of chronic kidney disease: Results from a population of older adults in Germany. Preventive Medicine. 2009;48(2):122-7.