Original Article

The Lack of a Standardized Definition of Chronic Dialysis Treatment in German Statutory Health Insurance Claims Data

Effects on Estimated Incidence and Mortality

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Summary

Background: Chronic kidney failure (CKF) is often treated with dialysis, which is invasive and costly and carries major medical risks. The existing studies of patients with CKF requiring dialysis that are based on claims data from German statutory health insurance (SHI) carriers employ varying definitions of this entity, with unclear consequences for the resulting statistical estimates.

Methods: We carried out a cohort study on four random samples, each consisting of 62 200 persons aged 70 or above, from among the insurees of the SHI AOK Nordost, with one sample for each of the years 2012, 2014, 2016, and 2018. The prevalence, incidence, mortality, and direct health care costs of CKF requiring dialysis were estimated and compared on the basis of four different definitions from literature and a new definition developed by the authors in reference to billing data.

Results: The different definitions led to variation in 12-month prevalences (range: 0.33–0.61%) and 6-month incidences (0.058–0.100%). The percentage of patients with prior acute kidney injury (AKI) ranged from 27.6% to 61.8%. Among incident patients, three-month survival ranged from 70.2% to 88.1%, and six-month survival from 60.5% to 81.3%. In CKF patients without prior AKI, the survival curves differed less across definitions (80.2–91.8% at three months, 70.7–84.4% at six months). The monthly health care costs ranged from €6010 to €9606, with marked variability across definitions in the costs of inpatient and outpatient care.

Conclusion: The lack of a standardized definition of CKF requiring dialysis in German SHI claims data leads to variability in the estimated case numbers, mortality, and health care costs. These differences are most probably in part due to the variable inclusion of inpatients who received short-term dialysis after AKI.

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Chronic kidney failure (CKF) requiring dialysis places a significant burden not only on patients but also on the health care system. Patients with CKF suffer considerable loss of quality of life and functionality (1, 2), complex multimorbid health impairments (3), and are at high risk for cardiovascular events (4), treatment complications, and (early) mortality (3, 5–8). Moreover, dialysis treatment itself is highly invasive, burdensome, and time-consuming. In the case of chronic hemodialysis (HD), the commonest method of renal replacement therapy in CKF (3), patients are treated 3–4 × per week for 4–5 h in dialysis centers and practices. From a care and health system perspective, CKF requiring dialysis takes up manifold medical, nursing, and monetary resources, particularly in old age (9). The direct health costs for dialysis patients in Germany are estimated to be more than 3 billion Euros per year (10).

In view of demographic aging, it is expected that the prevalence of patients with CKF requiring dialysis will continue to rise (11). Despite the relevance of CKF on both an individual and a structural level, its high risk profile, and the high costs involved, there is no nationwide dialysis registry in Germany. Although annual quality reports on dialysis are drawn up on behalf of the German Joint Federal Committee (*Gemeinsamer Bundesausschuss*, G-BA) (12), these have a number of limitations: The reports are based solely on data for outpatients with CKF requiring dialysis who have statutory health insurance and have survived on dialysis for at least 3 months. Since Germany does not have a central death registry, mortality data are incomplete. In view of the high premature mortality rate within the first 3 months of starting dialysis as well as different treatment and insurance modalities (day-care patients, privately insured patients), this suggests a relevant underestimation of the group of patients with CKF requiring dialysis in older age.

Routinely recorded health care data are becoming ever more important for clinical, epidemiological, and health care systems research (e1–e3) and represent a valuable alternative data basis for patients with CKF requiring dialysis. Likewise in Germany, claims data from statutory health insurers (SHI) were employed to analyze mortality, hospitalizations, and health care costs for CKF requiring dialysis (3, 10, 13–19). However, what is striking here is that the definitions used vary between the studies. At present, there is no standardized definition in Germany to identify patients with CKF requiring dialysis in claims data, also to differentiate those requiring short-term reversible dialysis treatment following, for example, acute kidney injury (AKI). However, a correct distinction between chronic dialysis treatment for CKF and acute short-term dialysis treatment following AKI is extremely important, since the two treatment modalities differ qualitatively and quantitatively and have different treatment goals.

The aim of this study was to analyze the variation between different definitions of CKF requiring dialysis in SHI claims data in the literature, as well as a new definition, in order to investigate the identifiability of patients with CKF requiring dialysis and their differentiation from those receiving dialysis treatment following AKI. To this end, we compared the definitions based on prevalence, incidence, early mortality, and direct health care costs following the initiation of dialysis in the billing data for patients aged ≥ 70 years insured by the SHI AOK Nordost.

Methods

Data basis

This secondary data-based cohort study was conducted on the basis of billing data from the AOK Nordost that were gathered as part of the GUIDAGE-CKD Innovation Fund project. Data from separate random samples from each of 4 years (2012, 2014, 2016, and 2018, with data from 1 January to 31 December of each year) were analyzed, each with n = 62 200 insurees aged at least 70 years without previous kidney transplant (see *eSupplement* for details on case number estimation and sampling).

Definition of CKF requiring dialysis

There is no uniform definition of CKF requiring dialysis based on diagnosis or treatment codes in SHI claims data. To identify insurees with CKF requiring dialysis, we applied criteria using diagnoses according to ICD-10-German Modification (GM) (e4) and fee schedule items (*Gebührenordnungspositionen*, GOP) in the German Uniform Value Scale (*Einheitlicher Bewertungsmaßstab*) for outpatient treatment as well as operation and procedure codes (*Operationen- und Prozedurenschlüssel*, OPS) for inpatient treatment. Only “confirmed” outpatient and “main” and “secondary” inpatient diagnoses were used. For the literature-based definitions, a literature search was conducted for relevant keywords and to identify the described criteria. A number of studies were excluded because that the criteria for the operationalization of CKF requiring dialysis were identical to other studies (15), were not described (16–18), or only a GOP code was given as a criterion (19). *Table 1* summarizes the criteria used for the literature-based definitions (a)–(d) of CKF requiring dialysis (3, 10, 13, 14). The selection of the criteria for a new definition (e), based on a billing rationale, that are required for reimbursement by the SHI was carried out following research in the relevant treatment catalogs, consultation with office-based and inpatient nephrologists with coding and billing expertise, and in coordination with the AOK Nordost. In contrast to the literature-based definitions, we used only OPS and ICD-10-GM codes billed for day-care treatment in definition (e), since acute short-term dialysis treatment, such as after AKI or sepsis, is predominantly performed in the hospital and patients are transferred to outpatient or day-care treatment if they become chronic.

The first exact date on which all criteria of a definition were fulfilled was defined as the index date of dialysis. To analyze the endpoints mortality and health care costs, incident cases in the 2nd and 3rd quarters of a year were identified. To this end, all cases that were already prevalent or deceased in the 1st quarter of a year or only became incident in the 4th quarter were excluded. Follow-up was carried out for up to 6 months following the index date, with censoring on the date of death or on December 31 of the respective year.

Endpoints and statistical analyses

The different definitions (a)–(e) were compared with regard to 12-month prevalence, 6-month incidence, age, and gender. Prevalence and incidence were standardized by year-, age-, and gender-specific weights from the German Federal Statistical Office (DESTATIS) for individuals aged 70 years and over in the German federal states falling under the insurance area of the AOK Nordost (Berlin, Brandenburg, Mecklenburg-Western Pomerania). Mortality within 6 months following the index date was calculated using the Kaplan–Meier method. Furthermore, the proportion of cases diagnosed with AKI (ICD-10-GM N17*) in the period from 3 months before up to the index date of dialysis was determined.

For the analysis of direct health care costs from an SHI perspective, all outpatient, inpatient, and drug costs within 6 months after the index date were analyzed overall and separately by care sector and adjusted to the cost level in 2018 according to purchasing power parity. The rates per person-month were calculated by dividing total costs by total person-time in months. Bootstrapping with 1000 replications was used to determine 95% confidence intervals [CI] for health care costs (20). Mortality analyses were stratified by the presence of prior AKI, age, sex, and the respective year.

Results

The varying definitions used led to significantly different case numbers, clinical characteristics, mortality data, and health care costs. Overall, the case numbers for prevalent patients varied between 832 and 1547 across all years, and

Table 1

Case numbers for patients with CKF requiring dialysis together with sociodemographic and clinical characteristics according to different definitions in claims data

Definition	Criteria*1	12-Month prevalence		6-Month incidence *2		Women, n (%)	Age, M (SD)	Prior AKI*4, n (%)
		Cases, n	Standardized*3, % [95% CI]	Cases, n	Standardized*3, % [95% CI]			
a) Gandjour et al., 2020 (10)	1. ICD-10-GM N18.5 "and" 2. ICD-10-GM Z49*, Z99.2	1466	0.58 [0.55; 0.61]	190	0.081 [0.071; 0.093]	67 (35.3)	80.8 (6.2)	86 (45.3)
b) Kolbrink et al., 2023 (3)	1. ICD-10-GM N18.5 "and" 2. Either 2.1. OPS 8-854.2–5, 8-855, 8-857 "or" 2.2. GOP 13610, 13611	1447	0.57 [0.54; 0.60]	178	0.073 [0.063; 0.084]	60 (33.7)	81.2 (6.5)	110 (61.8)
c) Lonnemann et al., 2017 (13)	1. ICD-10-GM N18.5 "and" 2. Either 2.1. ICD-10-GM Z49*, Z99.2 "or" 2.2. GOP 40800–8, 40812–3, 40820–3 "or" 2.3. OPS 8-854	1547	0.61 [0.58; 0.64]	213	0.089 [0.078; 0.101]	79 (37.1)	81.2 (6.2)	104 (48.8)
d) Schellartz et al., 2021 (14)	1. ICD-10-GM N18.5 "and" 2. Either 2.1. GOP 13611, 40823–7, 40837–8 "or" 2.2. OPS 8-853, 8-854, 8-855, 8-857	1262	0.50 [0.47; 0.53]	241	0.100 [0.088; 0.113]	81 (33.6)	81.0 (6.5)	120 (49.8)
e) Billing rationale	1. Outpatient dialysis: 1.1. ICD-10-GM Z49.1–2 "and" 1.2. ICD-10-GM Z99.2 "and" 1.3. GOP 13610, 13611 "or" 2. Day-care dialysis: 2.1. ICD-10-GM Z49.1–2 "and" 2.2. OPS 8-853, 8-854, 8-855, 8-857	832	0.33 [0.31; 0.35]	134	0.058 [0.050; 0.069]	40 (29.9)	80.3 (6.0)	37 (27.6)

*1 Only individuals fulfilling all criteria with the Boolean operator "and" were included in the analyses. The first date on which all criteria were fulfilled was defined as the index date. Commas and hyphens represent an "or" condition. Unless otherwise stated, both outpatient and inpatient codes were used.
*2 Incidence was determined as the proportion of all prevalent cases in the 2nd or 3rd quarter of an individual year out of all persons at risk (neither prevalent nor deceased in the respective 1st quarter).
*3 Prevalence and incidence are standardized for individuals aged ≥ 70 years. We used year-, age-, and gender-specific DESTASTIS weights for individuals aged ≥ 70 years from Berlin, Brandenburg, and Mecklenburg-Western Pomerania.
4 Number of cases with acute kidney injury (AKI; ICD-10-GM N17) within 3 months before or on the index date.
CKF, chronic kidney failure; GOP, fee schedule items (*Gebührenordnungspositionen*) in the German Uniform Value Scale (*Einheitlicher Bewertungsmaßstab*, EBM); ICD-10-GM, International statistical classification of diseases and related health problems, 10th revision, German Modification. Only "confirmed" outpatient and "main" and "secondary" (partial) inpatient diagnoses were used; M, mean; 95% CI, 95% confidence interval; OPS, German "Operations and Procedures Code"; a list and description of all codes used can be found in the *eSupplement*.

for incident patients between 134 and 241 *(Table 1)*. If the definition according to billing rationale (e) was used, both the standardized 12-month prevalence and the standardized 6-month incidence were at their lowest (prevalence: 0.33% [95% confidence interval: 0.31; 0.35]; incidence: 0.058% [0.050; 0.069]). In contrast, definition (c) resulted in the highest prevalence at 0.61% [0.58; 0.64] and definition (d) in the highest incidence at 0.100 % [0.088; 0.113]. The percentage of female patients with CKF requiring dialysis varied between 29.9% in definition (e) and 37.1% in definition (c), whereas the average age barely differed between 80.3 and 81.2 years.

The percentage of insurees diagnosed with AKI within the 3 months before or on the index date of dialysis was lowest when using definition (e) at 27.6%, significantly higher when using definitions (a), (c), and (d) at 45.3–49.8%, and highest with definition (b) at 61.8%. Survival probability was highest in definition (e) (88.1% and 81.3% at 3 and 6 months, respectively) and lowest in definition (b) (70.2% and 60.5% at 3 and 6 months, respectively; *Table 2, Figure*).

The total direct health care costs per person-month within 6 months following the dialysis index date varied between the different definitions from €6022 [5482; 6646] in definition (e) to €9635 [8081; 11,556] in definition (b) *(Table 2)*. The differences in individual care sectors were most evident in outpatient and inpatient costs: Outpatient costs were highest with definition (e) at €2935 [2766; 3126], while inpatient costs were highest with definition (b) at €6578 [4991; 8532]. Drug costs varied less markedly, ranging from €566 to €809.

Following stratification between patients with and those without a documented diagnosis of AKI before the start of dialysis, the survival probabilities were significantly higher in patients without prior AKI and varied less between the definitions (80.2–91.8% at 3 months, 70.7–84.4% at 6 months). In patients with prior AKI, the probability of survival at 6 months was by far the highest if definition (e) was used (75.4 % [62.6; 90.8]), whereas it was similar if definitions (a)–(d) were used (47.0–53.6%) *(eFigure 1)*. The differences between the definitions in terms of survival probability in the main analysis were similar in the subgroup analyses stratified by age, sex, and year *(eFigures 2–4)*.

Discussion

Our analysis shows that the use of different definitions of CKF requiring dialysis in SHI claims data leads to variability in the estimated prevalence, incidence, mortality, and health care costs. The definition of CKF requiring dialysis, based on an SHI billing rationale that takes into account outpatient and only day-care dialysis treatments led to lower case numbers and significantly higher survival probabilities following the initiation of dialysis. These divergences appear to be due in part to the presence of prior AKI and the inclusion of inpatients and intensive care patients receiving dialysis treatment following acute events alongside CKF patients requiring dialysis. The proportion of cases with prior AKI was around half to two-thirds when using the literature-based definitions compared to one-third when using the billing rationale-based definition. This is borne out by significantly higher inpatient health care costs for the literature-based definitions, although there was also significant variation between these, while outpatient care costs were highest for the billing rationale-based definition. The inclusion of patients treated in an inpatient setting, who likely have complex multimorbidity and receive short-term dialysis treatments, can result in an overestimation of case numbers as well as bias in the endpoints under consideration.

The estimates for early mortality following initiation of dialysis differ in international studies (8). Due to methodological differences, it is sometimes difficult to compare these estimates, not least since registry data often systematically exclude patients who died early on within the first 90 days after starting dialysis (21). Early mortality within 6 months after starting dialysis was estimated to be 19% based on French registry data (22), which is consistent with the results from definition (e). In order to precisely determine the mortality risks due to dialysis, further analyses based on SHI claims data or randomized controlled trials are required (23).

Although dialysis treatment for CKF is a highly invasive and costly treatment method, Germany does not have a national dialysis registry. As a result, there are no precise figures on prevalence or even on mean survival times of dialysis patients. Therefore, risk stratifications or predictions about adverse outcomes, as well as statements on the specific application of dialysis procedures in routine care, are currently not possible, thereby hampering tailored advice and decision-making for patients. The quality assurance data from which the GBA reports feed are subject to structural limitations in that they only collect data on people with statutory health insurance (meaning that around 13% of insurees go completely unrecorded [e5]); include no information on mortality; systematically underestimate prevalence due to the 3-month criterion; and do not yet show longitudinal trends. In view of this, SHI claims data currently represent the most valid data available in Germany for the analysis of mortality and other hard endpoints (for example, cardiovascular events) in CKF requiring dialysis.

However, there are challenges associated with the scientific use and correct interpretation of SHI claims data: For a multitude of clinical pictures and treatments, there is a lack of standardized procedures and uniform definitions, meaning that results can vary depending on the criteria selected. Moreover, there are only a handful of studies that validate claims data using other data sources. For clearly identifiable diseases such as hypertension and breast cancer, as well as for rarer diseases such as *Campylobacter* enteritis, claims data show good usability (24–26), whereas the ability to differentiate between type-1 and type-2 diabetes as well as specific stages of chronic kidney disease and the identification of emergency department treatments must be deemed limited (27–30). Likewise in the case of chronic obstructive pulmonary disease, the use of claims data alone is not optimal; here, a combination of claims and self-reported data from patients appears to be more expedient (31). Furthermore, there are relevant differences in the structure of insurees and clinical characteristics within the large number of health insurance carriers in Germany (32). To improve the scientific usability

Table 2

Survival probability and direct health care costs for patients with incident CKF requiring dialysis according to different definitions

Definition	Incident cases, n	Survival probability*1, % [95% CI]		Direct health care costs*2 (in €) within 6 months following incident CKF requiring dialysis, rate per person-month [95% CI]*3			
		At 3 months	At 6 months	Outpatient	Inpatient	Drugs	Total
a) Gandjour et al., 2020 (10)	190	82.1 [76.8; 87.7]	70.8 [64.4; 77.8]	1864 [1653; 2053]	4067 [3127; 5242]	661 [520; 825]	6797 [5824; 8010]
b) Kolbrink et al., 2023 (3)	178	70.2 [63.8; 77.3]	60.5 [53.4; 68.6]	1906 [1680; 2118]	6556 [4969; 8509]	606 [466; 767]	9606 [8055; 11527]
c) Lonnemann et al., 2017 (13)	213	74.2 [68.5; 80.3]	63.1 [56.7; 70.3]	1554 [1358; 1760]	5503 [4333; 6908]	564 [438; 713]	8020 [6820; 9377]
d) Schellartz et al., 2021 (14)	241	71.8 [66.3; 77.7]	61.4 [55.3; 68.3]	2057 [1847; 2246]	6227 [5019; 7626]	600 [494; 737]	9445 [8267; 10,808]
e) Billing rationale	134	88.1 [82.7; 93.7]	81.3 [74.7; 88.4]	2930 [2762; 3121]	2061 [1582; 2611]	807 [639; 1.012]	6010 [5471; 6632]

*1 The survival probability was calculated using the Kaplan–Meier method taking censoring into account (31st December or death within an individual year).
*2 The direct health care costs from an SHI perspective was determined as all outpatient and inpatient case costs as well as drug costs within 6 months following incident dialysis (index date) with censoring on death or on 31st December of the respective year. All drugs costs with a dispensing date and case costs with a final billing date within the follow-up period were included. Costs were adjusted to the cost level in 2018 according to purchasing power parity (OECD).
*3 The rate per person-month was calculated as the sum of costs divided by the sum of person-time in months in the follow-up period. Bootstrapping with 1000 replications was used to determine 95% confidence intervals.
CKF, chronic renal failure; 95% CI, 95% confidence interval.

of SHI claims data, efforts should be made towards the linkage of claims data with other data sources, and comparative studies should be further promoted (33, 34).

For CKF requiring dialysis, there is—over and above the general limitations of claims data—the difficulty that there is no clear and valid coding based on diagnoses or treatment codes and, thus, no way of differentiating it from dialysis treatments for other indications. Also, in the interests of good scientific practice and reproducibility of study results (35, 36), it should be mandatory to have a precise definition and provide the respective criteria (codes used, time period criteria) when using SHI claims data in scientific articles (37).

When using claims data on CKF requiring dialysis, limitations such as potential misclassification, flexibility in operationalization, and difficulties in the differentiation between short-term and chronic dialysis treatment must be taken into account. The determination of dialysis-related risks for mortality, other clinical events such as hospitalizations, and costs all play a central role in the appropriate allocation of resources, since not all patients benefit from dialysis (38). In the first instance, this involves informed decision-making by patients regarding the choice of appropriate CKF treatment pathway (39, 40) and evidence-based management of high-quality health care.

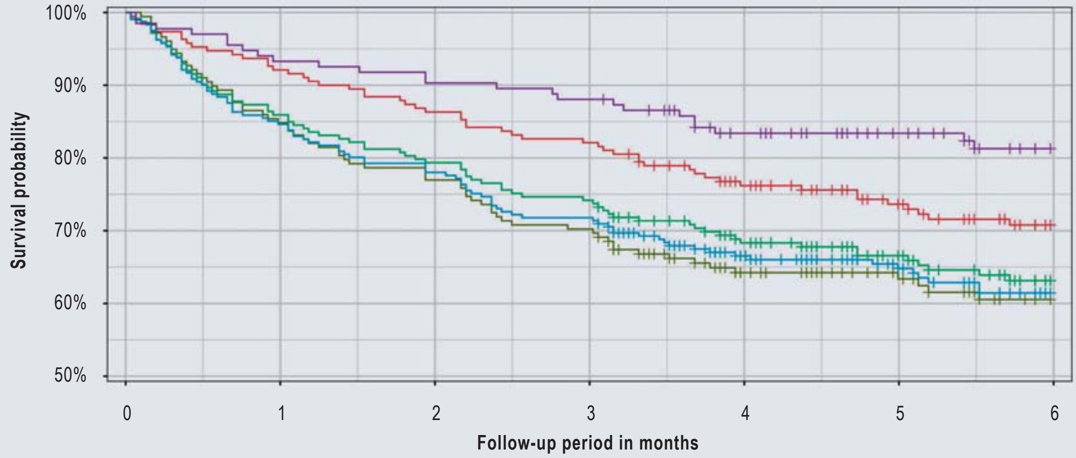
Limitations

The results of this study relate solely to insurees of the AOK Nordost aged ≥ 70 years. In order to make these statements generalizable, analyses based on other SHI claims data and other age groups should be undertaken. To achieve better comparability, estimates on prevalence and incidence were standardized in these analyses. Furthermore, only data for 4 separate years could be used. Therefore, the effects of different definitions on endpoints over longer follow-up periods should be further investigated. However, since in particular early mortality following the initiation of dialysis is of great clinical interest, the analyses presented here can nevertheless make a valuable contribution. For the analysis of health care costs, only inpatient and outpatient treatment costs as well as redeemed drug prescriptions were taken into consideration. Other aspects such as dialysis-related travel costs, remedies and medical aids, rehabilitative treatments, and non-prescription drugs should be analyzed for a more comprehensive view of health costs associated with CKF requiring dialysis.

Conclusion

Different definitions of CKF requiring dialysis in SHI claims data lead to variation in estimates for epidemiological, clinical, and health-economic endpoints. Our newly developed definition, which is based on plausible mortality figures and health care costs, makes it possible to more precisely identify patients with CKF requiring dialysis as distinct from patients receiving short-term dialysis treatment following AKI. The aspects and hurdles identified in this study in terms of the operationalization of CKF requiring dialysis in SHI claims data may also be of great relevance for other diseases and target populations beyond dialysis.

Figure



At Risk	0	1	2	3	4	5	6
a) Gandjour et al., 2020	190	175	164	156	135	109	77
b) Kolbrink et al., 2023	178	151	137	125	90	73	54
c) Lonnemann et al., 2017	213	183	169	158	132	105	71
d) Schellartz et al., 2021	241	204	188	173	134	105	75
e) Billing rationale	134	125	121	118	101	84	68

Events	0	1	2	3	4	5	6
a) Gandjour et al., 2020	0	15	26	34	45	49	53
b) Kolbrink et al., 2023	0	27	41	53	63	64	67
c) Lonnemann et al., 2017	0	30	44	55	67	70	75
d) Schellartz et al., 2021	0	37	53	68	80	83	88
e) Billing rationale	0	9	13	16	22	22	24

Kaplan–Meier survival curves within 6 months after incident chronic kidney failure (CKF) requiring dialysis for different definitions contained in claims data. The number of events is cumulative.

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Data sharing statement
The data used in this study cannot be made available in the manuscript, the supplemental files, or in a public repository due to German data protection laws (*Bundesdatenschutzgesetz*). To ensure the replicability of the results, the data used are stored on a secure data device at the Charité – Universitätsmedizin Berlin. Access to the raw data used in this study can only be provided to external parties under the conditions of a cooperation contract and upon written request (bis@charite.de).

Conflict of interest statement
ES and NE receive funding from Bayer AG. ES receives funding from the National Kidney Foundation (USA).

JF is employed by the AOK Nordost.

The remaining authors declare that no conflict of interests exists.
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Supplementary material
eReferences, eSupplement:
www.aerzteblatt-international.de/m2023.0015

Supplementary material to accompany the article:

The Lack of a Standardized Definition of Chronic Dialysis Treatment in German Statutory Health Insurance Claims Data

Effects on Estimated Incidence and Mortality

by Tim Bothe, Anne-Katrin Fietz, Nina Mielke, Julia Freitag, Natalie Ebert*, and Elke Schaeffner*

Dtsch Arztebl Int 2024; 121: 148–54. DOI: 10.3238/arztebl.m2024.0015

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Internet-Supplement to:

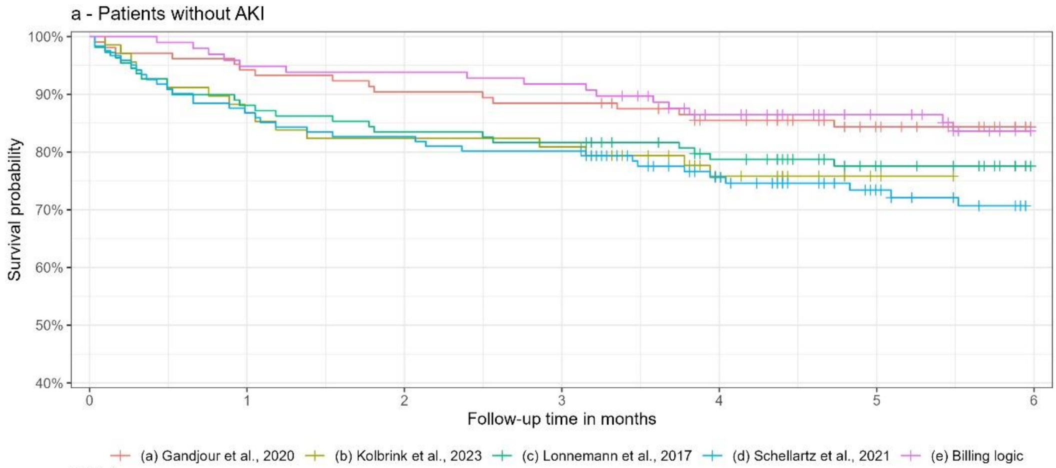
Non-standardized definition of chronic dialysis within German health claims data results in varying estimates for incidence and mortality

List of contents

Description and rationales for the sample size calculation and sampling procedure

In this study, we conducted a secondary data analysis for data which were acquired for another research project (GUIDAGE-CKD – Guideline-compliant care of older patients with chronic kidney diseases, funded by the Federal Joint Committees innovation fund, funding code 01VSF20020) which aimed to investigate trends in the healthcare service quality for patients with chronic kidney disease (CKD) over time. The sample size calculation was based on the primary endpoint CKD prevalence. In total, we aimed to test six CKD-related predefined quality indicators. We assumed that CKD prevalence increased from 25% in 2012 to 28% in 2018. The final sample size for each year tranche was calculated to be 6,220 persons based on a χ^2-Test for Multiple Proportions, with a power of 80% and alpha significance level of 0.0083 after Bonferroni-correction for six parallel hypotheses (α=0.05/6). We accounted for all analyses to be stratified by sex and five age groups (70-74, 75–79, 80–84, 85–89, and ≥90 years), resulting in a final sample size of 62,200 persons per year tranche. The sample size was calculated with nQuery 8. Before sampling, we excluded all persons aged <70 years or with a history of kidney transplantation (ICD-10 code Z94.0 or OPS code 5-555 in 2006 through the year preceding a respective year tranche). After application of the restriction criteria, a total of roughly 500,000 persons were eligible for sampling in each year tranche. The sampling was conducted independently for each year tranche (i.e., with replacement between the year tranches), stratified by sex and five age groups. We analysed treatment and diagnosis data from the outpatient and inpatient sector as well as dispensed medication data.

The application of the criteria for prevalent and incident dialysis-dependent chronic kidney failure (CKF) was applied independently for each year tranche. Due to the sampling procedure with replacement between the year tranches, the same persons could be drawn within several year tranches. We conducted the analyses on a case-level for consistency in the chosen operationalisations for prevalence (all respective criteria fulfilled within one year tranche) and incidence (prevalent cases excluding those who were prevalent or died within the first quarter or those that were only prevalent in the fourth quarter of a respective year tranche) throughout the single year tranches, thus ignoring multiple occurrences. Of all prevalent persons, 7.8% (definition (d)) to 10.0% (definition (a)) within one definition were counted in more than one year tranche as prevalent cases. For incidence, three persons in total (one when using definition (d), two in definition (e)) were counted twice as single incident cases over the four year tranches. The exclusion of these persons did not result in different mortality estimates and did not impact the differences between the definitions from the main analysis. For consistency in the operationalisation of incidence throughout the year tranches and the lack of longitudinal data for precise incidence estimations, we report the results with inclusion of multiple cases, since the 12-month-prevalence estimates are still informative and the exclusion did no impact the results on analyses for incident persons (mortality).

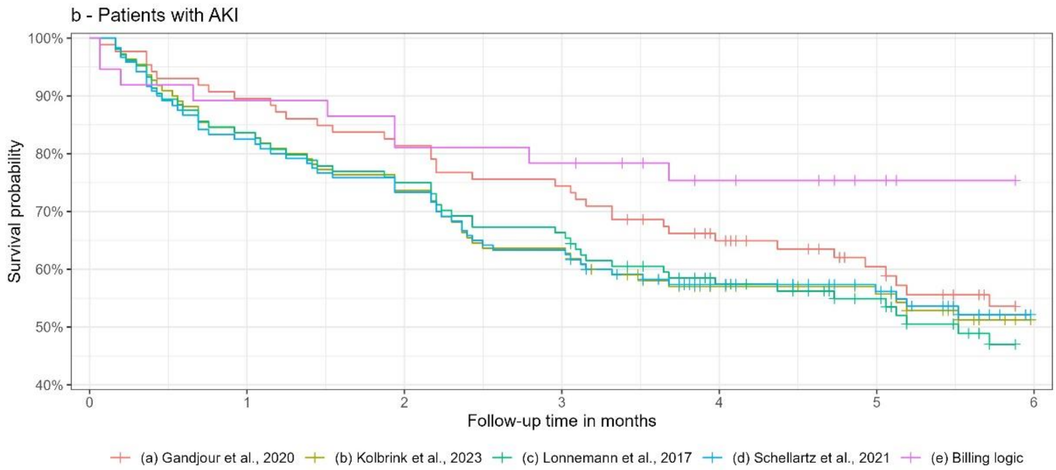


At Risk

	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	104	98	94	92	84	71	52
(b) Kolbrink et al., 2023	68	59	56	55	39	31	29
(c) Lonnemann et al., 2017	109	96	91	89	79	65	48
(d) Schellartz et al., 2021	121	105	100	97	76	58	46
(e) Billing logic	97	92	91	89	77	64	51

Events

	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	0	6	10	12	15	16	16
(b) Kolbrink et al., 2023	0	9	12	13	16	16	16
(c) Lonnemann et al., 2017	0	13	18	20	23	24	24
(d) Schellartz et al., 2021	0	16	21	24	29	31	33
(e) Billing logic	0	5	6	8	13	13	15



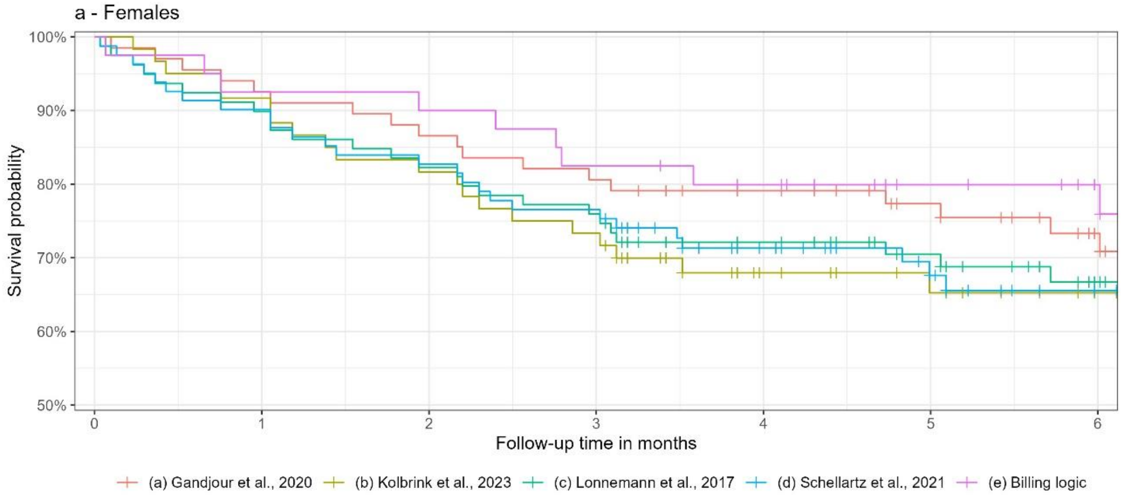
At Risk

	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	86	77	70	64	51	38	25
(b) Kolbrink et al., 2023	110	92	81	70	51	42	25
(c) Lonnemann et al., 2017	104	87	78	69	53	40	23
(d) Schellartz et al., 2021	120	99	88	76	58	47	29
(e) Billing logic	37	33	30	29	24	20	17

Events

	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	0	9	16	22	30	33	37
(b) Kolbrink et al., 2023	0	18	29	40	47	48	51
(c) Lonnemann et al., 2017	0	17	26	35	44	46	51
(d) Schellartz et al., 2021	0	21	32	44	51	52	55
(e) Billing logic	0	4	7	8	9	9	9

eFigure 1 – Kaplan-Meier survival curves within six months after incident chronic kidney failure (CKF) requiring dialysis for different definitions within claims data, stratified by patients without (a) and with (b) a diagnosis for acute kidney injury (AKI; ICD-10 N17*) within three months preceding or at the dialysis-index date.

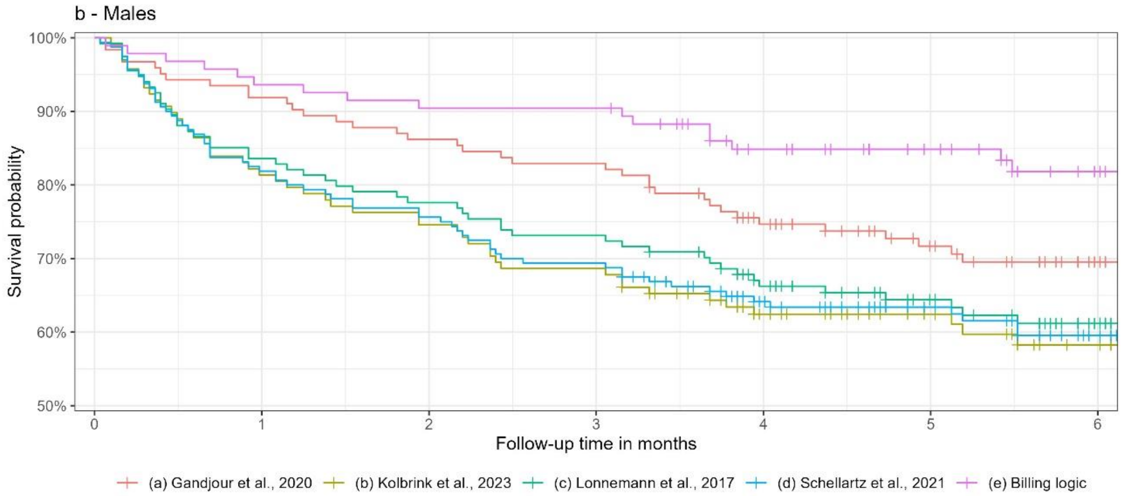


At Risk

	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	67	62	58	54	49	41	30
(b) Kolbrink et al., 2023	60	55	49	44	29	24	18
(c) Lonnemann et al., 2017	79	71	65	60	50	42	28
(d) Schellartz et al., 2021	81	73	67	62	46	35	24
(e) Billing logic	40	37	36	33	30	24	20

Events

	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	0	5	9	13	14	15	17
(b) Kolbrink et al., 2023	0	5	11	16	19	20	20
(c) Lonnemann et al., 2017	0	8	14	19	22	23	25
(d) Schellartz et al., 2021	0	8	14	19	23	25	26
(e) Billing logic	0	3	4	7	8	8	8



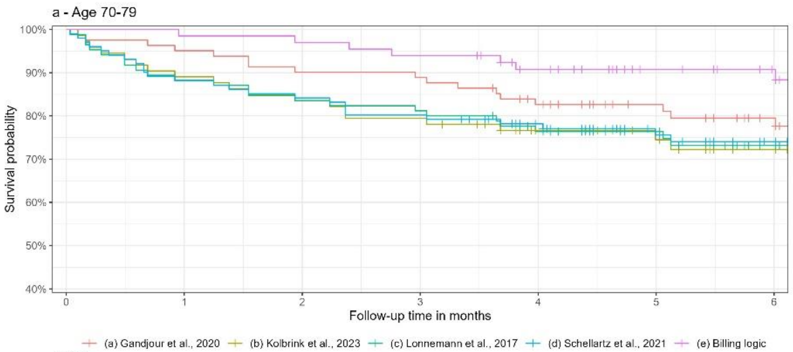
At Risk

	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	123	113	106	102	86	68	47
(b) Kolbrink et al., 2023	118	96	88	81	61	49	36
(c) Lonnemann et al., 2017	134	112	104	98	82	63	43
(d) Schellartz et al., 2021	160	131	121	111	88	70	51
(e) Billing logic	94	88	85	85	71	60	48

Events

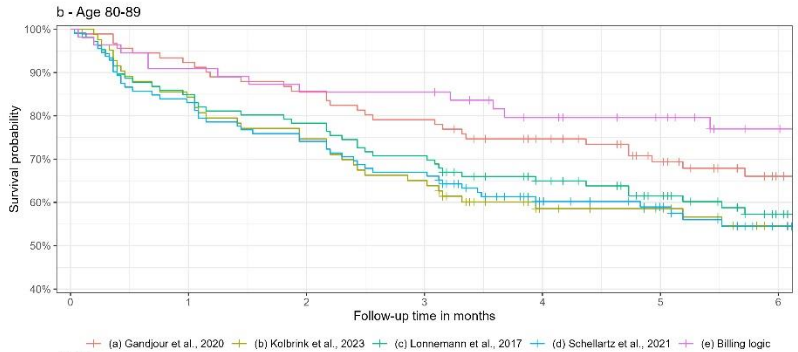
	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	0	10	17	21	31	34	36
(b) Kolbrink et al., 2023	0	22	30	37	44	44	47
(c) Lonnemann et al., 2017	0	22	30	36	45	47	50
(d) Schellartz et al., 2021	0	29	39	49	57	58	62
(e) Billing logic	0	6	9	9	14	14	16

eFigure 2 – Kaplan-Meier survival curves within six months after incident chronic kidney failure (CKF) requiring dialysis for different definitions within claims data, stratified by gender.



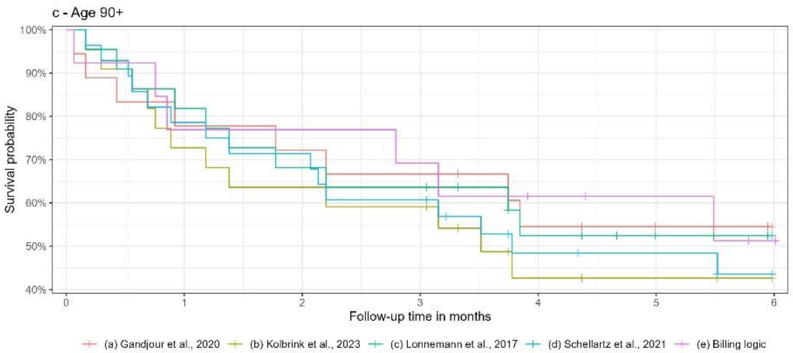
At Risk	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	81	77	73	72	64	53	43
(b) Kolbrink et al., 2023	73	65	61	58	47	35	27
(c) Lonnemann et al., 2017	85	75	71	69	62	49	38
(d) Schellartz et al., 2021	101	89	85	81	70	51	39
(e) Billing logic	66	65	64	62	55	45	38

Events	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	0	4	8	9	14	14	16
(b) Kolbrink et al., 2023	0	8	12	15	17	18	19
(c) Lonnemann et al., 2017	0	10	14	16	20	20	22
(d) Schellartz et al., 2021	0	12	16	20	22	24	25
(e) Billing logic	0	1	2	4	6	6	6



At Risk	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	91	84	78	72	62	49	30
(b) Kolbrink et al., 2023	83	70	62	54	36	32	23
(c) Lonnemann et al., 2017	106	90	83	75	61	50	30
(d) Schellartz et al., 2021	112	93	83	75	53	44	29
(e) Billing logic	55	50	47	47	39	33	26

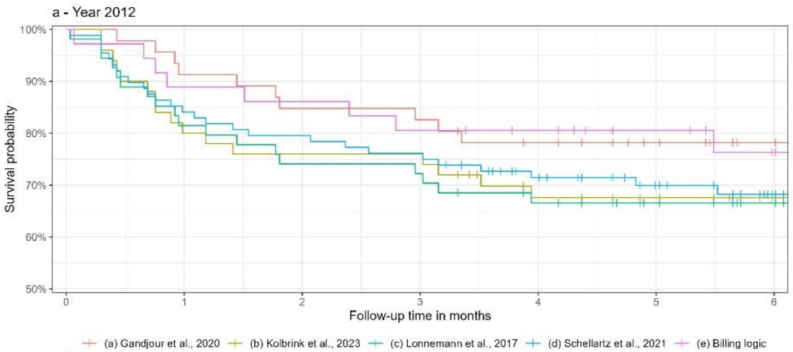
Events	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	0	7	13	19	23	27	29
(b) Kolbrink et al., 2023	0	13	21	29	34	34	36
(c) Lonnemann et al., 2017	0	16	23	31	37	40	43
(d) Schellartz et al., 2021	0	19	29	37	44	45	48
(e) Billing logic	0	5	8	8	11	11	12



At Risk	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	18	14	13	12	9	7	4
(b) Kolbrink et al., 2023	22	16	14	13	7	6	4
(c) Lonnemann et al., 2017	22	18	15	14	9	6	3
(d) Schellartz et al., 2021	28	22	20	17	11	10	7
(e) Billing logic	13	10	10	9	7	6	4

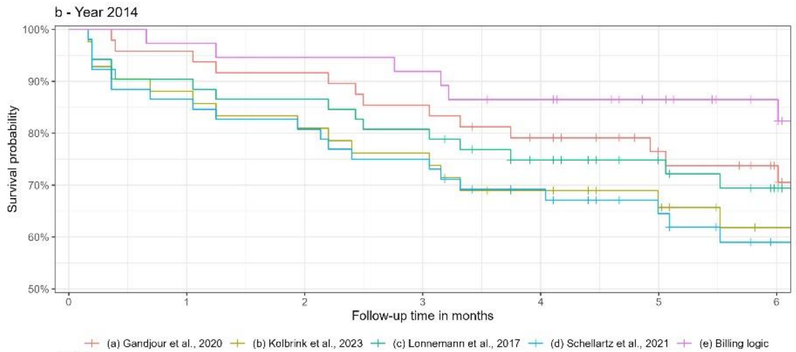
Events	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	0	4	5	6	8	8	8
(b) Kolbrink et al., 2023	0	6	8	9	12	12	12
(c) Lonnemann et al., 2017	0	4	7	8	10	10	10
(d) Schellartz et al., 2021	0	6	8	11	14	14	15
(e) Billing logic	0	3	3	4	5	5	6

eFigure 3 – Kaplan-Meier survival curves within six months after incident chronic kidney failure (CKF) requiring dialysis for different definitions within claims data, stratified by age groups.



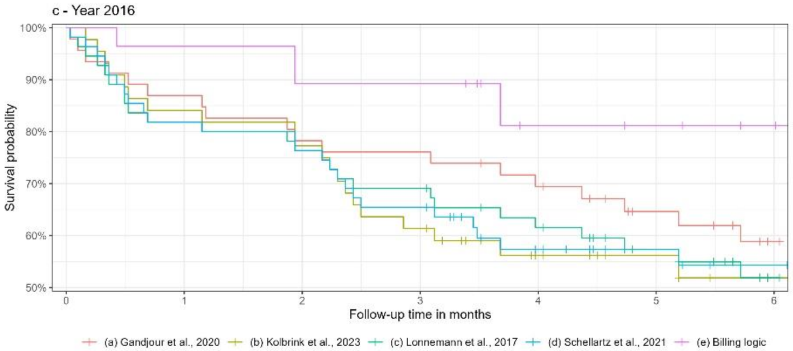
At Risk	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	46	42	39	38	34	27	21
(b) Kolbrink et al., 2023	50	40	38	38	30	27	19
(c) Lonnemann et al., 2017	54	44	40	39	34	27	20
(d) Schellartz et al., 2021	88	74	70	67	56	46	31
(e) Billing logic	36	32	31	29	27	21	16

Events	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	0	4	7	8	10	10	10
(b) Kolbrink et al., 2023	0	10	12	12	16	16	16
(c) Lonnemann et al., 2017	0	10	14	15	18	18	18
(d) Schellartz et al., 2021	0	14	18	21	25	26	27
(e) Billing logic	0	4	5	7	7	7	8



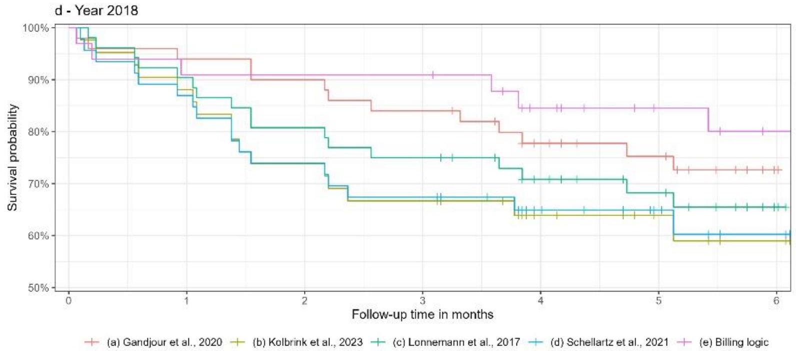
At Risk	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	48	46	44	41	36	28	23
(b) Kolbrink et al., 2023	42	37	34	32	26	20	15
(c) Lonnemann et al., 2017	52	47	45	42	35	28	22
(d) Schellartz et al., 2021	52	45	42	39	33	25	18
(e) Billing logic	37	36	35	34	31	26	21

Events	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	0	2	4	7	10	11	12
(b) Kolbrink et al., 2023	0	5	8	10	13	14	15
(c) Lonnemann et al., 2017	0	5	7	10	13	13	15
(d) Schellartz et al., 2021	0	7	10	13	16	18	20
(e) Billing logic	0	1	2	3	5	5	5



At Risk	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	46	40	36	35	31	24	14
(b) Kolbrink et al., 2023	44	37	34	27	17	13	10
(c) Lonnemann et al., 2017	55	45	42	38	32	24	12
(d) Schellartz et al., 2021	55	45	42	36	25	19	15
(e) Billing logic	28	27	25	25	19	18	16

Events	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	0	6	10	11	14	16	18
(b) Kolbrink et al., 2023	0	7	10	17	19	19	20
(c) Lonnemann et al., 2017	0	10	13	17	21	23	25
(d) Schellartz et al., 2021	0	10	13	19	23	23	24
(e) Billing logic	0	1	3	3	5	5	5



At Risk	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	50	47	45	42	34	30	19
(b) Kolbrink et al., 2023	42	37	31	28	17	13	10
(c) Lonnemann et al., 2017	52	47	42	39	31	26	17
(d) Schellartz et al., 2021	46	40	34	31	20	15	11
(e) Billing logic	33	30	30	30	24	19	15

Events	0	1	2	3	4	5	6
(a) Gandjour et al., 2020	0	3	5	8	11	12	13
(b) Kolbrink et al., 2023	0	5	11	14	15	15	16
(c) Lonnemann et al., 2017	0	5	10	13	15	16	17
(d) Schellartz et al., 2021	0	6	12	15	16	16	17
(e) Billing logic	0	3	3	3	5	5	6

eFigure 4 – Kaplan-Meier survival curves within six months after incident chronic kidney failure (CKF) requiring dialysis for different definitions within claims data, stratified by years.

eTable 1 – Description of all diagnosis and treatment codes used

Category	Code	Description
ICD-10-GM	N17*	Acute renal failure
	N18.5	Chronic kidney disease, stage 5
	Z49*	Care involving dialysis
	Z49.0	Preparatory care for dialysis
	Z49.1	Extracorporeal dialysis
	Z49.2	Other dialysis (peritoneal dialysis)
	Z99.2	Dependence on renal dialysis
	Z94.0	Kidney transplant status (exclusion before sampling only, see Description and rationales for the sample size calculation)
GOP	13610	Additional flat-rate for medical care during hemodialysis, peritoneal dialysis and special procedures
	13611	Additional flat-rate for medical care during peritoneal dialysis
	40800–8	Dialysis material costs (single or weekly dialysis)
	40812–3	Dialysis material costs (surcharges for infection dialysis or intermittent peritoneal dialysis (IPD))
	40820–2	Dialysis material costs (single or weekly dialysis for patients until age 18 years)
	40823	Flat-rate costs for dialysis for insured persons aged 18 and over
	40824	Flat-rate costs for dialysis for insured persons aged 18 and over at their place of residence
	40825	Flat-rate costs for peritoneal dialysis for insured persons aged 18 and over
	40826	Flat-rate costs for peritoneal dialysis for insured persons aged 18 and over at their place of residence
	40827	Flat-rate costs for intermittent peritoneal dialysis for insured persons aged 18 and over at their place of residence
	40837	Supplement to the flat rate 40816 or 40825 for intermittent peritoneal dialysis
	40838	Supplement to flat rate 40817, 40819, 40827 or 40828 for intermittent peritoneal dialysis
OPS	5-555	Kidney operations: Kidney transplantation (exclusion before sampling only, see Description and rationales for the sample size calculation)
	8-853	Hemofiltration
	8-854	Hemodialysis
	8-855	Hemodiafiltration
	8-857	Peritoneal dialysis

Abbreviations: ICD-10-GM: Diagnosis codes in accordance with the International Classification of Diseases, 10th revision, German modification. ICD-10-GM codes were only considered if they were coded as “secure” (outpatient) or “main” or “secondary” (inpatient and partly-inpatient). GOP: *Gebührenordnungsposition* (physicians‘ billing code) according to the German Uniform Value Scale (*Einheitlicher Bewertungsmaßstab; EBM*) for outpatient treatments. OPS: Operational and procedural codes (*Operationen- und Prozedurenschlüssel*; German adaptation of the international classification of procedures in medicine) for inpatient treatments..

eTable 2 – STROBE criteria

	Item No.	Recommendation	Page No.
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6, Supplementaries
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5-6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7, Table 1
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7, Tables 1-2

	Item No.	Recommendation	Page No.
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	5, Supplementaries
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	n/a
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	n/a
		(*e*) Describe any sensitivity analyses	7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	Table 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7, Table 1
		(b) Indicate number of participants with missing data for each variable of interest	n/a
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	Figure 1

	Item No.	Recommendation	Page No.
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time *Case-control study*—Report numbers in each exposure category, or summary measures of exposure *Cross-sectional study*—Report numbers of outcome events or summary measures	7-8, Tables 1-2, Figure 1
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-8, Tables 1-2, Figure 1
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8, Supplementaries
Discussion			
Key results	18	Summarise key results with reference to study objectives	8-9, 11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	9-11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8-9
Generalisability	21	Discuss the generalisability (external validity) of the study results	9-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	5, 12