

Association between Kidney Donor Profile Index (KDPI) and Kidney Transplant Outcomes in Non-US Cohorts: A Systematic Review

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Introduction. End-stage kidney disease is a global health issue. While prediction models like the Kidney Donor Profile Index (KDPI) assess donor quality, the published evidence on its performance is heterogenous. This study aimed to systematically review the association between KDPI and transplant outcomes to optimize clinical decisions and allocation strategies.

Methods. We searched PubMed, Scopus, and Web of Science for studies up to December 2024. We included studies on adult kidney transplant recipients that reported KDPI values and compared them with transplant outcomes. The review question was structured according to PICO: population, adult kidney transplant recipients; exposure, KDPI; comparator, lower KDPI categories or lower donor-risk strata; and outcomes, graft survival, patient survival, delayed graft function (DGF), and kidney function. Studies were assessed for quality using the Newcastle-Ottawa Scale. Exclusion criteria involved non-human, pediatric studies, and research without specific transplant outcomes. A grey literature search via Google Scholar, as well as backward and forward citation searching were performed.

Results. Overall, 10 studies met the inclusion criteria. These studies included 15,879 participants and were conducted across several countries, mostly in Germany. Higher KDPI values were associated with poorer graft survival, reduced kidney function, and an increased incidence of DGF. However, the relationship between KDPI and patient survival was less clear, with some studies reporting no significant association.

Conclusions. Higher KDPI values were associated with poorer graft survival, increased risk of DGF, and reduced kidney function post-transplant. Further studies should explore its interaction with recipient factors and long-term outcomes.

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INTRODUCTION

End-stage kidney disease (ESKD) has a remarkable global health burden. Its prevalence is rising due to demographic shifts, increased prevalence

of risk factors, and improved access to kidney replacement therapies.¹ While incidence rates of treated ESKD have stabilized in many high-income nations, regions such as East and Southeast Asia

have experienced a remarkable rise in new cases.² Although hemodialysis remains the most widely used modality of kidney replacement therapies globally, it is associated with lower survival rates compared to kidney transplantation, which is widely recognized as the optimal treatment for ESKD. Studies have demonstrated that pre-emptive kidney transplantation, performed before the initiation of maintenance dialysis, has advantages, such as reduced all-cause mortality and improved graft survival.³ These findings highlight the role of kidney transplantation as a life-saving intervention for individuals with ESKD.²

Several prediction models have been developed to evaluate kidney transplant survival outcomes, with the aim of helping clinicians in assessing donor kidney suitability. Commonly used models include the Kidney Donor Risk Index (KDRI),⁴ Estimated Post-Transplant Survival (EPTS) score, Maryland Aggregate Pathology Index (MAPI),⁵ and Living Kidney Donor Profile Index (LKDPI).⁶ Earlier classification systems, such as the distinction between standard criteria donors (SCD) and expanded criteria donors (ECD), categorized donor kidneys based on characteristics such as age, kidney function, hypertension, and the cause of death.⁷ However, the predictive accuracy of these classifications has been challenged by factors such as recipient age.

The Kidney Donor Profile Index (KDPI) provides another approach for evaluation of donor kidney quality. The KDPI, expressed as a cumulative percentage, indicates the relative risk of graft failure, with higher values reflecting greater risk compared to kidneys transplanted in the preceding year. The KDPI is derived from the KDRI, which evaluates ten donor-specific characteristics, including age, height, weight, medical history of diabetes and hypertension, serum creatinine levels, hepatitis C status, ethnicity, cause of death, and whether the donor experienced cardiac death, to create an overall risk assessment.⁸

Despite the growing use of KDPI as a tool for kidney transplant outcomes, the published evidence on its performance is heterogeneous across settings, donor types, recipient populations, and outcome definitions. While KDPI is widely used to assess donor quality, its predictive accuracy varies across different clinical settings and populations, which highlights the need to assess its implementation

in various demographic and geographic contexts. These differences underscore the necessity for a systematic review to assess the effectiveness of KDPI and to determine its applicability in different transplant conditions. Accordingly, the present review was designed using a prespecified PICO framework to assess the association between KDPI and clinically relevant kidney transplant outcomes. Therefore, the aim of our study was to systematically review and the evidence on the association between the KDPI and kidney transplant outcomes.

MATERIALS AND METHODS

We carried out the study in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.⁹ The review question was structured as follows: population, adult kidney transplant recipients; exposure, KDPI; comparator, lower KDPI categories or lower donor-risk strata; and outcomes, graft survival, patient survival, delayed graft function, and kidney function.

Search strategy

We conducted a systematic search across PubMed, Scopus, and Web of Science without restrictions, covering publications up to December 11, 2024. We combined controlled vocabulary and free-text terms and customized the strategy for each database to maximize sensitivity. These databases were selected because they provide broad and complementary coverage of biomedical literature, and no single database can be expected to identify all relevant studies. The search strategy included the following terms: "Kidney Donor Profile Index" or "KDPI," combined with transplantation-related terms such as "transplant*," "graft*," "Kidney Transplantation," "Transplantation," "Kidney graft*," and "Renal Transplant*." Outcome-specific terms were intentionally not incorporated into the search strategy to maximize sensitivity and avoid excluding potentially relevant studies that evaluated KDPI and transplant outcomes but did not explicitly report outcome-related keywords in their titles, abstracts, or indexing fields. Instead, all transplant-related outcomes were assessed during the title/abstract screening, full-text review, and data extraction stages. Specific steps of the search strategy and results are detailed in Table S1. In addition, a grey literature search was performed

Table S1. Search strategies for PubMed, Scopus, Web of Science, and Google scholar.

Step	Search strategy	Results (Search date: Dec 11, 2024)
PubMed		
1	"Kidney Donor Profile Index"[Title/Abstract] OR "KDPI"[Title/Abstract]	409
2	"Kidney Transplantation"[Mesh] OR "Transplantation"[Mesh] OR "transplant*"[Title/Abstract] OR "graft*"[Title/Abstract] OR "Kidney Transplantation"[Title/Abstract] OR "Transplantation"[Title/Abstract] OR "Kidney graft*"[Title/Abstract] OR "Renal Transplant*"[Title/Abstract]	1,034,781
3	#1 AND #2	394
Scopus		
1	TITLE-ABS-KEY ("Kidney Donor Profile Index" OR "KDPI")	434
2	TITLE-ABS-KEY ("transplant*" OR "graft*" OR "Kidney Transplantation" OR "Transplantation" OR "Kidney graft*" OR "Renal Transplant*")	1,573,449
3	#1 AND #2	423
Web of Science		
1	TS = ("Kidney Donor Profile Index" OR "KDPI")	628
2	TS = ("transplant*" OR "graft*" OR "Kidney Transplantation" OR "Transplantation" OR "Kidney graft*" OR "Renal Transplant*")	1,251,767
3	#1 AND #2	514
Google Scholar (Search date: Dec 12, 2024)		
1	("Kidney Donor Profile Index" OR "KDPI") AND ("transplant" OR "graft")	About 4,250

using Google Scholar (search date: December 12, 2024). Google Scholar was used as an adjunct source to capture grey literature and records that may not be fully indexed in bibliographic databases. The query ("Kidney Donor Profile Index" OR "KDPI") AND ("transplant" OR "graft") returned approximately 4,250 results, and the first 300 were manually screened.¹⁰ Backward and forward citation tracking was conducted for all included studies, and reference lists of relevant studies and reviews were examined to minimize the risk of missing eligible articles. This multi-source strategy was used to maximize search sensitivity and reduce the likelihood of publication bias.

Study selection

All identified studies were imported into EndNote software, where duplicate entries were removed. Titles and abstracts screening was conducted independently based on predefined inclusion criteria. Full-text articles of studies meeting the initial screening criteria were then reviewed independently, under the supervisor of the principal investigator.

The inclusion criteria were studies involving adult kidney transplant recipients, with reported KDPI values, and research comparing KDPI categories or values with kidney transplant outcomes, such as graft survival, patient survival, delayed graft function (DGF), acute rejection, or other clinical

outcomes. Eligible studies included observational designs, such as cross-sectional, cohort (prospective or retrospective), and case-control studies.

Exclusion criteria included studies involving non-human or pediatric subjects, research not addressing KDPI as a key variable, studies lacking specific kidney transplant outcomes, and publications like case reports, opinion pieces, editorials, or conference abstracts without full data. Duplicate publications or overlapping data from the same population without novel insights were also excluded.

Data extraction and risk of bias assessment

Data extraction was conducted for the following information: the first author, year of publication, country, study design, study population, sample size (total and each group), participant demographics (e.g., proportion of males and age values), KDPI definition, comparisons, reported outcomes, and main findings. For studies reporting quantitative associations, the effect size, confidence interval, and adjustment variables were extracted whenever available and summarized consistently in the supplementary table. The risk of bias assessment was performed using the Newcastle-Ottawa Scale (NOS) for cohort and cross-sectional studies. The NOS evaluates study quality in three domains: the selection of participants, the comparability of study groups, and the ascertainment of outcomes.

Within these domains, a maximum of one star can be assigned per item, except in the comparability domain, which allows for up to two stars. The maximum score for cohorts is nine and for cross-sectional studies is eight.

Data synthesis

Because the included studies differed in KDPI categorization, outcome definitions, follow-up duration, and reporting formats, the findings were synthesized narratively. A meta-analysis

was not performed because the available data were not sufficiently comparable for valid pooling. Accordingly, formal quantitative heterogeneity statistics (I^2 , Q-test, Tau^2) were not calculated, as these are only interpretable within a pooled meta-analytic framework.

RESULTS

Study selection

Of the 1331 articles initially identified, 752 duplicates were removed, leaving 579 studies for

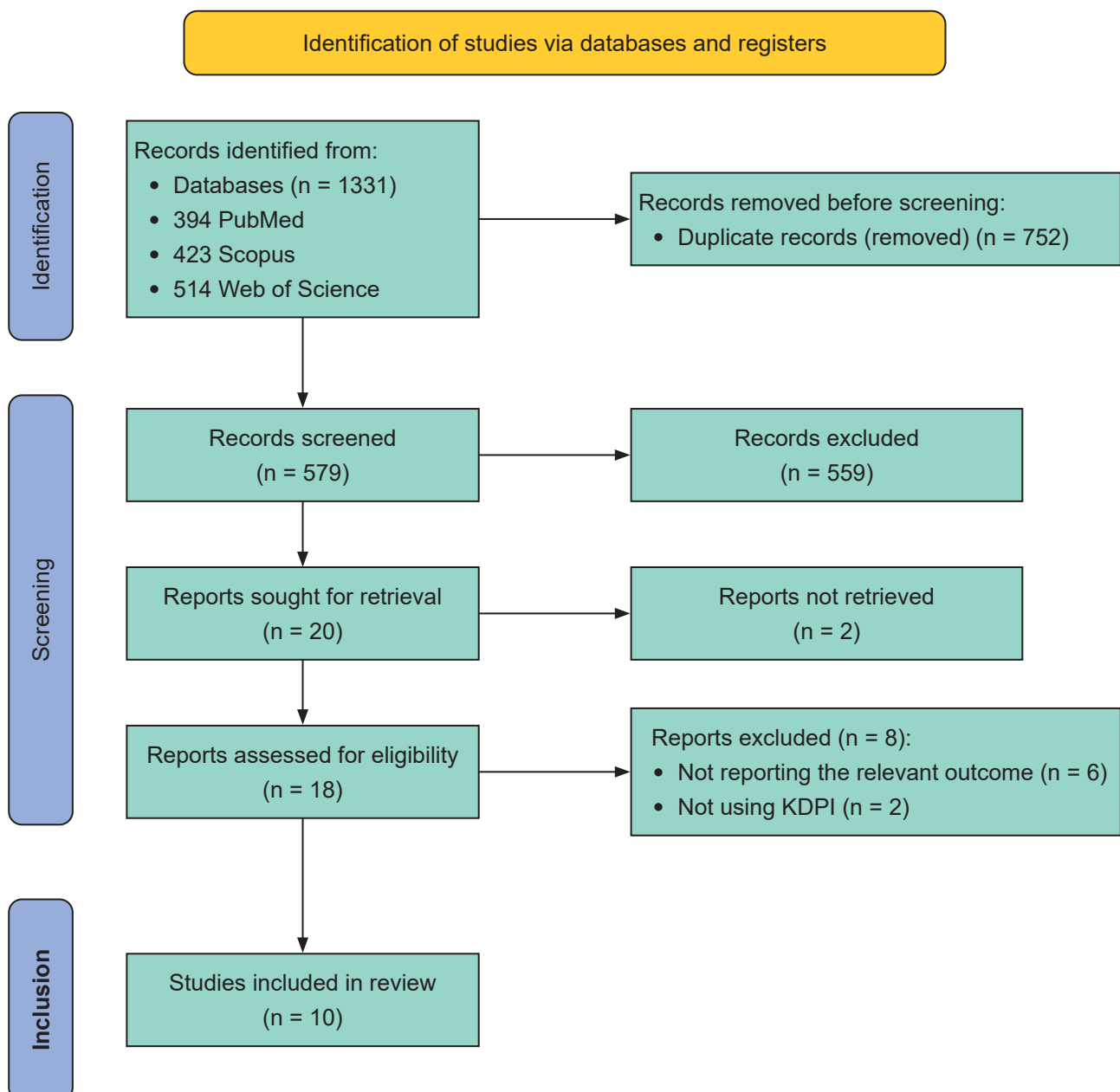


Figure 1. Study selection process.

screening. After excluding 559 articles based on the screening process, 20 studies were selected for full-text review. However, the full-texts of two studies could not be found. Among 18 remaining articles, six were excluded for not reporting the outcomes of interest or relevant data¹¹⁻¹⁶ and two were excluded because of not using KDPI.^{17,18} Ultimately, 10 studies met the inclusion criteria and were included in the review (Figure 1).¹⁹⁻²⁸

Risk of bias assessment

The mean risk of bias score for the included cohort studies was 6.2, with scores ranging from 6 to 7. Among the cohort studies, four had an overall score of 6,^{23,25,27,28} while one received a score of 7.²⁰ The lowest scoring criteria were the adequacy of follow-up duration and the representativeness of the exposed cohort (Table S2). These scores indicate moderate methodological quality, with limitations primarily in specific domains rather than uniformly across all aspects of study design.

For the cross-sectional studies, the mean risk of bias score was 6.4, with scores ranging from 2 to 8. The majority of these studies scored 8^{19,21} or 7.^{22,26} The appropriate statistical tests was the domain with the highest scores in all studies (Table S3). The lower score observed in one study reflected important weaknesses in selected domains, such as sampling or reporting, and therefore this study was interpreted with greater caution rather than excluded from the review. Overall, the NOS results were used to inform the interpretation of the findings and to highlight the need for caution when considering studies with lower methodological quality.

Study characteristics

The pooled study population consisted of 15,879 individuals, ranging from 85 to 5,755 participants. The studies were conducted in multiple countries such as Mexico,²⁴ Germany,^{21,22,26} Spain,¹⁹ Greece,²⁷ Brazil,^{25,28} South Korea,²⁰ and Argentina.²³ The age range of participants varied slightly depending on the study, typically between 36.8 and 57.4 years among the total participants. In terms of sex distribution, male participants accounted for a significant portion of the population, with male recipients ranging from 27.8% to 68.2%. The study designs included five cross-sectionals^{19,21,22,24,26} and five cohorts (Table 1).^{20,23,25,27,28}

Findings

A total of 10 studies were included, and the findings presented a range of conclusions about how KDPI affected kidney transplant outcomes. A large number of included studies suggested that a higher KDPI was associated with poorer transplant outcomes, including graft failure and reduced graft function. Bachmann *et al.*²⁶ found that kidneys with a KDPI > 85% exhibited significantly worse graft survival compared to those with lower KDPI scores, with the 5-year graft survival rate dropping from 92% for KDPI < 35% to 65% for KDPI > 85% ($P < .001$). This trend was consistent with other studies, such as Prado *et al.*,²⁵ who reported that KDPI $\geq 85\%$ was linked to significantly lower 5-year graft survival (59.6%), compared to lower KDPI ranges ($P < .001$).²⁵ Similarly, higher KDPI was associated with a significant decline in kidney function, measured as estimated glomerular filtration rate (eGFR), over the first year post-transplant, as demonstrated by Foresto *et al.*²⁸ and Lee *et al.*,²⁰ who both noted a significant inverse correlation between KDPI and eGFR at 1-year post-transplantation (Table S4).

The DGF was another outcome related to KDPI. Several studies, including García-Covarrubias *et al.*,²⁴ Dahmen *et al.*,²² and Lehner *et al.*,²¹ found a higher incidence of DGF in recipients of kidneys with higher KDPI scores. For instance, Bachmann *et al.* found that the rate of DGF was significantly higher in kidneys with KDPI > 85%, at 40%, compared to 19% for kidneys with KDPI < 35% ($P < .001$).²⁶ Similarly, Foresto *et al.* found that DGF incidence increased with higher KDPI, with the highest KDPI group (86%-100%) having a DGF incidence of 59.9% (Table S4).²⁸

The relationship between KDPI and patient survival was less clear. While several studies, including Calvillo-Arbizu *et al.*¹⁹ and Dahmen *et al.*,²² did not find a significant association between KDPI and overall patient survival, Prado *et al.* suggested that other factors, such as donor-specific antibodies and cold ischemia time, played a role in affecting patient survival.²⁵ Nevertheless, the studies overall indicated that while KDPI predicted graft survival and function, it had a less pronounced effect on patient survival, with patient survival rates remaining relatively stable across different KDPI categories (Table S4).

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Table S2. Risk of bias assessment for the included cohort studies

Study ID	1. Representativeness of the exposed cohort a) truly representative of the average (describe) in the community b) somewhat representative of the average in the community c) selected group of users eg nurses, volunteers d) no description of the derivation of the cohort	2. Selection of the non exposed cohort a) drawn from the same community as the exposed cohort b) drawn from a different source c) no description of the derivation of the non exposed cohort	3. Ascertainment of exposure a) secure record (eg surgical records) b) structured interview c) written self report d) no description	4. Demonstration that outcome of interest was not present at start of study a) yes b) no	5. Comparability of cohorts on the basis of the design or analysis a) study controls for the most important factor b) study controls for any additional factor (This criteria could be modified to indicate specific control for a second important factor.)	6. Assessment of outcome a) independent blind assessment b) record linkage c) self report d) no description	7. Was follow-up long enough for outcomes to occur a) yes (select an adequate follow up period for outcome of interest) b) no	8. Adequacy of follow up of cohorts a) complete follow up - all subjects accounted for b) subjects lost to follow up unlikely to introduce bias - small number lost - > % (select an adequate %) follow up, or description provided of those lost c) follow up rate < % (select an adequate %) and no description of those lost d) no statement	Overall Score
Lee (2018)	D	A	A	A	A,B	B	A	D	7
Bigignano (2020)	D	A	A	B	A,B	B	A	D	6
Prado (2020)	D	A	A	B	A,B	B	A	D	6
Darema (2023)	D	A	A	B	A,B	B	A	D	6
Foresto (2023)	D	A	A	B	A,B	B	A	D	6

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability

Table S3. Risk of bias assessment for the included cross-sectional studies

Study ID	1. Representativeness of the exposed cohort	2. Sample size: a) Justified and satisfactory. * b) Not justified.	3. Non-respondents: a) Comparability between respondents and non-respondents established, and the response rate is satisfactory. * b) The response rate is unsatisfactory, or the comparability between respondents and non-respondents is unsatisfactory. c) No description of the response rate or the characteristics of the responders and the non-responders.	4. Ascertainment (risk factor): a) Validated measurement tool. ** b) Non-validated measurement tool, but the tool is available or described. * c) No description of the measurement tool.	5. Comparability: (Maximum 2 stars) 1) The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled. a) The study controls for the most important factor (select one). * b) The study control for any additional factor. *	6. Assessment of outcome a) Independent blind assessment. ** b) Record linkage. * c) Self report. * d) No description.	7) Statistical test: a) The statistical test used to analyze the data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and the probability level (p value). * b) The statistical test is not appropriate, not described or incomplete.	Overall Score
Calvillo-Arbizu (2018)	B	B	C	A	A,B	B	A	8
Lehner (2018)	B	B	C	A	A,B	B	A	8
Dahmen (2019)	C	B	C	A	A,B	B	A	7
García-Covarrubias (2020)	B	B	C	C	-	D	A	2
Bachmann (2022)	C	B	C	A	A,B	B	A	7

Table 1. Baseline characteristics of the included studies.

First Author (Year)	Country Location	Study Design	Study Population	Total Sample Size	Sample Size (Cases)	Sample Size (Controls)	Male N (%)	Age (year)	KDPI definition	Comparison
García-Covarrubias (2020)	Mexico	Cross-sectional study	Deceased kidney donors from January 1, 2011, to June 30, 2019, at the General Hospital of Mexico Dr Eduardo Liceaga	85	KDPI > 75%: 11	KDPI < 17%: 35	58 (68.2%), Case: 7 (12.1%), Control: 24 (41.4%)	Donors: 36.8 (13.3)	NA	Compared KDPI groups (0-16, 17-49, 50-75, > 75)
Bachmann (2022)	Germany	Retrospective single-center analysis	Kidney transplant recipients between January 1st, 2006, and December 31st, 2016 at Klinikum rechts der Isar, Munich	383	KDPI > 85%: 85	KDPI < 35%: 127	Total: 133 (34.7%), Case: 57 (67.1%), Control: 76 (59.8%)	Case: 61 (10), Control: 46 (13)	Calculated using donor and recipient characteristics using OPTN	Compared different KDPI groups
Calvillo-Arbizu (2018)	Spain	Retrospective analysis	Andalusian Autonomous Transplant Coordination Information System regarding single kidney transplants from deceased donors performed between January 1, 2006, and December 31, 2015	2734	2734	NA	1725 (63.1%) in recipients	52.08 (12.99)	Mapped from donor factors	The first quartile of KDPI values
Dahmen (2019)	Germany	Retrospective, single-center study	Kidney transplant recipients between 2007 and 2014 at University Hospital of Münster	968	KDPI > 85%: 191	KDPI < 35%: 78	350 (60.3%); Case: 127 (66.5%); Control: 46 (59.0%)	Median (IQR): Total: 57.4 (19.9), Case: 68.3 (6.2), Control: 50.6 (15.6)	Calculated using donor characteristics using OPTN	KDPI > 85% compared with KDPI < 35%, and 35-85%
Darema (2023)	Greece	Single-center retrospective cohort study	Kidney transplant recipients in Laiko General Hospital, Athens, Greece, between 1 January 2008 and 31 December 2018	394 donors, 456 recipients	NA	NA	Total: 264 (57.9%)	Median: 52 (IQR 43-59)	Calculated using donor characteristics by OPTN	Compared different KDPI groups
Foresto (2023)	Brazil	Single-center, retrospective cohort study	Deceased donor kidney transplant recipients from January 2013 to December 2017	3059	848	561	1872 (61.2%); Case (KDPI 86-100%): 539 (63.3%), Control (KDPI ≤ 35%): 327 (58.3%)	Median: 49.7 (IQR 39.2–58.6)	Calculated using donor characteristics	Compared different KDPI groups

Table 1. Continued

First Author (Year)	Country Location	Study Design	Study Population	Total Sample Size	Sample Size (Cases)	Sample Size (Controls)	Male N (%)	Age (year)	KDPI definition	Comparison
Lee (2018)	South Korea	Multicenter cohort study	Kidney transplant recipients at three transplant centers between 1996 and 2016 in South Korea	469	238	231	271 (27.8%); Case: 139 (58.4%); Control: 132 (57.1%)	Case: 49.7 (9.0); Control: 47.2 (10.0)	Calculated using donor characteristics with a "KDPI calculator" on the OPTN	Compared high and low KDPI groups (based on median of KDPI 67%)
Lehner (2018)	Germany	Retrospective single-centre study	Deceased donor adult kidney transplant recipients from 1991 to 2014 at one of the three transplant units at the Charité' Berlin	987	KDPI > 85%: 319	KDPI ≤ 20%: 119	Total: 586 (59.4%); Case: 186 (58%); Control: 68 (57%)	Median (IQR): Case: 66 (63-69); Control: 46 (36-54)	Calculated using donor characteristics	Categorized into four KDPI groups: ≤ 20, 21-34, 35-85, and > 85%
Prado (2020)	Brazil	Retrospective cohort study	Deceased donor kidney transplant recipients from January 2009 to May 2013	589	KDPI ≥ 85%: 170	KDPI ≤ 20%: 58	Total: 344 (58.4%)	49.6 (12.5)	Calculated using donor characteristics using OPTN	Compared different KDPI groups
Bisignano (2020)	Argentina	Retrospective cohort analysis	Kidney transplant recipients between January 2008 and December 2017	5755	KDPI > 70%: 1438	KDPI < 20%: 1440	Case: 647 (45%); Control: 1195 (83%)	NA	Calculated using donor characteristics using OPTN	Compared different KDPI groups

Abbreviations: KDPI: Kidney Donor Profile Index; OPTN: Organ Procurement and Transplantation Network; IQR: Interquartile Range; NA: Not Available SD: Standard Deviation.

age, comorbidities, and the presence of chronic kidney disease, interacted with KDPI to influence transplant outcomes. Dahmen *et al.*) demonstrated that older donor age was associated with worse graft survival,²² and similar findings were noted by Lehner *et al.*, who emphasized that kidneys from older donors were more likely to be allocated within high KDPI categories.²¹ Furthermore, the predictive value of KDPI was influenced by the type of donor, with studies like Darema *et al.* showed that KDPI predicted graft failure in standard-criteria donor transplants, while its effect was less in expanded-criteria donor transplants (Table S4).²⁷

DISCUSSION

The studies included in this review demonstrated that a higher KDPI was associated with poorer graft survival, increased risk of DGF, and reduced post-transplant kidney function. Specifically, kidneys with higher KDPI scores were associated with lower 5-year graft survival rates and significantly reduced eGFR. Additionally, the incidence of DGF was higher in recipients of kidneys with higher KDPI. Despite the strong association between KDPI and graft outcomes, its predictive value for patient survival was less definitive, with other factors such as donor age and cold ischemia time appearing to have a more prominent role. Taken together, these findings suggest that KDPI is a useful adjunctive tool for donor risk stratification, but not a standalone determinant of allocation decisions, because recipient factors, preservation variables, and center-level practices also shape outcomes.

Our findings suggested that donor factors such as age and comorbidities were associated with KDPI and may help explain transplant outcomes, a prior systematic review also emphasized the effects of donor demographics, particularly age, sex, and body mass index, on kidney transplant success.²⁹ Their meta-analysis indicated that younger male donors tend to produce better graft survival and lower rates of DGF,²⁹ which aligns with our findings that KDPI, influenced by donor age, also predicted poorer outcomes. The differences between these studies can be due to the predictive frameworks; while the KDPI is a more focused prediction tool on donor quality based on objective metrics like age and comorbidities, other studies consider broader demographic variables and their impact on long-term transplant outcomes.

Table S4. Outcomes and findings of the included studies

First Author (Year)	Outcomes	Findings
García-Covarrubias (2020)	Histologic score, graft survival	No significant differences between KDPI quartiles for creatinine ($P = .21$), MDRD ($P = .12$), CKD-EPI ($P = .11$)
Bachmann (2022)	Transplant failure	Kidney transplants with a KDPI or LKDPI $> 85\%$ had significantly worse outcomes compared to those with lower scores. Within 5 years post-transplantation, 47 patients experienced graft failure and 34 patients died with a functioning graft. Among these, transplant failure occurred more frequently with higher (L)KDPI: 8 patients with KDPI $< 35\%$, 17 with KDPI 35–85%, and 22 with KDPI $> 85\%$ ($P = .018$). PNF occurred more often in kidneys with higher (L)KDPI: 1 kidney with (L)KDPI $< 35\%$, 6 with 35–85%, and 7 with $> 85\%$. The eGFR 3 years post-transplant was significantly lower in kidneys with higher (L)KDPI: 61 ml/min/1.73 m² for KDPI $< 35\%$, 45 ml/min/1.73 m² for 35–85%, and 39 ml/min/1.73 m² for $> 85\%$ ($P < .001$). Focusing on deceased donor kidney transplants, the eGFR at 3 years was 65 ml/min/1.73 m² for KDPI $< 35\%$, 45 ml/min/1.73 m² for 35–85%, and 38 ml/min/1.73 m² for $> 85\%$ ($P < .001$). The 5-year graft survival was also worse for higher (L)KDPI: 92% for (L)KDPI $< 35\%$, 88% for 35–85%, and 65% for $> 85\%$ ($P < .001$). Despite this, the average death-censored graft survival was still relatively long in the high-risk group (7.5 years), compared to 9.3 years in the medium-risk group and 10.3 years in the low-risk group. Death-censored graft survival in transplants from deceased donors was 9.1 years for KDPI $< 35\%$ and 10.6 years for 35–85%. The rate of DGF was significantly higher in kidneys with higher (L)KDPI: 19% for (L)KDPI $< 35\%$, 39% for 35–85%, and 40% for $> 85\%$ ($P < .001$). The Charlson Comorbidity Index of recipients correlated with the (L)KDPI of all recipients, regardless of donor type ($r = 0.18$, $P < .001$).
Calvillo-Arbizu (2018)	Graft and patient survival	For adult recipients (aged: 18–59 years), KDPI showed HR: 1.013 (95% CI: 1.006–1.019) for death-censored graft survival and of 1.013 (95% CI: 1.004–1.023) for patient survival. For elderly recipients (aged: 60+ years), KDPI presented HR: 1.016 ($P = .001$) for death-censored graft survival and of 1.011 ($P = .007$) for patient survival
Dahmen (2019)	1-y-eGFR, death-censored allograft survival, DGF	The mean 1-year eGFR was 50 ± 20 mL/min/1.73m² and decreased with increasing KDPI categories (65 ± 19 for KDPI $< 35\%$, 53 ± 19 for KDPI 35–85%, and 39 ± 15 for KDPI $> 85\%$). Donor age categories mirrored these differences, with donor age significantly influencing 1-year eGFR, alongside factors like recipient BMI, CIT, and HLA mismatches. Multivariable analysis confirmed that donor age, last serum creatinine, and cerebrovascular death were also significant predictors of eGFR. For graft survival, higher KDPI and older donor age were associated with reduced survival rates. Recipients of kidneys with KDPI $> 85\%$ had significantly worse allograft survival compared to those with KDPI $< 35\%$ (log-rank $P < .001$) and KDPI 35–85% ($P = .003$). Similarly, kidneys from older donors (> 60 years) showed inferior allograft survival compared to younger donors (< 40 years, $P = .011$). Cox regression analysis revealed KDPI (HR 1.026, $P < .001$) and donor age (HR 1.037, $P < .001$) as independent predictors of graft survival, while patient survival rates were unaffected by either KDPI or donor age. DGF rates were not significantly influenced by KDPI or donor age, although recipient BMI, CIT, dialysis vintage, and donor creatinine levels impacted DGF incidence. Male recipients were more prone to acute rejection, and surgical complications were more frequent in older male recipients and those with male donors or prolonged CIT. A strong correlation was found between KDPI and donor age ($R^2 = 0.76$), with KDPI being marginally superior to donor age in predicting 1-year eGFR ($P < .001$ vs. $P = .004$). ROC analysis demonstrated that KDPI and donor age had similar moderate predictive values for allograft failure, while the ECD/SCD classification showed no significant predictive power.

When comparing our results on KDPI with pathology-based models like the MAPI, it becomes clear that while both models aim to assess kidney donor quality, they use different sets of information and methodologies. The MAPI score, which evaluates kidney pathology based on five key factors such as arteriolar hyalinosis and glomerulosclerosis, has been used to classify kidneys as suitable or

unsuitable for transplantation, with scores above seven showing poor organ quality.³⁰ However, Wang *et al.* highlighted that kidney biopsy findings, such as those used in MAPI, do not always predict graft failure or DGF.³¹ In fact, the predictive ability of these histopathological markers has often been inconsistent across studies, pointing to the complexity of assessing kidney quality solely based

Table S4. Continued

First Author (Year)	Outcomes	Findings
Darema (2023)	Death-censored graft survival, DGF, eGFR, overall patient survival	A higher KDPI was associated with adverse transplant outcomes, particularly in SCD recipients. DGF was significantly more frequent with higher KDPI scores (58 vs. 51, $P = .045$) and was linked to reduced kidney function over time. In recipients of SCD kidneys, higher KDPI was associated with lower eGFR at 1, 3, and 5 years post-transplant, even after adjusting for recipient characteristics and immunosuppression. Conversely, no significant relationship between KDPI and DGF or graft function was observed in ECD recipients. Regarding graft survival, KDPI independently predicted a higher risk of graft failure, with each unit increase in KDPI correlating with a 1% higher risk (HR: 1.01, $P = .016$). Donors with KDPI > 79 presented a threefold greater risk of graft failure compared to those with KDPI < 25, although no significant differences were seen when comparing KDPI > 79 to intermediate KDPI ranges (25–54 or 54–79). However, a KDPI > 85 did not specifically predict graft loss (log-rank $P = .19$). Graft survival also worsened with higher donor KDRI and age. In contrast, KDPI was not a significant predictor of overall patient survival, whether analyzed as a continuous variable or using a threshold of 85. Similarly, donor KDRI and age showed no significant association with patient survival. Subgroup analyses reinforced that the effects of KDPI on outcomes were primarily observed in SCD recipients, with no significant associations in ECD transplants.
Foresto (2023)	1-y eGFR, patient and graft survival	The incidence of DGF increased with KDPI strata, from 50.6% in the KDPI 0%–35% group to 59.9% overall. While the duration of DGF was consistent across KDPI groups, higher KDPI kidneys were associated with increased rates of CMV infections or disease (57.8% in KDPI 86%–100% vs. 36.7% in KDPI 0%–35%). Acute rejection rates did not differ significantly among KDPI groups. Kidney function, as measured by the eGFR, was inversely correlated with KDPI. Median 1-year eGFR decreased from 64.8 mL/min/1.73 m² in the KDPI 0%–35% group to 39.1 mL/min/1.73 m² in the KDPI 86%–100% group. This decline was significant regardless of DGF or CIT, although within specific KDPI strata, the presence of DGF or extended CIT further reduced eGFR. Notably, the proportion of recipients with eGFR below 50 mL/min/1.73 m² increased with higher KDPI scores. In a Cox regression analysis, higher KDPI and longer CIT were independent risk factors for lower 1-year eGFR (< 50 mL/min/1.73 m²), while kidneys from male donors were associated with a reduced risk. Acute rejection also emerged as a factor associated with diminished kidney function at the end of the first year post-transplant. Survival analysis showed 1-year graft survival of 91.9% and death-censored graft survival of 95.1%, with no significant differences attributable to KDPI. However, technical complications disproportionately affected graft survival in the KDPI 36%–50% group, though these were unrelated to donor quality. The primary cause of death across all groups was infections (69.4%). The findings underscore that while higher KDPI scores are associated with reduced kidney function and higher risks of delayed graft function, the impact on graft survival is less pronounced, particularly within the first year post-transplant.
Lee (2018)	Patient and graft survival, DGF, biopsy-proven acute rejection, serum creatinine	DGF was more frequent in the low KDPI group ($P < .05$); however, KDPI was not a significant factor for DGF in multivariate analysis. Biopsy-proven acute rejection rates did not differ significantly between groups, but were associated with recipient age (HR 0.970, CI 0.946–0.995, $P = .017$), PRA levels (HR 1.011, CI 1.003–1.019, $P = .010$), and HLA mismatches (HR 1.360, CI 1.107–1.673, $P = .003$). High KDPI recipients exhibited worse allograft function throughout the first year post-transplant ($P < .05$). Histologically, the high KDPI group had significantly higher total and global glomerulosclerosis ($P < .001$ for both), with a positive correlation between glomerulosclerosis and KDPI score ($\rho = 0.368$, $P < .001$). Other injury markers showed no significant differences. Allograft failure occurred more frequently in the high KDPI group (39 vs. 22 cases), with chronic rejection more common in this group. The allograft survival rate was significantly better in the low KDPI group ($P < .001$, Log-rank test). High KDPI was a significant risk factor for graft failure in univariate (HR 3.050, CI 1.577–5.896, $P < .001$) and multivariate analysis (adjusted HR 3.695, CI 1.873–7.288, $P < .001$). Patient survival rates were not significantly different (12 vs. 10 deaths, $P > .05$).

on pathology.³¹ Our study focused on KDPI as an alternative approach by considering a combination of donor characteristics and kidney function. Unlike the MAPI score, which primarily relies on

pathological features visible in biopsy samples, KDPI provides a comprehensive, data-driven tool that uses donor age, cause of death, and kidney function to estimate donor risk. However, both

Table S4. Continued

First Author (Year)	Outcomes	Findings
Lehner (2018)	Patient, graft survival, and graft function	In the > 85% KDPI group, 71% of kidneys were allocated within the Eurotransplant Senior Program. Recipients in this group had higher age and mismatches but shorter CIT. Donors in the high KDPI group were associated with increased proportions of hypertension and diabetes, while previous kidney transplantation was more frequent in lower KDPI categories. The median KDPI across the cohort was 66%, with higher KDPI utilization compared to the US cohort (32.3% vs. 9.2% for > 85% KDPI kidneys). Elderly recipients (≥ 65 years) had a median KDPI of 97% and received a substantial proportion (62%) of > 95% KDPI kidneys. Graft survival rates declined with higher KDPI scores. The 2-, 5-, and 10-year overall graft survival rates were 88.3%, 76.0%, and 54.4%, respectively, with death-censored rates of 92.1%, 85.1%, and 70.5%. Outcomes for KDPI > 85% were significantly worse (log-rank $P < .001$), although differences diminished after 5 years within this category. Graft function (measured by eGFR) was lower in high KDPI groups at 1 year (median eGFR: KDPI < 20 = 65.8 mL/min/1.73m ² ; KDPI > 85% = 35.2 mL/min/1.73m ²). However, all KDPI groups exhibited similar rates of annual eGFR decline. DGF rates increased with KDPI but plateaued in the highest KDPI categories (KDPI < 20 = 30%; KDPI > 85% = 49%). Multivariate analysis identified KDPI, CIT, and HLA mismatches as independent predictors of reduced graft survival, while older recipient age mitigated death-censored graft loss.
Prado (2020)	Graft survival, renal function	Kidneys with a KDPI $\geq 85\%$ had significantly lower 5-year graft survival (59.6%) compared to lower KDPI ranges (KDPI 0–20: 80.1%; KDPI 21–59: 79.9%; KDPI 60–84: 73.9%; $P < .001$). Similarly, 5-year death-censored graft survival was lower in the KDPI $\geq 85\%$ group (78.6%) versus other ranges (KDPI 0–20: 89.8%; KDPI 21–59: 91.6%; KDPI 60–84: 83.0%; $P = .006$). AUC-ROC for graft loss prediction was 0.577, with KDPI 85% showing 39% sensitivity and 73% specificity for predicting 5-year death-censored graft loss. Kidney function at 1 and 5 years was significantly lower with higher KDPI ($P < .002$). Key risk factors for 5-year graft loss included KDPI (HR 1.01; $P = .011$), donor-specific antibodies (DSA; HR 2.48; $P < .001$), positive B-cell crossmatch (HR 2.64; $P = .002$), PRA Class II > 80% (HR 3.24; $P = .005$), and longer cold ischemia time (CIT; HR 1.001 per minute; $P = .032$). Donor criteria, including ECD status, were also associated with higher graft loss risk (HR 2.07; $P = .001$). Multivariate analysis confirmed KDPI (HR 1.00; $P = .008$), DSA (HR 2.77; $P < .001$), and acute rejection (HR 1.73; $P = .034$) as independent predictors of death-censored graft loss, while recipient age and delayed graft function were not significant.
Bisignano (2020)	Graft survival	KDPI was a predictor of graft survival. Increased KDPI quartile (KDPI > 70%: HR: 1.99; 1.73, 2.29), recipient age > 60 years, diabetes, and dialysis time were all associated with an increased probability of graft loss.

Abbreviations: KDPI: Kidney Donor Profile Index; MDRD: Modification of Diet in Renal Disease; CKD-EPI: Chronic Kidney Disease Epidemiology Collaboration; HR: Hazard Ratio; CI: Confidence Interval; eGFR: Estimated Glomerular Filtration Rate; PNF: Primary Non-Function; DGF: Delayed Graft Function; CIT: Cold Ischemia Time; HLA: Human Leukocyte Antigen; PRA: Panel Reactive Antibody; DSA: Donor-Specific Antibodies; AUC-ROC: Area Under the Receiver Operating Characteristic Curve; SCD: Standard-Criteria Donor; ECD: Expanded-Criteria Donor; KDRI: Kidney Donor Risk Index.

approaches have common limitations. Despite advances in molecular analysis and histopathology, no single method has successfully entered routine clinical practice.³² The challenge remains in refining these models to improve their predictive accuracy, with KDPI may offer a more clinically applicable framework while MAPI, although valuable, may require additional research and standardization to improve its reliability for routine use in donor assessment.^{30,31}

In our study, we found that the KDPI was an effective tool in predicting graft outcomes, with higher KDPI scores associated with lower graft survival, particularly in older donors or those with comorbidities. Comparing our findings to

the use of ECD and SCD, Gomes *et al.* found that although ECD kidneys had higher rates of DGF and longer cold ischemia times, graft and patient survival rates between ECD and SCD recipients were not significantly different when stratified by DGF status.³³ It suggested that appropriate management can provide comparable survival outcomes. However, the risk associated with ECD kidneys was higher in younger recipients, with an increase in all-cause mortality and death with a functioning graft compared to SCD kidneys.³⁴ While both the KDPI system and the SCD/ECD classification aim to optimize kidney allocation, KDPI provides a more comprehensive approach by considering a broader range of donor

characteristics, which may allow for better matching of donor kidneys to recipients. Pascual *et al.* emphasized that ECD kidneys might be useful, especially for patients aged 40 or older or those with diabetic nephropathy, as they had better survival than remaining on dialysis.³⁵ Therefore, while ECD kidneys had lower expected survival rates than SCD kidneys, the KDPI system helps to refine decision-making to optimize kidney use and improving transplant outcomes in carefully selected recipients.

Our findings highlighted the usefulness of the KDPI in the assessment of kidney quality and improving transplant decision-making. By using KDPI scores into clinical practice, clinicians can better identify higher-risk kidneys and make more informed decisions about graft allocation. This is in accordance with the previous recommendations, which highlight the importance of risk prediction models to identify recipients at high risk of graft failure.³⁶ The KDPI can help to determine which kidney, especially from ECD, should be transplanted, that allows for better organ utilization. Clinicians can also use KDPI alongside recipient factors such as age and comorbidities to improve patient selection and provide more personalized post-transplant care. This approach has the potential to improve transplant outcomes and reduce graft failure to improve overall patient care. Our findings support KDPI as an adjunctive measure that can complement, rather than replace, recipient assessment, ischemia-time considerations, and center-specific clinical judgment.

Limitation of the study

Our study has limitations that should be considered. First, due to differences in study designs, inconsistent categorization of KDPI, and outcome measures across the included studies, the evidence was synthesized narratively rather than pooled quantitatively, which restricted our ability to pool data and draw more definitive conclusions. Second, many studies lacked complete participant information, especially regarding important transplant-related factors such as cold ischemia time, which made comparisons between studies more difficult. Third, variations in the way KDPI were measured and categorized across studies led to inconsistencies that could influence the overall results. Fourth, the reliance

on observational studies also presents a limitation, as they are susceptible to residual confounding and biases that could impact the accuracy of the findings. Fifth, although KDPI has been widely studied in registry-based and validation cohorts, our review included only adult kidney transplant studies that reported extractable KDPI-outcome data. The evidence base was composed mainly of non-US cohorts, which limits direct generalizability to U.S. registry settings, where KDPI is used as a central allocation tool. Therefore, many KDPI-related publications that were methodological, allocation-focused, validation-only, or did not report analyzable outcomes were not eligible for inclusion. This strict eligibility framework explains the relatively small number of included studies and should not be interpreted as evidence of an incomplete search. As a result, the final number of included studies was relatively small and should be interpreted in light of the review's strict eligibility criteria rather than as evidence of an incomplete search. Sixth, most eligible studies were conducted outside the United States, which may limit the direct generalizability of our findings to U.S. registry populations, where KDPI is a central allocation tool. Additionally, although our search included major bibliographic databases, grey-literature screening, and citation tracking, it was primarily focused on the terms 'Kidney Donor Profile Index' and 'KDPI'. Therefore, studies indexed predominantly under related terminology, such as 'Kidney Donor Risk Index (KDRI)', may not have been captured. Future systematic reviews should consider broader search strategies incorporating additional synonyms, controlled-vocabulary terms, and databases such as Embase to further maximize search sensitivity. One included study was judged to have a very high risk of bias (NOS score = 2). Although this study was retained to provide a comprehensive overview of the available evidence, its findings were interpreted cautiously and were not considered in isolation when drawing the overall conclusions. The principal findings of this review remained consistent across the moderate-quality studies, reducing the likelihood that this single low-quality study materially influenced the overall interpretation. Although this broad approach was chosen a priori to maximize sensitivity, the final number of eligible studies was small, which should

be considered when interpreting the efficiency of the search strategy. Because the review was not prospectively registered in PROSPERO, this should be considered when interpreting the review methods and reporting transparency. To address these limitations, future research should prioritize prospective multicenter studies that report standardized KDPI categories, consistent outcome definitions, and effect estimates with precision; evaluate incremental predictive value beyond recipient, preservation, and center-level variables; and include external validation in U.S. and other registry-based cohorts. A future updated systematic review with meta-analysis may also be feasible if sufficiently homogeneous data become available.

CONCLUSIONS

This study showed that a higher KDPI was associated with worse graft survival and reduced kidney function. Future studies should (1) examine the independent and incremental predictive value of KDPI after adjustment for recipient- and center-level variables, (2) use standardized KDPI thresholds and harmonized outcome definitions, (3) report effect estimates with confidence intervals, (4) include more non-US and especially U.S. registry-based cohorts for external validation, and (5) assess whether KDPI meaningfully improves decision-making compared with existing donor risk tools.

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Ethical approval

Not required.

Consent to Publish declaration

Not applicable.

Consent to Participate declaration

Not applicable.

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Conflict of interests

No conflict of interest declared.

Authors' contributions

MV and FK conceptualized the topic; FR and MPNK searched the databases; HS, NS, FK, and MV performed screening and full-text review; FR, MPNK, and FK performed data extraction; MV, HS, and FK performed quality assessment; MV, FR, MPNK, HS, NS, and FK prepared the first draft of the manuscript; MV, FR, MPNK, HS, NS, and FK critically revised and edited the manuscript; MV and FK supervised this project. All authors reviewed and approved the final version of the manuscript.

Data availability statements

The data that supports the findings of this study are available in the supplementary material of this article.

CLINICAL TRIAL NUMBER

Not applicable.

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Selection

- 1) Representativeness of the exposed cohort
 - a) truly representative of the average _____ (describe) in the community *
 - b) somewhat representative of the average _____ in the community *
 - c) selected group of users e.g. nurses, volunteers
 - d) no description of the derivation of the cohort
- 2) Selection of the non-exposed cohort
 - a) drawn from the same community as the exposed cohort *
 - b) drawn from a different source
 - c) no description of the derivation of the non-exposed cohort
- 3) Ascertainment of exposure
 - a) secure record (e.g. surgical records) *
 - b) structured interview *
 - c) written self-report
 - d) no description
- 4) Demonstration that outcome of interest was not present at start of study
 - a) yes *
 - b) no

Comparability

- 1) Comparability of cohorts on the basis of the design or analysis
 - a) study controls for _____ (select the most important factor) *
 - b) study controls for any additional factor *

(This criteria could be modified to indicate specific control for a second important factor.)

Outcome

- 1) Assessment of outcome
 - a) independent blind assessment *
 - b) record linkage *
 - c) self-report
 - d) no description
- 2) Was follow-up long enough for outcomes to occur
 - a) yes (select an adequate follow up period for outcome of interest) *
 - b) no
- 3) Adequacy of follow up of cohorts
 - a) complete follow up - all subjects accounted for *
 - b) subjects lost to follow up unlikely to introduce bias - small number lost - > ____ % (select an adequate %) follow up, or description provided of those lost) *
 - c) follow up rate < ____% (select an adequate %) and no description of those lost
 - d) no statement

Selection (maximum five stars)

- 1) Representativeness of the sample:
 - a) Truly representative of the average in the target population* (all subjects or random sampling)
 - b) Somewhat representative of the average in the target population* (non-random sampling)
 - c) Selected group of users
 - d) No description of the sampling strategy
- 2) Sample size:
 - a) Justified and satisfactory*
 - b) Not justified
- 3) Non-respondents:
 - a) Comparability between respondents and non-respondents characteristics is established, and the response rate is satisfactory*
 - b) The response rate is unsatisfactory, or the comparability between respondents and non-respondents is unsatisfactory
 - c) No description of the response rate or the characteristics of the responders and the non-responders

- 4) Ascertainment of the exposure (risk factor):
 - a) Validated measurement tool**
 - b) Non-validated measurement tool, but the tool is available or described*
 - c) No description of the measurement tool

Comparability (maximum two stars)

- 1) The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.
 - a) The study controls for the most important factor (select one). *
 - b) The study control for any additional factor. *

Outcome (maximum three stars)

- 1) Assessment of the outcome:
 - a) Independent blind assessment**
 - b) Record linkage**
 - c) Self report*
 - d) No description
- 2) Statistical test:
 - a) The statistical test used to analyze the data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and the probability level (*P* value)*
 - b) The statistical test is not appropriate, not described or incomplete.