Employment of Patients With Kidney Failure Treated With Dialysis or Kidney Transplantation - A Systematic Review and Meta-Analysis

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Abstract

Background: Patients with kidney failure treated with dialysis or kidney transplantation experience difficulties maintaining employment due to the condition itself as well as the treatment. We aimed to establish the rate of employment before and after initiation of dialysis and after kidney transplantation and to identify predictors of employment during dialysis and post-transplant.

Methods: This systematic review and meta-analysis was carried out according to Preferred Reporting Items for Systematic Reviews and Meta-Analysis, PRISMA, for studies that included employment rate in adults receiving dialysis or a kidney transplant. The literature search included cross sectional or cohort studies published in English in the period from January 1966 to August 2020 in the databases PubMed, Embase, and Cochrane Library. Data of employment rate, study population, age, gender, educational level, dialysis duration, kidney donor, ethnicity, dialysis modality, waiting time for transplantation, diabetes, and depression were extracted.

Quality assessment was performed using the Newcastle-Ottawa Scale. Meta-analysis for predictors for employment and odds ratio; confidence intervals; and test for heterogeneity were calculated using Chi-squared statistics and \( I^2 \). PROSPERO registration number: CRD42020188853.

Results. 33 studies with 162,059 participants during dialysis and 31 studies with 137,742 participants receiving kidney transplantation. Dialysis patients were on average 52.6 years old (range 16-79), 60.3% males and kidney transplant patients 46.7 years old (range 18-78), 59.8% males. The employment rate (weighted mean) for dialysis patients was 26.3% (range 10.5-59.7%); pre-transplant 36.9% (range 25-86%), and post-transplant 38.2% (range 14.2-85%). Predictors for employment during dialysis and post-transplant were male, non-diabetic, peritoneal dialysis, and higher educational level, and post-transplant: pre-transplant employment, younger age, transplantation with a living donor kidney, and without depression.

Conclusions: Patients with kidney failure had a low employment rate during dialysis, pre- and post-transplant. Kidney failure patients should be supported through a combination of clinical and social measures to ensure they remain in work.

Background

Kidney failure with a need of renal replacement therapy affects about 0.1% of the global population. According to the National Kidney Foundation statistics more than 2 million people world-wide receive chronic dialysis treatment or are living with a functioning kidney transplant [1, 2]. Kidney failure reduces quality of life, increases psychosocial problems and has profound implications on maintenance of normal employment [3, 4]. To a large extent this is a consequence of disease-related co-morbidity and uraemia-related symptoms, but it is also due to time-consuming treatments with hemo- or peritoneal dialysis. Therefore, kidney failure entails not only high costs because of the treatment itself but also results in lost productivity due to reduced labour force. A Canadian study stated that kidney diseases cost more than 217 billion Canadian dollars annually in health care services alone [5]. In addition to this comes loss of labour force.

Over the past decades, replacement therapy in kidney failure has improved in terms of home-based dialysis modalities with automated peritoneal dialysis or home hemodialysis rendering it easier for some patients to plan their time. Also, an increasing number of patients are receiving kidney transplants, and the survival rate is increased following transplantation [6]. Despite this, studies from all over the world have shown that many patients with kidney failure are not employed [7].

The employment rate in the general population of 15 to 64 years of age ranges between countries from 46–47% in South Africa and India to 85% in Iceland. The average employment rate in The Organization for Economic Co-operation and Development (OECD) countries is 69% [8]. The employment rate is lower in subjects below upper secondary educational level compared to upper secondary level or more [8]. For subjects suffering from chronic diseases, the employment rate is lower. Prognostic factors for employment include severity of the chronic disease, employment status before getting the condition and the educational level [9–11]. These somatic and social factors may also influence employment status in kidney failure patients.

Previous studies have reported employment rates and predictors for employment during dialysis or after kidney transplantation but the results have never been summarized in a systematic review for kidney failure patients receiving dialysis as well as after kidney transplantation [12–14]. The aims of this study were: First, to conduct a systematic review focusing on employment rate before and after initiation of dialysis (hemodialysis and peritoneal dialysis) and after kidney transplantation. The focus has been patients with kidney failure as they probably have the most difficulty maintaining a job. Second, to establish predictors of employment during dialysis and post-transplant. The predefined predictors - based on the authors’ general knowledge of the field both related to other chronic disorders and specific for kidney disorders - were socioeconomic factors such as age, gender, level of education, pre-employment and dialysis modality, time on dialysis, waiting-time for transplant, donor type as well as comorbidities such as diabetes and depression.

Methods

Protocol
This systematic review was carried out according to Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) [15] for studies that included employment rate in kidney failure patients during dialysis and after kidney transplantation. PROSPERO registration number: CRD42020188853.

**Selection criteria and search strategies**

The literature search included the period from January 1966 to August 2020 in the databases PubMed, Embase, and Cochrane Library using the following search terms: (chronic* kidney disease OR chronic* renal disease OR kidney transplant* OR renal transplant* OR dialysis OR hemodialysis OR peritoneal dialysis) AND (employment OR work ability OR disability pension). Articles in English and German were included. The search was done in the databases in the following order: PubMed, Embase, and Cochrane Library. Articles were selected primary based on the titles and abstracts if necessary. Studies worldwide were included. Articles including employment, work ability or disability, return to work or disability pension were selected and duplicates were excluded. Reference lists in the selected articles were reviewed, and more articles were included if relevant. Full-time and part-time employment, but not ‘working as housewives’ was included in our definition of employment.

**Data extraction, quality assessment and risk-of-bias**

The data collected included e.g. author names, year of publication, study design, date for data collection, employment rate, study population, age, gender, educational level, dialysis duration, kidney donor, ethnicity, dialysis modality, waiting time for transplantation, diabetes, and depression. Quality assessment was independently assessed by two reviewers (LK and RKC) using the Newcastle-Ottawa Scale (NOS) for cross-sectional and cohort studies [16] in order to assess risk of bias for all studies. Any disagreements were resolved by discussion until consensus was reached. The rating scale was based on 9 items dividing the studies into high (7–9), moderate (4–6) or low (1–3) quality. A low NOS score (range 1–3) indicated a high risk of bias and a high NOS score (range 7–9) indicated a lower risk of bias. For cross-sectional studies the quality assessment included: representativeness of the sample, sample size, non-respondents, ascertainment of the risk factor, comparability, assessment of outcome, and statistical testing. For cohort studies the assessment included: representativeness of the exposed cohort, selection of the non-exposed cohort, ascertainment of exposure, demonstration that the outcome of interest was not present at start of study, comparability; assessment of outcome, length of follow-up and adequacy of follow up.

**Analytical approach**

For outcomes reported in numbers or percentages, the odds ratio and 95% confidence intervals (CI) were calculated if possible. Meta-analysis for the pre-defined potential important predictors for employment before and during dialysis and after kidney transplantation: age, gender, level of education, pre-employment, dialysis modality, time on dialysis, waiting-time for transplant, donor type as well as comorbidities such as diabetes and depression were carried out. In addition to the predefined predictors, attempts have been made to find information on ethnicity, health insurances, self-assessed ability to work and quality of life, but there were only enough data on ethnicity for analysis. Test for heterogeneity was done using Chi-squared statistics and $I^2$, where $I^2$ below 40% might not be important; 30–60% may represent moderate heterogeneity; 50–90% substantial heterogeneity; and 75–100% considerable heterogeneity.

Meta-analysis for predictors for employment and odds ratio; confidence intervals; and test for heterogeneity were calculated using the software Review Manager (RevMan, version 5.3. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014).

**Results**

**General description of included studies**

The search yielded 2,310 references addressing kidney failure and employment. From the titles 133 studies were considered relevant for evaluation, and of those 58 met the inclusion criteria. Figure 1 shows the results of the systematic search strategy.

Table 1 summarizes the general characteristics of the studies. In total 27 studies described employment in kidney failure-patients during dialysis [17–43]; 25 after kidney transplantation [3, 4, 12, 13, 44–64]; and 6 [14, 65–69] addressed both dialysis and kidney transplantation. In total 33 studies regarding dialysis, and 31 regarding kidney transplantation were included with a total of 162,059 and 137,742 participants, respectively. The publication year of the included studies ranged from 1981 to 2020 (median 2013). Most of the studies (81%) were cross-sectional in design, analysing data at a specific point in time. The cross-sectional studies [3, 12–14, 17–19, 21, 22, 24–39, 41–49, 51, 54, 55, 57, 59, 61–64, 66–69] were small to medium sized with a median of 139–233 participants for kidney transplant and dialysis patients, respectively, while the cohort studies [4, 20, 23, 40, 50, 52, 53, 56, 58, 60, 65] were mainly larger population studies (median 2,103 for dialysis patients and 1,254 for kidney transplant patients). More than half of the studies were single-center studies, and the studies were mainly from high income countries. Study details are shown in Tables 1 to 3.
Table 1
General characteristics of the included studies, by dialysis and kidney transplantation

| Geography                               | Dialysis (n = 33) | Kidney transplantation (n = 31) |
|-----------------------------------------|-------------------|-------------------------------|
| Europe                                  | 10                | 13                            |
| North America                           | 11                | 14                            |
| Others (Asia, South America, New Zealand) | 12                | 4                             |
| **Study design**                        |                   |                               |
| Cross sectional                         | 29                | 23                            |
| Cohort study                            | 4                 | 8                             |
| **Study sampling method**               |                   |                               |
| Single centre                           | 13                | 24                            |
| Multicentre                             | 13                | 2                             |
| Registry                                | 7                 | 5                             |
| **Type of dialysis***                   |                   |                               |
| Hemodialysis                            | 15                |                               |
| Peritoneal dialysis                     | 10                |                               |
| Dialysis-modality unknown               | 17                |                               |
| **Number of participants**              |                   |                               |
| *Cross sectional studies*               |                   |                               |
| median                                  | 233               | 139                           |
| range                                   | 43–105,636        | 34 – 1,278                    |
| SD                                      | 22,449            | 255                           |
| *Cohort studies*                        |                   |                               |
| median                                  | 2,103             | 1,253                         |
| range                                   | 359–4,734         | 358 – 71,976                  |
| SD                                      | 1,997             | 27,826                        |

*Does not sum up to 33 because some studies included more than one type of dialysis
| Reference         | Country     | Study design | Study population                                                              | Study period | Participation rate | Age years (mean) | Sex (Male) % | Results                                                                 | Quality assessment |
|-------------------|-------------|--------------|-------------------------------------------------------------------------------|--------------|--------------------|------------------|--------------|-------------------------------------------------------------------------|-------------------|
| Albatineh 2019    | Kuwait      | Cross sectional | 336 HD patients from six dialysis centers                                     | n.a          | n.a.               | > 21             | 43.5         | Employed 17.9%                                                          | 4                 |
| Al -Jumaih 2011   | Saudi Arabia| Cross sectional | 100 HD patients selected randomly from 3 centers                              | n.a          | n.a.               | (53.4)           | 68           | Employed 28%                                                            | 3                 |
| AlShahrani 2018   | Saudi Arabia| Cross sectional | 233 patients from all hemodialysis centers                                     | 2016-17      | n.a.               | > 20             | 78.5         | Employed 26.6%                                                          | 3                 |
| Curtin 1996       | U.S.        | Cross sectional | 359 stratified from 31 centers                                                | n.a          | n.a.               | 18–62 (43)       | 50           | Employed: before dialysis 73%; during dialysis 24%                     | 7                 |
| Ghani 2018        | Sweden      | Cohort       | 4734 patients; HD = 2667; PD = 2067                                          | 1995–2012    | 96%                | HD/PD (48/47)    | HD 65; PD 62 | Employed before dialysis: total 65.3%; HD/PD 57%/76%; during dialysis: total 59.7%; HD/PD 51%/71% | 6                 |
| Grubman-Nowak 2020| Poland      | cross sectional | 60 HD patients                                                                | 2016-19      | (60)               | 60               | Employed 25%                                                          | 3                 |
| Gutman 1981       | U.S.        | Cross sectional | 2481 from 17 dialysis centers                                                 | 1979         | n.a.               | 21–59 (49)       | 55           | Employed 24%                                                            | 8                 |
| Helanterá 2012    | Finland     | Cross sectional | 819 from Finnish Kidney and Liver Association registry                        | 2007         | n.a.               | 15–64            | 62           | Employed: total 23.9%; HD 19%; homeHD 44%; APD 39%; CAPD 16%          | 7                 |
| Holley 1994       | U.S.        | Cross sectional | 77 patients; HD = 46; PD = 31                                                  | 1993         | 21–54              | 47               | Employed: 42.8%                                                       | 5                 |
| Huang 2017        | China       | Cross sectional | 166 patients in working age from 4 dialysis centers in Shanghai               | 2015         | n.a.               | (48.5)           | 64           | Employed 15.7%                                                          | 5                 |
| Imanishi 2017     | Japan       | Cohort       | 3151 dialysis patients in working age < 60                                    | 1999–2011    | n.r.               | 18–59            | n.a.         | Employed 51%                                                            | 5                 |
| Jarl 2018         | Sweden      | Cohort       | 1056 on dialysis from Swedish Kidney Registry                                 | 1995–2012    | n.r.               | 20–60 (50.3)     | 63.5         | Pre-dialysis:28%; during dialysis 18%                                   | 6                 |

n.a: not analyzed; n.r.: not relevant; HD: hemodialysis; PD: peritoneal dialysis; yr: year; APD: Automated Peritoneal Dialysis; CAPD: Continuous Ambulatory Peritoneal Dialysis; NHHD: nocturnal home hemodialysis
| Reference | Country   | Study design | Study population | Study period | Participation rate | Age years (mean) | Sex (Male) % | Results | Quality assessment |
|-----------|-----------|--------------|------------------|--------------|--------------------|------------------|---------------|---------|-------------------|
| Julian Mauro 2013 | Spain | Cross sectional | 161 in dialysis (HD = 83; PD = 78) from 8 centers in Spain in working age | 2007-9 | n.a. | 16–65 (41) | 61.5 | Employed: total 30.4%; HD 41%; PD 35.9% | 3 |
| Kasiske 1998 | U.S. | Cross sectional | 36646 receiving dialysis placed on a waiting list for kidney transplant. | 1994-96 | n.r. | all ages | 59 | Employed pre-dialysis: Fulltime 53.4%; part-time 6.5%; during dialysis: Fulltime 34.5%; part-time 8.2% | 5 |
| Kutner 1991 | U.S. | Cross sectional | 283 dialysis patients, 15 patents from each of 81 treatment facilities | 1987 | 99% of invited | 18–59 (44.7) | n.a. | Employed 11% | 4 |
| Kutner 2008 | U.S. | Cross sectional | 105636 dialysis patients from ESRD Facility Survey | 2004 | n.r. | 18–54 | n.a. | Employed 18.9% | 6 |
| Kutner 2010 | U.S. | Cross sectional | 1643 from US Renal Data System | 2009 | n.r. | >18 (59.6) | 55 | Pre-dialysis 35.6%; During dialysis 11.6% (4 months after start) | 5 |
| Kwan 2013 | Hong Kong | Cross sectional | All new consecutive automated PD-patients matched to CAPD-controls; 270; APD/CAPD 90/180 | 1995–2001 | n.a. | APD/CAPD (50.5/57.8) | ADP 67; CAPD 54 | Employed: Total 35.2%; APD/CAPD 71.2%/17% | 5 |
| Li 2018 | Hong Kong | Cross sectional | 101 (20 NHHD; 81 CAPD) | 2009-14 | 87% | 18–64 (47/52) | 55 | Employed: total 42.6%; NHHD: 80%; CAPD: 33.3% | 4 |
| Molsted 2004 | Denmark | Cross sectional | 112 from one university hospital; 59 in working age < 60 year: | n.a. | 75% | >18 (57.8) | 64 | Employed (in working age): 22% | 4 |
| Nakayama 2015 | Japan | Cross sectional | 179 (102 PD; 77 HD) from 5 dialysis centers | 2013 | n.a. | (63) | 68 | Pre-dialysis: 63%; during dialysis 49.2%. | 7 |
| Neumann 2018 | Germany | Cross sectional | 353 (1 year follow-up) stratified sample of 153 PD; 200 HD from 55 dialysis unit 6–24 months after initiation of dialysis | 2014–2015 | 74% | >18 (63.1) | 68 | Employed: total 17.1%; (PD 26.9%; HD 13.2%) | 4 |

n.a: not analyzed; n.r.: not relevant; HD: hemodialysis; PD: peritoneal dialysis; yr: year; APD: Automated Peritoneal Dialysis; CAPD: Continuous Ambulatory Peritoneal Dialysis; NHHD: nocturnal home hemodialysis
| Reference       | Country   | Study design | Study population                                                                 | Study period | Participation rate | Age years (mean) | Sex (Male) | Results                                                                 | Quality assessment |
|-----------------|-----------|--------------|----------------------------------------------------------------------------------|--------------|--------------------|------------------|------------|------------------------------------------------------------------------|-------------------|
| Panagopoulou    | Greece    | Cross sectional | 40 HD; 36 PD                                                                      | n.a.         | n.a.               | HD/PD (57/59)    | PD 58;     | Employed before dialysis: HD: 78%; PD 43%; During dialysis: total 25%; HD: 20%; PD 31% | 3                 |
| Parajuli 2016   | U.S.      | Cross sectional | 200 from one kidney transplant center; dialysis > 1 year before transplant         | n.a.         | 48%                | >18 (57)         | PD 58;     | Employed before dialysis: HD 93.5%; During dialysis HD 35%             | 4                 |
| Ravindan 2020   | India     | Cross sectional | 503 HD patients from 11 centers                                                   | 2015         | 95%                | 13-              | 74         | Employed:11.1%                                                          | 3                 |
| Takaki 2006     | Japan     | Cross sectional | 317 HD patients from 4 dialysis centers                                            | n.a.         | n.a.               | 18–64 (54.2)     | 66         | Employed: Total 42.3%; Male 54.1%; Female 19.4%                        | 5                 |
| Tanaka 2020     | Japan     | Cross sectional | 229; 36 PD + HD; 103 HD; 90 PD                                                    | 2012-15      | 69.9%              | PD + HD (57.4);  |
|                 |           |              |                                                                                    |              |                    | HD (62.7); PD (65.5) |
|                 |           |              |                                                                                    |              |                    |                  | PD + HD 75; HD 80; PD 69 |
|                 |           |              |                                                                                    |              |                    |                  | Employed: Total 52.8%; PD + HD 63.9%; HD 53.4%; PD 47.8%                | 4                 |
| Theorell 1991   | Sweden    | Cross sectional | 470 patients in Sweden on dialysis                                                | 1988         | 65.5%              | 25–64            | 59.8       | Employed: 20%                                                          | 6                 |
| Walker 2016     | New Zealand | Cross sectional | 43; a part of a larger study                                                      | 2014-15      | n.a.               | 22–79            | 48         | Employed: 27.9%                                                         | 3                 |
| van Manen 2001  | The Netherlands | Cohort       | 659 consecutive patients on dialysis; 359 completed follow-up                     | 1997-99      | 54.5%              | 18–65 (48.7)     | 60         | Employed: before dialysis 35%; 1 year on dialysis: 29.8%               | 3                 |
| Wilk 2019       | U.S.      | Cross sectional | 759 from one dialysis centers                                                     | 2010-18      | 65%                | HD (59)          | n.a.       | Employed 10.5%                                                         | 5                 |
| Wolcott 1988    | U.S.      | Cross sectional | 33 PD; 33 HD matched by sex, age and diabetic status                               | n.a.         | n.a.               | 20–65            | 70         | Employed: 19.7%; PD:30%; HD:9%                                        | 5                 |
| Zimmerman 2006  | Canada    | Cross sectional | 81 patients randomly selected from a waiting list for donor transplant (1/3 not in dialysis) | n.a.         | 66%                | (48.4)           | 56.2       | Employed: 32.9%                                                        | 4                 |

n.a: not analyzed; n.r.: not relevant; HD: hemodialysis; PD: peritoneal dialysis; yr: year; APD: Automated Peritoneal Dialysis; CAPD: Continuous Ambulatory Peritoneal Dialysis; NHHD: nocturnal home hemodialysis
Table 3  
Characteristics of the Individual Studies Among Kidney Failure Patients Receiving a Kidney Transplantation.

| Reference | Country | Study design | Study population | Study period | Participation rate (%) | Age years (mean) | Sex (Male) % | Results | Quality assessment |
|-----------|---------|--------------|------------------|--------------|------------------------|-----------------|--------------|---------|-------------------|
| Bohike 2008 | Brazil | cross-sectional | 272 with kidney transplant-a systematic random sampling of 1512 kidney transplant patients from 11 centers stratified by transplantation centers | 2003-4 | 97% | >18 (40.8) | n.a. | Pre-transplant employed: Full-time 11.8%; part-time 13.2%; Post-transplant employed: Full-time 23.2%; part-time 6.3% | 9 |
| Chen 2007 | Taiwan | cross-sectional | 113 with kidney transplant | 5 months (2003-4) | 98% | >18 (43.7) | 54.9 | Post-transplant employed: Full-time 50.4%; part-time 8% | 3 |
| Chisholm-Burnes 2011 | U.S. | cross-sectional | 75>1 year post-transplant | n.a. | 90% | 21-65 (47.6) | 57.3 | Post-transplant employed 39% | 8 |
| Danuser 2017 | Switzerland | cohort | 689 from the Swiss Transplant Cohort Study | 2008-12 | 65% | 18-65 | 65 | Pre-transplant employed 58.9%; Post-transplant employed 56.2% | 7 |
| De Baere 2010 | Belgium | cross-sectional | 79 with kidney transplant | n.a. | 77.3% | 18-65 | 62 | Pre-transplant employed 63.1%; Post-transplant employed 58.6% | 4 |
| De Pasquale 2019 | Italy | cross-sectional | 81 consecutive kidney transplant patients from one center | 2016-17 | 72% | (46.3) | 58 | Pre-transplant employed 68%; Post-transplant employed 38% | 5 |
| Eng 2012 | U.S. | cross-sectional | 204 with graft survival >1 yr | 2002-7 | 55% | 18-65 (48.1) | 57 | Post-transplant employed 56% | 7 |
| Epenberger 2015 | Switzerland | cross-sectional | 354 with kidney transplant in one hospital; 282 in working age | 2000-11 | 58% | 42-61 (53.5) | 71 | Pre-transplant employed: Full-time 33%; part-time 21%; 1 year post-transplant: full-time 36%; part-time 20% | 7 |
| Grubman-Nowak 2020 | Poland | cross-sectional | 101 patients with kidney transplant | 2016-19 | n.a. | (48) | 60 | Post-transplant employed 57% | 3 |
| Helanterá 2012 | Finland | cohort | 1818 with kidney transplant from Finnish Kidney and Liver Association registry | 2007 | n.r. | 15-64 (49) | 62 | Post-transplant employed 40% | 7 |
| Jarl 2018 | Sweden | cohort | 3247 with kidney transplant from Swedish Kidney Registry | 1995-2012 | n.r. | 20-60 (43.3) | 64.5 | Pre-transplant employed 62%; Post-transplant employed 61.1% | 6 |

n.a: not analyzed; n.r.: not relevant; yr: year
| Reference       | Country   | Study design | Study population                                                                 | Study period | Participation rate (%) | Age (mean) | Sex (%) | Results                                                                 | Quality assessment |
|-----------------|-----------|--------------|----------------------------------------------------------------------------------|--------------|------------------------|------------|---------|--------------------------------------------------------------------------|-------------------|
| Jordakieva 2020 | Austria   | cross sectional | 139 with kidney transplant in a multi-center questionnaire study                  | 2012         | n.a.                   | 18–55      | 58      | Post-transplant employed: Full-time 36%; part-time 13.7%                | 5                 |
| Julian Mauro 2013 | Spain   | cross sectional | 82 with kidney transplant from 8 centers in Spain in working age                  | 2007-9       | n.a.                   | 16–65      | 58.5    | Post-transplant employed: 39%                                          | 3                 |
| Markell 1997    | U.S.      | cross sectional | 58 with kidney transplant patients from one outpatient clinic                     | 1994         | 58%                    | 20–67      | 50      | Post-transplant employed: 43%                                          | 6                 |
| Matas 1996      | U.S.      | Cohort       | 636 with functioning kidney transplant                                            | 1985–1993    | 83%                    | >18        | 62      | Pre-transplant employed: Full-time 39%; part-time 5%                    | 5                 |
| Matas 2001      | U.S.      | Cross sectional | 1278 with primary living donor kidney transplant                                 | 1990–98      | n.a.                   | (32)       | 62      | Post-transplant employed: Full-time 41%; part-time 4%                   | 5                 |
| Messias 2014    | Brazil    | Cohort       | 358 with primary kidney transplants                                              | 2005-9       | 61.7                   | 17–72      | 67      | Post-transplant employed: 26%                                          | 6                 |
| Miyake 2019     | Japan     | Cohort       | 515 from one outpatient clinic being in paid employment at the time of transplant | 2017-18      | 98%                    | 20–64      | 68      | Post-transplant employed: Full-time 76%; part-time 9%                   | 5                 |
| Monroe 2005     | U.S.      | Cross sectional | 78 with kidney transplant; in working age; a stratified sample from one center during a 10 year period | n.a.         | 33%                    | 23–62      | 52      | Post-transplant employed: 49%                                          | 4                 |
| Nour 2015       | Canada    | Cross sectional | 60 with kidney transplant and functioning graft from one clinic                   | 2003-8       | 41.7%                  | 18–65      | 63.5    | Pre-transplant employed 68.3%; Post-transplant employed 38.3%           | 6                 |
| Panagopoulou 2009 | Greece | Cross sectional | 124 patients with kidney failure and 48 with kidney transplant                    | n.a.         | n.a.                   | (39)       | 67      | Pre-transplant employed: 86%; Post-transplant employed 56%             | 3                 |
| Parajuli 2016   | U.S.      | Cross sectional | 200 form one kidney transplant center; dialysis >1 year before transplant; investigated > 1 year after transplant | n.a.         | 48%                    | 28–82      | 60      | Employed: Prior to dialysis 93.5%; during dialysis 35%; Post-transplant 35.5% | 4                 |

n.a: not analyzed; n.r.: not relevant; yr: year
| Reference       | Country | Study design | Study population                                                                 | Study period       | Participation rate (%) | Age (years) (mean) | Sex (Male) % | Results                                                                 |
|-----------------|---------|--------------|----------------------------------------------------------------------------------|--------------------|------------------------|-----------------|--------------|-------------------------------------------------------------------------|
| Petersen 2008   | U.S.    | Cohort       | 47123 1 year post kidney transplant from United States Renal Data System         | 1995–2002          | n.r.                   | >18 (45.9)       | 60           | Employed: Pre-transplant: Fulltime 34.2%; part-time 6%; Post-transplant: Fulltime 38.1%; part-time 4.3% |
| Raiz 1997       | U.S.    | Cross sectional | 180 with kidney transplant from one transplant center                             | n.a.               | 61.4%                  | >19             | 53           | Employed: Prior to kidney failure: 86%; Pre-transplant 53%; 1 year post-transplant: 58% |
| Sangalli 2014   | U.S.    | Cross sectional | 227 with kidney transplant; in working age; 6 months follow-up from two outpatient clinics | 2007-9             | 67%                    | 18–65           | 59           | Post-transplant employed: 56.5%                                          |
| Slakey 2007     | U.S.    | cross sectional | 70 at least 48 months after kidney transplant; questionnaire study                | 1998–2000          | 47.9%                  | 20–75 (47)      | 51           | Post-transplant employed or in school 28.6%                              |
| Tzvetanov 2014  | U.S.    | Cohort       | 94,511 with kidney failure (baseline); N = 71,976 post-transplant from the United Network for Organ sharing database | 2004–11            | n.r.                   | 18–64           | n.a.         | Employed: Pre-transplant: 33% 1 year post-transplant 32.1%              |
| van der Mei 2006| Netherlands | Cross sectional | 239 with kidney transplant; 210 in working age                                     | 1996–2001          | 76.8%                  | 19–71 (50.3)    | n.a.         | Employed: 52.4%                                                         |
| van der Mei 2007| Netherlands | Cross sectional | 61 (3-month post-transplant); 58 (1 year post-transplant)                          | 2002-3             | 79%                    | 18–64 (44.2)    | 52.5         | Employed: Pre-dialysis: 72%; 1 year post-transplant: 52%                |
| van der Mei 2011| Netherlands | Cross sectional | 34 (T3) from one outpatient clinic in paid employment at the time of transplant    | 2002-3             | n.a.                   | 18–64 (50.5)    | 55.9         | Employed 6 year post-transplant: 67%                                   |
| Whitlock 2017   | U.S.    | Cross sectional | 325 from one kidney transplant center                                             | 2011-15            | n.a.                   | (52.3)          | 60.9         | Post-transplant employed 14.2%                                         |

n.a: not analyzed; n.r.: not relevant; yr: year

General description of study participants

Dialysis patients were on average 52.6 (16–79) years old and kidney transplant patients 46.7 (18–78) years old. More than half of dialysis and kidney transplant patients were males, 60.3% and 59.8%, respectively.

Employment rate during dialysis, pre- and post-transplant

Before and during dialysis

The weighted mean for the employment rate during dialysis was 26.3% (range 10.5–59.7) in- and between continents as shown in Table 4. The employment rate was 21.6% in the 16 studies which excluded patients more than 65 years of age [14, 20, 22, 23, 25, 26, 29, 30, 33, 35, 39–42, 65, 66,
In general, the employment rate decreased after initiation of dialysis. In 9 studies data before and after initiating dialysis were available [20, 24, 27, 31, 39, 40, 65, 67, 68]. In these studies, the change in the employment rate decreased 16.4% (weighted mean) ranging from a decrease of 5.2–58.5% in- and between countries. In a study from U.S. of 1,643 dialysis patients 36% were employed before dialysis and 11.6% after start of dialysis [27]. In a Japanese study, 63% were employed before dialysis and 49% after start of dialysis; 50.7% of HD-patients and 48% of PD-patients were employed [31].

Patients receiving peritoneal dialysis had a higher employment rate, 58.8% [14, 20, 28, 29, 31, 32, 34, 39, 41, 42, 66, 67] compared to patients in hemodialysis, 39.5% [14, 17–20, 22, 23, 29–34, 37, 39, 41, 42, 66–69].

**Pre- and post-transplant**

The employment rate pre-transplant was 36.9% (weighted mean) ranging from 25 to 86% in-between continents. The post-transplant employment rate was 38.2% (weighted mean, all studies) ranging between 14.2% and 85% in- and between continents as shown in Table 4. The employment rate was 34.4% when only including the 18 studies of kidney transplant patients, which had excluded patients 65 years or more (not in working age) [3, 4, 12–14, 46, 49, 52–55, 58, 60, 61, 63, 65, 66].

In 14 studies data pre- and post-transplant were available [4, 13, 44, 46, 47, 50, 55, 57, 60, 62, 65, 67, 68]. In these studies, the change in the employment rate pre- and post-transplant ranged from a decrease of 30% to an increase of 3.5% in- and between countries.

A Swiss study including 354 patients identified 32.9% working full-time one year before transplantation, 20.9% part-time and 11.9% part-time with part disability pension; in total, 65.7% were employed. One-year post-transplant 36.2% worked full-time, 19.5% part-time, and 10.6% part-time with part-time disability pension, in total 66.3% [13]. Another Swiss study found approximately the same relatively high rate of employment pre- and post-transplant [4]. In a cohort study performed in the U.S among 105,181 post-kidney transplant patients, 34.2% worked full-time, and 6% part-time pre-transplant.

One year post-transplant, 38.1% worked full-time, and 4.3% part-time [56]. In another U.S study from 2014 among 27,981 kidney failure-patients in the working age (18–64 years) a total of 33% worked pre-transplant and 32.1% one-year post-transplant [60].

**Predictors for employment during dialysis and post-transplant**

**During dialysis**

Twelve studies had information of normative comparison data to use for meta-analysis of predictors for employment during dialysis and only for few of the predictors wanted: dialysis modality (peritoneal vs hemodialysis), diabetics vs non-diabetics, educational level (more than vs high school or less), and gender (male vs female) [4, 20, 22, 23, 27, 33, 34, 39, 40, 42, 55, 58]. Predictors for employment during dialysis was non-diabetics, educational level more than high school, peritoneal dialysis, and male. Heterogeneity was small for non-diabetics, moderate for educational level and substantial/high for peritoneal dialysis and gender as indicted by the $I^2$ values, Table 5 and Fig. 2a-d (Supplementary).
Table 4.b. Employment Rate in Patients Pre-dialysis and During Dialysis, by Continent (Weighted Mean, Standard deviation, SD, and Range)

| Continent                                      | Pre-dialysis |               | During Dialysis |               |
|------------------------------------------------|--------------|---------------|-----------------|---------------|
|                                                | Weighted mean| SD            | range           | Weighted mean | SD            | range           |
| Europe                                         | 57.1         | 16.7          | 28.0-65.3       | 45.8          | 12.3          | 17.1-59.7       |
| North America                                  | 59.1         | 21.9          | 35.6-93.5       | 24.8          | 12.0          | 10.5-42.9       |
| Other (Asia, South America, New Zealand)       | 63.0         | 41.4          | 17.1-59.7       | 24.8          | 12.0          | 10.5-42.9       |
| Total                                          | 59.0         | 22.0          | 28.0-93.5       | 26.3          | 13.5          | 10.5-59.7       |

Table 4.b. Employment Rate in Patients Pre- and Post-kidney Transplantation, by Continent (Weighted Mean, SD, Range)

| Continent                                      | Pre-transplant |               | Post-transplant |               |
|------------------------------------------------|----------------|---------------|-----------------|---------------|
|                                                | Weighted mean  | SD            | range           | Weighted mean  | SD            | range           |
| Europe                                         | 61.3           | 11.1          | 54.0-86.0       | 53.7           | 8.9           | 38.0-67.0       |
| North America                                  | 36.0           | 21.2          | 33.0-85.6       | 36.3           | 9.7           | 14.2-58.0       |
| Other (Asia)                                   | 25.0           | 53.8          | 26.0-85.0       | 27.6           |               |                 |
| Total                                          | 36.9           | 19.3          | 25.0-86.0       | 38.2           | 14.6          | 14.2-85.0       |
Table 5. Predictors for Employment During Dialysis and Post-transplant

| DIALYSIS | Studies | Participants | Heterogeneity | Meta-analysis |
|----------|---------|--------------|---------------|--------------|
| Diabetes (non-diabetic/diabetic) | 7 | 479 | 6.34 | 0.39 | 5% | 1.68 (1.46, 1.93) |
| Education (>high school/<=high school) | 6 | 1704 | 10.0 | 0.08 | 50% | 2.57 (2.06, 3.21) |
| Dialysis type (peritoneal dialysis/hemodialysis) | 6 | 6081 | 19.3 | 0.002 | 74% | 2.24 (2.01, 2.51) |
| Gender (male/female) | 6 | 215 | 128 | <0.001 | 96% | 4.09 (3.59, 4.67) |

| POST TRANSPLANT | Studies | Participants | Heterogeneity | Meta-analysis |
|-----------------|---------|--------------|---------------|--------------|
| Gender (male/female) | 12 | 253 | 13.1 | 0.29 | 16% | 1.41 (1.19, 1.67) |
| Education (>high school/<=high school) | 10 | 2139 | 11.9 | 0.22 | 24% | 2.25 (1.85, 2.75) |
| Kidney donor (living donor/deceased donor) | 10 | 2597 | 8.7 | 0.47 | 0% | 2.74 (2.30, 3.27) |
| Pre-transplant employed (employed/unemployed) | 8 | 74408 | 26.8 | <0.001 | 74% | 13.63 (13.1, 14.2) |
| Diabetes (non-diabetic/diabetic) | 8 | 3114 | 15.2 | 0.03 | 54% | 1.62 (1.36, 1.92) |
| Ethnicity (white/other than white) | 5 | 944 | 5.1 | 0.28 | 21% | 1.95 (1.44, 2.64) |
| Age (<50 yr/>=50 yr) | 5 | 1566 | 6.5 | 0.17 | 38% | 2.29 (1.85, 2.84) |
| Dialysis type (peritoneal/hemodialysis) | 4 | 749 | 2.7 | 0.45 | 0% | 1.55 (1.02, 2.35) |
| Waiting time (<2 yr/>=2 yr) | 4 | 1226 | 0.2 | 0.98 | 0% | 1.82 (1.37, 2.42) |
| Depression (no depression/depression) | 3 | 1084 | 2.2 | 0.33 | 9% | 2.24 (81.5, 3.27) |
| Dialysis duration (<2 yr/>=2 yr) | 2 | 477 | 3.2 | 0.08 | 68% | 3.82 (2.51, 5.83) |

Post-transplant
Fifteen of the studies reporting employment rate post-transplant also had information of normative comparison data to use for a meta-analysis of predictors for employment post-transplant [3, 4, 12, 13, 44, 48–52, 55, 58–60, 63, 69]. There was only enough normative data for some of the wanted predictors: pre-employment, educational level, donor type, dialysis modality, diabetics, waiting time for transplant, time on dialysis, depression, gender, age, and ethnicity. The predictors for employment post-transplant with low heterogeneity was having a living donor, educational level more than high school, peritoneal dialysis, male, younger age, being white, waiting-time for transplant, and depression, and with moderate heterogeneity pre-transplant employment, non-diabetics, and shorter time in dialysis (<2 years), Table 5 and Fig. 3a-k (Supplementary).

Assessment of quality of included studies
The studies addressing employment during dialysis were assessed as of low quality (n = 8; 24.2%) [18, 19, 36, 40, 43, 66, 67, 69] medium quality (n = 20; 60.6%) [17, 20, 22–30, 32–35, 37, 41, 42, 65, 68]; and high quality (n = 4; 12.1%) [14, 21, 31, 39].

According to The Newcastle-Ottawa criteria of assessment, studies of post-transplant employment were assessed of low quality (score 1–3) (n = 4; 12.9%) [45, 66, 67, 69]; medium (score 4–6) (n = 19; 61.3%) [46–55, 58–65, 68]; and high quality (score 7–9) (n = 8; 25.8%) [3, 4, 12–14, 44, 56, 57].

Many studies were cross-sectional single center studies, with a relatively small number of participants and self-reported patient data. Only 3 studies were prospective cohort studies [4, 40, 50]. When only including the high-quality studies in the analyses the employment for dialysis patients changed from 26.3% (weighted mean, all studies) to 25.2% (weighted mean, high quality studies). The post-transplant employment rate changed from 36.9% (weighted mean, all studies), to 42.5% (weighted mean, high quality studies). The quality assessment is shown in Supplementary Tables 6a-6d.

Discussion
Key Findings
This is the first quantitative systematic review focusing on employment rate in kidney failure-patients during chronic dialysis treatment as well as kidney transplantation. In the systematic review we found that the employment rate decreased considerably during dialysis compared to pre-dialysis, likely because the treatment constitutes a barrier to full- or part-time employment. However, the post-transplantation employment rate decreased or
increased only slightly compared to pre-transplant and dialysis conditions. Our analyses support that it is very difficult to remain employed during dialysis and that employment depends on a combination of personal, clinical and work-related factors.

In the meta-analysis the strongest predictor of post-transplant employment was shown to be pre-transplant employment [4, 12, 13, 44, 49, 50, 52, 60] but with high heterogeneity between studies. Danuser et al. found that 81% of patients who worked pre-transplant were still employed post-transplant. [4] Sandhu et al. showed that among a US population, employment gave a privileged access to and shortened the waiting time for transplantation [70]. In the two prospective cohort studies [4, 50] employment status before transplant was also the most important predictor for employment 12 months after kidney transplant which support the results of this study and the result from Sandhu et al.

Educational level was also a predictor of post-transplant employment as patients with a higher educational level were more likely to be employed post-transplant [3, 4, 12, 13, 44, 48, 55, 58, 59, 63]. Persons with a higher educational level may have more job opportunities and flexibility, lower physical workload, good insurances, and better health care which may influence both the possibilities for employment before kidney-failure, during dialysis and post-transplant.

Being younger was also a predictor of post-transplant employment [4, 12, 13, 58, 59]. Danuser et al. found that younger patients were more likely to be employed before dialysis [4], which increases the chances of being in jobs during dialysis and post-transplant.

Having a living donor kidney may also influence the employment status [3, 4, 12, 13, 44, 49, 50, 52, 55, 63]. However, the association of receiving a living donor kidney and post-transplant employment may not be causal, but to a greater extent depend on the resources of the recipient and their surroundings [71, 72]. Having diabetes, and ethnicity other than white was also associated with a lower rate of living donor kidney transplantation [4, 71, 73] and influence the employment level [3, 4, 12, 44, 49–52, 58], supporting this assessment. A shorter waiting time for kidney transplantation increased the possibility of post-transplant employment [4, 12, 13, 55] which was shown especially for patients receiving a living donor kidney [4]. All these factors may therefore affect whether you receive a living donor and the employment status. The differences in employment rates may also be explained by the fact that the employment status determines the choice of dialysis modality and that employed with a higher level of education may have an increased interest and access to transplantation compared to unemployed [39, 40].

In general, employment constitutes a large and important part of our well-being and quality of life and persons with a high depression score have a lower well-being and quality of life and lower employment rates [4, 55, 58]. Studies have also shown that the depression scores decreased in patients who were employed post-transplant [4, 44]. Therefore, less depression may be related to employment and not having a transplantation per se.

The employment rate for kidney-failure-patients differs between studies and countries, but in general it is lower than the employment rate in the general population [8]. The variation between countries and continents may be related to differences in the mentioned predictors. Other factors may also cause some of the differences such as whether you have private or public health insurance. Kutner et al. from U.S showed that patients remaining employed after initiation of dialysis were twice as likely to have an employer-paid group insurance as those who did not remain employed [27]. Likewise, an Italian study by Sangalli et al. showed that employed more often had private health insurances than unemployed [58]. Contrary, a Chinese investigation found no effect on the employment level of having a medical insurance [22]. Other studies have shown that the probability of returning to work is reduced if you have already a disability pension [49], but receiving a disability pension may also be explained by being more handicapped and probably therefore unable to work. In countries without disability pension, patients may either be forced to work, or they are dependent on support from their relatives.

This study has identified potential factors which may increase the employment rate during dialysis pre- and post-transplant, including maintenance of pre-transplantation employment. Educational support, support in maintaining a job during dialysis, and early return to work after transplantation seem important for post-transplantation employment.

Comparison with existing reviews

Only one earlier review has investigated employment rate post-transplant in all adult patients [7]. However, this review only included 9 studies and a population of only 23,059. They found an employment rate of 39.4% (weighted mean) post-transplant while our review included 137,742 individuals with an employment rate of 38.2% (weighted mean- all studies) and 34.4% (weighted mean- only studies of patients below 65 years of age). The small differences in employment rates between the two reviews may be explained by the number of included studies, and the large variation in employment rates between the individual studies.

A review of 16–30 year old kidney failure-patients showed that those in dialysis were more likely to be unemployed than patients having a kidney transplant, corresponding to the findings in our review [74]. Overall, the previous studies support the findings in the present study that dialysis and post-transplant patients have a lower employment rate than the general population.

Strengths and limitations

The strengths of this review and meta-analysis are the wide search criteria ensuring inclusion of relevant studies and summarizes the knowledge of employment rate for kidney failure-patients during dialysis, pre- and post-transplant. However, there are some limitations. First, nearly all studies were without a control group and had no comparisons of employment rates with a background population. Second, most of the studies were cross-
sectional in design which limits the evidence of causality between employment and dialysis or kidney transplantation. Third, only few studies had independent results of the employment rate and many employment rates were self-reported, inducing a high risk of recall bias. Furthermore, 70% of the studies on dialysis and 45% of kidney transplantation included subjects more than 65 years old which can lead to an underestimation of the real employment rate. However, excluding studies with patients > 65 years of age did not change the employment rate very much. Finally, many studies did not include all the relevant risk factors for unemployment. Moreover, each country has their own social laws and social and health insurance systems to support kidney failure-patients staying at work or returning to work, which may also influence the employment rate, making it difficult to compare results across countries.

Implications for and future research and management of return to work

This review has identified areas of concern among adults with kidney failure. However, it is necessary to be cautious regarding the limitations mentioned. As is the case for other diseases and health in general, kidney failure-patients are also subject to social inequality regarding employment opportunities. There is a need for larger prospective cohort studies of kidney failure which ideally should include more detailed information about social and educational circumstances before and during replacement therapy and comparison of similar data with a relevant general background population from the same country.

Further studies should focus more on the predictors for staying employed to better understand the barriers and facilitation possibilities to support people with kidney failure to remain employed including clarifying the importance of dialysis duration, time since diagnosis of severe chronic kidney disease, the importance of family resources and specific social measures taken in each country. Future research should also focus on intervention through education, social support systems, and workplace and work task adaptation to find the best support systems to help kidney failure-patients to stay at work during dialysis as well as after transplantation. Also, studies should only focus on patients of working age with data on employment from independent sources such as tax or social benefits registries.

Conclusion

Kidney failure-patients have a low employment rate during dialysis as well as pre- and post-transplant. Pre-dialysis employment, a higher education, not having diabetes or depression, being younger, male, white, receiving a living donor kidney, and a short waiting time before transplantation were all predictors for post-transplant employment. It is important to support kidney failure-patients through a combination of clinical and social measures to ensure they remain in work.

Abbreviations

PD: peritoneal dialysis; HD: hemodialysis; APD: Automated Peritoneal Dialysis; CAPD: Continuous Ambulatory Peritoneal Dialysis; NHHD: nocturnal home; Yr: year; NOS: Newcastle Ottawa Quality Assessment Scale; SD: standard deviation; n.a.: not analysed; n.r.: not relevant

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Availability of data and materials

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Authors’ contributions

LK made the systematic research including reading articles, made the blinded quality assessment and the meta-analysis, drafting and revising the article. RC made the blinded quality assessment and the discussion afterwards of articles to be included in the research and the scores. Drafting and revising the article. TL drafted and revised the article; NHB drafted and revised the article.

All authors provided the intellectual content and critical discussion on the assessment and conclusions. Final approval of the version to be published.

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None.
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Figures

Figure 1
Flow chart illustrating the systematic search for studies examining employment outcome in patients with kidney failure receiving dialysis or transplantation.

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