Global Impact of Obesity and Diabetes on the Increase Incidence and Prevalence of Chronic Kidney disease (CKD) and End Stage Renal Disease (ESRD): A Systematic Review

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Research article

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Abstract

Background: Obesity and diabetes are the main causes of chronic kidney disease (CKD) and end stage renal disease (ESRD). The objective of this study was to analyze the impact of obesity and diabetes on CKD and ESRD incidence and prevalence.

Methods: A comprehensive literature search was conducted from 2001 to 2018. 494 articles were retrieved via PubMed and 125 articles through Google scholar and reference list of the selected articles. Among which thirty (30) studies met our inclusion criteria consisting of 17 cohorts, 11 cross-sectional, and 2 case-control studies.

Results: Majority of the studies indicated direct relationship between body mass index (BMI) and ESRD risk. Notably, the association of obesity and diabetes potentially increases the incidence and prevalence of CKD and ESRD. Results from the cohort, case-control and cross-sectional studies pointed out a positive association between obesity, diabetes and risks for renal disease outcomes. Even though many complications may occur, renal transplantation (RT) is still the preferred renal replacement therapy (RRT) advised in multiple studies for diabetic ESRD patients. Renal transplantation was associated with better quality of life and survival advantage than dialysis. Interestingly, overweight and obese ESRD patients on dialysis had a significant survival advantage in comparison to lean body weight patients.

Conclusion: Taken together, obesity and diabetes are significantly associated with the increasing incidence and prevalence of CKD and ESRD. Regulation of Weight and diabetes are highly recommended in obese and diabetic patients to prevent the subsequent renal disease. Previous reviews have discussed the relationship between obesity and ESRD or diabetes and ESRD separately. However, importantly, this review gives an insight on the association between obesity, diabetes and CKD/ ESRD.

Background

Obesity has nearly tripled worldwide since 1975. More than 1.9 billion adults across the globe in 2016 were overweight, of these over 650 million were obese [1]. It is estimated that the obesity prevalence will reach up to 51% of the world population by the year 2030 [2, 3]. Obesity and diabetes are the major cause of chronic kidney disease (CKD) and end stage renal disease (ESRD). Therefore, considered as the leading public health problem worldwide [4, 5]. It was analyzed that weight loss in obese chronic kidney disease patients may improve renal function [6]. Interventions to prevent or minimize CKD and its progression to ESRD have the potential in saving large number of human lives and minimizing healthcare expenditures [7].

Obesity is a key determinant along with the two important causative agents for ESRD, namely type-2 diabetes (Non-Insulin Dependent Diabetes Mellitus or NIDDM) and hypertension [8–11]. Population based studies in USA [12] and Europe [13] have described an independent association between a higher body mass index (BMI) and risk for the incidence of CKD. Furthermore, the excessive adiposity advocates the risk of kidney disease in patients having CKD of various causes [14].

Obesity is well known for causing morbidity, mortality, disability and has been associated to an increasing number of cardiovascular and metabolic comorbidities, such as hypertension and diabetes mellitus (DM). However, the risk for CKD in obesity is mainly independent of these comorbidities [15].

Renal alterations due to obesity includes proteinuria and/or albuminuria, hyper filtration and low glomerular filtration rate (GFR), however, mechanism underlying these changes are still not completely understood [16]. The national kidney foundation has recommended weight loss for the diabetic patients of stage 1–4 CKD [17]. The available data has shown that the incidence of some kidney disease varies greatly across different regions worldwide that have different prevalence of obesity, indicating that obesity may be a principal risk factor for kidney disease [18–21].

The prevalence of diabetes is expected to increase globally and the patients requiring renal replacement therapy (RRT) may also increase [22]. If the prevalence of diabetes continues with the same rate, it is projected to reach 592 million cases by 2035 [23]. Kidney transplantation is the most preferred RRT for diabetic patients with ESRD [24]. Increase in the end stage renal failure (ESRF) population is immense and influenced by age, gender and diabetes [25]. The incidence of ESRD with type-2 diabetes is increasing markedly with improved survival on RRT [26]. However, due to better treatment and care, the diabetes related ESRD incidence continue to fall in US in the diabetic population of all age groups [27].

There is a strong association between ESRD and the notable risk factors namely diabetes, hypertension and glomerulonephritis [28]. Type-2 diabetes mellitus has a significant impact on the increase incidence of ESRD [29]. Overall, ESRD is a global public health problem with a massive financial burden on health care systems [30, 31].

The objective of our literature review was to analyze the impact of obesity and diabetes on the increase CKD and ESRD incidence and prevalence. Previous studies on this topic have discussed the relationship between obesity and CKD/ESRD [4, 32–34] or diabetes and ESRD [24] separately. Our review provides a comprehensive insight on the association between obesity, diabetes and CKD/ ESRD. We thoroughly assessed the epidemiologic evidence on the relationship between obesity, diabetes and kidney disease, and carried out a systemic review of the studies that have evaluated the association between obesity, diabetes and CKD/ ESRD.

Methods

Data sources and searches

To identify the studies related to our topic, a comprehensive literature search was conducted through PubMed and Google scholar. All those articles were included which were focusing mainly on the "impact of obesity and diabetes on the increasing incidence and prevalence of CKD and ESRD" from 2001 to

2018.

The search terms included BMI or obesity, diabetes or diabetes type-2 or diabetic nephropathy, end stage renal disease or ESRD, chronic kidney disease or CKD, renal replacement therapy or RRT, dialysis or peritoneal dialysis or hemodialysis or PD or HD and kidney transplantation or renal transplantation or RT.

Selection criteria

The manuscript published in English language as full text articles were included in the study. The searched articles by PubMed and Google scholar were analyzed initially by titles closely related to define the obesity, diabetes and their impact on renal disease specifically the ESRDs. Articles with not well-defined titles were reviewed only on the abstract level. Furthermore, we made an additional search to see potential eligible studies through reference list of review articles that might have been missed in the initial searching. All population-based studies addressing the impact of obesity and diabetes on CKD and ESRD incidence and prevalence were included in this review. We excluded the studies published in language other than English and those who addressed only type-1 diabetes (Insulin Dependent Diabetes). The risk of bias across the studies might exist, but to our best, we tried to include all those studies related to our topic, irrespective of their statistically significant data or journal of publication to avoid the selection bias and publication bias. All the authors were qualified and experienced enough to follow the protocol for the selection of the studies.

Data collection and extraction

In this study, (AK) independently screened all the retrieved titles and abstracts as part of the search strategies to identify potentially eligible articles and subsequently verified by (SG). The quality of methodology and the risk of biasness in the included studies were assessed by two authors and the disagreements were discussed and resolved in the weekly meetings. Data extraction was carried out for different variables, including information about the author, type of study, country, study period, sample size, mean age, study objectives, BMI, diabetes, type of renal disease, main findings, ORs (odd ratios) or RRs (relative risks), statistical analysis, registry/data source. Remarks in the tables corresponds to conclusion. ORs and RRs were used as measures of the association between obesity, diabetes and CKD or ESRD.

Results

Literature search and inclusion

Figure 1 presents Preferred Reporting Items for Systematic review and Meta-Analysis (PRISMA) flow diagram for the article selection [35]. We retrieved 494 articles concerning our topic through PubMed search, and 125 additional articles were identified through Google scholar and through the reference list of the selected articles. After the selection process, 30 eligible studies were included in this review.

Study design and quality assessment

All the selected studies were comprehensively analyzed, and an appropriate study design was applied for all the reviewed studies. Based on our search, four types of studies were identified **1**- Retrospective, n = 13 (43.3%), **2**- Prospective, n = 4 (13.3%), **3**- Cross sectional, n = 11 (36.7%), **4**- Case-control, n = 2 (6.7%).

General characteristics of the included studies

General characteristics of the chosen studies addressing obesity, diabetes and ESRD are shown in Table 1. Maximum number of the included studies were based on adult population consisting of 18 to 98 years, while, male ratio was higher than female. Importantly, by distributing the retrieved studies geographically according to the continents (Fig. 2), 13 (43.3%) studies were performed in North America, 9 (30%) in Europe, 7 (23.3%) in Asia and only one study was carried out in Australia.

Majority of the studies were carried out in North America (43.3%) followed by Europe (30%), Asia (23.3%) and the lowest studies were performed in Australia (3.3%).

Importantly, thirteen (13) studies identified that the increase in BMI (mainly the obesity) have an impact on the increase incidence of ESRD. In addition, 11 studies revealed that diabetes is the most prominent risk factor for the increase incidence of ESRD while in 06 studies the ESRD patients were both: obese and diabetic. Two studies identified that obesity, diabetes and additional risk factors such as hypertension, glumerulonephritis, smoking and proteinuria are the major causative agents of increasing ESRD incidence [28, 36]. A case control study [6] in two ethnic groups (black and white) revealed the differences between black and white population in the incidence of ESRD in relation to the association between obesity and ESRD. Importantly, significant differences were observed in the study between the two groups regarding the increase odds of ESRD.

Table 1
General characteristics of the included studies

Reference	Study design	Sample size (N)	Age (Years) (Mean/ Median)	Studies addressing Obesity & diabetes & ESRD patients CKD/ESRD*	CKD/ESRD*	with obesity and diabetes*
Akwo *et al* [37]	Case control	2528	53.7	√	x	x
Coresh *et al* [38]	Cross sectional	28721	44.8 and 46.2	√	x	x
Foster *et al* [39]	Prospective	2676	43	√	x	x
Evangelista *et al* [40]	Cross sectional	37002	45.1 ± 0.15	√	x	x
Fox *et al* [41]	Retrospective	2585	At baseline = 43 On follow up = 61	√	x	x
Gelber *et al* [12]	Prospective	11104	52.7 ± 7.7	√	x	x
Speckman *et al* [42]	Prospective	23822	1. Family history of ESRD = 57.7 ± 14.7 2. No family history of ESRD = 61.2 ± 15.0	√	x	x
Hallan *et al* [43]	Cross sectional	65193	50.2 ± 17.4	√	x	x
Iseki *et al* [44]	Retrospective	100753	≥20	√	x	x
Kramer *et al* [45]	Prospective	5897	Obese age = 50.2 ± 9.7	√	x	x
Othman *et al* [14]	Retrospective	125	Obese age = 60 ± 15.4	√	x	x
Tozawa *et al* [36]	Retrospective	5403	48 ± 9	√	x	x
Gomez *et al* [46]	Cross sectional	4585	61.9 ± 10.6	√	x	x
Assogba *et al* [29]	Retrospective	9494	67.0 ± 16.5	x	√	x
NG *et al* [47]	Retrospective	30	59	x	√	x
Icks *et al* [48]	Retrospective	544	70.3 ± 11.4	x	√	x
Khan *et al* [28]	Cross sectional	407	M = 43.38 F = 42.4	x	√	x
Iseki *et al* [49]	Retrospective	7125	> 40	x	√	x
Iseki *et al* [50]	Retrospective	106,177	20–98	x	√	x
HSU *et al* [51]	Retrospective	21655	20–74	x	√	x
Hochman *et al* [52]	Cross sectional	130907	≥18	x	√	x
Plantinga *et al* [53]	Retrospective	8188	57.7	x	√	x
Chadban *et al* [54]	Cross sectional	11247	≥ 25	x	√	x
Amato *et al* [55]	Cross sectional	3564	≥ 18	x	√	x
Ejerblad *et al* [56]	Case control	1924	18–74	x	x	√
Vinhas *et al* [57]	Cross sectional	5167	20–79	x	x	√
HSU *et al* [15]	Retrospective	320,252	40 ± 13 (For class III obese)	x	x	√
Kramer *et al* [58]	Prospective	615192	20 +	x	x	√
Otero *et al* [59]	Cross sectional	237	49.58	x	x	√
Otero *et al* [60]	Cross sectional	2746	49.5	x	x	√

*The sign √ in all the column indicates “yes” while × indicates “not concern”

Risk factors for CKD/ ESRD

Several risk factors were identified in the selected studies which had an impact on the increase incidence and prevalence of CKD and ESRD (Fig. 3). However, obesity and diabetes were the most prominent risk factors point out by majority of the authors.

Majority of the studies observed that obesity and DM are the major risk factors for CKD and ESRD. **Abbreviations**: DM, Diabetes Mellitus; HT, Hypertension; CVD, Cardiovascular disease; PU, Proteinuria; MS, Metabolic syndrome; GN, Glumerulonephritis; Fam hist of ESRD, Family history of ESRD

Obesity is associated with profound increased incidence and prevalence of CKD and ESRD

Previously, the association between obesity and kidney disease has been described in several studies. Table 2 briefly summarizes the main characteristics and findings of 13 eligible studies which describes the impact of obesity on end stage renal disease. Most of the studies (n = 7) were conducted in USA, 2 in Japan and one each in Korea, Norway, UK and Spain. The sample size included in the studies were varied significantly ranging from 125 to 100753 individuals [14, 44]. The analysis indicates that obesity is the prominent risk factor for kidney disease including CKD [38, 40, 43] and ESRD [37, 42, 44, 58] leading to the ultimate or instant need for renal replacement therapy such as HD and PD or renal transplantation (RT).

Table 2
Obesity and its effects on the increasing incidence and prevalence of CKD and ESRD

Reference, year of publication	Type of study, Country and study period	Study Objective	BMI (kg/m^2) %	Type of Renal disease	OR/ RR and 95%CI	Registry/ Data source	Statistical analysis	Main findings	Remarks
Coresh *et al* [38] 2007	Cross sectional study USA 1988–1994 1999–2004	To update the estimated prevalence of CKD in the US	8079 (28%) Participants had BMI ≥ 30	CKD	Prevalence ratio for CKD Stage 4 (1999–2004) = 1.70 (1.11–2.51)	US-NHANES Survey	Logistic regression	Prevalence of CKD 1–4 increased from 10% in 1988–1994 to 13.1% in 1999–2000	Prevalence CKD in the 1999–2004 higher than in1988-199
Evangelista *et al* [40] 2018	Cross sectional study Korea 2008–2014	Prevalence of obesity according to the stages of CKD	Prevalence rate of general obesity were 37.8% in stage 4/5 CKD patients	CKD	Obesity related CKD stage 3b, OR = 1.22 (0.43–2.30)	KNHANES Survey	Logistic regression	Obesity was more prevalent in CKD patients than those without CKD	Weight loss good for th prevention disease progressior
Fox *et al* [41] 2004	Retrospective USA, 1978–1982, 1998–2001	Predictors identification of the development of new onset kidney disease	BMI at baseline with CKD = 26.8(± 4.2) BMI at follow up with CKD = 27.4(± 4.1)	KD	BMI as predictor of developing KD after mean of 18.5 y follow-up OR = 1.23 (1.08–1.41)	Framingham Offspring study	Logistic regression	Increase BMI, Diabetes and Smoking were related to development of KD.	BMI increas odds of developing disease by per SD unit
Gelber *et al* [12] 2005	Prospective USA 14 Years follow-up	Association between BMI and risk for CKD	398 participants were obese (3.6%)	CKD	10% increase in BMI after 14y follow-up and risk for CKD OR = 1.27 (1.06–1.53)	PHS study	Logistic regression	Higher baseline BMI was associated with increased risk for CKD	BMI was associated significantl increased r CKD after 14 years
Hallan *et al* [43] 2006	Cross sectional Norway 1995-97	Association between obesity smoking, physical inactivity and CKD	All categories of BMI were present	CKD	RR for BMI ≥ 30 kg/m^2 = 1.77 (1.47–2.14)	HUNT II study	Logistic regression	All classes of obesity (BMI ≥ 30 kg/m^2) increased the risk of CKD	Obesity, sm and physic inactivity w significant factors for
Iseki *et al* [44] 2004	Retrospective Japan (1983–2000)	Significance of BMI as a risk factor for the development of ESRD	25642 screeners were having a BMI of ≥ 25.5	ESRD	OR of BMI for developing ESRD= Men = 1.273 (1.121–1.446) Women = 0.950 (0.825–1.094)	OKIDS Registry (Okinawa)	Multi variate logistic analysis	404 screeners (232 men and 172 women) developed ESRD during the follow-up period	Higher BMI responsible the increas of ESRD in but not in w
Kramer *et al* [58] 2005	Prospective USA, (1973–1979)	Association of overweight and obesity with incident CKD in hypertensive adults	3094(32%) Participants were obese	CKD	OR (Obesity and increase odds of incident CKD at year 5) 1.40 (1.201.63)	HDFP Data	Linear regression	The incidence of CKD at year 5 was 34% in obese group.	Obese adul hypertensic an increase for CKD

Reference, year of publication	Type of study, Country and study period	Study Objective	BMI (kg/m^2) %	Type of Renal disease	OR/ RR and 95%CI	Registry/ Data source	Statistical analysis	Main findings	Remarks
Othman *et al* [14] 2009	Retrospective UK 10 y follow-up	Obesity impact on the rate of non-diabetic CKD progression	31% of the patients were obese	CKD	Higher baseline BMI ($P = 0.018$) and young age ($P = 0.016$) were significant predictors of eGFR fall / Y	Sheffield kidney institute UK record system	Uni and Multivariate regression analysis	The frequency of e GFR based CKD progression per year (> 1 ml /min/1.73 m^2/y) was 62.5% in overweight and 79.5% in Obese compared to 44.7% in normal weight CKD patients ($p = 0.007$)	Baseline BI strongly an pendently associa- te robust CKD progressior on the annu rate of eGF
Tozawa *et al* [36] 2002	Retrospective Japan 1997-99	Analysis of the effects of obesity and smoking on the development of proteinuria	34% of the participants were obese	Proteinuria as a risk factor for ESRD	RR for developing proteinuria was 1.45 (1.13–1.86) for obesity	Okinawa general health Maintenance Association screening	Logistic regression analysis	5.8% of participants developed proteinuria. RR (95%CI) for developing proteinuria was 2.27(1.55–3.32) $p < 0.0001$ for DM	Obesity, DN hypertensic smoking w key risk fac for develop proteinuria
Gomez *et al* [46] 2006	Cross sectional Spain	Assessment of the prevalence RI in patients with essential hypertension and BMI ≥ 25 kg/ m^2	2525 (55%) patients were obese and mean BMI was 35.1 ± 4.1	RI	High prevalence of RI was noted in the presence of Diabetes = 30.1% (24.4–32.9) vs 19.2% (17.6–20.8) in obese group	Spanish primary care centers data	Logistic regression analysis	Higher prevalence of Diabetes was observed in obese patients. Prevalence of RI was 22% (95%CI, 20.6–24.9) for overweight and 22.8% (95% CI, 21.0-24.7) for obesity	Overweight hypertensiv patients se primary car setting exh high preval MS and RI.
Akwo *et al* [37] 2015	Case control USA (2002–2009)	The relationship between BMI and ESRD in blacks and whites	Mean BMI at enrollment was (31.2 ± 7.7 kg/ m^2)	ESRD	Whites with class III obesity had more than 3-fold increase odds OR = 3.31 (1.08, 10.12) of ESRD.	SCCS Participants	Conditional logistic regression	Overweight persons at age 21 had 44% increase odds (OR 1.44; 95%CI, 1.13, 1.85) and obese 3-fold increase odds (OR 2.88; 95%CI, 2.16, 3.83) for ESRD comparing normal weight persons.	BMI (overw and obese) 21 was associated increased E incidents ir whites thar blacks. Incr BMI at enro was associ with 2-fold increase oc ESRD in ob whites
Foster *et al* [39] 2008	Prospective USA. Members who attended the (1978–1982) and (1998–2001) examination cycles were include in this study	Magnitude of association between BMI and CKD	36% of the sample was overweight and 12% was obese	CKD	One unit increase in BMI was associated with 5% increase in stage 3 CKD odds OR = 1.05 (1.02–1.09)	Framingham offspring participants	Logistic regression model	Obese individual had 68% increased odds of developing stage 3 CKD (OR 1.68 95% CI, 1.10–2.57)	Obesity is associated significant increase ris developing 3 CKD. .

Reference, year of publication	Type of study, Country and study period	Study Objective	BMI (kg/m^2) %	Type of Renal disease	OR/ RR and 95%CI	Registry/ Data source	Statistical analysis	Main findings	Remarks
Speckman *et al* [42] 2006	Retrospective USA 1995–2003	Relationship between obesity and family history of ESRD	Mean BMI for those with family history of ESRD Was 28.2 ± 8.0	ESRD	Reported family history of ESRD and association with being obese OR = 1.25 (1.14–1.37) and being Morbid obese OR = 1.40 (1.27–1.55)	Medicare supported RRT patient data	Logistic regression model	23% of patients reported family history of ESRD. Of these, 28.0% were overweight, 17.3% obese and 16.7% were morbidly obese	Obesity an start of dia therapy we independer associated reported fa history of E Genetic fac may contril familial risl ESRD.

In a community-based cohort of 2585 men and women, it was analyzed that each unit increase in BMI was associated with 23% (OR 1.23 95% CI, 1.08–1.41) increased risk of new onset renal disease [41]. The prevalence of CKD in the US in 1999–2004 was higher than 1988–1994. The cross-sectional analysis stated that prevalence of CKD increased from 10% in 1988–1994 to 13.1% in 1999–2004 with a prevalence ratio of 1.3 (95% CI, 1.2–1.4). This increase was due to the increase prevalence of diabetes and hypertension. This further raises concerns about future elevated incidence of kidney disease [38].

In a population-based study carried out by Evangelistq and colleague in South Korea determined that obesity was more prevalent in CKD patients than those without CKD. Importantly, prevalence rate of general obesity was 37.8% in stage 4 and 5 CKD patients. The study summarizes that weight loss is a good potential intervention to prevent the disease progression [40]. In a cohort of 11104 initially healthy men and 14 years of follow up, it was analyzed that higher baseline BMI was associated significantly with increased risk for CKD. The increase BMI (> 10%) was associated with significant increased risk for CKD (OR 1.27, 95%CI, 1.06–1.53) [12].

A case control study detected a significant difference between two ethnic groups: black and white in relation to the association between obesity and ESRD. BMI of overweight and obese persons at the age 21 was associated with increased ESRD incidence in both black and whites but more prominent in whites than in blacks, while BMI (overweight and obese) at enrollment was associated with non-significant odds of ESRD in blacks. However, significantly, obese whites had 2-fold increase odds of ESRD (OR 2.17, 95% CI, 0.94–4.98) [37].

Obesity is linked directly or indirectly in the development of chronic kidney disease. The results from the study with 18.5 years follow up, where 36% of the participants were overweight and 12% obese, revealed that 7.9% developed stage 3 CKD and 14.4% proteinuria. One unit increase in BMI was associated with 5% increase in the odds of stage 3 CKD (OR 1.05 (1.02–1.09) P = 0.005 [39].

Obesity, smoking and lack of physical activity are the significant risk factors for CKD [43], and the relative risk (RR) for BMI ≥ 30 kg/m^2 was 1.77 (95% CI,1.47–2.14). Using data from a community-based screening of 100735 participants in Okinawa, Japan, it was noted that a higher BMI is associated with the increased ESRD risk in men (OR 1.273, 95% CI, 1.121–1.446) P = 0.0002 but not in women in the general population [44].

Kramer *et al* in 2005, performed a prospective cohort study of 5897 incident dialysis patients with hypertension. Significant association of overweight and obesity was realized with the development of ESRD during a 5 year follow up. The incidence of CKD at year 5 was 34% in obese group and obese adults with hypertension had an increased risk for CKD, OR 1.40 (95% CI, 1.20–1.63) [58]. The cohort study with 23822 ESRD patients provides a detailed information about the association of obesity with the family history of ESRD in incident dialysis patients. Analysis showed that 23% of the patients reported family history of ESRD. Among which 28.0% were overweight, 17.3% obese and 16.7% were morbidly obese. Reported family history of ESRD was associated with being obese, OR 1.25 (95% CI, 1.14–1.37) and morbid obese, OR 1.40 (95% CI, 1.27–1.55) [42].

In summary, the obesity enhances the risk for developing the kidney disease particularly the ESRD in the general population. Furthermore, due to the large expenditures on the treatment of ESRD patients it is also an economic problem as well.

Diabetes is a prominent risk factor for the elevated burden of CKD and ESRD

A wide range of studies has been carried out to find the effect of diabetes on increasing kidney disease including ESRD. Table 3 explains the main characteristics and findings of 11 eligible studies defining the effect of diabetes on ESRD. Most of the studies were belonged to USA (n = 3), Japan (2), and one each from Pakistan, France, Malaysia, Germany, Australia and Mexico. High variations in the sample size of the included studies were identified ranging from 30 to 130907 individuals [47, 52]. By reviewing the summary of these studies, we concluded that diabetes is continue to be the prominent risk factor for kidney disease, including CKD [53, 55] and ESRD [49–52] leading to an urgent need for renal replacement therapy that is HD and PD or RT.

Table 3
Diabetes and its impacts on the rising incidence and prevalence of CKD and ESRD

Reference, year of publication	Type of study, Country and study period	Study Objective	Diabetes status	Type of Renal disease	OR/ RR and 95%CI	Registry/ Data source	Statistical analysis	Main findings	Rema
NG *et al* [47] 2018	Retrospective Malaysia	Rate of progression of type-2 DM to ESRD in Malaysia	All the included patients were type-2 diabetic	ESRD	The difference b/w the two groups (RAAS blocker user VS non RAAS blocker user) Was P = 0.001 (-3.69 to -1.13)	ESRD patient's data from Sultanah Bahiyah Hospital	SPSS, t-test and ANOVA	Short duration from DN to ESRD was noted, that is 5.63 ± 2.06 Y. Mean duration from DM to ESRD for pts receiving RAAS blocker Was 18.23 ± 2.38 as compared to 11.41 ± 2.94 who did not	The d to ESF shorte Malay popul comp other RAAS initiat recom diabet
Iseki *et al* [49] 2005	Observational (Retrospective) Japan 1997–2000	The effect of DM as a risk factor of developing ESRD	Incidence of DM was 2.3% (2.9% in men and 1.3% in women)	ESRD	OR of proteinuria as predictor for developing DM = 1.90 (1.14–3.17)	Dialysis unit (Okinawa)	Logistic regression analysis	Proteinuria was the strong predictor of the development of DM and higher the BMI, higher is the risk of ESRD	The p obesit increa Japar Asian and n effort of BM relate
Iseki *et al* [50] 2003	Retrospective Japan (1983–2000)	Clinical impact of proteinuria test on the development of ESRD	420 subjects developed ESRD, of which 100 (23.8%) had DM	ESRD	OR (ESRD and Protein urea) 2.71 (2.51–2.92)	OKIDS Registry (Okinawa)	Multi variate logistic analysis	Strong relationship was found b/w ESRD and proteinuria	Protei strong indep factor
HSU *et al* [51] 2004	Retrospective USA, 1976–1980 1988–1994	To know whether the increasing incidence of ESRD in the US is preceded by increased prevalence of CRI	24 ESRD cases/1000 persons in NHANES II and 38 ESRD cases/1000 in NHANES III were diabetic	ESRD	RR for progression to ESRD 1.7 (1.1–2.7)	NHANES II NHANES III USRDS	Poisson regression model	From 1978–1991, the prevalence of CRI and the incidence of ESRD increased	Growt ESRD growt CRI
Hochman *et al* [52] 2007	Cross sectional USA, USRDS Data of 2001	To estimate the prevalence and incidence of ESRD in the native American adults living on the Navajo nation	Majority of the ESRD Patients were diabetic	ESRD	ESRD prevalence was 0.63% and Incidence was 0.11%	USRDS	Two tailed Z-tests	Age adjusted prevalence and incidence of ESRD was 0.63% and 0.11% respectively	Highe and ir obser Ameri living Navaj which furthe
Plantinga *et al* [53] 2010	Retrospective USA 1999–2006	Estimation and comparison of CKD prevalence in people with diagnosed diabetes, undiagnosed diabetes, prediabetes, or no diabetes	826 were diabetics and 2272 prediabetes	CKD	CKD Prevalence by diabetes status for Diagnosed diabetes = 39.6 (35.1–44.3) and for undiagnosed diabetes = 41.7 (34.5–49.2)	US-NHANES Survey	Multi variate logistic regression analysis	39.6% of people with diagnosed and 41.7% with un-diagnosed diabetes had CKD	CKD w diagn predia undia diabet indivi interv prever progre
Chadban *et al* [54] 2003	Cross sectional Australia	To determine the prevalence of indicators of kidney damage in Australian adult population	Participants were tested for blood plasma glucose on Fasting and 2 hours after giving standard 75 g oral glucose	ESRD	OR for Proteinuria of DM vs no DM was 2.5 (1.8–3.5)	Australian Diabetes study	Logistic regression analysis	The prevalence of Proteinuria was 4-fold higher in those with DM compared with those without (8.7%, 95%CI 6.6%, 10.7%) vs (1.9%; 95% CI: 1.2%, 2.5% P < 0.001)	Protei Hema GFR e in the may p mean ESRD

Reference, year of publication	Type of study, Country and study period	Study Objective	Diabetes status	Type of Renal disease	OR/ RR and 95%CI	Registry/ Data source	Statistical analysis	Main findings	Rema
Amato *et al* [55] 2005	Cross sectional Mexico June 1999-Feb 2000	Assessment of the prevalence of CKD in a Mexican urban population	84 patients (siblings) had DM	CKD	DM as a risk factor for CKD in siblings OR = 1.9681 (1.34–2.90)	Questionnaire based data	Logistic regression analysis	The prevalence rate of Ccr < 15 ml/ min 1142 pmp and for Ccr < 60 ml/ min was 80.79 pmp.	Preva CKD i same devel count preval due to other as ge socio may a role
Icks *et al* [48] 2010	Retrospective population-based study Germany 2002-08	Estimation of the incidences of RRT in diabetic and non-diabetic population in Germany	270 (49.6%) of the incident RRT patients had diabetes.	RRT	RR (standardize) for Men= 7.9(5.9–10.8) and Women = 8.0(4.7–13.5)	Data from regional dialysis center in North Rhine-Westphalia	Poisson regression model	DN was the most frequent reason for RRT (29.7%) followed by vascular nephropathy (25.6%) and Glumerulonephropathy (12.9%).	The re RRT in estima diabet has in fold c non-d popul
Assogba *et al* [29] 2014	Retrospective France 2007–2011	Geographic variations and recent trends in the incidence of ESRD by diabetes status and type	The prevalence of diabetes type-2 increase from 2270 in 2007 to 2745 in 2011.	ESRD	Incidence rate of type2 diabetes related ESRD/Y increased till 2009 [6.9% (4.8–9.1)] Stabilized thereafter 0% (2.1–2.2)	REIN Data 2007-11	Logistic regression and Poisson regression model	ESRD incidence increased significantly for patients with type-2 diabetes (+ 7% annually till 2009) and stabilized then	Type-2 major ESRD Preve strate strong recom reduc incide
Khan *et al* [28] 2016	Cross sectional Pakistan	To discover the association of ESRD with various risk factors	183 Patient (45%) had diabetes in which 128 patients had ESRD.	ESRD	OR for diabetes related ESRD was 11.04	Data taken from 3 Hosp.	Odd ratio analysis	ESRD in diabetic patients was 11.04 times more than non-diabetic pts. GN patients had 3.115 times more risk of ESRD than non-GN.	Strong found ESRD major name hyper Glume The o factor less s

The longitudinal study in France in the year 2007–2011 consisting of 9494 patients with 3410 type-2 diabetes and mean age 67.0 ± 16.5, found that ESRD incidence increased significantly for patients with type-2 diabetes (+ 7% annually) (95% CI, 4.8–9.1) P < 0.0001 till 2009 and seems to be stabilized after 2009 (0%) (95% CI, 2.1–2.2) however, type-2 diabetes is still a major cause of ESRD incidence [29].

Hochman and colleagues estimated the prevalence and incidence of ESRD in native American adults living on the Navajo nation using USRDS data. Higher prevalence and incidence were observed in native American adults living on the Navajo nation. Age adjusted prevalence and incidence of ESRD was 0.63% and 0.11% respectively. Majority of the ESRD patients were diabetic [52]. To assess the prevalence of CKD in a Mexican urban population, a population based cross sectional survey was conducted. Prevalence rate of CKD in Mexico was like those in the developed countries. Increase prevalence was partially due to DM, however other factors such as genetic and socioeconomic may also play a role. OR for DM as a risk factor for CKD in siblings was 1.9681 (95% CI, 1.34–2.90) [55]. Plantinga *et al* in 2010 determined the estimation and comparison of CKD prevalence. Interestingly, 39.6% people with diagnosed and 41.7% with un-diagnosed diabetes had CKD. Prevalence of CKD by diabetes status for diagnosed diabetes was 39.6 (35.1–44.3) and for undiagnosed diabetes 41.7 (34.5–49.2) [53].

In a study in Germany determined that incidences of ESRD in patients with and without diabetes were 157.9 and 25.6 per 100,000 person/year respectively (6.2-fold increased risk for those with diabetes).[61] Diabetic nephropathy was the most frequent reason for RRT (29.7%) and the relative risk of RRT in the estimated adult population was increased by 8-fold comparing the non-diabetic population [48]. Khan *et al* 2016, revealed a significant relation between ESRD and three major risk factors namely diabetes, hypertension and glumerulonephritis. Importantly, the ESRD in diabetic patients was 11.04 times more than non-diabetic patients [28].

The longitudinal study in Cyprus 2004–2011 found that 84.4 pmp (36.0%) with ESRD were due to diabetic nephropathy suggesting that diabetes is a major cause of ESRD and specially in population under 65 years of age [62]. Furthermore, in a retrospective study, it was analyzed that the use of RAAS blockers has a significant impact on the delay onset of ESRD in diabetic patients. In this study it was described that some DN patients not receiving RAAS blockers developed ESRD in two years, while those receiving RAAS blockers took an average of 7 ± 1.91Y to progress into ESRD. Mean duration for the onset of ESRD was 4.59 ± 1.50 Y for those who were not prescribed RAAS blockers. The statistically significant difference was observed between the two groups, P = 0.001 (95% CI -3.69 to-1.13) [47].

In a cross-sectional study, it was described that early examination of proteinuria, Hematuria and GFR can provide a mean to reduce the ESRD burden. Strikingly, the prevalence of proteinuria was 4-fold higher in DM patients compared with those without DM. 8.7% (95% CI, 6.6%-10.7%) vs 1.9% (95% CI, 1.2%-2.5%) $P < 0.001$ [54].

The results of the different studies have confirmed that the ESRD incidence and prevalence is much higher in the diabetic than the non-diabetic population, demanding serious efforts to combat diabetes in order to stop or slow-down the ESRD progression.

The coupling of obesity and diabetes, and their ultimate impact in overwhelming growth of CKD and ESRD

The impact of obesity on the increase in the ESRD events have been carried out in several studies. However, obesity in combination with diabetes leads to ESRD risk much quickly than alone. Table 4 briefly describes the main characteristics and findings of 6 eligible studies in which the ESRD patients were obese and diabetic too. Four studies (2 each) were carried out in USA and Spain and one each in Sweden and Portugal. The sample size was varied among studies ranging from 237 to 615192 individuals [58, 59].

Table 4

Obesity, Diabetes and their effects on the increasing incidence and prevalence of CKD and ESRD

Reference, Year of publication	**Type of study, Country and study period**	**Study Objective**	**BMI (kg/m^2) %**	**Diabetes status**	**Type of renal disease**	**OR/ RR and 95%CI**	**Registry/ Data source**	**Statistical analysis**	**Main findings**
Ejerblad *et al* [56] 2006	Case control Sweden (May 1996-May1998)	Possible effects of Obesity on the incidence of moderately severe CRF	283 (14.7%) Patients had BMI ≥ 30 kg/m^2	One third of the patients were diagnosed with diabetic nephropathy.	CRF	OR for CRF association with BMI = For (BMI ≥ 35 kg/m^2) Men = 4.4 (2.4 to 8.2) Women = 3.1 (1.6 to 6.1)	Swedish National population register	Logistic regression model	Obesity (≥ 30 kg/m^2) in men and (≥ 35 kg/m^2) in women was associated with 3-4fold increased risk for CRF.
HSU *et al* [15] 2006	Retrospective USA 1964–1985	To determine the association between increase BMI and risk for ESRD	Of the total sample, there were n = 21856(6.8%) class I obese, n = 5540(1.7%) class II obese and n = 2417(0.8%) class III obese	6080 persons of class I, II and class III obesity were diagnosed with diabetes	ESRD	RR for ESRD was 3.57(3.05–4.18), 6.12(4.97–7.54) and 7.07(5.37–9.31) for class I, II and III obesity respectively	Member of Kaiser permanent of northern California	Multivariate analysis using cox model	Higher baseline BMI is an independent risk factor for ESRD even after adjustment for baseline BP and Diabetes mellitus.
Kramer *et al* [58] 2006	Prospective USA (1995–2002)	Increase BMI and obesity in incident ESRD population and survival advantage	Mean BMI increased from 25.7 to 27.5 kg/m^2 among incident patients (1995–2002)	Increased From 44–51% (1995–2002)	ESRD	The forecast Prevalence of total obesity and obesity stage ≥ 2 among incident ESRD patients with diabetes in 2007 was 44.6% (43.0 to 46.2%) and 22.7% (21.7–23.6%) respectively	USRDS	Auto regression method	BMI slope was higher in ESRD population (8%) vs total US population (4%) ($P < 0.0001$)
Otero *et al* [59] 2005	Cross sectional Spain 2004	Epidemiology of CKD in the Spanish population and associated risk factors	Obesity prevalence was 8% at G3 stage of renal function	Diabetes prevalence was 16.7%	CKD	Risk of CKD and ARF. DM OR= 4.48 (1.54, 13.04) Obesity OR= 7.7 (2.65,22.3)	EPIRCE study	Logistic regression analysis	High prevalence of HT (31.5%) DM (8%) Obesity (13.1% Smoking (22.7%) Alcohol intake (24%) was found
Otero *et al* [60] 2010	Cross sectional Spain Jan 2004-Jan2008	Prevalence of CKD in Spanish population	723(26.3%) participants were obese	420 were diabetic	CKD	Association b/w clinical characteristics and the presence of CKD. Obesity OR= 3.5 (2.0–6.0) HT OR= 6.2 (4.0-9.6) DM OR = 2.0 (1.4–2.8)	EPIRCE study	Logistic regression analysis	Obesity prevalence was (26.1%), Hypertension (24.1%) DM (9.2%) Dyslipidemia (29.3%)

Reference, Year of publication	Type of study, Country and study period	Study Objective	BMI (kg/m^2) %	Diabetes status	Type of renal disease	OR/ RR and 95%CI	Registry/ Data source	Statistical analysis	Main findings
Vinhas *et al* [57] 2011	Cross sectional Portugal, 2008-09	Prevalence of CKD, ESRD and associated risk factors in Portugal	The obesity prevalence was 33.7%	Diabetes prevalence was 11.7%, and Metabolic syndrome 41.5%	CKD	Adjusted OR for CKD: Diabetes = 1.20 (0.96–1.50) Obesity= 1.14 (0.94–1.39)	PREVADIAB Study	Logistic regression analysis	Prevalence of CKD stage 3–5 was 6% which is same as the other western countries but risk of ESRD was greater than the other European countries

Ejerblad and colleagues in the year 2006 described that obesity has direct or indirect impact in the development of chronic kidney disease and chronic renal failure. It was further analyzed that a strong association exist among obesity, diabetes and CRF risk, and the risk in the obese individual is mainly driven by type-2 diabetes and/or hypertension. OR for CRF association with BMI = For (BMI ≥ 35 kg/m^2) Men = 4.4 (95% CI, 2.4–8.2) Women = 3.1 (95% CI, 1.6–6.1) [56].

The cohort study reported by Hsu *et al* elaborated the impact of increased BMI on the risk of ESRD based on historical cohort data gathered in a large, integrated health care system in California from 1964–1985 with a large sample size of 320252 and mean age of 41.7 ± 13.3 years. There were 2417 class 3 obese individuals with mean weight of 116.4 ± 17.5. It was noted that the rate of ESRD increases with the increase in BMI that is 10/100000 person/year among normal weight to 108/100000 persons/year among extreme obese (≥ 40 kg/m^2). Remarkably, baseline BMI remained a strong risk factor for ESRD even after adjustment for diabetes and blood pressure [15].

Highest prevalence of obesity stage 2 (BMI ≥ 35 kg/ m^2) was observed in ESRD population with DM at dialysis initiation between the age of 45–64 years. It positively influenced the ESRD population on dialysis due to the survival advantage with obesity [58].

Chen *et al* determined that obesity was associated with increased proteinuria in the early stage while it was beneficial in terms of improved renal survival in the later stages confirming the reverse epidemiology. 28.8% of the patients developed ESRD by the end of the study period [63].

A Cross sectional study observed that prevalence of CKD in Spain was high especially in the elderly population. Two modifiable risk factors namely diabetes and hypertension were responsible for the increased prevalence of CKD. Association between clinical characteristics and the presence of CKD for obesity verses normal was OR 3.5 (95% CI, 2.0–6.0), hypertension verses absence OR 6.2 (95% CI, 4.0-9.6) and DM verses absence OR 2.0 (95% CI, 1.4–2.8) [60].

In another study, it was found that prevalence of CKD and cardiovascular risk factors was high in the randomly selected sample of the general population. Prevalence of obesity and DM was 13.1% and 8% respectively. Risk factors significantly involved in kidney disease were obesity, OR 7.72 (95% CI, 2.65, 22.3), DM, 4.48 (95% CI, 1.54, 13.04) along with the other risk factors [59].

Interestingly, higher prevalence of CKD was not responsible for the high incidence of ESRD in Portuguese population. Infact the high prevalence of risk factors may account for the high incidence of CKD. The obesity prevalence was 33.7%, diabetes 11.7% and metabolic syndrome 41.5%. ESRD incidence was higher than other European countries but lower than the US. Adjusted OR (95% CI) for CKD: Diabetes = 1.20 (0.96–1.50) and Obesity = 1.14 (0.94–1.39) [57].

Even though some studies have shown that obesity is the major risk factor for developing ESRD, independent of diabetes. However, this review reveals that obesity enhances the risk for developing diabetes and they in combination give rise to the kidney disease particularly the ESRD in the general population.

Discussion

ESRD in patients with obesity and diabetes is a life-threatening disease with a poor survival rate and is associated with high healthcare costs. In this review, we specified a clear eligibility-criteria and conducted a comprehensive research to achieve the objectives.

Obesity and its contribution in ESRD development

The obesity epidemics and diabetes are growing worldwide. It has a strong affect across the globe and have far reaching social and health consequences. Several studies carried out on this topic realized a strong co-relation between obesity, diabetes and kidney disease resulting that obesity and diabetes increases the risk of CKD and ESRD. Our systemic review based on retrospective, prospective, case control and cross-sectional studies, gives strong enough evidence regarding the unavoidable impact of obesity and diabetes on the increased growth of ESRD.

Fox *et al* evaluated that baseline BMI predicts subsequent kidney disease after a mean follow up of 18.5 years. In this cohort of 2285 men and women, increase of each unit in BMI was associated with 1.23-fold elevated risk for new onset kidney disease. Importantly in a cohort study (n = 100753), the relationship between obesity and the risk of kidney disease in men and women was analyzed. A strong dose-response relationship between BMI and risk of ESRD was found in men, but not in women [41].

In several other studies it was found that overweight and obesity is a common and strong risk factor for the development of ESRD in the general population. Furthermore, the increase in the BMI increased the rate of CKD, ESRD [15, 32, 39] and risk of chronic renal failure [56]. A case control study between two ethnic groups that is black and white showed a significant difference in the association between obesity and ESRD. Overweight and obesity at the age of 21 was associated with increased ESRD incidence in whites than in blacks. Strikingly, a 3-fold increase was observed in obese whites compared to normal weight person [37].

The risks for the adverse outcomes of obesity were progressive with increasing BMI. Furthermore, the obesity in the presence of DM increased the risk of graft failure. However, the study showed that obesity alone may also be a risk factor for a shorter time to graft failure [64]. Notably the prevalence of CKD in US in the year 1999–2004 was higher than 1988–1994 [38]. This increase in the prevalence was observed in the total sample regardless of their BMI state. As the data shows that 28% of the participants were obese, in our opinion, this would have been much better if the study had carried out on different BMI categories. On the other hand, the cross-sectional study by Evangelista *et al* provides enough information about obesity prevalence in CKD patients. Importantly, obesity was higher in prevalent CKD patients than non-CKD. This support the idea that weight loss might be a good potential intervention for the avoidance of disease progression [40].

Obese patients with family history of ESRD were at higher risk of developing ESRD than non-family history of ESRD. Obesity and the start of dialysis therapy were independently associated with patients having family history of ESRD and genetic factor may also contribute to the familial risk of ESRD [42]. It was concluded after 14 years of follow-up that higher baseline BMI was linked with enhanced risk for CKD [12]. Similar findings were carried out in another study where the baseline BMI was strongly and independently associated with rapid CKD progression [14].

The review study on “elevated BMI as a risk factor for CKD” summarized that the impact of obesity in the pathogenesis of CKD seemed to be independent of hypertension and DM [34]. Interestingly, the review study by Wang *et al* observed that obesity in women was associated with high risk than in man and a positive linkage was observed between BMI and risk for kidney disease [65].

Diabetes and its role in ESRD progression

Diabetes in ESRD patients is life threatening disease with low survival rate and high healthcare costs. The prevalence of diabetic ESRD is still on the rise while due to better management of healthcare system, the incidence rate has declined in the developed and some developing countries.

In the retrospective study, a high burden of CKD was observed among persons with undiagnosed diabetes and prediabetes. The prediabetes individuals need earlier detection and management strategies for the prevention of development, progression and complications of diabetes and CKD associated with DM [53]. Furthermore, early detection and treatment of DM can prevent the DM related ESRD, as DM has been the leading risk factor of incident dialysis in Japan since 1988 [49].

It was noted that diabetes related ESRD incidence was increased in the early 1990s in the US, however it decreased in the later years in all age groups due to reduction in prevalence of ESRD risk factors, better treatment and care. The ESRD patients with diabetes are better treated now than in the late 1990s. Similar findings were observed during the examined period (1978–1991), where the growth in ESRD incidence was higher than the growth in prevalent chronic renal insufficiency in the US [51].

In a cross-sectional study, it was analyzed that the prevalence of proteinuria was 4-fold higher in those with DM compared to those without DM, indicating that proteinuria is a good indicator of kidney damage. Furthermore, early investigation of proteinuria, hematuria and GFR in the initial stage of kidney disease may provide a mean to reduce the ESRD burden [54]. The findings of Iseki *et al* strengthens the results of Chadban *et al* where a strong relationship between ESRD and proteinuria was found. It was concluded that proteinuria is a strong and independent risk factor for ESRD [50, 54].

A cross sectional study was conducted by Hochman and colleagues to analyse the incidence and prevalence of ESRD in the native American adults living on the Navajo nation. Higher prevalence and incidence of ESRD were observed in native American adults living on the Navajo nation. Majority of the ESRD patients were diabetic and higher ESRD prevalence was noted than the incidence [52].

Moreover, to assess the prevalence of CKD in the Mexican urban population, a cross sectional study revealed that prevalence rate of CKD in Mexico was similar as in developed countries. The higher prevalence rate of kidney disease may be due to DM but other factors such as genetic and socioeconomic may also play a role. Diabetes was a prominent risk factor for CKD in the siblings [55].

A high proportion of RRT risk was due to diabetes [48]. Strong connection was found between ESRD and three major risk factors namely diabetes, hypertension and glomerulonephritis, and ESRF population was largely influenced by age, gender and diabetes [28]. Type-2 diabetes was found to be the major cause of ESRD incidence and preventive strategies were strongly recommended to reduce the burden of ESRD incidences [29]. The review study by Ghaderian and colleagues concluded that renal transplantation, particularly preemptive transplantation is the best renal replacement therapy in diabetic ESRD patients. Although many complications may be associated with renal transplantation, but several studies recommended that it is associated with survival benefit and better quality of life [24].

Our review has some limitations which needs to be mentioned. Firstly, our search strategy only included PubMed and Google scholar, which might have resulted in the loss of some important articles related to our topic. Secondly, we did not include the studies that have discussed only type 1 diabetes, and also those studies other than the English language, which also might have resulted in the loss of some important studies.

Conclusion

Our systematic literature review describes the significant effects of obesity and diabetes on the increasing incidence and prevalence of CKD and ESRD. It was analyzed that overweight and obesity in younger age is markedly and positively associated with future treated ESRD incidence. Obese individuals having family history of ESRD are at much higher risk than the general population. Furthermore, diabetes, particularly type-2 diabetes is the major cause of CKD and ESRD incidence leading to RRT. In conclusion, the incidence and prevalence of CKD and ESRD in diabetic and obese population is more than the non-diabetic and non-obese population. We strongly recommend regular provision of health education and awareness trainings by the healthcare professionals on the prevention of CKD and ESRD, to control the CKD and ESRD incidence and prevalence in the future.

Abbreviations

BMI: Body mass index; OR: Odd ratio; RR: Relative risk; DN: Diabetic nephropathy; CKD: Chronic kidney disease; GFR: Glomerular filtration rate; ESRD: End stage renal disease; RAAS: Renal-angiotensin-angiotensinogen-system; US-NHANES: United States national health and nutrition examination survey; USRDS: United states renal data system; KNHANES: Korean national health and nutrition examination survey; SD: Standard deviation; PHS: Physicians health study; HUNT: Health survey of Nord-Trondelag County; OKIDS: Okinawa dialysis study; HDFP: Hypertension detection and follow-up program; eGFR: Estimated glomerular filtration rate; DM: Diabetes mellitus; RI: Renal insufficiency; CRI: Chronic renal insufficiency; MS: Metabolic syndrome; SCCS: Southern community cohort study; Ccr: Creatinine clearance; PMP: Per million population; RRT: Renal replacement therapy; REIN: Renal epidemiology and information network; CRF: Chronic renal failure; SRTR: Scientific registry of transplant recipients; ARF: Atherosclerotic risk factor; EPIRCE: Studio epidemiologico de la insuficiencia renal en Espana; HT: Hypertension; PREVADIAB: Prevalence diabetes.

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

Not applicable

Competing interests

The authors declare that they have no competing interests.

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Authors contributions

AK and SG have conceived and designed the study. AK screened and retrieved all the articles. NK, ACD and YM were involved in data analysis. AK and NK were involved in drafting the manuscript. Critical review was done by SG and AK. All authors have read and approved the final version.

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Figures

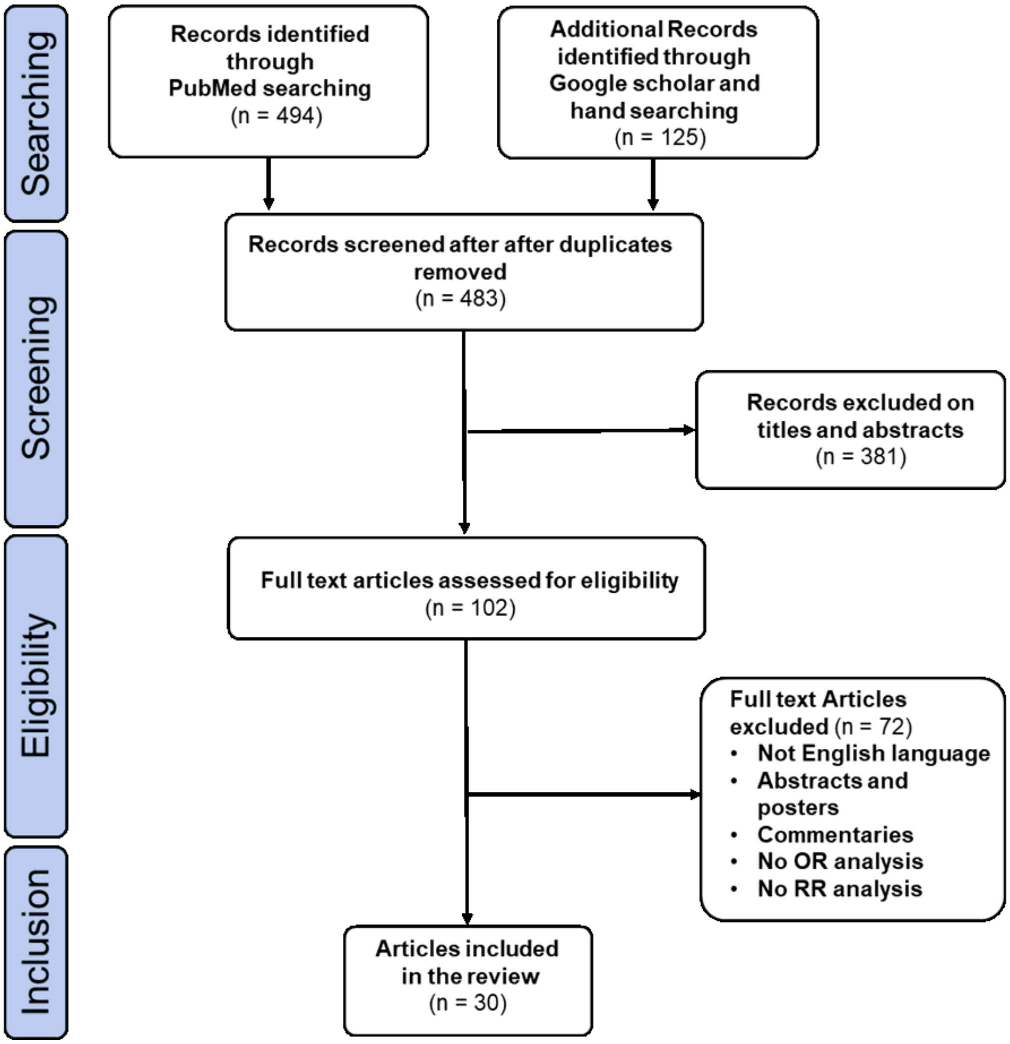

Figure 1

PRISMA Flow diagram of the systemic review process

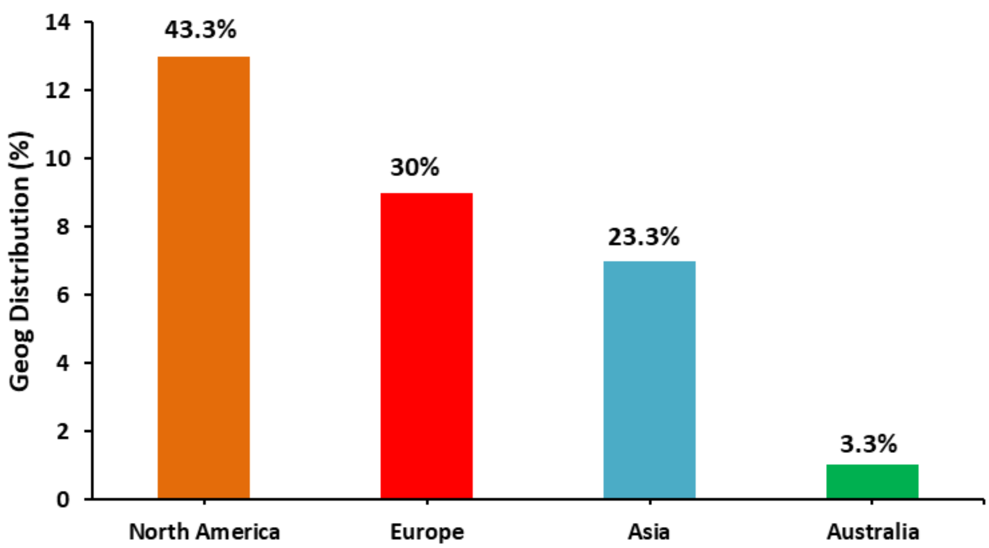

Figure 2

Geographical distribution of the 30 reviewed studies Majority of the studies were carried out in North America (43.3%) followed by Europe (30%), Asia (23.3%) and the lowest studies were performed in Australia (3.3%).

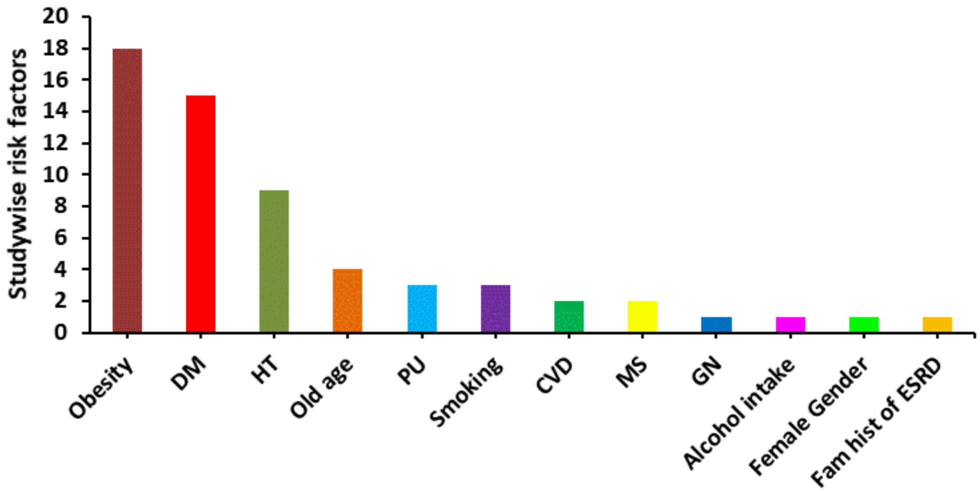

Figure 3

Risk factors for CKD and ESRD identified in different studies Majority of the studies observed that obesity and DM are the major risk factors for CKD and ESRD. Abbreviations: DM, Diabetes Mellitus; HT, Hypertension; CVD, Cardiovascular disease; PU, Proteinuria; MS, Metabolic syndrome; GN, Glumerulonephritis; Fam hist of ESRD, Family history of ESRD

Supplementary Files

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- PRISMAchecklistAK20201222.pdf