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Diabetes and higher HbA1c levels are independently associated with adverse renal outcomes in inpatients following multiple hospital admissions

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ABSTRACT

Objective: To assess the association between glycaemic status prior to the first hospital presentation with developing adverse renal outcomes overtime in patients with multiple hospital re-admissions.
Design: A prospective observational cohort study.
Participants: All inpatients aged ≥54 years admitted between 2013 and 16 to a tertiary hospital.
Main outcomes: We prospectively measured HbA1c levels in all inpatients aged ≥54 years admitted between 2013 and 16. Diabetes was defined as prior documented diagnosis of diabetes and/or HbA1c ≥6.5% (47·5 mmol/L). Included patients had ≥ two admissions (at least 90 days apart), baseline estimated glomerular filtration rate (eGFR) >30 ml/min/1·73m^2 and no history of renal replacement therapy. We assessed several renal outcomes: (a) 50% decline in eGFR; (b) rapid decline in renal function (eGFR decline >5 mL/min/1·73m^2/year) and (c) final eGFR<30 ml/min/1·73m^2.
Results: Of 4126 inpatients with a median follow-up of 465 days (254, 740), 26% had diabetes. The presence of diabetes was associated with higher odds of (a) 50% decline in eGFR (OR = 1·42;95% CI:1·18–1·70;$p < 0·001$); (b) rapid decline in renal function (OR = 1·40;95%CI:1·20–1·63;$p < 0·001$), and (c) reaching eGFR<30 ml/min/1.73m^2 (OR = 1·25;95%CI:1·03–1·53;$p < 0·05$). Every 1% (11 mmol/L) increase in baseline HbA1c was associated with significantly greater odds of (a) >50% decline in eGFR (OR = 1·07;95% CI:1·01–1·4;$p < 0·05$) and (b) rapid decline in renal function (OR = 1·11;95% CI:1·05–1·18;$p < 0·001$).
Conclusions: In patients with ≥two admissions, the presence of diabetes and higher HbA1c levels were strongly and independently associated with adverse renal outcomes at follow up. Such patients are at high risk of relatively rapid deterioration in renal function and a logical target for structured preventive interventions.

1. Introduction

Diabetes is the leading cause of chronic kidney disease (CKD) worldwide.[1] 1·2 million Australians were reported to have diabetes in

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2014–15. There were over one million hospitalisations with diabetes as the principal or additional diagnosis in 2015–16 in Australia.[2] People with diabetes have higher hospital readmission rates compared to people without diabetes which is a major driver of impaired health related quality of life and significant socioeconomical costs.[3] The role of glucose control in reducing micro and macrovascular complications of diabetes in the outpatient setting is well established[4]; however, there are no studies examining the relationship between glycaemic status leading to the initial hospital admission in people with multiple re-hospitalisation episodes and the risk of future decline in renal function. Studies related to the inpatient population have been generally confined to single admission episodes in the cardiac surgery setting or to critically ill patients looking at short term strict glycaemic control during the inpatient pre and post-operative periods.[5,6] Thus, whether diabetes and glycaemic control prior to an initial admission are independently associated with adverse renal outcomes in future hospitalisation episodes is currently unknown.

Estimates of glomerular filtration rate using eGFR equations have been used as a surrogate endpoint in clinical studies,[7] with the Food and Drug Administration (FDA) accepting a 30% decline in eGFR as a surrogate endpoint in clinical trials of new medications for diabetes.[8] In this regard, the typical annual absolute age related eGFR decline in the outpatient population is approximately 0·4–1·2 mL/min per 1·73 m^2 per year but this is approximately 2·1–2·7 mL/min per 1·73 m^2 per year in those with diabetes.[9] While chronic decline in renal function is important, shorter term decline in renal function provides important prognostic information as it has been demonstrated that an eGFR nadir at any time point is associated with increased cardiovascular events and all-cause mortality.[10,11] Furthermore, more rapid declines in eGFR (>5 ml/min per 1·73 m2 per year)[12] are strongly associated with progression to end stage kidney disease (ESKD) in the outpatient setting but there are no studies evaluating this outcome following recent hospitalisation.[13] However, despite the likely importance of long term glycaemic control in patients with diabetes and their risk of diabetic kidney disease, the role of HbA1c[14] as a prognostic factor in progression of renal function decline over short follow-up times in those who have had an inpatient admission is unclear.

We hypothesised that the presence of diabetes and higher HbA1c levels would, over the medium term, be independently associated with adverse renal outcomes in patients with multiple hospital admissions. To test this hypothesis, we evaluated the association between baseline glycaemic status defined categorically or using HbA1c as a continuous variable, with medium-term decline in renal function in patients re-admitted to a tertiary referral hospital.

2. Methods

2.1. Study design

This project was approved by the health service Human Research Ethics Committee and individual consent was waived due to the nature of the study. In this prospective observational cohort study, an automated HbA1c test was generated by the Cerner Millennium Electronic Medical Record® (CERNER, North Kansas City, Missouri), for all inpatients aged ≥54 years admitted to Austin hospital, Melbourne, Australia, between July 2013 and January 2016, who did not have an HbA1c measurement recorded within the preceding 90 days. The age value was chosen as it has been previously demonstrated that when using HbA1c measurements, the prevalence of previously unknown diabetes was substantially higher (5·4%) in hospital-based participants aged over 54 years.[15] HbA1c was measured using Roche immunoassay on Integra 800 (Roche Diagnostics, Risch-Rotkreuz, Switzerland) and the results were reported through the hospital electronic medical record system, Cerner® Millennium.

In the current analysis, only patients with two or more admissions (over a period of 90 to 1334 days), baseline eGFR >30 ml/min/1·73m^2 and no prior history of renal replacement therapy were included. As CKD is defined when changes in renal parameters persist for >90 days, in the current analysis, only inpatients with ≥two admissions which were at least 90 days apart were included.[16] Pre-specified baseline demographic data, principal admission diagnosis, clinical characteristics and baseline and final biochemical laboratory values were extracted using Excel 2016 Visual Basic for Application (VBA) from medical records and hospital databases. Estimated glomerular filtration rate was calculated based on the CKD-EPI formula using extracted data (age, gender and creatinine levels) on admission on the first presentation and just before discharge on last presentation to hospital.[17]

The primary outcome was defined as >50% percentage decline in eGFR and secondary outcomes were (i) development of rapid decline in renal function (eGFR decline >5 ml/min per 1·73 m^2 per year), and (ii) reaching a final eGFR<30 ml/min per 1·73 m^2.

2.2. Definitions

Inpatients were categorised into two subgroups (diabetes and no diabetes, including both type 1 and type 2 diabetes, no gestational diabetes included in the study) based on previous documented diagnosis of diabetes or HbA1c levels. Inpatients were diagnosed with diabetes if they had a prior history and documented diagnosis of diabetes or if their HbA1c at baseline was ≥6·5% (47·5 mmol/mol). Inpatients with a baseline HbA1c <6·5% (47·5 mmol/mmol) and no prior diagnosis of diabetes were considered to have no diabetes. These definitions are in accordance with the International Expert Committee and American Diabetes Association.[18]

2.3. Clinical and biochemical characteristics

Data regarding comorbidities were obtained from medical records to calculate a Charlson co-morbidity score to reflect patient comorbidities. Charlson comorbidity scores were calculated from ICD-10 AM codes.[19] Charlson score has been shown to be a strong predictor of clinical outcomes in patients with CKD.[20] In this study, the Charlson comorbidity score was modified to exclude diabetes and age, as these were considered as separate variables.[21]

2.4. Statistical analysis

Data were analysed with Stata software V·14·2 (StataCorp, College Station, TX, USA). Baseline characteristics were reported as medians and interquartile ranges (continuous characteristics) or counts and percentages (categorical characteristics) and compared between the diabetes categories using Kruskal-Wallis or Chi-squared/Fisher's exact tests respectively.

Logistic regression was used to estimate the maximum likelihood of development of renal outcomes given glycaemic state. Suitably selected subset of a priori chosen adjustment covariates included HbA1c, age, gender, systolic blood pressure, Charlson co-morbidity score (excluding age and diabetes), baseline eGFR (ml/min/1·73m^2), time (in days) between first and last test and haemoglobin (grams/l).

When assessing changes in eGFR (CKD-EPI) for all three outcomes, age and gender were not included in adjustment covariates as these covariates are included in the CKD-EPI equation. Standard analysis of collinearity and model fit were undertaken. A p value <0·05 was considered as statistically significant.

Margins of predictive probability for the defined primary renal outcomes adjusted for covariates including baseline eGFR, follow-up time, Charlson comorbidity score, systolic blood pressure and haemoglobin were calculated and then plotted. Analysis were performed both using diabetes status classified as yes/no diabetes and with HbA1c as a continuous variable.

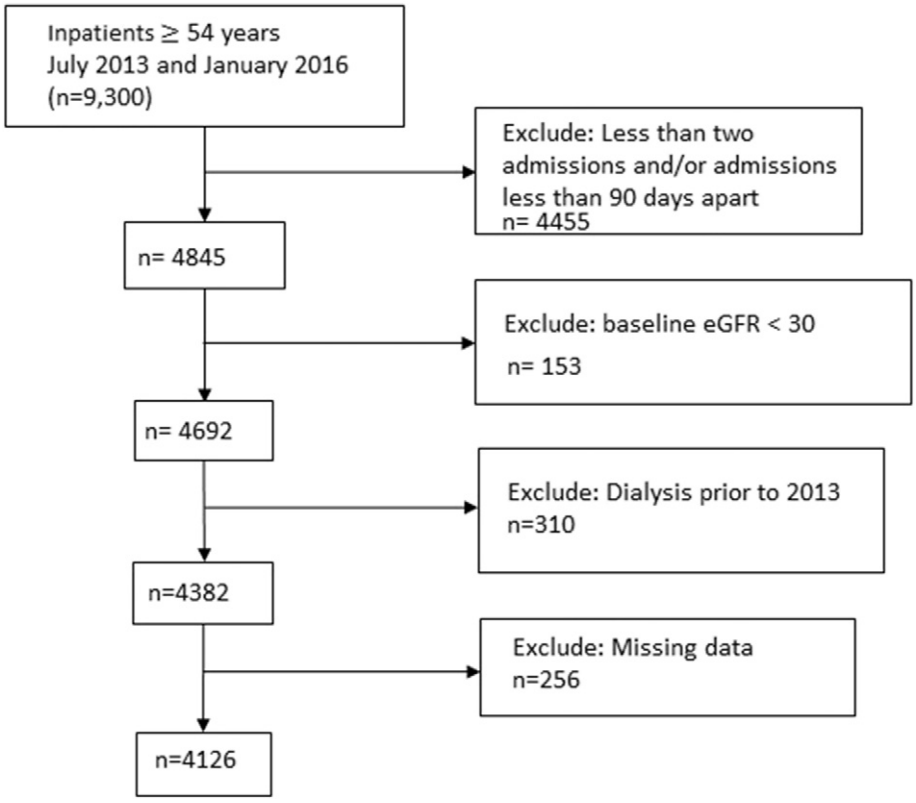

Fig. 1. Patients included in the study. Flowchart of study profile according to inclusion and exclusion criteria. Patients excluded for "missing data" did not have blood pressure recordings.

3. Results

Following exclusion of patients who met exclusion criteria or with missing data (Fig. 1), 4126 study patients were identified. The follow-up period was a median of 465 days (254, 740). The baseline characteristics of patients included and excluded were compared and were not statistically different (Table 1).

The baseline characteristics of included patients with diabetes and no diabetes are shown in Table 2. During their index admission, 26% of inpatients had diabetes and 59% were male. Median age was approximately 77 years for both groups. The median HbA1c in patients with diabetes was 7·4% (57·4 mmol/mol) and their Charlson score was higher. The median interval between the first and last measured creatinine and eGFR in patients with diabetes and no diabetes was similar at 15 months.

Baseline renal characteristics and renal outcomes are summarized in Table 3. Patients with diabetes had lower baseline eGFR and higher baseline serum creatinine levels. Nineteen percent of the patients with diabetes reached stage 4 CKD, over a median (IQR) follow-up period of 487 days (262, 774) compared to 13% percent of patients without diabetes ($p < 0{\cdot}001$).

Fig. 2 shows the association of diabetes and HbA1c with renal outcomes after adjustment for age (years), gender, Charlson comorbidity index excluding diabetes and age, estimated glomerular filtration rate (mL/min/1·73m^2), systolic blood pressure (mmHg), haemoglobin (grams/l), and follow-up time (years).

3.1. >50% decline in eGFR

Following adjustments for systolic blood pressure, Charlson comorbidity score (excluding age and diabetes), baseline eGFR, time between first and last test and haemoglobin, the presence of diabetes was associated with higher odds of developing a >50% decline in eGFR

Table 1
Baseline characteristics of patients included and excluded in study.

Characteristic	Included ($n = 4126$)	Excluded ($n = 5174$)	p-value*
Male	55%	56%	p = 0·46
Age (years) (IQR)	75 (66,83)	75 (65, 83)	p = 0·95
HbA1c (%) (mmol/L)	5·9 (5·5, 6·4)	5·9 (5·5, 6·4)	p = 0·93
Baseline eGFR (mL/min/1·73m^2)[a]	73 (49, 90)	72 (46, 91)	p = 0·60
Haemoglobin(g/L)	122 (106, 122)	120(104,134)	p = 0·31
Charlson score[b]	1 (0,2)	1 (0,2)	p = 0·97

* p-values were determined by Fisher's exact test for categorical variables and Kruskal-Wallis for continuous variables.

[a] eGFR, estimated glomerular filtration rate derived using the Chronic Kidney Disease-Epidemiology Collaboration equation formula.

[b] Charlson comorbidity index - a validated method of weighting chronic medical conditions (the score for diabetes and age were excluded as they were analysed as a separate variable). n = sample size. Data presented as medians with interquartile intervals.

Table 2
Baseline characteristics.*, a

Characteristic (n = 4126)	Diabetes ($n = 1084$)	No diabetes ($n = 3042$)	p-value*
Male (55%, $n = 2259$)	59%	53%	p < 0·001
Age (years) (IQR)	77 (69,84)	78 (68, 86)	p = 0·05
HbA1c (%) (mmol/L)	7·4 (6·8, 8·3)	5·7 (5·5, 6)	p < 0·001
Haemoglobin(g/L)	126 (113, 139)	129 (115,142)	p < 0.001
Systolic Blood Pressure (mmHg)	132 (120, 150)	135 (120,150)	p = 0·07
Interval between admissions (days)	487 (262, 774)	458 (251, 728)	p = 0·07
Charlson score[a]	2 (1,3)	1 (0,2)	p < 0·001

* p-values were determined by Fisher's exact test for categorical variables and Kruskal-Wallis for continuous variables.

[a] Charlson comorbidity index - a validated method of weighting chronic medical conditions (the score for diabetes and age were excluded as they were analysed as a separate variable). n = sample size. Data presented as medians with interquartile intervals.

Table 3
Baseline renal parameters and unadjusted renal outcomes.*, a, b

Characteristic (n = 4126)	Diabetes (n = 1084)	No diabetes (n = 3042)	p-value*
Baseline eGFR[a] (mL/min/1·73m^2)	68 (45, 87)	79 (60, 92)	p < 0·001
Final eGFR (mL/min/1·73m^2)	47 (29, 69)	60 (40, 79)	p < 0·001
Absolute change in eGFR per year (mL/min/1·73m^2)	−16 (−27, −6)	−14 (−26, −4)	p = 0·04
Overall Percentage change in eGFR (%)[b]	−23 (−42, −8)	−19 (−36, −6)	p < 0·001
Final eGFR < 30(mL/min/1·73 m2)	206 (19%‡)	413 (13%)	p < 0·001

* p-values were determined by Fisher's exact test for categorical variables and Kruskal-Wallis for continuous variables.
[a] eGFR, estimated glomerular filtration rate derived using the Chronic Kidney Disease-Epidemiology Collaboration equation formula.
[b] Percentage calculated per category. Data presented as medians with interquartile intervals.

(OR = 1·42; 95%CI: 1·18–1·70; $p < 0·001$) (Fig. 2). Every 1% increase in HbA1c levels was associated with higher odds of developing a >50% percentage decline in eGFR (OR = 1·07; 95% CI:1·01–1·4; $p < 0·05$) (Fig. 2).

Patients with diabetes and a baseline eGFR ≥45 ml/min/1·73m^2 had a higher predicted adjusted probability of having a >50% decline in eGFR overtime compared to those with no diabetes. This was greatest for those with baseline eGFR between 60 and 90 ml/min/1·73m^2 and at a follow-up of 1–2 years (Fig. 3).

3.2. Rapid decline in renal function

After adjusting for systolic blood pressure, Charlson co-morbidity score, baseline eGFR, time between first and last test and haemoglobin and undertaking standard assessment of collinearity, the presence of diabetes was associated with higher odds of rapid decline in renal function (OR = 1·40; 95% CI: 1·20–1·63; $p < 0·001$) (Fig. 2). Moreover, every 1% increase in HbA1c levels was associated with higher odds of rapid decline in renal function (OR = 1·11; 95% CI:1·05–1·18; p < 0·001). While the overall predicted probability of rapid decline in renal function decreased over time in both groups, the greatest difference between patients with diabetes and no diabetes was seen in the 1 to 2-year follow-up period (Fig. 3).

3.3. Final eGFR<30 ml/min/1·73m^2

When adjusted for systolic blood pressure, Charlson co-morbidity score, baseline eGFR, time between first and last test and haemoglobin, the presence of diabetes was associated with higher odds of reaching a final eGFR<30 ml/min/1·73m^2 (OR = 1·25; 95% CI:1·03–1·53; p < 0·05) (Fig. 2). No significant association was seen between HbA1c levels and developing a final eGFR<30 ml/min/1·73m^2 (OR = 1·02, 95% CI: 0·94–1·09; $p = 0·57$) (Fig. 2).

4. Discussion

4.1. Main findings

We investigated the association between glycaemic status and renal functional decline over the medium term in a prospective observational study of 4126 in-patients with multiple hospital admissions. We found that the presence of diabetes was strongly and consistently associated with a greater decline in renal function over time. Moreover, we found that higher HbA1c levels were associated with higher odds of decline in renal function. Finally, we showed that such findings were consistent for several key renal outcomes including a >50% decline in eGFR; the development of a rapid decline in renal function (eGFR decline>5 ml/min per 1·73 m^2 per year) and reaching a final eGFR<30 ml/min per 1·73 m^2 in in-patients with at least two hospital admissions.

4.2. Relationship to previous studies

We used routine HbA1c testing together with a previous diagnosis of diabetes to define glycaemic status. Glycosylated haemoglobin (HbA1c) is the test of choice in the hospital inpatient cohort to detect diabetes[22] as HbA1c measurements are less likely to be affected by short term glycaemic variability. However, HbA1c levels have not been investigated as a co-variable to assess the association of glycaemic status and adverse renal outcomes following an inpatient admission. In advanced CKD the value of HbA1c may be less sensitive to detect associations

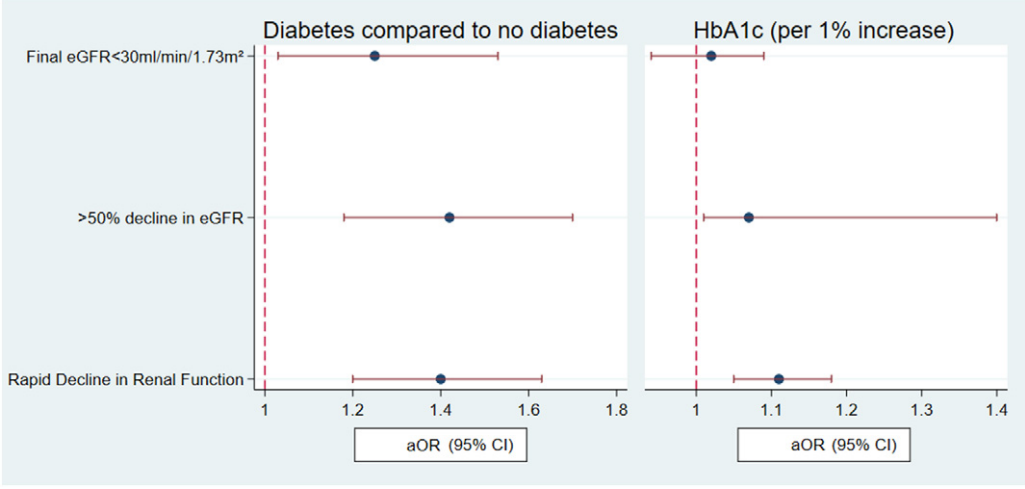

Fig. 2. Association of diabetes and HbA1c with renal outcomes. Results of the logistic regression analyses, adjusted for age (years), gender, Charlson comorbidity index excluding diabetes and age, Chronic Kidney Disease Epidemiology Collaboration equation estimated glomerular filtration rate (mL/min/1.73 m2), systolic blood pressure, haemoglobin, follow-up time (years) are demonstrated. Abbreviations: eGFR = estimated glomerular filtration rate (mL/min/1.73 m2); aOR = odds ratio, applicable to categorical variables; aIRR = incidence rate ratio, applicable to continuous variables.

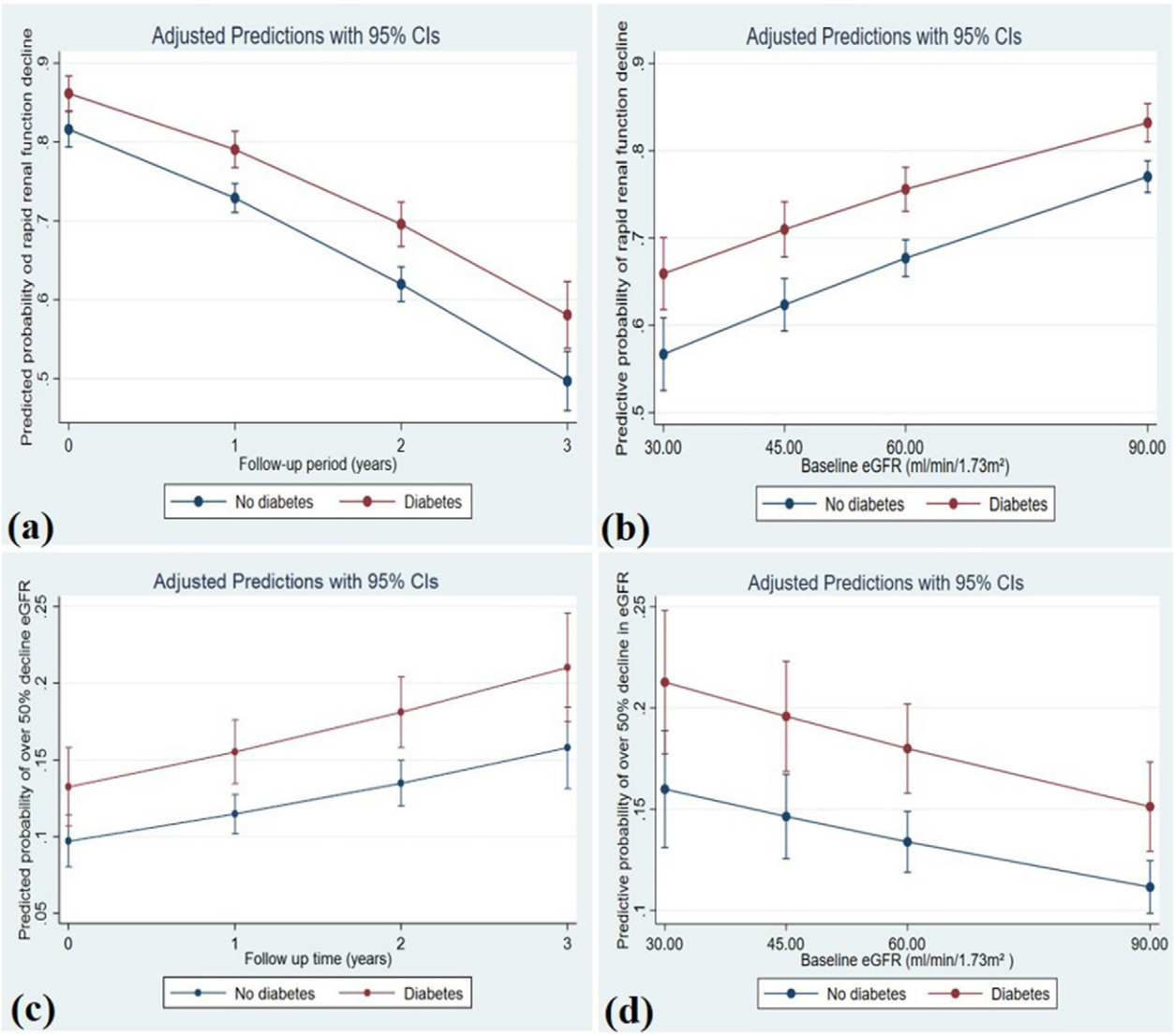

Fig. 3. Adjusted predicted probabilities (with 95% CI) of reaching defined renal outcomes. (a, b) The figure is generated from the results of calculation of margins of adjusted predictive probability (with 95% CI) of rapid renal function decline. (a) Patients with diabetes (red) have 42% higher odds having >50% decline in eGFR over the study period, compared to the group with no diabetes (blue). (b) All patients with diabetes (red) continued to have a higher predicted probability of rapid decline in renal function regardless of their baseline eGFR, but this was highest in patients with baseline eGFR ranging between 45 and 60 ml/min/1·73m^2. (c, d) Adjusted predicted probability (with 95% CI) of developing >50% decline in eGFR. (c) Patients with diabetes (red) have 42% higher odds having >50% decline in eGFR over the study period, compared to the group with no diabetes (blue). (d) Patients with diabetes (red) and a baseline eGFR equal and >45 ml/min/1·73m^2 demonstrated to have a significantly higher predicted probability of having >50% decline in eGFR overtime compared to no diabetes. This was greatest with baseline eGFR between 60 and 90 ml/min/1.73m^2 and at a follow-up of 1–2 years.

with renal outcomes as HbA1c may be limited by impaired glucose metabolism, marked reduction in insulin clearance, use of erythropoiesis stimulating medications and chronic anaemia. Despite this, we were able to demonstrate associations between both the presence of diabetes as well as with HbA1c level as a continuous variable and renal outcome.

4.3. Study implications

Our findings imply that, in a population of general ward patients with multiple hospital admissions, the presence of diabetes and of an elevated HbA1c provide strong identifiers for increased risk of rapid renal functional deterioration over a period of slightly more than a year. Moreover, they imply that in patients with diabetes are a high-risk population which may represent an appropriate target group for trials of specific kidney protective interventions. Finally, in their aggregate, they imply that if such interventions were to be applied they should target all patients with diabetes.

4.4. Strengths and limitations

The strengths of the current study include its prospective nature, a large sample size and use of HbA1c as a continuous variable and renal parameter measurements. Moreover, the access to HbA1c levels eliminated the possible effects of short term increases of blood sugar levels in the acutely ill inpatient population, so called “stress hyperglycaemia”. Furthermore, the independent association of diabetes and HbA1c on developing poor renal outcomes in a large inpatient cohort was investigated by adjusting for key patient related factors including age, gender, baseline renal function, systolic blood pressure, Charlson comorbidity index and haemoglobin. Although, multiple definitions have been proposed to describe rapid decline in renal function, our selection of multiple renal outcomes and the consistent associations between these outcomes and glycaemic status with diagnosis of diabetes as a categorical outcome and HbA1c levels as a continuous outcome lend robustness to our observations.

Limitations of this study are its observational nature and the possible presence of confounders, which were unaccounted for, such as presence of other conditions, which may affect renal function. However, we believe that the Charlson comorbidity index, age, and renal function used were robust markers of each patient's preadmission status and consider it unlikely that additional variables would have materially altered our observations. Furthermore, due to the study population being limited to inpatients aged 54 years and above, our findings may not apply to younger inpatients; however, only small proportion of the hospital inpatient population in Australia are aged <54 years.[23] While glycosylated haemoglobin (HbA1c) is the test of choice to detect diabetes in the hospital inpatient cohort, we acknowledge the potential limitations of HbA1c with its validity being affected by anaemia, haemoglobinopathies and reduction of glycated haemoglobin formation in patients with CKD.[24] We addressed this issue by including haemoglobin as one of the major adjustment covariates in our analysis. We also acknowledge that we did not have access to blood glucose measurements in this cohort but previous studies have demonstrated a linear relationship between HbA1c and capillary glucose readings in the inpatient population[25]. Finally, despite a relatively short follow up period of the current study, we were consistently able to demonstrate adverse outcomes in those with diabetes or by using HbA1c as a continuous variable.

5. Conclusion

In this large prospective cohort study, we evaluated the independent association between baseline glycaemic status defined using HbA1c, with decline in renal function over a little more than a year in patients with multiple admissions to a tertiary referral hospital. We found that the presence of diabetes and higher HbA1c levels were strongly and independently associated with adverse renal outcomes at follow up. Such patients are at high risk of relatively rapid deterioration in renal function and are a logical target for structured preventive interventions.

Declaration of competing interests

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The authors report no conflict of interest.

The data from this research is available to be shared upon request.

References

1. MacIsaac RJ, Jerums G, Ekinci EI. Effects of glycaemic management on diabetic kidney disease. World J Diabetes 2017;8:172-86.
2. Statistics ABo. National health survey: first results. , *http://wwwabsgovau/ausstats/abs@nsf/mf/4364055001* 2014–2015.
3. Ostling S, Wyckoff J, Ciarkowski SL, et al. The relationship between diabetes mellitus and 30-day readmission rates. Clin Diabetes Endocrinol 2017;3:3.
4. Duckworth W, Abraira C, Moritz T, et al. Glucose control and vascular complications in veterans with type 2 diabetes. New England Journal of Medicine 2009;360:129-39.
5. Furnary AP, Gao G, Grunkemeier GL, et al. Continuous insulin infusion reduces mortality in patients with diabetes undergoing coronary artery bypass grafting. J Thorac Cardiovasc Surg 2003;125:1007-21.
6. Pomposelli JJ, Baxter 3rd JK, Babineau TJ, et al. Early postoperative glucose control predicts nosocomial infection rate in diabetic patients. JPEN J Parenter Enteral Nutr 1998;22:77-81.
7. Al-Aly Z, Zeringue A, Fu J, et al. Rate of kidney function decline associates with mortality. J Am Soc Nephrol 2010;21:1961-9.
8. Levey AS, Inker LA, Matsushita K, et al. GFR Decline as an End Point for Clinical Trials in CKD: A Scientific Workshop Sponsored by the National Kidney Foundation and the US Food and Drug Administration. Am J Kidney Dis 2014;64:821-35.
9. Andrassy KM. Comments on 'KDIGO 2012 clinical practice guideline for the evaluation and management of chronic kidney disease. Kidney Int 2013;84:622-3.
10. O'Hare AM, Choi AI, Bertenthal D, et al. Age affects outcomes in chronic kidney disease. J Am Soc Nephrol 2007;18:2758-65.
11. Keith DS, Nichols GA, Gullion CM, Brown JB, Smith DH. Longitudinal follow-up and outcomes among a population with chronic kidney disease in a large managed care organization. Arch Intern Med 2004;164:659-63.
12. Adeera Levin PES, Bilous RW, Coresh J, De Francisco ALM, De Jong PE, Griffith KE, et al. Kidney disease: Improving global outcomes (KDIGO) CKD work group. KDIGO 2012 clinical practice guideline for the evaluation and management of chronic kidney disease. Kidney Int Suppl 2013;3:1-150.
13. Turin TC, Coresh J, Tonelli M, et al. Short-term change in kidney function and risk of end-stage renal disease. Nephrol Dial Transplant 2012;27:3835-43.
14. Egi M, Bellomo R, Stachowski E, et al. The interaction of chronic and acute glycemia with mortality in critically ill patients with diabetes. Crit Care Med 2011;39:105-11.
15. Simpson AJ, Krowka R, Kerrigan JL, et al. Opportunistic pathology-based screening for diabetes. BMJ Open 2013;3.
16. Chawla LS, Bellomo R, Bihorac A, et al. Acute kidney disease and renal recovery: consensus report of the Acute Disease Quality Initiative (ADQI) 16 workgroup. Nat Rev Nephrol 2017;13:241-57.
17. Levey AS, Stevens LA, Schmid CH, et al. A new equation to estimate glomerular filtration rate.[Erratum appears in Ann Intern Med. 2011 Sep 20;155(6):408]. Ann Intern Med 2009;150:604-12.
18. Association AD. Diagnosis and classification of diabetes mellitus. Diabetes Care 2014;37:S81-90.
19. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:373-83.
20. Huang YQ, Gou R, Diao YS, et al. Charlson comorbidity index helps predict the risk of mortality for patients with type 2 diabetic nephropathy. J Zhejiang Univ Sci B 2014;15:58-66.
21. Nanayakkara N, Nguyen H, Churilov L, et al. Inpatient HbA1c testing: a prospective observational study. BMJ Open Diabetes Res 2015;3, e000113.
22. Committee IE. International Expert Committee report on the role of the A1C assay in the diagnosis of diabetes. 2009;7.
23. Australian Institute of Health and Welfare 2017 A. Australia's hospitals 2015–16 at a glance;, https://www.aihw.gov.au/getmedia/d4e53b39-4718-4c81-ba90-b412236961c5/21032.pdf.aspx?inline=true. Accessed Cat. no. HSE 189. Health services series no. 77.
24. Ly J, Marticorena R, Donnelly S. Red blood cell survival in chronic renal failure. Am J Kidney Dis 2004;44:715-9.
25. Moghissi ES, Hirsch IB. Hospital management of diabetes. Endocrinol Metab Clin North Am 2005;34:99-116.