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eMAP:CKD: electronic diagnosis and management assistance to primary care in chronic kidney disease

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ABSTRACT

Background. The increasing burden of chronic kidney disease (CKD) underpins the importance for improved early detection and management programs in primary care to delay disease progression and reduce mortality rates. eMAP:CKD is a pilot program for primary care aimed at addressing the gap between current and best practice care for CKD.

Methods. Customized software programs were developed to integrate with primary care electronic health records (EHRs), allowing real-time prompting for CKD risk factor identification, testing, diagnosis and management according to Kidney Health Australia's (KHA) best practice recommendations. Primary care practices also received support from a visiting CKD nurse and education modules. Patient data were analyzed at baseline (150 910 patients) and at 15 months (175 917 patients) following the implementation of the program across 21 primary care practices.

Results. There was improvement in CKD risk factor recognition (29.40 versus 33.84%; $P < 0.001$) and more complete kidney health tests were performed (3.20 versus 4.30%; $P < 0.001$). There were more CKD diagnoses entered into the EHR (0.48 versus 1.55%; $P < 0.001$) and more patients achieved KHA's recommended management targets ($P < 0.001$).

Conclusion. The eMAP:CKD program has shown an improvement in identification of patients at risk of CKD, appropriate testing and management of these patients, as well as increased documentation of CKD diagnosis entered into the EHRs. We have demonstrated efficacy in overcoming the verified gap between current and best practice in primary care. The success of the pilot program has encouraging implications for use across the primary care community as a whole.

Keywords: chronic kidney disease, e-health, electronic health record, primary care, technology

INTRODUCTION

The incidence and prevalence of chronic kidney disease (CKD) is a growing public health concern [1]. It is reported that 1.7 million (10%) Australian adults have indicators of CKD, with only 103 700 (0.61%) Australians self-reported as having CKD, indicating a poor awareness of CKD [2]. One in three Australian individuals has a risk factor for CKD and 16% of the Australian population have indicators of kidney damage [3]. The incidence of CKD in Australia is higher than that of diabetes (5.1%) [2], with CKD being a stronger predictor of cardiovascular disease (CVD) [4]. The high prevalence of CKD is

concerning given the risk of progressive decline in renal function resulting in end-stage kidney disease (ESKD). The number of treated ESKD patients across Australia has doubled over the past decade [3], an increase also seen in Europe and the USA [1].

A reduction in renal function, as measured by estimated glomerular filtration rate (eGFR), and increased albuminuria have been shown to predict ESKD, CVD and death [5]. Early detection, diagnosis and subsequent management of CKD can delay disease progression and reduce mortality rates [6]. However, early detection is difficult due to the largely asymptomatic nature of the disease.

Twenty-two percent of Australian patients present late to specialist nephrology care [7]. Early referral has been shown to slow the rate of eGFR decline and is associated with better survival [8], with a reduction in the burden of CKD [6]. Working closely with primary care can reduce late referrals [9].

Australian individuals with CKD incur 85% higher health care costs [10]. Screening the entire population for CKD, however, is not cost effective in terms of early detection and management [11]. Instead, current recommendations encourage targeted screening for individuals with CKD risk factors, including hypertension, diabetes mellitus, established CVD, obesity, cigarette smoking, Aboriginal or Torres Strait islander (ATSI) peoples and a family history of stage 5 CKD. Kidney Health Australia–Caring for Australasians with Renal Impairment (KHA-CARI) guidelines recommend a screening approach that includes blood pressure (BP) measurement, a urine test for albuminuria and serum creatinine to determine an eGFR [12].

General practitioners (GPs) play an integral role in the early detection of CKD [13], and 93% of CKD can be detected in primary care [14]. Despite this, CKD is significantly underrecognized and undertreated in the community. The AusHeart study [15] assessed the prevalence of CKD in Australian primary care. Thirty-seven percent of patients with kidney function test data had abnormal kidney function; however, <18% of these patients were correctly identified as having CKD. It is therefore imperative to increase awareness of CKD among GPs.

Computer-based diagnostic and management systems have long been promoted for their potential to improve the quality of health care. The existence of comprehensive primary care databases lend themselves to the development of clinical-decision support systems (CDSSs) [16, 17] interacting with primary care computer systems making recommendations about patient management [18]. While primary care screening for renal impairment in high-risk populations is feasible, an effective system requires computerized databases that code for various risk factors as well as for diagnosis.

The Electronic Diagnosis and Management Assistance to Primary Care in Chronic Kidney Disease (eMAP:CKD) program uses a computerized database with codes from primary health care databases as well as clinical and biochemical parameters to identify patients at risk of CKD and guide appropriate further testing, diagnosis and management. The electronic tools developed for the eMAP:CKD project are the first of their kind and will be integral to implementing best practice guidelines in primary care. This study evaluates the eMAP:CKD project 15 months after implementation, assessing its impact on the identification of CKD risk factors, diagnosis and management, with the ultimate goal of improved CKD care in our community.

MATERIALS AND METHODS

Innovative technology

Electronic tools were developed to interact with existing primary care software. These software tools are compatible with 80% of existing practice electronic health records (EHRs) in Australia and are used to alert primary care in real time to patients at risk of CKD, prompting appropriate testing and enabling pathways for appropriate management according to best practice recommendations contained in the KHA CKD Management in General Practice, 2nd edition [19]. The customized software tools include Primary Care Sidebar, Pen Computer Systems Clinical Audit Tool (CAT) and cdmNET chronic disease management system.

PrimaryCare Sidebar is used to identify patients with risk factors for CKD, enabling point of care prompting for appropriate further testing. The CKD risk factors included in the identification matrix are smoking, obesity, diabetes, hypertension, established CVD and ATSI persons >30 years of age. These were identified using CAT diagnosis codes as well as clinical and biochemical parameters entered into the EHRs. Family history of CKD was not included in the identification matrix as a risk factor for CKD, due to initial PrimaryCare Sidebar coding limitations. When subjects fulfilled the definition of CKD with repeat abnormal results (reduced eGFR or albuminuria) >3 months apart, PrimaryCare Sidebar prompts primary care in real time that a diagnosis of CKD may be indicated.

PenCAT is a tool used for the collection of key CKD data measurements, allowing practice staff to review their practice population health. The optional cdmNET tool is a web-based service that assists health care providers in optimizing treatment for CKD, including creating individualized care plans, monitoring progress, automating follow-up and facilitating collaboration among the care team.

The eMAP:CKD program consists of various other elements provided to participating primary care practices as described in Table 1.

Population and setting

Twenty-two participating practices were recruited from the North West Melbourne Macedon Ranges Medicare Local (NWMMRML). This region was selected due to the high burden of chronic disease in the area. Current patients were defined as those >15 years of age and having attended primary care within the preceding 24 months. Patients who were already receiving renal replacement therapies (either dialysis or transplantation) were excluded from the study.

Ethics approval was obtained from the Western Health Research and Ethics Committee.

Data management and analysis

Using the PenCAT tool, de-identified patient data were extracted from existing EHRs and sent to a repository from

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Table 1. Components of the eMAP:CKD program provided to all participating primary care practices

1	Software packages interacting with EHRs
	– Primary Care Sidebar: identifies patients with risk factors for CKD, prompting for appropriate testing
	– PenCAT: collection of CKD data measurements
	– cdmNet: optimizes management of CKD
2	Nursing outreach program
	– Renal nurse from an acute care hospital providing support and education to primary care practices
3	Program coordinators
	– Program coordinators from Networking Health Victoria and Macedon Ranges and North Western Melbourne Medicare Local
4	Kidney Check Australia Task Force education modules
	– Early detection and management of CKD
	– Management of stage 3 CKD in general practice
	– A sinister combination: CKD and diabetes
5	3 monthly learning workshops
	– Structured nephrologist delivers learning workshops
6	3 monthly individual feedback reports provided to primary care practices
	– Benchmark performance against other practices
	– Quality assurance feedback
7	Practice visits by proxy

which data were analyzed at baseline and again 15 months later. Data quality was evaluated by assessing the recording of patient demographic information and CKD risk factors in EHRs.

Data were analyzed for appropriate CKD testing in patients with identified risk factors. Testing included a complete kidney health check [BP measurement plus both urine albumin:creatinine ratio (ACR) and a serum creatinine to determine an eGFR], as per KHA best practice guidelines. Baseline results were compared with results at 15 months following implementation of the program. The risk factors associated with complete testing for CKD were analyzed using χ^2 analysis in a subgroup analysis.

Further data interrogation included patients who, on appropriate testing, had biochemical parameters suggestive of possible CKD, as well as the entry of CKD as a diagnosis in the EHRs. The severity of kidney disease was identified in those patients with a documented CKD diagnosis according to the KHA-CARI guidelines [12]. These patients were classified as low risk, mild risk, moderate risk or severe risk and were compared at baseline and 15 months.

Management of CKD was assessed in patients with a diagnosis of CKD who received treatment with targets defined by KHA CKD Management in General Practice guidelines [19]. Treatment targets included BP, body mass index (BMI), hemoglobin A1c, low-density lipoprotein (LDL), total cholesterol (TC), smoking cessation, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker (ACEI/ARB) use and statin use.

Statistical analyses were performed using Stata/IC version 13.1 software (StataCorp, College Station, TX, USA). Results were expressed as a percentage of the total population. P-values were calculated using two-sample *Z*-test for comparing proportions, *t*-test for comparing means and χ^2 analysis of categorical data with binary outcomes (yes/no). P-values <0.05 were considered statistically significant.

Table 2. Patient demographics at baseline and at 15 months following program implementation

	Baseline (*n*)	15 months (*n*)	χ^2 test
Total patients	150 910	175 917	
Mean age (SD)	39.66 (±16.64)	40.51 (±16.60)	$P < 0.001$
Male	71 376	82 890	$P < 0.001$
ATSI	780	953	$P = 0.41$
Mean BMI (SD)	27.95 (±6.5)	27.88 (±6.3)	$P = 0.13$

SD, standard deviation.

RESULTS

Patient demographics

Twenty-two primary care practices in the MRNWMML were recruited to participate in the study. There was one practice dropout, allowing for data from 21 primary care practices to be included. The total number of patients included in the baseline analysis was 150 910, with 175 917 patients included in the 15-month data analysis (Table 2). The largest primary care practice had 50 194 and 61 863 patients included in the study at baseline and 15 months later. The smallest practice had 895 and 850 patients included, respectively.

Completeness of data documentation

Following implementation of the eMAP:CKD project, there was a significant improvement in the completeness of risk factor data recorded in the entire population in the EHRs. At baseline, only 42 632 patients (28.25%) had an ATSI status recorded. This increased to 68 784 patients (39.10%) at 15 months ($P < 0.001$). A similar improvement was noted in the documentation of patient smoking status (54.91 versus 59.50%; $P < 0.001$) and BMI (22.90 versus 25.51%; $P < 0.001$) recorded in the EHRs. The recording of BP measurement in the entire population was significantly lower over the 15-month study period (56.32 versus 44.76%; $P < 0.001$).

CKD risk factor documentation

The CKD risk factors identified from the EHRs are illustrated in Figure 1. There was a significant improvement in documentation of obesity, diabetes and CVD 15 months following implementation of the eMAP:CKD program. At baseline, 44 361 patients (29.4%) had at least one risk factor for CKD documented, compared to 59 524 patients (33.84%) 15 months after implementation of the program ($P < 0.001$).

Testing for CKD in at-risk patients

There was a significant improvement in testing for CKD in patients with documented risk factors over the study period (Figure 2). At baseline, 4826 patients (10.88%) with identified CKD risk factors underwent the complete recommended testing (3.20% of total population), compared to 7544 patients (12.67%) 15 months later (4.29% of total population) ($P < 0.001$). There was a significant improvement in testing for urine ACR and BP recording, but not for eGFR measurements.

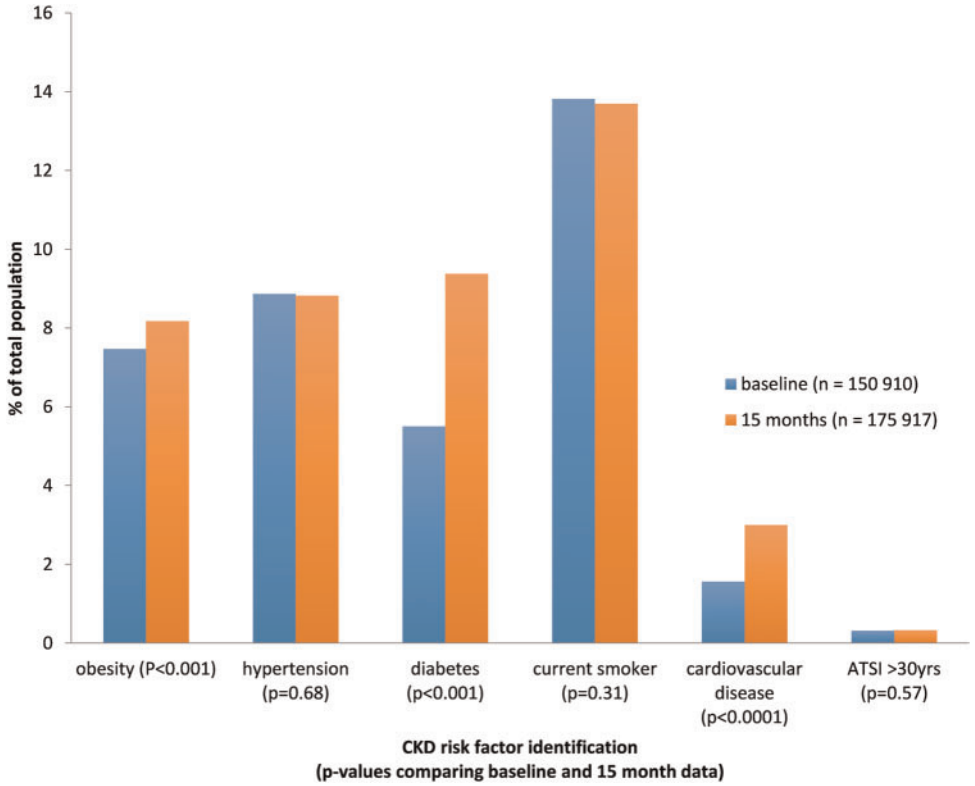

FIGURE 1: CKD risk factor documentation in EHRs at baseline and 15 months following implementation of the eMAP:CKD program.

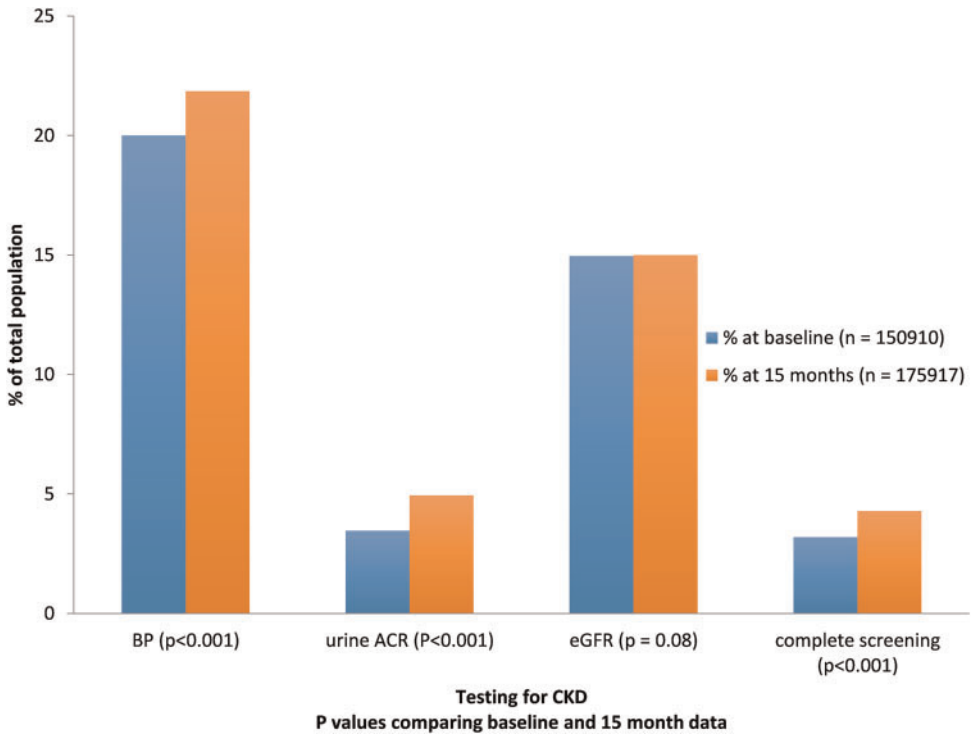

FIGURE 2: Testing for CKD in at-risk patients at baseline and 15 months following implementation of the eMAP:CKD program.

Table 3. Documented risk factors predicting complete screening for CKD

	Baseline (*n*)	15 months (*n*)	χ^2 test
Diabetes	3310	4452	$P < 0.001$
ATSI >30 years old	57	89	$P = 0.08$
VD	801	1115	$P < 0.001$
Obesity	2245	3737	$P < 0.001$
Hypertension	1746	2399	$P < 0.001$
Smoking	752	1304	$P < 0.001$

Risk factors that predict testing for CKD

In a subgroup analysis, complete testing for CKD was improved in patients across all CKD risk factors except the ATSI population over the 15-month study period (Table 3).

Documentation of CKD as a diagnosis in EHRs

There was significant improvement in EHRs documentation of CKD diagnosis in the entire study population, from 726 patients (0.48%) at baseline to 2730 patients (1.55%) at 15 months ($P < 0.001$). There was wide variation among individual practices in the testing and documentation of CKD in patients with risk factors.

There was significant improvement in CKD documentation across patients at low, mild, moderate and severe risk for a composite endpoint of CVD and ESKD following implementation of the eMAP:CKD program (Figure 3). At baseline, 272 patients (64.45%) with documented CKD had low or mild risk, compared to 150 patients (35.55%) at moderate or severe risk. At 15 months, 930 patients (62.46%) with CKD were at low or mild risk, compared to 559 patients (37.54%) with moderate or severe risk ($P = 0.45$).

Patients with biochemical parameters suggestive of CKD irrespective of a documentation of CKD in the EHRs

A total of 4386 and 5093 patients had biochemical parameters suggestive of possible CKD at baseline and 15 months, respectively. Of these patients, the identification of CKD (i.e. documentation as a diagnosis in the EHRs) significantly improved from 342 patients (7.80%) to 1240 patients (24.40%) at 15 months ($P < 0.001$).

Management of patients with documented CKD

There was a significant improvement in the number of patients meeting KHA management targets at 15 months (see Figure 4).

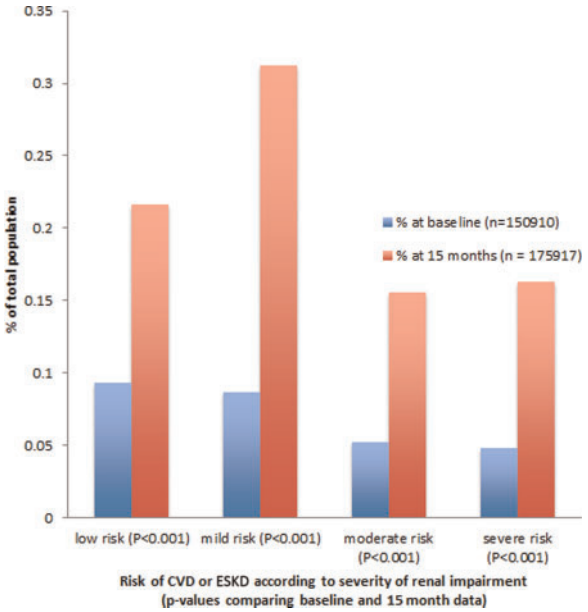

FIGURE 3: The risk for CVD or ESKD in patients with documented diagnosis of CKD in the EHR over the 15-month study period, according to severity of renal impairment determined by combined eGFR and albuminuria.

DISCUSSION

The eMAP:CKD study is the largest cohort in Australia to date defining the characteristics of CKD in a real-life primary care setting. Our study is the first of its kind using primary care EHR codes and clinical and biochemical data to improve quality outcomes in CKD.

When compared with the Australian population demographics as reported by the Australian Bureau of Statistics [2], our study population had a higher rate of obesity (32.00 versus 24.00%), diabetes (5.50 versus 5.10%) and smoking (39.44 versus 16.10%). This likely reflects the low socioeconomic demographics of our study population. Socioeconomic status is a well-recognized risk factor for CKD and disease progression [20]. The study region was specifically chosen due to the high burden of chronic disease in a community comprised largely of non-English-speaking immigrants. The eMAP:CKD project has therefore been trialed and proven in a multicultural patient population. This implies greater relevance to its use in a variety of populations, both nationally and internationally.

At odds with expectations is the much lower documented rates of hypertension (8.86 versus 31.60%) and CVD (1.57 versus 16.7%) compared with rates reported in the 2012 Australian Health Survey [2]. This likely reflects poor data entry in the EHR, especially at project baseline. BP documentation was frequently made in the 'free text' component of the EHR rather than the diagnostic component coding for hypertension. While BP data were poorly recorded in the entire study population, an improvement in BP data entry was seen in patients with documented CKD following implementation of the eMAP:CKD program.

Despite the identified issues with CKD risk factor data entry in the real-life EHRs setting, this study has recorded a similar rate of CKD risk factors to that reported in the AusDiab study [3]. This most likely reflects a higher rate of CKD risk in our catchment, especially as our study patient population was slightly younger (age >15 years) than that reported in the AusDiab study (age >25 years).

The eMAP:CKD program resulted in a significant improvement in at-risk patients who underwent a complete kidney health check, mainly driven by improved urine ACR testing and not eGFR. This likely reflects the routine eGFR reporting as part of a general panel of electrolyte testing rather than specific targeted testing for CKD. Proteinuria/albuminuria is the most

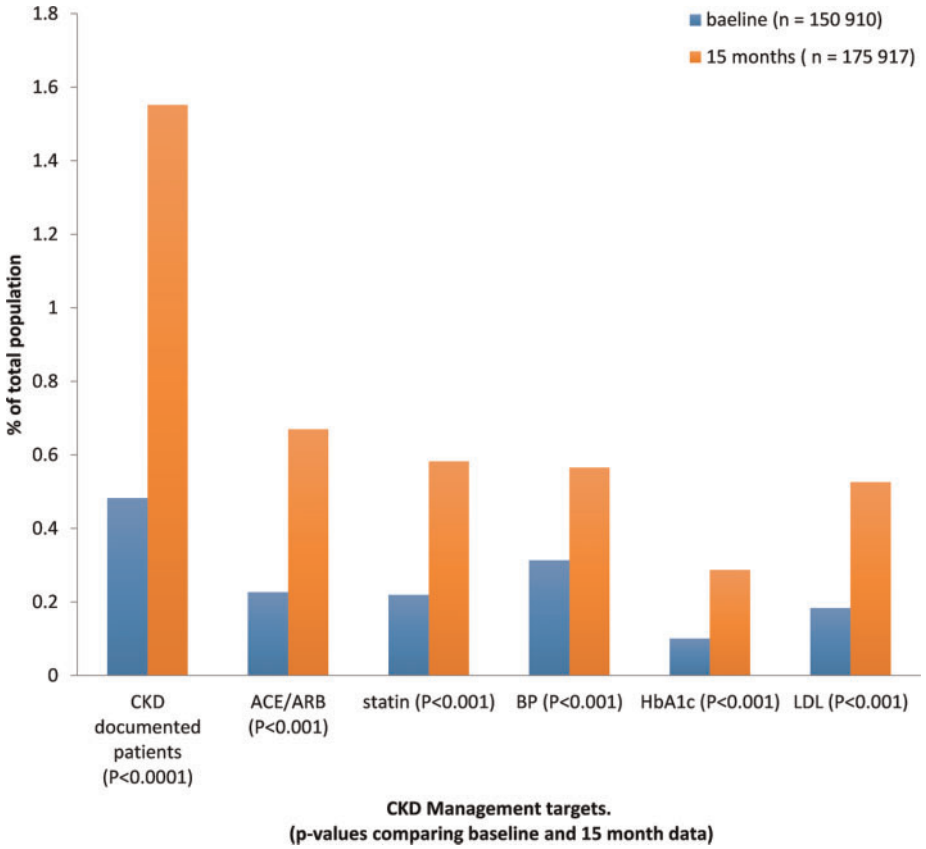

FIGURE 4: Patients with CKD documented in the EHR meeting KHA management targets at baseline and 15 months following implementation of the eMAP:CKD project.

important determinant of likely progression to ESKD with additional prognostic value for increased mortality [21]. It is reassuring that the eMAP:CKD program resulted in a significant improvement in urine ACR testing.

There was significant improvement in CKD documentation in the EHRs from 0.48 to 1.55% following implementation of the eMAP:CKD program. However, this, remains lower than the Australian adults reported to have indicators of kidney damage in the AusDiab study (16%) or seen by the Australian Institute of Health and Welfare (10%). In our study only 7.80% of at-risk patients with biochemical parameters suggestive for CKD had a diagnosis of CKD entered into the primary care EHRs. This improved to 24.40% at 15 months. The improvement in CKD documentation is paramount to the program's success, as a documented diagnosis of CKD is needed for the software to assist primary care the in the management of CKD. We anticipate the documentation and management of patients with CKD to improve even further once the eMAP:CKD program has been implemented for a longer period.

The benefit of a program such as eMAP:CKD may not be confined to kidney disease alone. Fifteen months following implementation of the project, a significant improvement in the documentation of risk factors such as obesity, diabetes and CVD were seen. Given that risk factors for CKD often overlap with those of other chronic diseases, an increase in identification of those at risk of chronic disease as a whole will allow for improved management in a variety of chronic health issues.

Throughout the study, results were expressed as a percentage of the total population. The eMAP:CKD is a real-world study aimed at assessing the impact the project has on the total population over a 15-month study period. Following implementation of the project, there was a vast improvement in the number of patients documented as having risk factors for CKD as well as the number of patients with a CKD diagnosis entered into the EHR. As such, 'total population' is the most constant denominator to test the effect the eMAP:CKD program over the study period.

Limitations

Electronic assistance to primary care using software tools interacting with EHRs is limited by the requirement for patient information to be entered correctly into the EHRs in order for the program to work. This includes both completeness of risk factor documentation as well as completeness of diagnostic codes in the individual diseases. As this program was introduced in a 'real-life' setting, missing data and nonsensical data would be expected. Furthermore, as patients are de-identified prior to the extraction of practice data, the migration of patients between practices cannot be corrected for. The possibility of selection bias exists, as practices voluntarily participated in this program, and as such may be more conscientious about early detection and management of CKD. In addition, not all patients with biochemical parameters suggestive of possible CKD necessarily have CKD, as impairment in eGFR or urine ACR is often seen in acute kidney injury and is merely an indicator of kidney damage. A diagnosis of CKD requires repeat testing, which was

not assessed in our study. The same limitation also exists in data sets like the Australian Health Survey, where indicators of CKD are based on cross-sectional testing. The Sidebar e-health tool used in our study, however, is designed to prompt for repeat testing, and a diagnosis of CKD is only indicated with repeat abnormal tests >3 months apart, ensuring patients aren't incorrectly documented as having CKD.

The formula used to calculate the reported eGFR was changed in pathology labs in Australia in July 2012 (during the study period) from the Modification of Diet in Renal Disease study equation to the more accurate Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation. Large population-based cohort studies [22] concluded that the new CKD-EPI equation results in a lower prevalence of CKD recorded in primary care with no evidence of increased all-cause mortality. This change in the formula used would result in fewer patients with biochemical parameters of CKD at 15 months, possibly biasing our results toward a negative effect.

eMAP:CKD is a quality assurance program comparing results before and after implementation of a program containing multiple elements in addition to the software tools. It was not possible to analyze the contribution of each individual element to the study outcomes. A cluster randomized control trial is therefore warranted.

CONCLUSION

The eMAP:CKD program, introduced in a real-world setting, has shown an improvement in the identification of patients at risk of CKD, the appropriate testing and management of these patients as well as increased documentation of a CKD diagnosis entered into the EHR over a 15-month study period. We have confirmed the suspected gap between 'best care' and current practice in primary care in Australia and have verified that the eMAP:CKD program can help overcome this disparity. The success of the pilot program has encouraging implications for use across the primary care community as a whole, ultimately reducing in the general burden of CKD.

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CONFLICT OF INTEREST STATEMENT

None declared.

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Albuminuria is associated with a higher prevalence of depression in a population-based cohort study: the Maastricht Study

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ABSTRACT

Background. Depression is common in individuals with chronic kidney disease (CKD). However, data on the association of albuminuria, which together with reduced estimated glomerular filtration rate (eGFR) defines CKD, with depression are scarce and conflicting. In addition, it is not clear when in the course from normal kidney function to CKD the association with depression appears.

Methods. We examined the cross-sectional associations of albuminuria and eGFR with depressive symptoms and depressive episodes in 2872 and 3083 40- to 75-year-old individuals, respectively, who completed the baseline survey of an ongoing population-based cohort study conducted in the southern part of The Netherlands between November 2010 and September 2013. Urinary albumin excretion (UAE) was the average UAE in two 24-h urine collections and eGFR was calculated with the Chronic Kidney Disease Epidemiology Collaboration equation based on creatinine and cystatin C. Depressive symptoms were assessed with the 9-item Patient Health Questionnaire (PHQ-9) and the presence of a minor or major depressive episode was assessed with the MINI-International Neuropsychiatric Interview.

Results. In total, 5.4% had a minor or major depressive episode. UAE was <15 mg/24 h in 81.2%, 15–<30 mg/24 h in 10.3% and ≥30 mg/24 h in 8.6%. In a multivariable logistic regression analysis adjusted for potential confounders, and with UAE <15 mg/24 h as reference category, the odds ratio for a minor or major depressive episode was 2.13 [95% confidence interval (CI) 1.36–3.36] for UAE 15–<30 mg/24 h and 1.81 (95% CI 1.10–2.98) for UAE ≥30 mg/24 h. The average eGFR was 88.2