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Impact of the KidneyWise toolkit on chronic kidney disease referral practices in Ontario primary care: a prospective evaluation

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ABSTRACT

Objectives Chronic kidney disease (CKD) is common; therefore, coordination of care between primary care and nephrology is important. Ontario Renal Network's KidneyWise toolkit was developed to provide guidance on the detection and management of people with CKD in primary care (www.kidneywise.ca). The aim of this study was to evaluate the impact of the April 2015 KidneyWise toolkit release on the characteristics of primary care referrals to nephrology.

Design and setting The study was a prospective pre-post design conducted at two nephrology sites (community site: Trillium Health Partners in Mississauga, Ontario, Canada, and academic site: St Joseph's Healthcare in Hamilton, Ontario, Canada). Referrals were compared during the 3-month time period immediately prior to, and during a 3-month period 1 year after, the toolkit release.

Primary and secondary outcome measures The primary outcome was the change in proportion of referrals for CKD that met the KidneyWise criteria. Additional secondary referral and quality of care outcomes were also evaluated. Multivariable logistic regression was used to evaluate preselected variables for their independent association with referrals that met the KidneyWise criteria.

Results The proportion of referrals for CKD among people who met the KidneyWise referral criteria did not significantly change from pre-KidneyWise to post-KidneyWise implementation (44.7% vs 45.8%, respectively, adjusted OR 1.16, 95% CI 0.85 to 1.59, p=0.36). The proportion of referrals for CKD that provided a urine albumin-creatinine ratio significantly increased post-KidneyWise (25.8% vs 43.8%, adjusted OR 1.45, 95% CI 1.06 to 1.97, p=0.02). The significant independent predictors of meeting the KidneyWise referral criteria were academic site, increased age and use of the KidneyWise referral form.

Conclusions We did not observe any change in the proportion of appropriate referrals for CKD at two large nephrology centres 1 year after implementation of the KidneyWise toolkit.

Strengths and limitations of this study

- ► A prospective study conducted in two large nephrology centres.
- ► Prespecified primary and secondary objectives using multiple imputation to account for incomplete data.
- ► Relatively short time period (1 year) in which to observe changes in referral characteristics.
- ► No information available on patients who were not referred.

BACKGROUND

Chronic kidney disease (CKD), defined by the persistence of an estimated glomerular filtration rate (eGFR) of less than 60 mL/min/1.73 m^2 and/or albuminuria (urine albumin-creatinine ratio (ACR) greater than 3.0 mg/mmol), affects 10%–12% of adults in Canada.[1] A number of guidelines make recommendations on the timing of referral of persons with CKD from primary care to nephrology, although it is unclear how familiar primary care providers are with these.[2–6] Late referral may lead to unplanned initiation of renal replacement therapy and other adverse outcomes.[7 8] Conversely, early referral may not be feasible when considering the availability of nephrology services and, furthermore, may be unnecessary and/or may not improve outcomes.[9–12] Regardless of the timing of referrals, enhanced CKD care and improved coordination between primary care and nephrology are important for people with CKD.

The Ontario Renal Network's (ORN) KidneyWise (www.kidneywise.ca; online supplementary appendix)[2 13] toolkit was developed in 2015 in an effort to provide succinct guidance for the detection and management of CKD in the primary care setting, incorporating recommendations from a number of relevant guideline documents.[3 14 15] We implemented knowledge translation strategies to coincide with the release of the toolkit to promote uptake, including development of

a web-based platform and mobile application, presentations at accredited local, provincial and national primary care medical conferences, as well as dissemination from regional nephrology primary care programme to referring primary care providers. Embedded within the toolkit is a standardised referral form which mirrors the nephrology referral criteria outlined in the toolkit.

The objective of this study was to evaluate the impact of the KidneyWise toolkit release on referral characteristics and quality of care at two sites in Ontario, Canada. We hypothesised that dissemination of the toolkit would lead to (1) an increased proportion of referrals which met KidneyWise referral criteria for CKD (low eGFR or proteinuria); and (2) improvement in the quality of CKD-relevant care in people with CKD who had been referred.

METHODS

KidneyWise toolkit

The ORN, a provincial agency, oversees and funds kidney care services in Ontario. There are 27 regional programmes that provide general nephrology, multidisciplinary kidney care clinics and dialysis services to those in need in their respective regions. One of its priorities is to improve quality and coordination of CKD care in primary care which, through the efforts of a small working group of nephrologists and primary care providers, led to the development of the KidneyWise toolkit.[2 13] Embedded within the KidneyWise toolkit are recommended criteria for referral to nephrology, adapted from several existing guidelines, with an emphasis on the Canadian Society of Nephrology (CSN) recommendation.[3 5 6] As a result, an eGFR less than 30 mL/min/1.73 m^2 or urine ACR greater than 60 mg/mmol were two key referral criteria that were common to KidneyWise and the CSN recommendations. Concerns were raised by the working group that some patients may be at higher risk of progression but who would not meet either criteria. Therefore, KidneyWise also recommended referral for those with an eGFR of 30–44 mL/min/1.73m^2 and urine ACR of 30–59 mg/mmol. Finally, with respect to evidence of rapid progression, we noted substantial variation in the guidelines, ranging from a 5[3] to a 15 mL/min/1.73 m^2 decline over 1 year.[6] Balancing out the need for more timely referral for those with evidence of rapid progression, while avoiding an excessive volume of referrals, we recommended referral for those with an eGFR less than 60 mL/min.173m^2 and a decline of at least 5 mL/min/1.73 m^2 over 6 months.

Study design and population

The study was a prospective pre-post design. Nephrology referrals received at two sites (Trillium Health Partners (THP) in Mississauga, Ontario, Canada, and St Joseph's Healthcare Hamilton (SJHH) in Hamilton, Ontario, Canada) were evaluated during two 3-month time periods. The first time period occurred from January to March 2015, immediately prior to the toolkit release. The second period occurred 1 year after the toolkit release (April–June 2016). THP is a community-based centre and is the sole nephrology provider in Mississauga, a city with a population of 713 000. SJHH, an academic centre affiliated with McMaster University, is similarly the sole provider for a city with a population of about 537 000. Both centres have an estimated referral base of about 1 million people. At SJHH, all referrals are triaged centrally at a single location; therefore, all referrals were captured during the conduct of the study. Conversely, at THP, referrals could either go to a central location at the hospital or directly to private nephrologist offices. In this study, only the central location referrals at THP were captured.

Toolkit dissemination

Dissemination of the toolkit incorporated a number of passive and active strategies to promote uptake. At a provincial and national level, one of the authors (AKG) presented KidneyWise at a number of accredited primary care medical conferences; additionally, a paper version of the toolkit was handed out to conference attendees. Physician leaders from each of the regional nephrology programmes in the province were informed in person of the contents of KidneyWise and were encouraged to promote its dissemination in their local regions. A web-based platform and mobile application were also developed and their use encouraged at the same conferences. At both sites, a copy of the toolkit was sent to referring physicians encouraging use of the KidneyWise referral form with future requests. Many of the nephrologists at the two sites also embedded statements within their consultation letters that encouraged use of the KidneyWise toolkit. Finally, KidneyWise was frequently promoted by two authors (KSB and AKG) on Twitter.

Outcomes

Relevant data were extracted from referrals onto paper case report forms. The primary outcome was the change in the proportion of referrals for CKD (low eGFR and/or proteinuria) meeting the KidneyWise criteria before and after the toolkit introduction. Although the KidneyWise toolkit recommends two eGFR and ACR values at least 3 months apart to confirm chronicity, the primary outcome for the purposes of this study was based on a single value. The rationale for this was the observed high background referral rate providing only a single eGFR and/or proteinuria measure. A sensitivity analysis was also performed for the primary outcome using the stricter requirement for two qualifying values.

Prespecified secondary referral outcomes include (1) change in the proportion of appropriate referrals for low eGFR (<30 mL/min/1.73 m^2); (2) change in the proportion of appropriate referrals for proteinuria (urinary ACR>60 mg/mmol); (3) change in the proportion of appropriate referrals for low eGFR or proteinuria which provided at least one urine ACR value (actual, not estimated); (4) change in the proportion of appropriate

referrals for low eGFR or proteinuria which provided at least one urinalysis; and (5) change in the proportion of late referrals (defined here as eGFR<15 mL/min/1.73 m^2 and/or a 2-year kidney failure risk[14] ($KFRE_2$)>10%).

Secondary prespecified quality of care outcomes which aligned with the recommendations in the toolkit were as follows: (1) change in the proportion of persons referred who were on an ACE inhibitor or angiotensin receptor blocker (all referrals and those with an indication (eg, ACR > 3 mg/mmol with diabetes mellitus, ACR > 30 mg/mmol without DM)); and (2) change in the proportion of persons referred who were on a statin (all referrals and those with a primary prevention indication (eg, CKD with DM, CKD without DM and ≥50 years of age)).

Statistical analysis

Assuming that the baseline proportion of referrals that met the KidneyWise criteria was 50% (based on a previous audit conducted at the SJHH site) and that the toolkit would lead to a relative 20% increase in this proportion (ie, to an absolute value of 60%), 519 referrals would be required during each time period to detect a significant difference (alpha 0.05) with 90% power. Assuming that more than 2000 referrals are received at the two sites over a 1-year period (the SJHH site received ~2000 referrals the previous year), a 3-month collection period before and after toolkit introduction was considered sufficient to achieve the required sample size.

Continuous variables were described as means and SD or medians and IQRs and categorical variables expressed as proportions. Where required, urine protein based on dipstick or 24-hour urine protein was converted to approximate urine ACR as previously described.[16 17] Data were assumed to be missing at random for logistic regression analyses; multiple imputation was performed (set of 15) using Markov chain Monte Carlo procedures assuming a multivariate normal distribution. A two-sided p value<0.05 was regarded as significant without adjustment for multiple comparisons. For the primary and secondary outcomes, the pre-post difference in proportion of categorical variables was assessed by calculating the OR and its associated 95% CI using logistic regression, adjusted for referral site. An additional analysis conducted for the primary outcome using mixed effects logistic regression (site as a random intercept) did not materially change the original estimates and are therefore not reported here. The differences between normally and non-normally distributed continuous variables were assessed using the Student's t-test and Wilcoxin rank-sum test, respectively.

Multivariable analysis of predictors of a referral meeting the KidneyWise criteria were carried out using the following preselected variables based on clinical plausibility: age, sex, presence of DM, referral site, time period (pre vs post) and use of the KidneyWise referral form (the latter during the second time period only). All statistical analyses were performed using Stata V.15.1.

Patient and public involvement

Patients were not directly involved in this study.

RESULTS

There were 1043 referrals combined over the two time periods; 69.2% were at the academic site (SJHH) and 40.2% during the first time period (table 1). The mean age of persons referred was 63 years and was significantly higher at the academic site compared with the community site (64±18.2 vs 60±20.2; p=0.001). The proportion with DM was similar at the two sites (43.0% overall) with greater ethnic diversity at the community site. Overall, the severity of CKD in people referred was higher at the academic site with a lower eGFR (low eGFR referrals: median 33.1 vs 40.4 mL/min/1.73 m^2, p<0.001), higher ACR (proteinuria referrals: 59.0 vs 31.7 mg/mmol, p=0.044) and higher $KFRE_5$ (low eGFR referrals: 5.0% vs 1.8%; p<0.001). The differences noted between the two time periods in the demographics of people referred, as well as the referral indication, were driven by the substantial increase in referrals from the community site during the post-KidneyWise time period (see online supplementary table S1). Sixty-three of 624 referrals (10.1%) used the KidneyWise referral form post-KidneyWise, all at the academic site.

Primary outcome

The proportion of referrals for CKD that met the KidneyWise referral criteria between the two time periods did not significantly change from pre-KidneyWise to post-KidneyWise implementation (44.7% vs 45.8%, respectively, adjusted OR 1.16, 95% CI 0.85 to 1.59, p=0.358; table 2). Using the stricter requirement for two eGFR and/or ACR values meeting the referral criteria did not alter the conclusions, although the proportion meeting the criteria was substantially lower during both time periods (21.4% vs 24.5%, respectively, adjusted OR 1.26, 95% CI 0.87 to 1.82, p=0.237).

Secondary outcomes

The proportion of referrals for proteinuria with a urine ACR>60 mg/mmol significantly increased post-KidneyWise implementation (32.6% vs 45.7%, adjusted OR 2.04, 95% CI 1.06 to 4.01, p=0.032, table 2). The proportion of referrals for CKD that provided a urine ACR also significantly increased post-KidneyWise (25.8% vs 43.8%, adjusted OR 1.45, 95% CI 1.06 to 1.97, p=0.0179). An exploratory analysis conducted by forcing use of the KidneyWise referral form into the model suggested that this effect was largely explained by the latter (post-KidneyWise time period: adjusted OR 1.20, 95% CI 0.88 to 1.63, p=0.255; KidneyWise referral form: adjusted OR 4.24, 95% CI 2.13 to 8.44, p<0.001). There were no significant differences in any of the other referral outcomes between the two time periods (table 2).

Table 1 Baseline characteristics of the patients referred

	Academic site	Community site	P value	Pre-KidneyWise	Post-KidneyWise	P value
N (%)	722 (69.2)	321 (30.8)		419 (40.2)	624 (59.8)	
Age, Mean (SD)	64.2±18.1	60.0±20.2	0.001	64.1±17.2	62.0±19.9	0.077
Female, No. (%)	326 (45.2)	145 (45.8)	0.892	197 (47.0)	274 (44.2)	0.375
DM, No. (%)	313 (44.7)	124 (39.2)	0.115	179 (45.2)	258 (41.6)	0.27
Race, No. (%)						
Caucasian	420 (58.1)	145 (45.2)	<0.001	218 (52.0)	347 (55.6)	0.011
Black–African	18 (2.5)	19 (5.9)		8 (1.9)	26 (4.2)	
Asian	13 (1.8)	22 (6.9)		9 (2.2)	26 (4.2)	
Hispanic	6 (0.83)	3 (0.93)		3 (0.72)	6 (0.96)	
Mid-east/Arabian	12 (1.7)	23 (7.2)		5 (1.2)	30 (4.8)	
Indigenous	6 (0.83)	0 (0)		3 (0.72)	3 (0.48)	
Indian subcontinent	19 (2.6)	42 (13.1)		20 (4.8)	41 (6.6)	
Other/Unknown	228 (31.6)	67 (20.9)		153 (36.6)	142 (22.8)	
Reason for referral, No. (%)						
CKD	427 (59.1)	138 (43.0)	<0.001	233 (55.6)	332 (53.2)	<0.001
Proteinuria/DM	129 (17.9)	65 (20.3)		89 (21.2)	105 (16.8)	
Hypertension	32 (4.4)	12 (3.7)		28 (6.7)	16 (2.6)	
Stones	17 (2.4)	35 (10.9)		8 (1.9)	44 (7.1)	
Haematuria	13 (1.8)	21 (6.5)		4 (0.95)	30 (4.8)	
GN/Nephrotic syndrome	13 (1.8)	11 (3.4)		8 (1.9)	20 (3.2)	
AKI	22 (3.1)	11 (3.4)		13 (3.1)	20 (3.2)	
Other	65 (9.0)	28 (8.7)		36 (8.6)	57 (9.1)	
eGFR, mL/min/1.73 m^2, median (IQR)						
All (N=889)	40.2 (29.4–66.4)	53.9 (38.8–85.3)	<0.001	43.8 (30.5–71.5)	44.7 (31.6–74.6)	0.406
Low eGFR (N=510)	33.1 (26.9–41.8)	40.4 (30.5–49.6)	<0.001	33.5 (27.0–43.8)	35.8 (28.3–44.4)	0.307
Urine ACR, mg/mmol, median (IQR)						
All (N=616)	9.2 (1.0–74.0)	3.4 (1.0–17.8)	0.002	9.3 (2.0–61.1)	4.0 (1.0–45.4)	<0.001
Low eGFR or proteinuria (N=481)	11.0 (1.2–81.1)	5.0 (1.7–43.2)	0.072	12.1 (2.5–76.2)	5.7 (1.0–67.7)	0.012
Proteinuria (N=170)	59.0 (15.9–121.4)	31.7 (6.2–89.2)	0.044	30.0 (11.1–89.2)	62.4 (11.4–118.2)	0.318
$KFRE_2$, %, median (IQR)						
All (N=582)	Low eGFR	0.16 (0.0042–0.77)	<0.001	0.56 (0.021–2.4)	0.44 (0.051–1.62)	0.879
Low eGFR (N=213)	(N=213)	0.57 (0.23–1.5)	<0.001	1.4 (0.47–4.3)	1.1 (0.37–3.4)	0.306
$KFRE_5$, %, median (IQR)						

Continued

Table 1 Continued

	Academic site	Community site	P value	Pre-KidneyWise	Post-KidneyWise	P value
All (N=582)	1.8 (0.13–7.7)	0.51 (0.013–2.4)	<0.001	1.05 (0.046–6.3)	1.3 (0.062–5.1)	0.879
Low eGFR (N=213)	5.0 (1.8–14.0)	1.8 (0.72–4.5)	<0.001	4.3 (1.4–12.9)	3.3 (1.2–10.2)	0.306

Missing values: female—4; DM— 27; race—272. Not provided: eGFR—154; urine ACR—427. Not calculable: $KFRE_2$/$KFRE_5$—461.
ACR, albumin-creatinine ratio; AKI, acute kidney injury; CKD, chronic kidney disease; DM, diabetes mellitus; DMN, diabetic nephropathy; eGFR, estimated glomerular filtration rate; GN, glomerulonephritis; $KFRE_2$, 2-year kidney failure risk; $KFRE_5$, 5-year kidney failure risk.

The proportion of people referred who were on an ACE inhibitor or angiotensin receptor blocker and had an indication was 75.3% overall (table 3) and was not significantly different before and after KidneyWise implementation (76.4% vs 74.8%, adjusted OR 0.96, 95% CI 0.52 to 1.73, p=1.000). Similarly, the proportion of those on a statin with an indication did not significantly change from preimplementation to postimplementation (71.0% vs 65.8%, respectively, adjusted OR 0.77, 95% CI 0.54 to 1.10, p=0.158).

The significant independent predictors of received referrals meeting the KidneyWise criteria were academic site, increased age and use of the KidneyWise referral form (table 4). Referrals that used the KidneyWise referral form had a lower eGFR, higher ACR and higher kidney failure risk compared with those that did not use the form (table 5).

DISCUSSION

Implementation of the KidneyWise toolkit was not associated with an increased proportion of referrals that met the KidneyWise referral criteria or improvement in quality of CKD care delivered in primary care. Utilisation of the KidneyWise referral form, a surrogate measure of KidneyWise awareness, appeared to be restricted to the academic site's catchment area.

It is uncertain which criteria, if any, primary care providers considered when determining whether a patient required referral prior to KidneyWise implementation. In the Canadian context, the Canadian Society of Nephrology (CSN) published a commentary on the Kidney Disease International Guideline Organisation (KDIGO) which included referral recommendations.[5] These recommendations were similar to KidneyWise: eGFR less than 30 mL/min/1.73 m^2 or urine ACR greater than 60 mg/mmol, but differed with respect to decline in kidney function (abrupt 20% drop vs 5 mL/min/1.73 m^2 decline over 6 months). While the similarities between the two referral guidelines might suggest that dissemination of KidneyWise would have a limited effect on referral patterns, it should be noted that the proportion of referrals for low eGFR or proteinuria that met these common referral recommendations was low. Furthermore, the authors are unaware of prior local efforts to promote the CSN referral criteria which had been published in a nephrology rather than primary care journal.

A number of studies have examined the characteristics of primary care referrals to nephrology, including the appropriateness of referrals.[18–22] In many of these studies, the introduction of automated eGFR has led to an increased volume of referrals, many deemed perhaps unnecessary. Similar to the present findings, Akbari and colleagues found that at an academic centre in Ottawa, Ontario, only 55% of referrals were considered necessary using similar criteria to those used in KidneyWise (eGFR<30 mL/min/1.73 m^2, ACR>60 mg/mmol, or 20% decline in eGFR over 1 year).[18] Another study found

Table 2 Primary and secondary referral outcomes of patients referred

	No. of patients/Total no. (%)			Adjusted OR*	P value
	Overall	Pre-KidneyWise	Post-KidneyWise		
Primary outcome					
KidneyWise criteria met†	344/759 (45.3)	144/322 (44.7)	200/437 (45.8)	1.16 (0.85–1.59)	0.358
Secondary outcomes					
eGFR<30 mL/min/1.73 m^2‡	177/565 (30.6)	76/233 (32.6)	101/332 (30.4)	1.01 (0.69–1.49)	1.000
ACR>60 mg/mmol§	77/194 (39.7)	29/89 (32.6)	48/105 (45.7)	2.04 (1.06–4.01)	0.0322
eGFR 30–44 mL/min/1.73 m^2 and ACR 30–59 mg/mmol†	7/759 (0.92)	3/322 (0.93)	4/437 (0.92)	1.12 (0.18–7.84)	1.000
eGFR decline ≥5 mL/min/1.73 m^2 in 6 months‡	66/565 (11.7)	27/233 (11.6)	39/332 (11.8)	1.02 (0.58–1.81)	1.000
$KFRE_2$≥10% or eGFR<15 mL/min/1.73 m^2‡	36/759 (4.7)	19/322 (5.9)	17/437 (3.9)	0.54 (0.25–1.11)	0.0991
$KFRE_5$>5%‡	126/302 (41.7)	52/111 (46.9)	74/191 (38.7)	0.86 (0.51–1.44)	0.615
ACR provided†	355/759 (46.8)	132/322 (41.0)	223/437 (51.0)	1.45 (1.06–1.97)	0.0179
Urinalysis provided†	317/759 (41.8)	123/322 (38.2)	194/437 (44.4)	1.22 (0.90–1.68)	0.215
ORN form used	–	–	63/624 (10.1)	–	–

*Models adjusted for referral site. Referent is pre-KidneyWise time period.
†Restricted to referrals for low eGFR and/or proteinuria.
‡Restricted to referrals for low eGFR.
§Restricted to referrals for proteinuria.
ACR, albumin-creatinine ratio; eGFR, estimated glomerular filtration rate; $KFRE_2$, 2-year kidney failure risk; $KFRE_5$, 5-year kidney failure risk; ORN, Ontario Renal Network.

that despite the implementation of an educational intervention prior to eGFR reporting, referral volume increased.[19] Conversely, a targeted educational intervention in nine primary care and five nephrology practices demonstrated an increase in the proportion of patients with an eGFR<,30 mL/min/1.73 m^2 who were referred to nephrology.[23]

Interventions in primary care to influence physician behaviour have had mixed results. A previous systematic review found that the use of structured referral forms and the involvement of consultants in educational activities, both techniques employed here, improved referral appropriateness.[24] More recent trials have found that the use of performance feedback methods, including peer comparison with active choice framing and audit and feedback reporting, as well as accountable justification, increased appropriate prescribing behaviour in primary care.[25–27] The knowledge translation strategies employed here were primarily passive and may have been less effective than more active strategies.[28 29] It should be noted that CKD severity was higher at the academic site and, similarly, utilisation of the KidneyWise referral form was only observed at the academic site. There may be local differences in referral patterns of primary care providers and/or the earnestness and methods with which nephrologists encouraged appropriate referral at the two sites.

Table 3 Quality of care outcomes at the time of referral

	No. of patients/Total no. (%)			Adjusted OR*	P value
	Overall	Preimplementation	Postimplementation		
On an ACEI or ARB (missing: 103)					
Low eGFR or proteinuria referral	438/683 (64.1)	177/267 (66.3)	261/416 (62.7)	0.87 (0.62 to 1.23)	0.473
DM/ACR>3 or no DM/ACR>30	238/316 (75.3)	84/110 (76.4)	154/206 (74.8)	0.96 (0.52 to 1.73)	1.000
On a statin (missing: 103)					
Low eGFR or proteinuria referral	433/688 (62.9)	175/269 (65.1)	258/419 (61.6)	0.86 (0.61 to 1.21)	0.405
DM and/or CKD/age>49	440/649 (67.8)	174/245 (71.0)	266/404 (65.8)	0.77 (0.54 to 1.10)	0.158

*Models adjusted for referral site. Referent is pre-KidneyWise time period.
ACEI, angiotensin converting enzyme inhibitor; ACR, albumin-creatinine ratio; ARB, angiotensin receptor blocker; CKD, chronic kidney disease; DM, diabetes mellitus; no., number.

Table 4 Multivariable predictors of a referral meeting the KidneyWise referral criteria.

	Met KidneyWise referral criteria			
	OR (95% CI)	P value	OR (95% CI)	P value
Time period	1.18 (0.87 to 1.59)	0.292	–	–
Site	0.59 (0.41 to 0.83)	0.002	0.60 (0.44 to 0.82)	0.001
Age	1.23 (1.12 to 1.35)	<0.001	1.32 (1.21 to 1.43)	<0.001
Male sex	1.25 (0.93 to 1.68)	0.142	1.16 (0.88 to 1.52)	0.303
DM	1.05 (0.78 to 1.43)	0.736	1.18 (0.89 to 1.56)	0.253
KidneyWise referral form	–	–	2.09 (1.21 to 3.61)	0.008

*First model inclusive of both time periods. Second model includes only the postimplementation time period.
DM, diabetes mellitus.

We observed that the proportion of referrals for proteinuria meeting the KidneyWise criteria increased postimplementation, as did the proportion of CKD referrals that provided an ACR. The effect size was large and the time interval between the two time periods was relatively short, suggesting that this observation is likely due to dissemination of KidneyWise rather than other secular phenomena. The finding that use of the KidneyWise referral form was a strong predictor of CKD referrals including an ACR supports this hypothesis.

Feedback from referring primary care providers at a number of KidneyWise presentations indicated that incorporation of KidneyWise into their office-based electronic medical record (EMR) systems to facilitate appropriate and timely referrals would be vital to changing their behaviour and improving workflow. To that end, work has been completed to facilitate KidneyWise incorporation into one of the major EMR systems in Canada.[30]

Appropriate utilisation of ACE inhibitors or angiotensin receptor blockers in patients referred to nephrology was already quite high at baseline, similar to what has been previously described in a Canadian jurisdiction.[31] On the other hand, use of statins was more modest, again consistent with previous work.[31 32] While we did not see any change in the use of statins post-KidneyWise, there would appear to be an opportunity to improve statin utilisation in those with increased cardiovascular risk.

This study has limitations that require consideration. Although the total number of referrals exceeded projections for the sample size determination, only 73% of the referrals were for low eGFR and proteinuria. A post hoc analysis indicates that we had 78% power to detect the original estimated effect size, suggesting the study may have been underpowered. However, based on the observed effect size, it seems unlikely that a larger sample size would have changed our conclusions. We do not have information on patients who may have met the KidneyWise referral criteria but were not referred. Only two sites were included in this study; however, they both have large catchment areas and are likely to be representative of other urban centres in Ontario. As already outlined, the strategies employed to promote uptake of KidneyWise may have been ineffective despite evidence that a majority of primary care providers were aware of KidneyWise.[33] Additional time may have been required to realise the full impact of the KidneyWise toolkit on referral patterns. A follow-up 1-month audit (September 2018) at the SJHH site revealed that 68% of referrals for CKD met the KidneyWise criteria, up from 44.6% previously. Additionally, 23% of referrals during this time period used the KidneyWise referral form, implying increased awareness of the toolkit over time. Nevertheless, interventions such as electronic decision support tools that promote desired behaviours may be required to substantially improve referral practices and/or quality of CKD care.[34] Finally, a large increase in referral number was observed at the community site, reflecting local changes in how referrals were directed to the central location, rather than

Table 5 Referral form characteristics and use of ORN referral form

	KidneyWise form used		KidneyWise form not used		
	N (%)	Median (IQR)	N (%)	Median (IQR)	P value
eGFR, mL/min/1.73 m^{2}*	37 (7.3)	30.8 (24.8–37.1)	473 (92.7)	35.2 (27.6–44.6)	0.039
Urine ACR, mg/mmol†	14 (8.2)	93.8 (76.9–153.4)	156 (91.8)	39.5 (10.8–100.2)	0.009
$KFRE_2$, %*	32 (10.6)	2.6 (0.65–7.8)	270 (89.4)	1.1 (0.35–3.4)	0.019
$KFRE_5$, %*	32 (10.6)	7.8 (2.0–22.4)	270 (89.4)	3.4 (1.1–10.3)	0.019

*Restricted to referrals for low eGFR.
†Restricted to referrals for proteinuria.
ACR, albumin-creatinine ratio; eGFR, estimated glomerular filtration rate; $KFRE_2$, 2-year kidney failure risk; $KFRE_5$, 5-year kidney failure risk; ORN, Ontario Renal Network.

necessarily a substantial overall increase in the number of referrals received.

In summary, we did not observe any change in the proportion of referrals for CKD that met the KidneyWise referral criteria at two large nephrology centres in Ontario, Canada, 1 year after implementation of the toolkit. We did, however, observe an increase in referrals for proteinuria that met the KidneyWise criteria, suggesting some impact of KidneyWise dissemination on referral patterns. Future efforts, including incorporation of KidneyWise into EMR systems, will require careful evaluation to determine whether such strategies may prove effective in improving the appropriateness of primary care referrals to nephrology.

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Patient consent for publication Not required.

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