Process quality indicators for chronic kidney disease risk management: a systematic literature review

K.P.J. Smits
G. Sidorenkov
H.J.G. Bilo
M. Bouma
G.J. Navis
P. Denig

Int J Clin Pract 2016; 70(10): 861-869

Abstract

Background: Quality indicators (QIs) can be used for measuring the quality of actions of healthcare providers. This systematic review gives an overview of such QIs measuring processes of care for chronic kidney disease (CKD), and identifies the QIs that have content, face, operational and/or predictive validity.

Methods: Pubmed and Embase were searched using a strategy combining the terms 'quality of care', 'quality indicators' and 'chronic kidney disease'. Papers were included if they focused on developing, testing or applying QIs for assessing the quality of care in adult patients with CKD not on renal replacement therapy.

Results: Two hundred and seventy-three QIs from thirty-one papers were extracted, including QIs on adequate monitoring of kidney function and vascular risk factors, on indicated treatment, drug safety, adherence and referral to a specialist. The QIs that were considered content, face and operational valid focused on monitoring of glomerular filtration rate, albumin-creatinine ratio, lipid levels and blood pressure, the use of non-steroidal anti-inflammatory drugs, nitrofurantoin and bisphosphonates in patients with CKD, and QIs on monitoring haemoglobin and treatment with angiotensin-converting-enzyme inhibitors/angiotensin-II-receptor-blockers in patients with CKD and comorbidities. No QIs were tested for predictive validity. In addition, only two QIs focused on diet and no other QIs focused on lifestyle management.

Conclusions: Based on this review, sufficiently validated QIs can be selected for measuring the quality of CKD care. This review provides insight in QIs that need further validation, and in areas of care where QIs are still lacking.

Introduction

Previous studies showed that the quality of processes of care in patients with chronic kidney disease (CKD) is not optimal with regard to monitoring of risk factors and risk factor management, in particular prescription of drugs.[1-4] Quality indicators (QIs) can be helpful for giving feedback to healthcare providers, and in quality assurance and improvement programs. The use of QIs can lead to better quality of care and, hence, fewer complications and hospitalizations.[5] In order to be relevant, useful and acceptable for the healthcare providers, these indicators should be properly developed. Ideally, QIs should have sufficient content, face, operational and predictive validity.[6,7] Content validity represents whether the QIs are underpinned by evidence, either from clinical guidelines or scientific evidence. Face validity reflects whether a group of experts in the field accepts the QIs as sufficiently valid and accurately measuring quality. Operational validity or feasibility means that the QIs can be measured using the routinely collected data from clinical practice, thus preventing the need of double or extra registration effort and burden.[6,8] Predictive validity means that the QI can be seen as an intermediate parameter, which is predictive of a relevant clinical outcome. Especially when QIs are used for external purposes, such as in a pay-for-performance programme, evidence is needed that the measured care leads to better patient outcomes.

This review focuses on QIs measuring processes of care in patients with CKD. Such process indicators reflect the quality of actions of healthcare providers, such as whether tests are performed or treatment is prescribed as recommended by the guidelines.[9] Several sets of QIs for patients with CKD have previously been developed by individual research groups[10] or by quality improvement organizations, such as the UK Quality Outcomes Framework (QOF)[11] and the US Renal Physicians Association (RPA).[12] To our knowledge, an overview of the developed QIs and their validity is lacking. Such an overview will be useful to support a proper selection of relevant and sufficiently validated QIs and the development of QI sets for CKD care on national and international level.[13] Therefore, the aims of this review are (I) to identify the existing QIs intended for measuring processes of care in patients with CKD, and (II) to identify the QIs that have sufficient content, face, operational and predictive validity.

Methods

Search strategy

We searched Pubmed and Embase for papers using a strategy combining the terms 'quality of care', 'quality indicators' and 'chronic kidney disease' excluding kidney cancer (Appendix 1, Table S2.1). We used both MeSH/Emtree terms as well as free text terms in the title, abstract and keywords and there was no restriction on publication year. A snowballing procedure was used to find papers not covered by our search strategy.

Study Selection

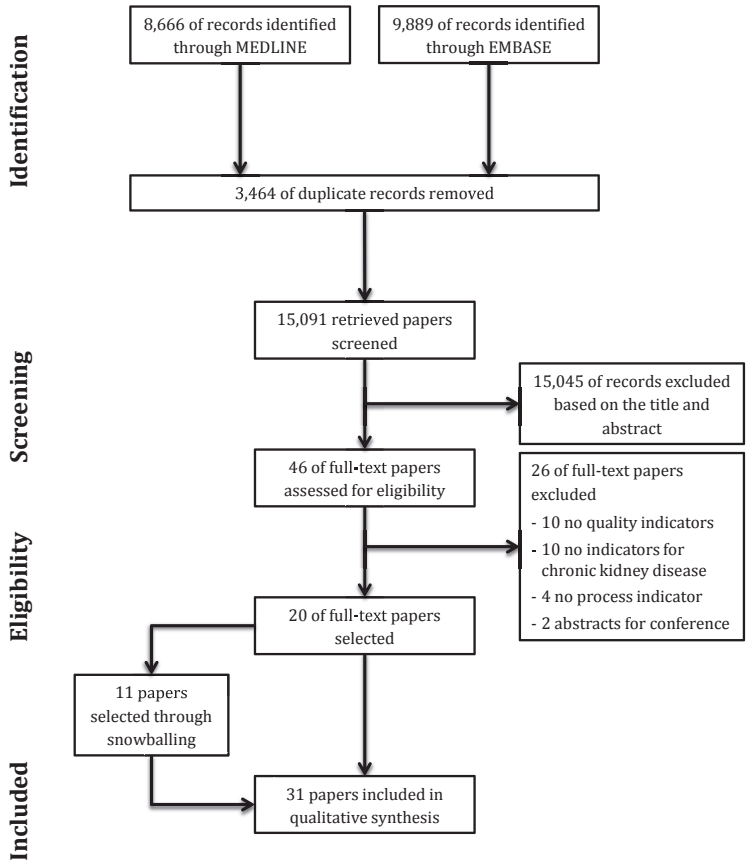
The papers were included when they focused on (I) developing QIs, or (II) testing the validity of QIs, or (III) applying QIs to measure the quality of processes of care in a population of adult patients with CKD not on renal replacement therapy. Two researchers (GS, KS) screened the titles and abstracts of the retrieved papers and selected relevant papers. Next, the full text of the selected papers was read by both researchers to determine whether the papers were eligible for inclusion (Figure 2.1). Disagreement between reviewers was resolved through discussion. The included papers were described in terms of general characteristics, which were aim, design of study, setting and number of QIs. The QIs from the papers were retrieved and classified according to the measured process of care aspects, including monitoring, pharmacotherapy, drug safety, medication adherence and referral. The data were extracted by one author (KS) and checked by two authors (GS, PD) using a structured data collection form. Disagreement was resolved through discussion.

Furthermore, the type of validity assessed was recorded, distinguishing content, face, operational and predictive validity (Table 2.1).

Table 2.1: Types of validity

Type of validity	Explanation
Face validity	Indicators are assessed and accepted by a group of experts or professionals in the field
Content validity	Indicators are based on literature review or evidence-based clinical guidelines
Operational validity	Feasibility of reliable calculation of indicators is demonstrated or defended in the view of available data
Predictive validity	Indicators are associated with clinical patient outcomes

Figure 2.1: Flow diagram of selection process of the included studies



Validity of quality indicators

For content validity, the following classes were defined: (I) unknown when the source of QIs was not adequately described, (II) inadequate when evidence underlying the QI was assessed as insufficient by the authors, (III) adequate when QIs were derived by the authors from evidence-based recommendations, or (IV) adequate when QI were previously derived by others from evidence-based recommendations. For face, operational and predictive validity, the following classes were defined: the QI was (I) not tested, (II) not adequately tested, (III) adequately tested but not valid, (IV) adequately tested and valid, or (V) previously adequately tested and valid. The QIs presented in the papers were considered to be adequately tested for face validity when an expert panel consisting of representatives in the field followed a structured assessment procedure and accepted the QIs as valid. The QIs were considered adequately tested for operational validity when they

were applied or tested in an appropriate patient population using routinely available data from clinical practice. The population was considered appropriate when it was representative of the target population with regard to age and CKD stage. The data source used for testing the operational validity was scored with 'A' for electronic medical records or administrative data, 'B' for medical chart reviews or 'C' for self-reported data, where A implies that the QIs could be calculated using routinely available data. Finally, the QIs were considered adequately tested for predictive validity when an association was tested with a relevant patient outcome in an analysis adjusting for possible confounders.

Results

We searched in Pubmed (n=8,666) and Embase (n=9,889) up to 31 December 2015 and identified a total of 15,091 papers after removing the duplicates. After title and abstract screening and additional snowballing, a total of 51 papers remained for full text analysis. Thirty-one studies were eligible for inclusion in the review.

General characteristics

Of the 31 papers, three papers focused on developing QIs, four papers focused on testing QIs and 24 studies focused on assessing the quality of care using QIs (Table 2.2).

All papers provided information to classify content validity, nine papers provided information to assess face validity, and 28 papers provided information to allow assessment of operational validity. There were no papers on predictive validity (Table 2.2). Fifteen papers were based on studies conducted in the US, nine in Europe, four in Canada and three in Asia. In total, 273 QIs were identified. The median number of QIs per paper was 6 (interquartile range of 2-11). More than half of the papers (n=18) were published in the last 5 years (2011-2015). Twenty-nine papers included QIs that measured appropriate pharmacotherapy, eighteen papers included QIs that measured adequate monitoring of kidney function or risk factors, six papers included QIs on drug safety issues, five papers included QIs on referrals and one paper included QIs on medication adherence (Table 2.2). Furthermore, all but one QI were designed in a cross-sectional manner, meaning that they measure the quality of care at one point in time and do not take into account previous measurements or prescriptions. The longitudinal QI focused on the lack of intensification of antihypertensive therapy.[14]

Table 2.2: Characteristics of included papers, including assessment of quality of content, face, operational and predictive validity of quality indicators in the papers

			Type of indicators					Type of validity				
Study	**Number of indicators**	**Aim**	**Monitoring**	**Treatment**	**Drug safety**	**Adherence**	**Referral**	**Content**	**Face**	**Operational**	**Data source**	**Predictive**
Allen *et al.*, 2011[3]	18	Assess	√	√	√			√	0	√	A	0
Ang *et al.*, 2013[36]	8	Assess		√				√	0	√	A	0
Arora *et al.*, 2015[17]	19	Assess	√	√	√			x	0	√	A	0
Assogba *et al.*, 2012[37]	2	Assess		√				√	0	√	A	0
Bailie *et al.*, 2005[18]	8	Assess		√				x	0	√	B	0
Bellizzi *et al.*, 2010[19]	9	Assess	√	√				x/√	Ø	√	C	0
De Wet *et al.*, 2012[42]	2	Assess	√	√				+	+	√	A	0
Debenito *et al.*, 2014[41]	3	Assess	√	√				+	0	√	A	0
Desrochers *et al.*, 2011[38]	66	Develop		√	√	√	√	√	√/-	√†	B	0
Eilat-Tsanani *et al.*, 2014[20]	5	Assess	√					+/√	0/+	√	A	0
Israni *et al.*, 2003[31]	11	Assess	√	√			√	x	0	√	B	0
Jameson *et al.*, 2014[39]	13	Assess		√	√			x	0	√	A	0
Karunaratne *et al.*, 2013[21]	3	Assess		√				+/x	0/+	√	A	0
Kausz *et al.*, 2001[32]	16	Assess	√	√				x	0	√	B	0
Kuo *et al.*, 2009[35]	11	Assess	√	√				x	0	√	A	0
Litvin *et al.*, 2011[1]	3	Assess		√	√			√	0	√	A	0
Litvin & Ornstein, 201[10]	10	Develop	√	√	√		√	√	√	0	-	0
Mold *et al.*, 2014[22]	8	Assess	√	√			√	+	0	√	B	0
Murray *et al.*, 2005[33]	13	Assess	√	√				x/√	0	√	B	0
Patapas *et al.*, 2012[23]	8	Assess		√				x	0	√	B	0
Philipneri *et al.*, 2008[24]	6	Assess	√	√				√	0	√	A	0
Rucker *et al.*, 2011[25]	5	Test	√	√			√	√	0	√	A	0
Rushforth *et al.*, 2015[43]	1	Develop		√				+	√	0	-	0
Samal *et al.*, 2015[26]	8	Assess	√	√				+	0	√	A	0
Snyder *et al.*, 2009[27]	3	Assess		√				√	0	√	C	0
Thorp *et al.*, 2012[40]	1	Test	√					-	0	√	A	0
Tonelli *et al.*, 2001[30]	5	Assess		√				x	0	√	B	0
Tonelli *et al.*, 2002[14]	2	Assess		√				√	0	√	C	0
Usher-Smith *et al.*, 2007[28]	2	Test	√	√				+/√	+	√	A	0
Van den Heuvel *et al.*, 2008[29]	2	Test	√	√				+	-	0	-	0
Winkelmayer *et al.*, 2005[34]	2	Assess		√				√	0	√	A	0

Content validity: x = source of indicators is unknown/not adequately described, - = evidence underlying QI is lacking, √ = translated from guidelines by authors, + = previously developed based on guidelines. Face/operational/predictive validity: 0 = not tested, Ø = not adequately tested, - = tested but not valid, + = previously tested and validated, √ = tested and valid. Data source shown for: A = electronic medical records or administrative data, B = medical charts review, C = self-reported data. Two signs imply that the paper includes some indicators for which one sign applies and other indicators for which the other sign applies.

† Desrochers *et al*. did tested the operational validity, but also assessed the inter-rater reliability and responsiveness of the developed indicators/criteria. Reliability means that the indicator/criteria yield the same outcome when measured by different evaluators.

Different definitions for CKD were used in the papers. The majority based their definitions on the estimated glomerular filtration rate (eGFR) and stages as defined by KDIGO and KDOQI,[1,3,10,15-29] while others used creatinine clearance rate,[14,30] serum creatinine,[31-33] albuminuria/proteinuria measurements,[34] or International Classification of Diseases-codes.[35] Some studies used combinations of measurements and/or codes.[36-40] Some papers did not specify the definition of CKD but referred to guidelines using the KDOQI staging.[41-43] Most papers defined indicators for CKD stages 3-5 (Appendix 1, Table S2.2).

Validity of quality indicators on monitoring

Most QIs on adequate monitoring focus on markers for mineral and bone disorder (MBD) (24 QIs), kidney function (22 QIs), anaemia (19 QIs) and lipid levels (11 QIs) (Table 2.3).

Combining evidence on the validity of QIs with similar definitions from different studies, resulted in five general QIs on monitoring that were considered to have sufficient content, face and operational validity in at least one study. These QIs measured adequate monitoring of the eGFR,[3,10,26] albumin/creatinine ratio (ACR),[42] lipid levels,[10,24] and blood pressure in patients with CKD,[10,28] and haemoglobin levels in patients with CKD and comorbidities.[20] One QI on monitoring the complete blood count[10] was considered content and face valid but was not adequately tested on operational validity yet. The other QIs on monitoring of serum creatinine, serum albumin, serum phosphorus/phosphate, serum calcium, serum intact parathyroid hormone (iPTH), vitamin D, iron, haematocrit, anaemia, glycated haemoglobin (HbA_{1c}), body composition, diet and plasma homocysteine/C-reactive protein in patients with CKD, and on monitoring proteinuria, lipid levels, HbA_{1c} and blood pressure in patients with CKD and comorbidities were not sufficiently validated (Appendix 1, Table S2.2). Most of them were not tested on face validity, and some also lacked information on content validity. The QI on monitoring haemoglobin in all patients with CKD was assessed as lacking sufficient evidence by the authors[40] and is thus considered not content valid.

Validity of quality indicators on treatment

Most QIs on treatment focus on pharmacotherapy, including angiotensin-converting-enzyme inhibitors (ACE-i)/ angiotensin-II-receptor-blockers (ARBs) (42 QIs), other antihypertensives (18 QIs), lipid lowering drugs (18 QIs) or drugs related to anaemia (15 QIs). Combining evidence on the validity of QIs with similar definitions from different studies, one general QI was considered to have sufficient content, face and operational validity in at least one study. This QI measured treatment with ACE-i/ARBs in patients with CKD and hypertension.[21,28,36,37,42,43]

Table 2.3: Theme and definitions of extracted quality indicators

		Type of validity					
Theme of indicators	**Number of indicators**	**Content**	**Face**	**Operational**	**Data source (A)**	**Predictive**	**Number of studies**
Monitoring							
Kidney function	22	13	4	19	12	0	13
MBD	24	10	0	24	15	0	9
Anaemia	19	7	2	18	11	0	12
Lipid levels	11	6	1	10	5	0	9
HbA_{1c}	7	3	0	7	4	0	7
Blood pressure	4	4	2	2	2	0	4
Body composition	4	4	0	4	0	0	1
Diet	1	1	0	1	0	0	1
Plasma homocysteine/C-reactive protein	1	0	0	1	0	0	1
Treatment							
ACE-i/ARB	42	27	5	39	25	0	27
Other antihypertensives	18	3	2	18	8	0	11
Lipid lowering drugs	18	7	0	16	11	0	12
Anaemia related drugs	15	7	0	11	3	0	9
MBD related drugs	12	7	0	7	2	0	5
Glucose lowering drugs	4	2	0	3	0	0	3
ASA	2	0	0	2	0	0	2
Diet	2	0	0	2	0	0	1
Safety							
NSAIDs	6	5	2	5	3	0	6
Inappropriate drugs	23	23	13	20	8	0	3
Inappropriate dosages	21	21	17	17	0	0	1
Inappropriate combinations	4	4	4	4	0	0	1
Adherence							
Adherence	8	8	8	8	0	0	1
Referral							
Nephrologist	4	3	1	3	1	0	4
Other specialists	1	1	1	1	0	0	1

MBD: mineral and bone disorder; HbA_{1c}: glycated haemoglobin; ACE-i: angiotensin-converting-enzyme inhibitors; ARB: angiotensin-II-receptor-blocker; ASA: acetylsalicylic acid; NSAIDs: non-steroidal anti-inflammatory drugs.

One QI measuring treatment with ACE-i/ARB in patients with CKD, hypertension and proteinuria,[10] and two QIs measuring lack of antihypertensive treatment or too low a dose of antihypertensives[38] were considered content and face valid but were not adequately tested on operational validity. QIs focusing on treatment with ACE-i/ARBs in other patient populations, treatment with other (specific) antihypertensives, and on low protein diet were not adequately validated or assessed as not face valid (Appendix 1, Table S2.2). Furthermore, the other QIs focusing on treatment with lipid lowering drugs, erythropoietin, iron, phosphate binders, vitamin D, glucose lowering drugs, and nutritional supplements in patients with CKD were also assessed as not face valid in one study.[38]

Validity of quality indicators on drug safety

Forty out of the 54 QIs on drug safety were extracted from one paper.[38] Five other papers provided ten similar and four additional QIs on drug safety. Combined evidence on the validity of QIs measuring the use of non-steroidal anti-inflammatory drugs (NSAIDs),[1,3,10,22,38] nitrofurantoin[3,38] and bisphosphonates[3,10,38] were considered content, face and operational valid. Furthermore, several QIs were considered content and face valid but were not sufficiently validated on operational validity. They measured, among others, inappropriate use of glucose lowering drugs (2 QIs), nutritional supplements (2 QIs), anti-epileptic drugs (2 QIs), antivirals (2 QIs), antifungals (2 QIs), antibiotics (4 QIs), antigout drugs (2 QIs), inappropriate dosages for several drugs (5 QIs) and drug interactions (4 QIs). Other indicators, including indicators focusing on dosing of CKD-MDB drugs and haematopoietic drugs were assessed as not face valid in one study[38] (Appendix 1, Table S2.2).

Validity of quality indicators on medication adherence

All eight QIs focusing on medication adherence came from one paper[38] and they were found to be content and face valid (Appendix 1, Table S2.2). These QIs measure adherence to treatment for anaemia, hypertension, calcium-phosphorus metabolism, diabetes and treatment with lipid lowering drugs. The operational validity of these indicators was only tested using chart review.

Validity of quality indicators on referral

Combining evidence on the validity of three QIs with similar definitions from different studies measuring referral to a nephrologist for patients with a lower eGFR[10,22,25] was considered content, face and operational valid (Appendix 1, Table S2.2). A similar QI in a more general CKD population was not sufficiently tested.[31] Finally, one QI measuring referral for smoking cessation[38] was considered content and face valid but the operational validity was only tested using chart review.

Discussion

This systematic review gives an overview of 31 papers that developed, tested and/or applied process QIs for assessing the quality of care in patients with CKD not on renal replacement therapy. These 31 papers included 273 QIs focusing on several aspects of monitoring, pharmacotherapy, drug safety, medication adherence and referral. Only two QIs were encountered for management of protein intake but none on other lifestyle factors, such as dietary sodium restriction. Overall, the QIs that were considered content, face and operational valid focused on monitoring eGFR, ACR, lipid levels, blood pressure in patients with CKD, haemoglobin in patients with CKD and comorbidities, on undertreatment with ACE-i/ARBs in patients with CKD and hypertension, use of NSAIDs, nitrofurantoin and bisphosphonates, and referral to a nephrologist for patients with a poor kidney function. Several QIs were found to be content and face valid, but were not adequately tested on operational validity. These included QIs on monitoring of the complete blood count, treatment with ACE-i/ARBs in patients with CKD, hypertension and proteinuria, lack of antihypertensive treatment, too low a dose of antihypertensives, and a range of QIs on drug safety and medication adherence. The QIs that were found to be not valid focused on monitoring and treating of MBD and (other) anaemia risk factors, and prescribing other treatments, such as lipid lowering and glucose lowering drugs, for patients with CKD. We found no studies assessing the predictive validity of QIs.

The content validity could be assessed in all papers and 166 QIs in 22 papers were considered content valid. On the other hand, for 107 indicators evidence was not provided to support their content validity and, therefore, they cannot be implemented. These included the QIs on prescribing a low or very low protein diet for specific CKD stages. Surprisingly, only two papers adequately tested for face validity using an expert panel, resulting in 55 QIs that were considered face valid.[10,38] A substantial number of QIs on pharmacotherapy was tested and considered as not face valid in one study.[38] For certain areas, such as the drugs related to anaemia and MBD, it may be difficult to translate the recommendations in well-defined indicators, specifying the patients who are in need of such treatment.[44] In most studies (n=28), the QIs were applied to measure the quality of care, thus enabling the assessment of the operational validity. Sixteen studies used electronic medical records or administrative data, showing the feasibility of routine calculation for 108 QIs. On the other hand, in nine studies patient data were reviewed by the researchers in order to measure quality of care, thus reducing the feasibility of routine measurement. Another three studies used self-

reported data, reducing the feasibility but also introducing a possible bias due to the use of potentially subjective information.

This review identifies the QIs covering various areas of CKD care. However, not all relevant areas were covered by the QIs that were content, face and operational valid. The areas that were not well covered included monitoring of MBD risk factors, anaemia risk factors, blood pressure and HbA_{1c} levels, as well as treatment of MBD, anaemia, high HbA_{1c}, and lipid levels. Furthermore, most QIs on safety were content and face valid but their operational validity was not tested for routinely available data. These areas are important for CKD care, because inadequate monitoring and treatment of these risk factors and use of inappropriate drugs might result in an increased risk of complications and disease progression.

We focused on QIs for adult patients with CKD not on renal replacement therapy. In the selected studies, various definitions of CKD were used in the QIs. These criteria were often based on the CKD stages classification according to KDOQI guideline,[16] that is, based on glomerular filtration rate. The CKD stages 1-5 represent the loss of kidney function as described in the KDIGO and KDOQI guidelines.[15,16] Mild loss of kidney function often remains unobserved, and guidelines usually focus on treatment of patients with moderate-to-severe kidney disease (stages 3-5). As a consequence, most QIs have been developed for CKD stages 3-5. There were no QIs specifically for patients with CKD stage 1 and 2. For some indicators the CKD stage was not specified. For example, some indicators used serum creatinine levels,[31-33] or diagnostic codes[35] to identify patients with impaired renal function or CKD. Most of these indicators were not content valid nor tested on face validity. Several indicators focused on patients with elevated albuminuria levels[34,37] or with lowered creatinine clearance.[14,30,38] Such indicators were mostly content valid.

All but one of the QIs covered by this review are cross-sectional, which means they measure quality of care at a single point in time. Such indicators can be easily calculated using administrative databases. We found one longitudinal indicator, which focused on the intensification of antihypertensive treatment.[14] Longitudinal indicators require more detailed information about the timing of measurements and prescriptions (e.g. electronic health records). Such indicators have been previously developed and applied for treatment of type 2 diabetes and cardiovascular risk factors.[45-47] More attention should be given to the development and validation of longitudinal indicators for CKD care, since they have shown to give meaningful information about timeliness of treatment intensification or deintensification in other areas, such as diabetes and hypertension.[48,49]

Two papers in this review included composite measures of CKD care that consisted of multiple indicators focusing on both the process and outcomes of

care.[42,43] Such composite measures can give insight in the overall quality of care. Since our focus was on quality indicators of the process of care, we did not include these composite measures in our review.

Several professional organizations developed QIs for CKD care in the past. For example, the RPA in the US developed 29 process QIs, including indicators for MBD, high blood pressure, anaemia, and dyslipidaemia management. The National Institute for Health and Care Excellence (NICE) in the UK describes fourteen process indicators in their CKD quality standard, including indicators focusing on monitoring, disease progression, cardiovascular risk, and blood pressure.[11] Furthermore, the QOF, a pay-for-performance system in the UK, uses two process QIs for CKD. When comparing our selection with those indicator sets, sixteen QIs from the RPA, five of the QIs from the NICE set, and both QIs from the QOF set were also covered by our review. These QIs focus on measuring kidney function (NICE, QOF), MBD (RPA), anaemia (RPA), lipid levels (RPA) and blood pressure (NICE, RPA), and on treatment with ACE-i/ARBs (QOF, RPA) and other antihypertensives (RPA), treatment related to anaemia (NICE, RPA) and MBD (RPA) and referral to a specialist (NICE). On the other hand, thirteen QIs from the RPA and nine QIs from the NICE were not covered by our review. This was likely due to the fact that many of the indicators focus on patients with advanced CKD and on preparing patients for renal replacement therapy. For example, QIs from the RPA that are not included in our review focus on monitoring iPTH when prescribing a phosphate binder, monitoring blood pressure when receiving erythropoietin, monitoring serum bicarbonate, prescribing elemental calcium for patients with low calcium and normal phosphorous levels, and prescribing low phosphorus diet for patients with high iPTH and/or phosphorous levels. Of note, the RPA indicators were developed fifteen years ago and are based on partly outdated guidelines.

This review has some limitations. First, although the initial search strategy identified a large number of papers, only 31 were included in the review. Therefore, the search strategy lacks specificity. During the development of the search strategy, we tried to increase the specificity of the search by making the search terms more specific. However, this led to missing papers we identified earlier as relevant for inclusion. Moreover, there is no standard for scoring the validity of the indicators. Therefore, we created our own scoring system for assessing the content, face and operational validity of the indicators. We based our choices on definitions provided previously.[6] Second, we summarised the information about the validity of QIs that came from different studies. For this, we combined the evidence on the validity of indicators with similar definitions. What is considered similar, however, is a matter of judgment.

To our knowledge, this is the first overview of QIs for CKD care that measure the actions of healthcare providers. The QIs that are considered content, face and operational valid focus on adequate monitoring of eGFR, lipid levels and blood pressure, on (under)treatment with ACE-i/ARBs, on use of NSAIDs, nitrofurantoin and bisphosphonates. This selection can be helpful for giving feedback to healthcare professionals to learn about their clinical practice. Further development and validation is needed to cover other areas that are relevant for CKD care, such as management of lifestyle factors.

Acknowledgements

This study has been funded by ZonMW—the Netherlands Organisation for Health Research and Development. The funder was not involved in the study design, data collection, data analysis, manuscript preparation or publication decisions.

References

1. Litvin CB, Nietert PJ, Wessell AM, Jenkins RG, Ornstein SM. Recognition and management of CKD in primary care. Am J Kidney Dis 2011; 57(4): 646-7.
2. Stadler SL, Bhardwaja B, Olson KL, Powers JD, Lanese D. An assessment of cholesterol goal attainment in patients with chronic kidney disease. J Clin Lipidol 2010; 4(4): 298-304.
3. Allen AS, Forman JP, Orav EJ, Bates DW, Denker BM, Sequist TD. Primary care management of chronic kidney disease. J Gen Intern Med 2011; 26(4): 386-92.
4. van Zuilen AD, Blankestijn PJ, van Buren M, et al. Quality of care in patients with chronic kidney disease is determined by hospital specific factors. Nephrol Dial Transplant 2010; 25(11): 3647-54.
5. Ivers N, Jamtvedt G, Flottorp S, et al. Audit and feedback: effects on professional practice and healthcare outcomes. Cochrane Database Syst Rev 2012; 6: CD000259.
6. Campbell SM, Braspenning J, Hutchinson A, Marshall M. Research methods used in developing and applying quality indicators in primary care. Qual Saf Health Care 2002; 11(4): 358-64.
7. Chassin MR, Loeb JM, Schmaltz SP, Wachter RM. Accountability measures--using measurement to promote quality improvement. N Engl J Med 2010; 363(7): 683-8.
8. McGlynn EA, Asch SM. Developing a clinical performance measure. Am J Prev Med 1998; 14(3 Suppl): 14-21.
9. Donabedian A. The quality of care. How can it be assessed? JAMA 1988; 260(12): 1743-8.
10. Litvin CB, Ornstein SM. Quality indicators for primary care: an example for chronic kidney disease. J Ambul Care Manage 2014; 37(2): 171-8.
11. National Institute for Health and Clinical Excellence (NICE). Chronic Kidney Disease in adults Quality standard 5; 2014.
12. Bolton WK. Renal physicians association clinical practice guideline: appropriate patient preparation for renal replacement therapy: guideline number 3. J Am Soc Nephrol 2003; 14(5): 1406-10.
13. Stelfox HT, Straus SE. Measuring quality of care: considering conceptual approaches to quality indicator development and evaluation. J Clin Epidemiol 2013; 66(12): 1328-37.
14. Tonelli M, Gill J, Pandeya S, Bohm C, Levin A, Kiberd BA. Barriers to blood pressure control and angiotensin enzyme inhibitor use in Canadian patients with chronic renal insufficiency. Nephrol Dial Transplant 2002; 17(8): 1426-33.
15. Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group. KDIGO 2012 Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease. Kidney Inter, Suppl 2013; 3: 1-150.
16. National Kidney Foundation. K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification. Am J Kidney Dis 2002; 39(2 Suppl 1): S1-266.
17. Arora P, Elkin PL, Eberle J, et al. An observational study of the quality of care for chronic kidney disease: a Buffalo and Albany, New York metropolitan area study. BMC Nephrol 2015; 16: 199.
18. Bailie GR, Eisele G, Liu L, et al. Patterns of medication use in the RRI-CKD study: focus on medications with cardiovascular effects. Nephrol Dial Transplant 2005; 20(6): 1110-5.

19. Bellizzi V, Di Iorio BR, Brunori G, et al. Assessment of nutritional practice in Italian chronic kidney disease clinics: a questionnaire-based survey. J Ren Nutr 2010; 20(2): 82-90.

20. Eilat-Tsanani S, Reitman A, Dayan M, Mualem Y, Shostak A. Management of kidney disease in patients with diabetes in the primary care setting. Prim Care Diabetes 2014; 8(2): 159-63.

21. Karunaratne K, Stevens P, Irving J, et al. The impact of pay for performance on the control of blood pressure in people with chronic kidney disease stage 3-5. Nephrol Dial Transplant 2013; 28(8): 2107-16.

22. Mold JW, Aspy CB, Smith PD, et al. Leveraging practice-based research networks to accelerate implementation and diffusion of chronic kidney disease guidelines in primary care practices: a prospective cohort study. Implement Sci 2014; 9: 169.

23. Patapas JM, Blanchard AC, Iqbal S, Vasilevsky M, Dannenbaum D. Management of aboriginal and nonaboriginal people with chronic kidney disease in Quebec: quality-of-care indicators. Can Fam Physician 2012; 58(2): e107-11.

24. Philipneri MD, Rocca Rey LA, Schnitzler MA, et al. Delivery patterns of recommended chronic kidney disease care in clinical practice: administrative claims-based analysis and systematic literature review. Clin Exp Nephrol 2008; 12(1): 41-52.

25. Rucker D, Hemmelgarn BR, Lin M, et al. Quality of care and mortality are worse in chronic kidney disease patients living in remote areas. Kidney Int 2011; 79(2): 210-7.

26. Samal L, Wright A, Waikar SS, Linder JA. Nephrology co-management versus primary care solo management for early chronic kidney disease: a retrospective cross-sectional analysis. BMC Nephrol 2015; 16: 162.

27. Snyder JJ, Collins AJ. KDOQI hypertension, dyslipidemia, and diabetes care guidelines and current care patterns in the United States CKD population: National Health and Nutrition Examination Survey 1999-2004. Am J Nephrol 2009; 30(1): 44-54.

28. Usher-Smith J, Young A, Chatfield S, Kirby M. Chronic kidney disease in primary care. Br J Cardiol 2007; 14: 221-8.

29. van den Heuvel HG, Simpson RG. Which quality and outcomes framework (QOF) clinical indicators are applicable for British Forces Germany Health Service (BFG HS) primary care? J R Army Med Corps 2008; 154(4): 224-6.

30. Tonelli M, Bohm C, Pandeya S, Gill J, Levin A, Kiberd BA. Cardiac risk factors and the use of cardioprotective medications in patients with chronic renal insufficiency. Am J Kidney Dis 2001; 37(3): 484-9.

31. Israni A, Korzelius C, Townsend R, Mesler D. Management of chronic kidney disease in an academic primary care clinic. Am J Nephrol 2003; 23(1): 47-54.

32. Kausz AT, Khan SS, Abichandani R, et al. Management of patients with chronic renal insufficiency in the Northeastern United States. J Am Soc Nephrol 2001; 12(7): 1501-7.

33. Murray BM, Malireddi K, Vavilala V. Delivery of predialysis care in an academic referral nephrology practice. Ren Fail 2005; 27(5): 571-80.

34. Winkelmayer WC, Fischer MA, Schneeweiss S, Wang PS, Levin R, Avorn J. Underuse of ACE inhibitors and angiotensin II receptor blockers in elderly patients with diabetes. Am J Kidney Dis 2005; 46(6): 1080-7.

35. Kuo HW, Tsai SS, Tiao MM, Liu YC, Yang CY. Management of chronic kidney disease in Taiwan: room for quality improvement. J Nephrol 2009; 22(5): 654-61.

36. Ang GY, Heng BH, Liew AS, Chong PN. Quality of care of patients with chronic kidney disease in national healthcare group polyclinics from 2007 to 2011. Ann Acad Med Singap 2013; 42(12): 632-9.

37. Assogba GF, Couchoud C, Roudier C, et al. Prevalence, screening and treatment of chronic kidney disease in people with type 2 diabetes in France: the ENTRED surveys (2001 and 2007). Diabetes Metab 2012; 38(6): 558-66.

38. Desrochers JF, Lemieux JP, Morin-Belanger C, et al. Development and validation of the PAIR (Pharmacotherapy Assessment in Chronic Renal Disease) criteria to assess medication safety and use issues in patients with CKD. Am J Kidney Dis 2011; 58(4): 527-35.

39. Jameson K, Jick S, Hagberg KW, Ambegaonkar B, Giles A, O'Donoghue D. Prevalence and management of chronic kidney disease in primary care patients in the UK. Int J Clin Pract 2014; 68(9): 1110-21.

40. Thorp ML, Smith DH, Johnson ES, et al. Should measuring haemoglobin among chronic kidney disease patients be a performance measure? J Evid Based Med 2012; 5(4): 194-204.

41. Debenito JM, Billups SJ, Tran TS, Price LC. Impact of a clinical pharmacy anemia management service on adherence to monitoring guidelines, clinical outcomes, and medication utilization. J Manag Care Spec Pharm 2014; 20(7): 715-20.

42. de Wet C, McKay J, Bowie P. Combining QOF data with the care bundle approach may provide a more meaningful measure of quality in general practice. BMC Health Serv Res 2012; 12: 351.

43. Rushforth B, Stokes T, Andrews E, et al. Developing 'high impact' guideline-based quality indicators for UK primary care: a multi-stage consensus process. BMC Fam Pract 2015; 16(1): 156.

44. Smits KP, Sidorenkov G, Bilo HJ, et al. Development and initial validation of prescribing quality indicators for patients with chronic kidney disease. Nephrol Dial Transplant 2016; 31(11): 1876-86.

45. Martirosyan L, Braspenning J, Denig P, et al. Prescribing quality indicators of type 2 diabetes mellitus ambulatory care. Qual Saf Health Care 2008; 17(5): 318-23.

46. Voorham J, Denig P, Wolffenbuttel BH, Haaijer-Ruskamp FM. Cross-sectional versus sequential quality indicators of risk factor management in patients with type 2 diabetes. Med Care 2008; 46(2): 133-41.

47. Kerr EA, Smith DM, Hogan MM, et al. Building a better quality measure: are some patients with 'poor quality' actually getting good care? Med Care 2003; 41(10): 1173-82.

48. Sidorenkov G, Haaijer-Ruskamp FM, de Zeeuw D, Denig P. A longitudinal study examining adherence to guidelines in diabetes care according to different definitions of adequacy and timeliness. PLoS One 2011; 6(9): e24278.

49. Sussman JB, Kerr EA, Saini SD, et al. Rates of Deintensification of Blood Pressure and Glycemic Medication Treatment Based on Levels of Control and Life Expectancy in Older Patients With Diabetes Mellitus. JAMA Intern Med 2015; 175(12): 1942-9.