CHRONIC KIDNEY DISEASE CHANGE PACKAGE 2023

Population Health Strategies for Cardiovascular and Kidney Disease Risk Reduction

CKD intercept

NATIONAL KIDNEY FOUNDATION®

Contents

This is an interactive PDF. All references and URLs shown in magenta are clickable hyperlinks.

Thank you

The National Kidney Foundation thanks the following faculty for their contributions and commitment of time and energy to the Change Package updates:

Susanne Nickolas, MD, MPH, PhD
Tenured Professor of Medicine and Clinical Hypertension Specialist in the Divisions of Nephrology and Endocrinology; Director, Laboratory for Chronic Kidney Disease Pathogenic Mechanisms and Therapeutics; and Chair, UCLA Nephrology Racial and Health Equity Committee
David Geffen School of Medicine at the University of California, Los Angeles

Sri Lekha Tummalapalli, MD, MBA, MAS
Nephrologist and health services researcher
Weill Cornell Medicine

Jenna Norton, PhD, MPH
2023 Program Director: Division of Kidney, Urologic, & Hematologic Diseases
National Institute of Diabetes and Digestive and Kidney Diseases

LaTasha Seliby Perkins, MD
Practicing family physician and assistant professor of family medicine
Georgetown University School of Medicine

Raquel C. Greer, MD, MHS
Program Director for Kidney Health Equity, Division of Kidney, Urologic, & Hematologic Diseases,
National Institute of Diabetes and Digestive and Kidney Diseases

Dinushika Mohottige, MD, MPH
Assistant Professor in Institute of Health Equity Research at the Icahn School of Medicine at Mount Sinai and the Barbara T. Murphy Division of Nephrology
Mt. Sinai

Suelyn Boucree, MD, MBA, FACP, ACHE
Network Medical Director of Quality, Hackensack Meridian Health
Hackensack Meridian Health

Milda Saunders, MD, MPH
Associate Professor of Medicine, General Internal Medicine and MacLean Center of Clinical Medical Ethics Living Donor Advocate Physician
University of Chicago Medicine

Christine Chang, MD, MPH
Acting Director of the Evidence-based Practice Center Division, Center for Evidence and Practice Improvement
Agency for Healthcare Research

Bruce Bagley, MD, FAAFP
Board Chair
Kansas City Health Collaborative

Susan T. Crowley, MD, MBA, FASN
Professor of Medicine (Nephrology); Executive Director, VHA Kidney Medicine Program, Specialty Care Services; Chief, Kidney Medicine
VA Connecticut Healthcare System

Patrick O'Connor, MD, MA, MPH
Primary care physician and chronic disease epidemiologist
HealthPartners Institute

Joanne Haralampopoulos MD
Assistant professor of medicine and practicing primary care hospitalist
Edward Hines Jr Veterans Hospital

Annu Mehta, MD
Department Head, Women's health Clinic
Captain James Lovell Federal Health Care Center

Blake Cameron, MD, MBI
Associate Professor of Medicine-Nephrology
Duke Health

Karen Greathouse, RD, CCTD, Fellow, National Kidney Foundation
Transplant Dietitian
University of Michigan Health System

Ann Bullock, MD
Former Director (retired), Division of Diabetes Treatment and Prevention
Indian Health Service

Joshua J. Neumiller, PharmD, CDCES, FASCP, FADCES
Vice Chair & Allen I. White Distinguished Professor, Pharmacotherapy
Washington State University

Linda Awdishu, PharmD, MAS
Professor of Clinical Pharmacy Division Head, Division of Clinical Pharmacy Skaggs School of Pharmacy and Pharmaceutical Sciences
University of California, San Diego

Mark Loafman, MD, MPH
Chair, Family and Community Medicine
Cook County Hospital Health System

Sandra Serna, MPH
Director, Office of Health Equity
Virginia Department of Health

Introduction

The Chronic Kidney Disease Change Package was developed by the National Kidney Foundation (NKF) to assist primary care programs with a systematic approach for transforming CKD care, advancing health equity, and improving health care quality. At the heart of the Change Package is a dashboard of process improvement activities that can be utilized to address CKD screening, recognition, and management. It is intended to serve as a resource from which ambulatory practices can select approaches to build a CKD quality improvement program based on local practice needs and workflows.

Since the initial release of the Change Package in 2018, milestones in kidney care have occurred that make updates essential:

- Implementation of the 2021 CKD–EPI race–free eGFR equations,
- Implementation of CKD-specific quality measures,
- Implementation of novel, evidence-based therapies for kidney and cardiovascular protection, and
- Interventions to improve equity in CKD care.

2021 CKD–EPI Race-Free eGFR Equations

In response to national recognition that race is a social not a biological construct and the call for removal of race in clinical algorithms, the NKF and the American Society of Nephrology (ASN) established a task force to reassess the use of race in the estimation of GFR–one of the two guideline–concordant tests used to assess kidney health. Recommendations from the Task Force[1] were published September 23, 2021:

1. Immediate implementation of the CKD–EPI 2021 eGFR creatinine equation refit without the race variable in all US laboratories.
2. National efforts to facilitate increased, routine, and timely use of cystatin C, especially to confirm eGFR in adults who are at risk for or have chronic kidney disease.
3. Research on GFR estimation with new endogenous filtration markers and on interventions to eliminate race and ethnic disparities should be encouraged and funded.

Implementation of the 2021 CKD–EPI race-free eGFR equation is a starting point for kidney disease health equity. It also provides an opportunity for clinical laboratories to standardize to a single equation, which is important to clinicians and their patients because both are best served when laboratories report standardized results across all communities regardless of where patients are tested. In addition, standardized testing is essential to research and public health.

A March 2023 laboratory proficiency testing survey found 65.8% of U.S. laboratory respondents have adopted the 2021 CKD-EPI eGFRcr race free equation. However, because the survey was conducted by one of seven CMS approved laboratory accreditation organizations, the adoption rate is likely overstated. The Modification of Diet in Renal Disease (MDRD) and the 2009 CKD–EPI equations were the most common equations utilized by laboratories that had not implemented the equation at the time of the survey.[2]

For several years the NKF Laboratory Engagement Initiative (LEI) has advanced the Kidney Profile which combines guideline-concordant tests recommended for CKD diagnosis into a single, orderable unit–estimated glomerular filtration rate (eGFR) and urine albumin–creatinine ratio (uACR). The Kidney Profile makes it easier for clinicians to order both and helps eliminate the possibility of overlooking one of the recommended tests. However, while population screening with eGFR and uACR has been shown to be cost effective[3], few laboratories have established the Kidney Profile since its introduction in 2018.

The NKF continues national efforts to advance implementation of the CKD–EPI 2021 race-free eGFRcr equation as well as the Kidney Profile.

CKD–Specific Quality Measures

In 2020 the National Committee for Quality Assurance (NCQA) released the Kidney Health Evaluation for Patients with Diabetes (KED) measure for HEDIS measurement year 2022. KED calls for kidney health evaluations in those with diabetes and is defined as an eGFR and a uACR (containing a quantitative urine albumin test and urine creatinine test) with service dates four or less days apart.[4] The first measurement year yielded national averages for KED ranging from 33.5 to 44.2.[4]

The Centers for Medicare and Medicaid Services (CMS) established the NKF's Kidney Health Evaluation Measure (CMS951) in the Medicare Merit-based Incentive Payment System (MIPS) for measure year 2023. It calls for all patients aged 18-75 years with a diagnosis of diabetes at the start of the measurement period to receive kidney health evaluation which is defined by an eGFR *and* uACR during the measurement period.[5] In January 2024, the measure will replace the current eGFR assessment with the 2021 CKD-EPI race free eGFR.

Novel Therapies for Kidney and Cardiovascular Protection

Novel, evidence-based therapies have also become available including sodium-glucose cotransporter-2 (SGLT2) inhibitors, non-steroidal mineralocorticoid receptor agonist (ns-MRA), and glucagon-like peptide 1 (GLP-1) receptor agonists and have demonstrated efficacy in slowing kidney disease progression and preventing cardiovascular events in people with type-2 diabetes.[6] The SGLT2 inhibitor class has demonstrated similar benefits for individuals with CKD and/or heart failure in the absence of type-2 diabetes.[7,8,9,10,11]

Interventions to Improve Equity in CKD Care

In addition to implementation of the 2021 CKD-EPI race-free eGFR, other steps are being taken to advance equity in kidney care. These include facilitating access to and affordability of the novel evidence-based medications as well as access to home dialysis, nephrology care, and interdisciplinary care.

Successful CKD Health Care Transformation

Successful transformation generally encompasses the following six stages of change:

1. Understand CKD and its Management in Primary Care
2. Assess the Quality of CKD Care in Your Institution
3. Secure Organizational Buy-in to Improve CKD Care
4. Convene a Multi-disciplinary Team to Develop the CKD Quality Improvement Strategy
5. Develop the Implementation Plan for Your CKD Intervention
6. Execute and Measure Your Impact

Each of these stages then links to suggested, actionable change ideas that are supported by evidence-based, guideline-driven Tools and Resources. In turn, these tools and resources can be utilized to implement interventions in priority populations.

Abbreviations

AAFP: American Academy of Family Physicians, Leawood, KS

ACC: American College of Cardiology, Washington DC

ACP: American College of Physicians, Philadelphia, PA

ADA: American Diabetes Association, Arlington, VA

AHA: American Heart Association, Dallas, TX

AHRQ: Agency for Healthcare Research and Quality, Rockville, MD

ASCP: American Society for Clinical Pathology, Chicago, IL

CDC: Centers for Disease Control and Prevention, Atlanta, GA

CMS: Centers for Medicare & Medicaid Services, Baltimore, MA

DCRM: Diabetes, cardiorenal, and/or metabolic diseases

HHS: United States Department of Health and Human Services, Washington DC

IHI: Institutes for Healthcare Improvement

Intermountain: Intermountain Health System, Salt Lake City, UT

IPRO: Island Peer Review Organization, Morrisville, NC

KDIGO: Kidney Disease: Improving Global Outcomes

KDOQI: Kidney Disease Outcomes Quality Initiative

MIPS: Merit-based Incentive Payment System

NCQA: National Committee for Quality Assurance, Washington DC

NIDDK: National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD

NIH: National Institutes of Health, Bethesda, MD

NKF: National Kidney Foundation, New York, NY

NSAIDS: nonsteroidal anti-inflammatory drugs

RE-AIM: Reach • Effectiveness • Adoption • Implementation • Maintenance

SDOH: Social Determinants of Health

VA: The U.S. Department of Veterans Affairs

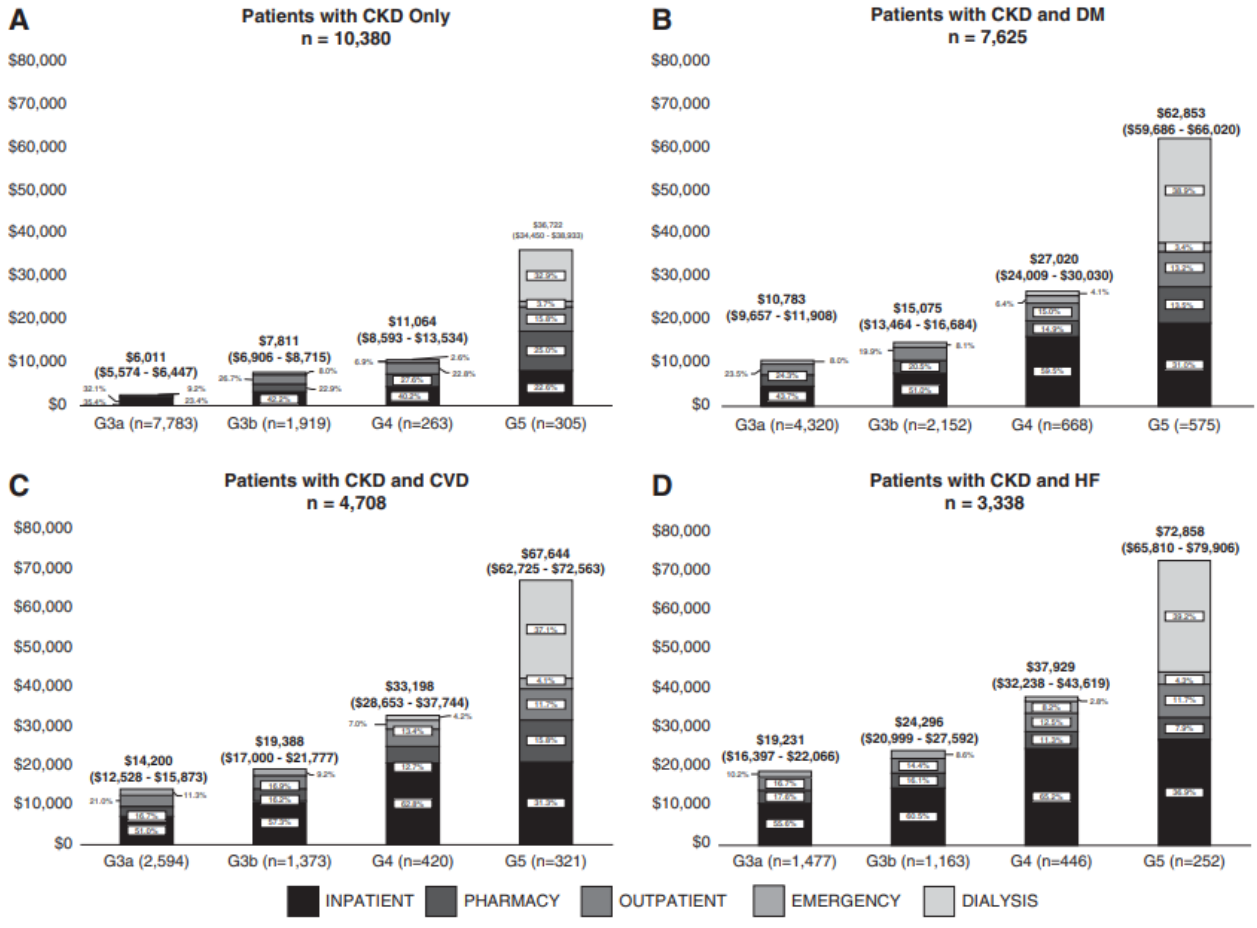
STAGE OF CHANGE 1

Understand Chronic Kidney Disease and its Management in Primary Care.

Prevalence and cost

Chronic Kidney Disease (CKD) remains a largely under-recognized and growing public health issue. Nearly 90% of the estimated 37 million U.S. adults with CKD remain unaware of their condition.[12] Kidney health inequity continues to manifest as a disproportionate prevalence of diabetes, hypertension, and CKD for Blacks/African American people and other races as well as lower access to nephrology care, home dialysis and kidney transplant.[13,14]

Inertia in earlier CKD recognition and management exacerbates CKD as a disease multiplier, often leading to heart failure, coronary artery disease and premature cardiovascular death.[15,16] In fact, nearly 50% of patients with CKD die from cardiovascular disease before reaching end-stage renal disease.[15,16] Earlier identification and intervention provide opportunities to prevent or slow CKD progression, thereby improving outcomes and mitigating health care costs associated with cardiovascular disease and events. For patients with CKD and cardiovascular disease, annualized mean medical costs (inpatient, pharmacy, outpatient, emergency, and dialysis) have been estimated to range from $14,200 in Stage G3a to $67,644 in Stage G5. In patients with CKD and heart failure, annualized mean medical costs increase from $19,231 in Stage G3a to $72,858 in Stage G5.[17]



Nichols GA, Ustyugova A, Anouk DL et al., J Am Soc Nephrol. 2020 Jul;31(7):1594–1601.

CKD Diagnosis and Management

Two guideline concordant tests are used to assess CKD: glomerular filtration rate estimated from serum creatinine concentration (eGFR) utilizing the 2021 CKD-EPI 2021 race-free eGFR algorithm and urine albumin-creatinine ratio (uACR). CKD is defined as the presence of eGFR < 60 ml/min/1.73m^2 and/or markers of kidney damage present for three months or more.[18] The primary marker of kidney damage is the uACR > 30 mg/g. In clinical practice the most common tests for CKD include eGFR and uACR, and those at highest risk for CKD-persons with diabetes and/or hypertension should be tested at least annually.[18, 19]

Management includes reducing the risk for progression and risk of associated complications such as cardiovascular disease, acute kidney injury (AKI), CKD anemia, CKD metabolic acidosis, as well as CKD mineral and bone disorder.

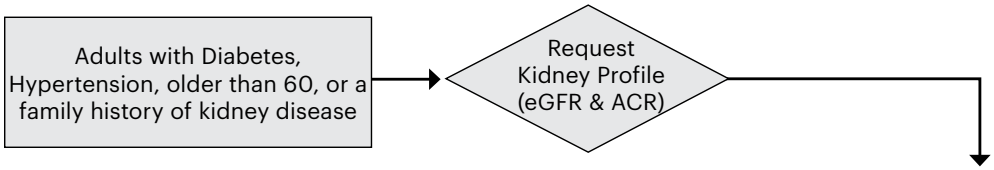
Prevention of CKD progression and cardiovascular risk reduction requires patient-specific considerations including:

- Setting blood pressure goals[20,21,22,23]
- Hemoglobin A1c targets[24,25]
- Use of medications (widely accepted/used ACEs, ARBs and statins as well as novel therapies such as non-steroidal Mineralocorticoid Receptor Antagonists (ns-MRA), Sodium-glucose cotransporter-2 (SGLT2) inhibitors, glucagon-like peptide 1 (GLP-1) receptor agonists). When prescribing medications, the level of estimated glomerular filtration rate should be considered to reduce patient safety hazards, and prolonged use nephrotoxins such as of nonsteroidal anti-inflammatory drugs (NSAIDs) should generally be avoided.[26,27]
- Referral for medical nutrition therapy[28,29]
- Key considerations for referral to nephrology specialists include an eGFR < 30 ml/min/1.73m2, severe albuminuria (uACR > 300mg/g), undetermined CKD etiology and acute kidney injury.[30,31]

> *Underappreciation and attention to the link between poor cardiovascular outcomes and kidney disease is one big issue. Conversations about cardiovascular risk have dominated much of the health care prevention space - particularly pertaining to stroke, ACS, MI - yet the link between these outcomes and kidney disease/factors that increase risks for adverse cardiovascular events including CKD are not discussed enough so CKD can also be considered an urgent priority.*
>
> ***Dinushika Mohottige, MD, MPH***
> *Mt. Sinai*

Risk of Chronic Kidney Disease Progression and Frequency of Assessment

(according to estimated glomerular filtration rate (eGFR) and albumin-creatinine ratio (ACR))



CKD is classified on the basis of:

- Cause (C)
- GFR (G)
- Albuminuria (A)

GFR categories (mL/min/1.73m²) Description and range				Albuminuria categories Description and range		
				A1	A2	A3
				Normal to mildly increased	Moderately increased	Severely increased
				<30 mg/g <3 mg/mmol	30-299 mg/g 3-29 mg/mmol	≥300 mg/g ≥30 mg/mmol
	G1	Normal or high	≥90	**1**	**1**	**2**
	G2	Mildly decreased	60-89	**1**	**1**	**2**
	G3a	Mildly to moderately decreased	45-59	**1**	**2**	**3**
	G3b	Moderately to severely decreased	30-44	**2**	**3**	**3**
	G4	Severely decreased	15-29	**3**	**3**	**4+**
	G5	Kidney failure	<15	**4+**	**4+**	**4+**

The GFR and albuminuria grid depicts the risk of progression, morbidity, and mortality by color, from best to worst (green, yellow, orange, red, deep red).

The numbers in the boxes are a guide to the frequency of assessment annually.

- Green: annual assessment for those at risk. (Green can reflect CKD with normal eGFR and albumin-to-creatinine ratio (ACR) only in the presence of other markers of kidney damage, such as imaging showing polycystic kidney disease or kidney biopsy abnormalities)
- Yellow: suggests assessment at least once per year;
- Orange: suggests assessment twice per year;
- Red: suggests assessment three times annually;
- Deep red: suggests assessment four times each year.

These are general parameters only, based on expert opinion and must take into account underlying comorbid conditions and disease state, as well as the likelihood of impacting a change in management for any individual patient.

Vassalotti JA, Centor R, Turner BJ, Greer RC, Choi M, Sequist TD; National Kidney Foundation Kidney Disease Outcomes Quality Initiative. Practical Approach to Detection and Management of Chronic Kidney Disease for the Primary Care Clinician. Am J Med. 2016 Feb;129(2):153-162.e7.

STAGE OF CHANGE 2

Assess the Quality of CKD Care in Your Institution.

	Change Ideas		Resources and Tools
2.1	Evaluate rates of guideline-concordant CKD testing-estimated glomerular filtration rate (eGFR) and urine albumin-to-creatinine ratio (uACR)–among patients with hypertension and/or diabetes.	2.1.a	NKF Chronic Kidney Disease Data Analysis Strategy—a concise overview of unrecognized CKD plus data mining parameters via CKD*intercept*™ Practice Assessment[80]
2.2	Evaluate rates of CKD diagnosis using available electronic health record (EHR) laboratory data to identify individuals with existing evidence of CKD but no CKD ICD10 code in their records.	2.2.a	NKF CKD*intercept*™ Practice Assessment[81]
		2.2.b	Sonic Healthcare USA/Chronic Kidney Disease Population Health[82]
		2.2.c	LabCorp Diagnostic Assistant[83]
2.3	Request *Kidney Health Evaluation for Patients with Diabetes* HEDIS Measure data for the organization from local payers.	2.3.a	NCQA Kidney Health Evaluation for Patients with Diabetes HEDIS Measure[84]
2.4	Utilize Hierarchical Condition Categories (HCC) coding to evaluate the economic impact of improving CKD coding accuracy on risk adjustment in value-based contracts.	2.4.a	AAFP Hierarchical Condition Category Coding[85]
		2.4.b	NKF SCM23 Abstract: A Retrospective Multisite Examination of Chronic Kidney Disease Using Longitudinal Laboratory Results and Metadata to Inform Value Based Care[86]
2.5	Utilize Area Deprivation Index and American Community Survey data to map ZIP codes in your community that may be disproportionately impacted by health disparities in rates of CKD, diabetes, and/or hypertension.	2.5.a	CDC Integrating Social Determinants of Health with Treatment and Prevention: A New Tool to Assess Local Area Deprivation[87]
		2.5.b	U.S. Census Bureau® American Community Survey Data[88]
		2.5.c	AHRQ Social Determinants of Health Database[89]
		2.5.d	CMS Data Mapping Medicare Disparities by Hospital[90]

STAGE OF CHANGE 3

Secure Organizational Buy-in to Improve CKD Care.

	Change Ideas
3.1	Compare institutional data gathered in Stage of Change 2 to national benchmarks where possible.

> *Culture is ultimately what drives continuous improvement. Quality improvement frameworks matter. Understanding the problem matters. Analyzing data matters. These things are all essential. But culture is foundational. Leaders at all levels, whether clinic medical directors or system CMOs, must invest in improvement, believe in improvement, and "rally the troops" around a vision of improvement. This needn't be rocket science...it starts with humility and an attitude that "we can and should do better." The specific tools and methods follow from that.*
>
> ***Blake Cameron, MD, MBI***
> *Duke Health*

	Resources and Tools
3.1.a	HHS Healthy People 2030 Increase the proportion of adults with diabetes who get a yearly urinary albumin test (uACR)[91] Baseline: 48.4% (Medicare beneficiaries with diabetes mellitus had uACR in 2016) Target: 66.4%
3.1.b	HHS Healthy People 2030 Increase the proportion of people on Medicare with chronic kidney disease who get recommended tests[92] Baseline: 36.6% Target: 49.5%
3.1.c	HHS Healthy People 2030 Increase the proportion of adults with chronic kidney disease who know they have it [93] Baseline: 7.3% (adults ≥ 18 years with CKD knew they had reduced kidney function 2013-16) Target: 10.1%
3.1.d	Chronic Kidney Disease Testing Among At-Risk Adults in the U.S. Remains Low: Real-World Evidence from a National Laboratory Database[12] [94]
3.1.e	CKD Quality Improvement Intervention with PCMH Integration: Health Plan Results.[31] [95]
3.1.f	Chronic Kidney Disease Disparities: Educational Guide for Primary Care. Prepared for the Centers for Medicare & Medicaid Services (CMS) by the National Committee for Quality Assurance (NCQA)[32] [96]
3.1.g	Trends in Quality of Care for Patients with CKD in the United States[33] [97]
3.1.h	Social Determinants of Racial Disparities in CKD[34] [98]
3.1.i	Social Determinants of CKD Hotspots[35] [99]
3.1.j	Social Justice as a Tool to Eliminate Inequities in Kidney Disease[36] [100]
3.1.k	Socioeconomic factors and racial disparities in kidney disease outcomes[37] [101]
3.1.l	HHS Health Equity in Healthy People 2030 An overview of the program's focus including overarching goals, health literacy, social determinants of health and tools for action[102]

STAGE OF CHANGE 3			
	Change Ideas		**Resources and Tools**
3.2	Build a business case for deploying CKD improvement activities. Consider including the organization's *Kidney Health Evaluation for Patients with Diabetes* HEDIS Measure data from local payers and HCC coding evaluation on the economic impact of CKD diagnosis breakdowns on risk adjustment in value-based contracts.	3.2.a	See below for suggested CKD primary care team members

Consider all possible leverage points to Leadership Buy-In

3.3	Consider engaging support for your program from primary care, nephrology, quality, population health, pathology, and other teams supporting primary care.	3.3.a	Intermountain The Benefit of Interdisciplinary Teams in Healthcare[103]
		3.3.b	Transforming Care Teams to Provide the Best Possible Patient-Centered, Collaborative Care[38] [104]

STAGE OF CHANGE 4

Convene a Multi-disciplinary Leadership Team to Develop the CKD Quality Improvement Strategy.

	Change Ideas		Resources and Tools
4.1	Take a broad approach to defining the planning team. Consider including representatives from primary care, nephrology, informatics, population health, quality, pharmacy, health equity, nursing, pathology, diabetes care and education specialists, community outreach, dietitians, etc. on this team.		
4.1.1	Primary care	4.1.1.a	Chronic Kidney Disease in Primary Care: An Opportunity for Generalists[39] [105]
4.1.2	Pharmacy	4.1.2.a	Optimizing use of SGLT2 inhibitors and other evidence-based therapies to improve outcomes in patients with type 2 diabetes and chronic kidney disease: an opportunity for pharmacists[40] [106]
		4.1.2.b	CDC Public Health and Pharmacy: Collaborative Approaches to Improve Population Health—a downloadable PDF[41] [107]
		4.1.2.c	Community-Based Pharmacy Solutions for All—Resources to join payers, pharmacies and communities to enhance health services locally[108]
4.1.3	Pathology	4.1.a	NKF Laboratory Engagement Initiative[109]
4.1.4	Informatics	4.1.4.a	Development and Validation of a Pragmatic Electronic Phenotype for CKD[42] [110]
		4.1.4.b	Medical records-based chronic kidney disease phenotype for clinical care and "big data" observational and genetic studies[43] [111]
		4.1.4.c	PheKB a knowledgebase for discovering phenotypes from electronic medical records: Chronic Kidney Disease[112]
4.1.5	Community Outreach/Community Health Workers	4.1.5	NKF Community Health Workers an NKF resource that advances Community Health Workers and their role in connecting patients to health care services via identification, prevention, and risk management associated with CKD[113]
4.2	Review organizational population health data to identify specific opportunities for improvement in care. Approaches might include evaluation of:	4.2	Practical Approach to Detection and Management of Chronic Kidney Disease for the Primary Care Clinician[19] [114] NKF Chronic Kidney Disease Data Analysis Strategy—a concise overview of unrecognized CKD plus data mining parameters via CKD*intercept*™ Practice Assessment[115]

> *The pharmacotherapy clinic leader said we're (clinical pharmacists) the best kept secret in the institution. We're here to address many of the barriers facing primary care physicians to initiate guideline directed therapies in CKD, including working through prior authorizations that take time and burdens on the primary care clinic.*
>
> ***Joshua J. Neumiller, PharmD, CDCES, FASCP, FADCES***
> *Washington State University*

STAGE OF CHANGE 4	
Change Ideas	**Resources and Tools**

Screening and Diagnosis:

- EHR and/or claims data to determine rates of guideline-concordant CKD testing (eGFR and uACR) among patients with hypertension and/or diabetes
- Available EHR laboratory data to assess rates of CKD diagnosis among patients with hypertension and/or diabetes and existing laboratory evidence of CKD
- Available EHR laboratory data to determine rates of CKD testing (eGFR and uACR) among patients with a CKD ICD10 code in their medical record

A1C and/or Blood Pressure Goal Attainment:

- Percentage of patients with CKD and diabetes with A1C within recommended range
- Percentage of patients with CKD whose blood pressure is within recommended range

Preventing CKD Progression and/or Reduce Cardiovascular Risk:

- Percentage of patients with CKD and Type 2 Diabetes prescribed GLP-1 RAs
- Percentage of patients with diabetes and/or hypertension on problem list/encounter with a uACR ≥ 30 who were prescribed an ACE inhibitor or ARB medication
- Percentage of patients with Type 2 Diabetes and CKD on problem list/encounter with an eGFR ≥ 20 who were prescribed an SGLT2i medication
- Percentage of patients with Type 2 Diabetes and CKD on problem list/encounters with an eGFR ≥ 25 and uACR ≥ 30 who were prescribed a non-steroidal MRA medication
- Annual CKD testing (eGFR and uACR) and risk stratification in at-risk populations—those with diabetes and/or hypertension and/or other risk factors
- Percentage of individuals aged 18 years and older with a diagnosis of CKD who were prescribed select SGLT2i therapy within a 12-month period
- Percentage of individuals with heart failure, Type 2 diabetes/atherosclerotic cardiovascular disease and CKD prescribed select SGLT2i therapy within a 12-month period

STAGE OF CHANGE 4			
	Change Ideas		**Resources and Tools**
4.3	Build consensus on evidence-based, guideline-driven interventions/quality metrics that are to be evaluated by the multi-disciplinary leadership team that are appropriate for clinic locations, patient panels, and workflows.		How to specify healthcare process improvements collaboratively using rapid, remote consensus-building: a framework and a case study of its application[44] [116] AHA Leveraging Implementation Science for Cardiovascular Health Equity: A Scientific Statement from the American Heart Association[45] [117]
4.3.1	• Identify evidence-based recommendations and guidelines that support CKD recognition and implementation of interdisciplinary patient care for CKD	4.3.1.a	ADA 11. Chronic Kidney Disease and Risk Management: Standards of Care in Diabetes—2023[46] [118]
		4.3.1.b	KDIGO 2022 Clinical Practice Guideline for Diabetes Management in Chronic Kidney Disease[6] [119]
		4.3.1.c	KDOQI US Commentary on the 2012 KDIGO Clinical Practice Guideline for the Evaluation and Management of CKD[47] [120]
		4.3.1.d	DCRM Multispecialty Practice Recommendations for the Management of Diabetes, Cardiorenal, and Metabolic diseases[48] [121]
		4.3.1.e	ACP Diabetes Management in Chronic Kidney Disease: Synopsis of the KDIGO 2022 Clinical Practice Guideline Update[49] [122]
		4.3.1.f	ASCP Choosing Wisely An initiative of the ABIM Foundation[123]
		4.3.1.g	VA/DoD Clinical Practice Guidelines Management of Chronic Kidney Disease (CKD) (2019)[124]
4.3.2	• Annual CKD testing (eGFR and uACR) and risk stratification in at-risk populations—those with diabetes and/or hypertension and/or other risk factors	4.3.2.a	ADA 11. Chronic Kidney Disease and Risk Management: Standards of Care in Diabetes—2023[46] [118]
		4.3.2.b	KDIGO 2022 Clinical Practice Guideline for Diabetes Management in Chronic Kidney Disease[6] [119]
		4.3.2.c	ASCP Choosing Wisely An initiative of the ABIM Foundation[123]
4.3.3	• Attainment of blood pressure target	4.3.3.a	AAFP The 2022 Blood Pressure Targets in Adults with Hypertension: A Clinical Practice Guideline From the AAFP[125]
		4.3.3.b	KDIGO 2021 Clinical Practice Guideline for the Management of Blood Pressure in Chronic Kidney Disease[50] [126]
		4.3.3.c	KDOQI US Commentary on the 2012 KDIGO Clinical Practice Guideline for Management of Blood Pressure in CKD[51] [127]

> *With regard to highlighting the importance of both eGFR and uACR screening in primary care, explaining the independent association with these markers for both kidney disease progression and cardiovascular disease risk is often a lightbulb moment for providers. Both are important, but there is a bit of confusion about the need for screening both parameters and additional education is often needed.*
>
> ***Joshua J. Neumiller, PharmD, CDCES, FASCP, FADCES***
> *Washington State University*

> *Bring the connection between blood pressure and kidney disease to the patients earlier and you'll be surprised how many hang on to that, and they help each other in the group patient education sessions to kind of keep that in mind.*
>
> ***LaTasha Seliby Perkins, MD***
> *Georgetown University School of Medicine*

STAGE OF CHANGE 4			
	Change Ideas		**Resources and Tools**
4.3.4	• Attainment of A1c target	4.3.4.a	ADA Standards of Care in Diabetes—2023 Abridged for Primary Care Providers[128]
		4.3.4.b	NIDDK Guiding Principles for the Care of Patients with or at Risk for Diabetes[129]
4.3.5	• Use of ACE Inhibitor or Angiotensin Receptor Blocker in patients with diabetic kidney disease, CKD and HTN, and/or CKD and uACR > 30 where tolerated and appropriate	4.3.5.a	KDOQI US Commentary on the 2012 KDIGO Clinical Practice Guideline for the Evaluation and Management of CKD[25] [120]
		4.3.5.b	HHS Healthy People 2023: Increase the proportion of patients on Medicare with chronic kidney disease who get recommended tests[92]
4.3.6	• Use of an SGLT-2i in patients with CKD and eGFR >20 where tolerated and appropriate	4.3.6.a	ADA 11. Chronic Kidney Disease and Risk Management: Standards of Care in Diabetes—2023[46] [118]
		4.3.6.b	ADA/KDIGO Diabetes management in chronic kidney disease: a consensus report by the American Diabetes Association (ADA) and Kidney Disease: Improving Global Outcomes (KDIGO)[52] [130]
		4.3.6.c	Prescribing SGLT2 inhibitors in patients with CKD: expanding indications and practical considerations[53] [131]
		4.3.6.d	SGLT2 inhibition for CKD and cardiovascular disease in type 2 diabetes: report of a scientific workshop sponsored by the National Kidney Foundation[54] [132]
4.3.7	• Use of Statins	4.3.7.a	ACC/AHA 2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines[55] [133]
		4.3.7.b	KDIGO Clinical Practice Guideline for Lipid Management in CKD: Summary of Recommendation Statements and Clinical Approach to the Patient[56] [134]
4.3.8	• Use of Non-steroidal Mineralocorticoid Receptor Antagonist (ns-MRA) in patients with Type 2 diabetes, normokalaemia, and residual albuminuria despite other standard-of-care therapies.	4.3.8.a	KDIGO 2022 Clinical Practice Guideline for Diabetes Management in Chronic Kidney Disease[6] [119]
		4.3.8.b	ADA/KDIGO Diabetes Management in Chronic Kidney Disease: A Consensus Report by the American Diabetes Association (ADA) and Kidney Disease: Improving Global Outcomes (KDIGO)[52] [130]
		4.3.8.c	ADA 11. Chronic Kidney Disease and Risk Management: Standards of Care in Diabetes—2023[46] [118]
4.3.9	• Use of long-acting GLP-1 Receptor Agonist in patients with Type 2 diabetes not meeting glycemic targets despite first-line SGLT2 inhibitor ±metformin, ideally one with proven CVD benefit	4.3.9.a	KDIGO 2022 Clinical Practice Guideline for Diabetes Management in Chronic Kidney Disease[6] [119]
		4.3.9.b	ADA/KDIGO Diabetes Management in Chronic Kidney Disease: A Consensus Report by the American Diabetes Association (ADA) and Kidney Disease: Improving Global Outcomes (KDIGO)[52] [130]

STAGE OF CHANGE 4

Change Ideas		Resources and Tools	
4.3.10	• Medical nutrition therapy referral	4.3.10.a	KDOQI Clinical Practice Guideline for Nutrition in CKD: 2020 Update[57] [120]

> *It's amazing to me how few people have any knowledge about nutrition interventions that can be done to slow the progression of CKD.*
>
> ***Karen Greathouse, RD, CCTD***
> *Fellow, National Kidney Foundation, University of Michigan Health System*

4.3.11	• NSAIDs avoidance	4.3.11.a	Keeping kidneys safe: the pharmacist's role in NSAID avoidance in high-risk patients (Tables 3, 4 and Pages e20–e21)[58] [136]
		4.3.11.b	Reducing inappropriate non-steroidal anti-inflammatory prescription in primary care patients with chronic kidney disease[59] [137]
		4.3.11.c	NSAIDS in CKD: Are They Safe?[60] [138]
		4.3.11.e	Nonsteroidal anti-inflammatory drug use among persons with chronic kidney disease in the United States[61] [139]
		4.3.11.f	Healthy behaviors, risk factor control and awareness of chronic kidney disease[62] [140]
4.3.12	• Use of a risk prediction model (i.e., the Kidney Failure Risk Equation)	4.3.12.a	Kidney Failure Risk Calculator[141]
		4.3.12.b	A Predictive Model for Progression of Chronic Kidney Disease to Kidney Failure[63] [142]
4.4	Consider how social determinants of health and CKD disparities will be prioritized in the CKD program.	4.4.a	Using Z Codes: The Social Determinants of Health (SDOH) Data Journey to Better Outcomes[143]
		4.4.b	NKF Social Determinants of Kidney Disease delineates the relationship between kidney disease and social determinants of health[144]
		4.4.c	HHS Healthy People 2030 Social Determinants of Health[145]
		4.4.d	CMS Chronic Kidney Disease Disparities: Educational Guide for Primary Care[146]
		4.4.e	CDC- A Practitioner's Guide for Advancing Health Equity, Community Strategies for Preventing Chronic Disease[147]
		4.4.f	AAFP The EveryONE Project™ Toolkit. Advancing Health Equity through Family Medicine[148]
4.5	Use available EMR or other data to clearly articulate the impact of SDOH within the geographies being considered for the CKD program.	4.5.a	AHRQ SDOH Data and Analytics: Datasets and analytic tools that can power understanding of SDOH[149]
		4.5.b	Siren-Social Interventions Research and Evaluation Network to improve health and health equity by advancing high quality research on health care sector strategies to improve social conditions[64] [150]

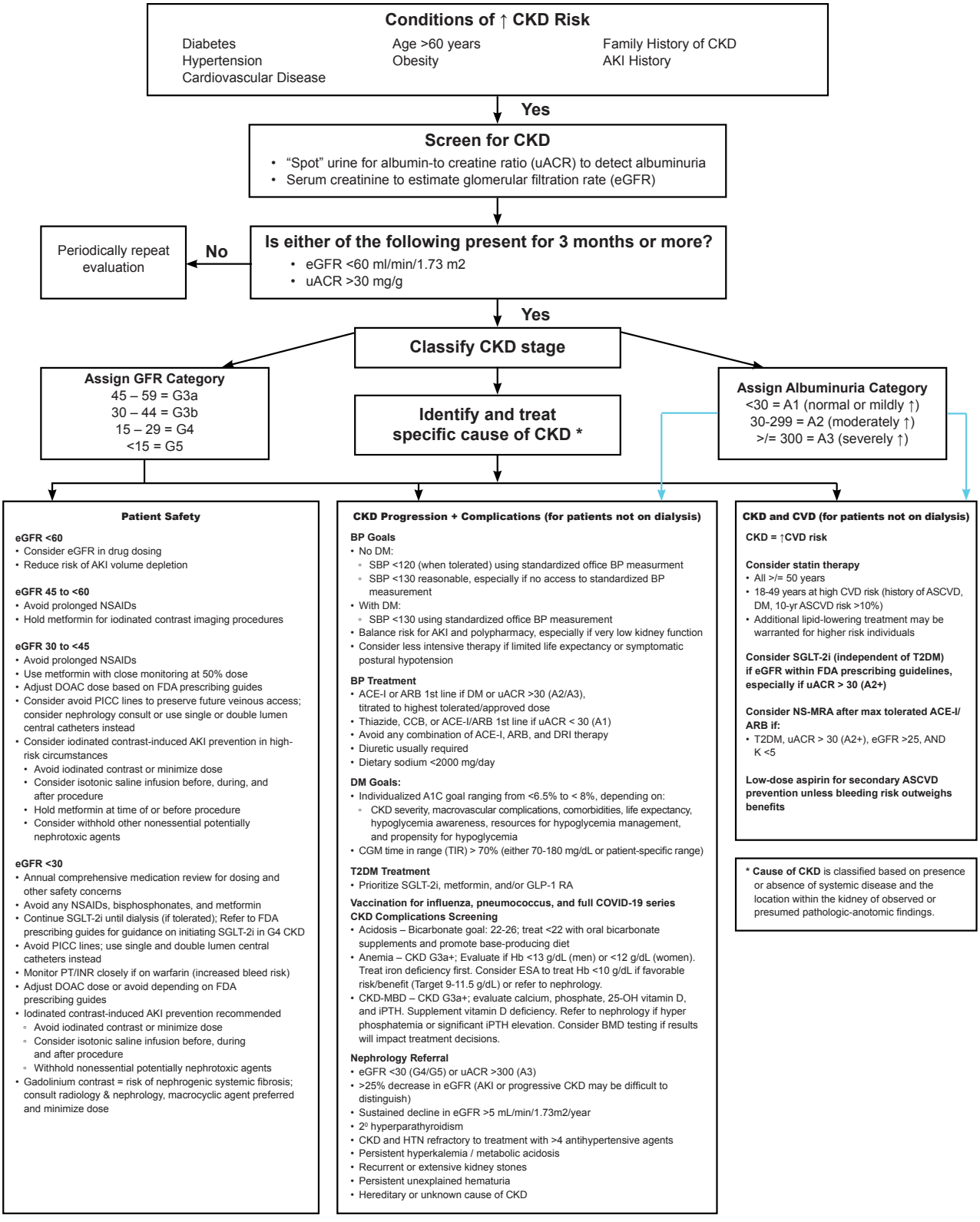
> *Making that connection between the association of certain SDOH with outcomes–what's related to access–what's related to biology–and having a validated and consistent way of identifying connections–that's the challenge and it might be different for different diseases.*
>
> ***Christine Chang, MD, MPH***
> *Agency for Healthcare Research*

STAGE OF CHANGE 4			
Change Ideas		**Resources and Tools**	
		4.5.c	PRAPARE—Protocol for Responding to and Assessing Patients' Assets, Risks, and Experiences. Implementation and Action—Toolkit (provides users with the resources, best practices, and lessons learned to guide implementation, data collection, and responses to social determinant needs.)[65] [151]
		4.5.d	The Gravity Project. Consensus-driven standards on social determinants of health. (A collaborative, public/private initiative to develop consensus-driven data standards to support collection, use, and exchange of data to address the social determinants of health)[152]
		4.5.e	National Institute on Minority Health and Health Disparities. PhenX Social Determinants of Health (SDOH) Assessments Collection. (A web-based catalog of recommended data measurement protocols to assess individual and structural factors that shape behaviors and health outcomes.)[153]
		4.5.f	UNITE US Cross-sector collaboration software powered by community to assist providers, health plans, government, and non-profits to identify solutions and deliver and pay for services that impact whole-person health[154]
4.6	Clearly articulate the parameters for appropriate collaboration between primary care and nephrology as determined by multi-disciplinary leadership team.	**4.6.a**	VA Chronic Kidney Disease Prevention, Early Recognition, and Management (VHA Directive 1053)[66] [155]
		4.6.b	NIDDK—Collaborate with the Nephrologist[156]
		4.6.c	Duke Institute for Health Innovation. Improving Chronic Disease Management in Duke Primary Care: Building a Virtual Medical Neighborhood[157]
		4.6.d	See page 18 for example of a CKD Primary Care Management Algorithm

> *The majority of patients we see as nephrologists are first seen by primary care physicians, so we really depend on them to make critical decisions in terms of how care is delivered, because it impacts what happens in a patient's life down the road.*
>
> ***Susanne Nicholas, MD, MPH, PhD***
> *David Geffen School of Medicine at the University of California, Los Angeles*

NATIONAL KIDNEY FOUNDATION®

How to Manage CKD



STAGE OF CHANGE 4			
	Change Ideas		**Resources and Tools**
4.7	Identify an implementation framework to guide evaluation of implementation strategies for the proposed CKD interventions and track health outcomes. Below are some widely used implementation frameworks for consideration	4.7.1	Ten recommendations for using implementation frameworks in research and practice[67] [158]
			NIH Toolkit Part 1: Implementation Science Methodologies and Frameworks[159]
			Context in Implementation Science[67] [160]
			Choosing implementation strategies to address contextual barriers: diversity in recommendations and future directions[68] [161]
4.7.1	• RE-AIM (reach, effectiveness, adopt, implement, maintain)	4.7.1.a	RE-AIM. Improving Public Health Relevance and Population Health Impact. Resources and Tools. [162]
4.7.2	• PDSA (plan, do, study, act)	4.7.2.a	IHI The Plan-Do-Study-Act (PDSA) Worksheet [163]
		4.7.2.b	AHRQ Health Literacy Universal Precautions Toolkit. Plan-Do-Study-Act (PDSA) Directions and Examples[164]
4.7.3	• CFIR (Consolidated Framework for Implementation Research)	4.7.3.a	The updated Consolidated Framework for Implementation Research based on user feedback[70] [165]
		4.7.3.b	Consolidated Framework for Implementation Research[166]

STAGE OF CHANGE 5

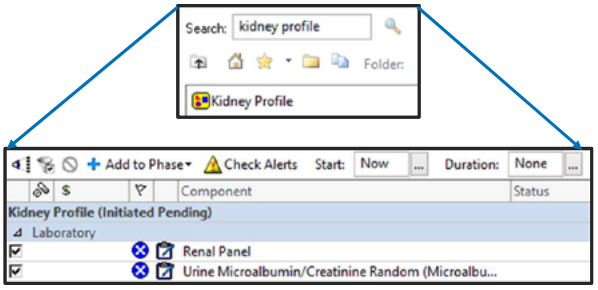
Develop the Implementation Plan for Your CKD Intervention.

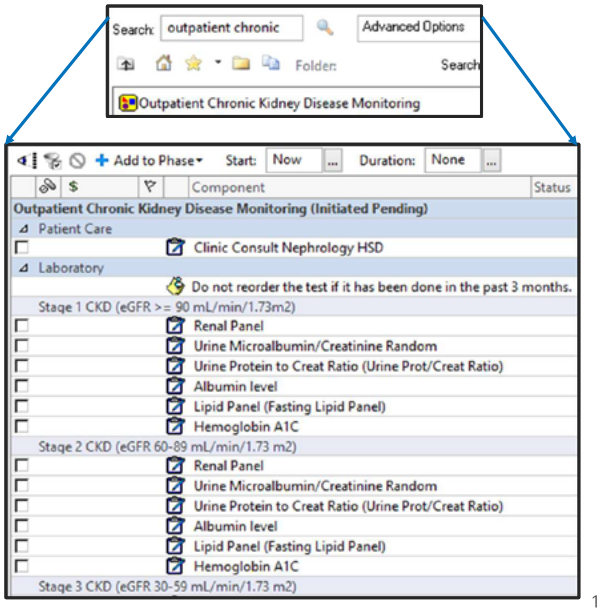
	Change Ideas		Resources and Tools
5.1	Identify evidence-based implementation strategies based on published literature or organizational expertise.	5.1.a	AAFP Basics of Quality Improvement[167]
		5.1.b	ACP Quality Improvement in Healthcare: ACP Resources and Programs[168]
		5.1.c	It Takes an Average of 17 Years for Evidence to Change Practice—the Burgeoning Field of Implementation Science Seeks to Speed Things Up[71] [169]
5.2	Ensure care team members carrying out the CKD intervention have helped identify implementation strategies appropriate to practice or clinic needs and requirements.	5.2.a	AHRQ Create and Support High Functioning Care Teams to Deliver High-Quality Evidence-Based Care[170]
		5.2.b	AHRQ Tools and Resources for Practice Transformation and Quality Improvement[171]
		5.2.c	AHRQ EvidenceNOW Tools for Change—A Curated Collection for Practices and Practice Facilitators[172]
5.3	Consider the implementation of an EHR-based CKD registry.	5.3.a	Development of an electronic health record-based chronic kidney disease registry to promote population health management[72] [173]
5.4	Develop the recommended CKD care plan for your institution.	5.4.a	NIDDK Development of an Electronic CKD Care Plan[175]
5.5	Consider the development of clinical decision support for CKD.	5.5.a	AHRQ Clinical Decision Support—Accelerating Evidence into Practice through CDS[176]
			See Addendum 1 - Srinivas TR, Coran JJ, Thatcher et al. Redesigning Kidney Disease Care to Improve Value Delivery. POPULATION HEALTH MANAGEMENT Volume 25, Number 5, 2022
		5.5.b	Use of Clinical Decision Support to Improve Primary Care Identification and Management of Chronic Kidney Disease (CKD)[73] [177]
		5.5.c	Sonic Healthcare USA/Chronic Kidney Disease Population Health[82]
		5.5.d	LabCorp Diagnostic Assistant[83]

> *Take a panel approach: here's all the patients that look like they have CKD but don't have a CKD diagnosis. Let's look through and get them a diagnosis if they need it. Here's all the patients who do have CKD but aren't getting evidence-based care (e.g., receiving an ACE inhibitor or ARB, avoiding nephrotoxins like NSAIDs). Let's get them to the care that they should be on (unless contraindicated) and away from the care that could further harm their kidneys (e.g.,NSAIDs).*
>
> ***Jenna Norton, PhD, MPH***
> *National Institute of Diabetes and Digestive and Kidney Diseases*

STAGE OF CHANGE 5

	Change Ideas		Resources and Tools
5.6	Review and update order sets for diabetes and hypertension to ensure they reflect agreed upon parameters for the CKD program including CKD assessment with the Kidney Profile, medication management, referrals for nutrition, nephrology, etc.	5.6.a	NKF Management Algorithm: How to Manage your CKD Patients—an NKF tool that facilitates management of patients with or at risk for CKD[178]
		5.6.b	Implementation of a CKD Checklist for Primary Care Providers[74] [179]
		5.6.c	Order Set Example which has been configured to accommodate institution preferences while still advancing guideline-concordant CKD testing: eGFR (part of the Renal Panel) AND uACR (listed individually with older nomenclature, Urine Microalbumin/Creatinine)
5.7	Consider embedding the CKD heat map in the electronic tools to facilitate CKD staging/risk stratification.		See page 8 for CKD heat map.
5.8	Where appropriate create dot phrases and other EMR tools to facilitate entry of CKD information.		See *Example of Public Dot Phrase for CKD* below.



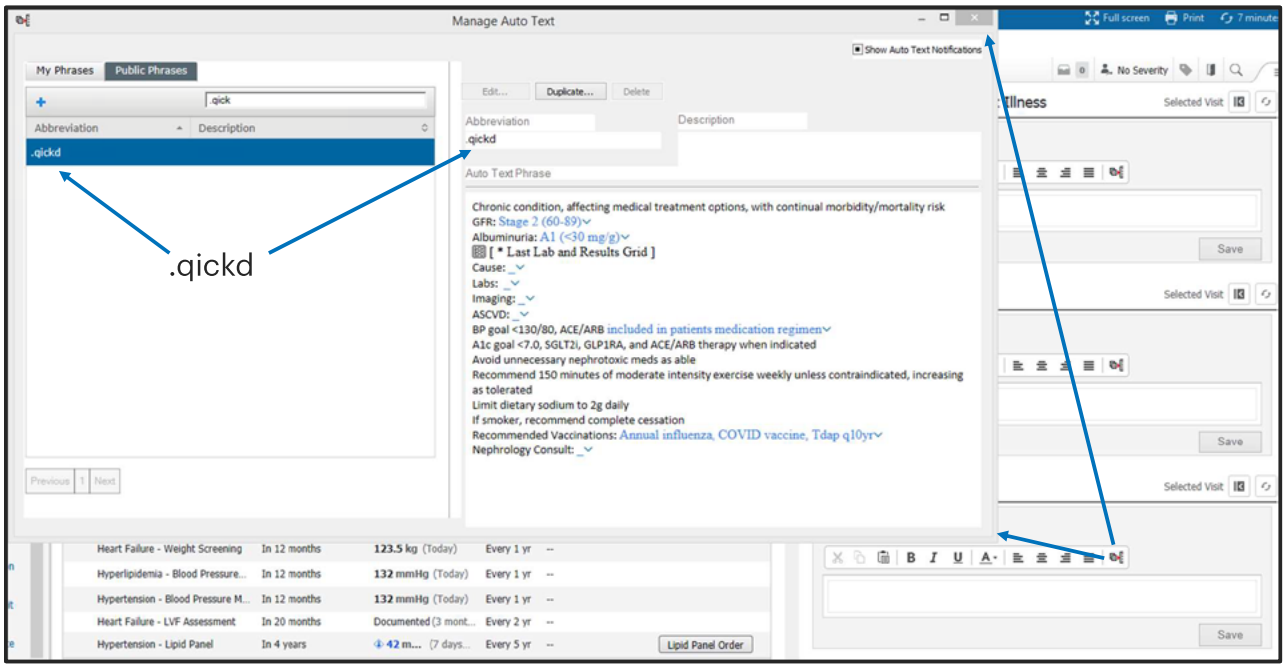


1

STAGE OF CHANGE 5

Change Ideas	Resources and Tools

When a dot phrase, often an abbreviation or acronym, is typed into the EHR, it triggers pre-saved components of effective care which are dropped into progress notes. The dot phrase example includes components of effective care for Stage 2 CKD.



5.9	Consider the use of the Kidney Health Evaluation for People with Diabetes MIPS measure.	5.9.a	CMS Kidney Health MIPS CMS951v1[180]
5.10	Include assessment for SDOH in the CKD intervention.	5.10.a	CMS The Accountable Health Communities Health-related Social Needs Screening Tool[181]
		5.10.b	AHRQ Identifying and Addressing Social Needs in Primary Care Settings[182]
		5.10.c	Health Leads The Health Leads Social Health Data Toolkit[183]
		5.10.d	AAFP The EveryONE Project™ Toolkit. Advancing Health Equity through Family Medicine[148]
5.11	Consider including resources to address identified SDOH needs in the intervention tools.	5.11.a	NowPow builds community referral networks that promote meaningful partnerships, drive impact and equity, and deliver data to bridge gaps in community care[183]
		5.11.b	The 211 network confidentially connects those in need to expert, caring help in finding food and assistance with expenses for housing, utilities, healthcare, etc.[184]

STAGE OF CHANGE 5			
	Change Ideas		**Resources and Tools**
5.12	Within the context of available resources, consider novel community-level approaches for identified SDOH-related needs such as collaborations with service-enriched housing organizations (e.g., general low income, multifamily housing, utilities assistance, finding childcare, partners for health services including chronic disease prevention, English as a second language classes).	5.12.a	Aunt Bertha zip code directed search for food, health, housing and employment programs[185]
		5.12.b	SAHFNET Stewards of affordable housing for the future advances, creation, and preservation of healthy, sustainable, affordable rental homes that foster equity, opportunity, and wellness for patients of limited economic resources[186]
		5.12.c	NeighborWorks America—drives change at the local level for individuals, families and communities through public and private partnerships[187]
		5.12.d	Community Housing Partners—a resource for quality-built, responsibly managed, service-enriched homes for low-income individuals and families across the Southeast and Mid-Atlantic[188]
5.13	Outline a strategy for seamless communication among various members of the CKD interdisciplinary patient care team.	5.13.a	ACP High Value Care Coordination (HVCC) Toolkit (resources to facilitate more effective and patient-centered communication between primary care and subspecialist clinicians)[189]
		5.13.b	NIDDK Collaborate with a Registered Dietitian[190]
		5.13.c	NIDDK Professional and Continuing Education[191]
		5.13.d	AHRQ Care Coordination[193]
5.14	Make CKD patient education a seamless experience in primary care.	5.14.a	NKF Kidney Basics Online educational resources[194]
		5.14.b	NKF Patient Education Library: Brochures[195]
		5.14.c	NKF Patient Education (2-Sided Flyers)[196]
		5.14.d	Medical Education Institute, Inc Kidney School[197]
5.15	Include referral information for local support groups or peer-mentoring programs.	5.15.a	NKF PEERS - a peer mentoring program[198]

> *When you learn you've got a health issue, go to reputable sources for information. Don't go to 'Mr. Bob Talks about Kidney Disease' on YouTube. Go to a site such as the National Kidney Foundation. You're going to find information that's factual and that's going to help you along the way. I urge patients not to put everything on the doctor,and understand there are reliable sources of information available like the NKF. It's up to us to educate ourselves so when we speak to our doctors it can be a dialog.*
>
> ***Ann Dalin***
> *Kidney Transplant Patient*

> *One of the things that really helped me was to be able to join a patient organization and listen to other patients share their experiences. Now I'm so inundated with information, you know, it allows me to be more comfortable in talking on the same level about disease management to my nurses, the techs and the physicians. And if something doesn't feel right, if the medication isn't working, it has encouraged me to be more vocal and more proactive.*
>
> ***Patrick O. Gee, PhD***
> *Kidney Transplant Patient*

STAGE OF CHANGE 5			
	Change Ideas		**Resources and Tools**
5.16	Utilize multiple channels of outreach to engage patients around CKD awareness and screening.	5.16.a	NIDDK Family Reunion Kidney Health Guide[199]
		5.16.b	NIDDK Kidney Sundays: A Toolkit[200]
		5.16.c	The Role of Faith-Based Models in Community Outreach and Patient Care[75] [201]
		5.16.d	From the Memphis Model to the North Carolina Way: Lessons Learned from Emerging Health System and Faith Community Partnerships[76] [202]
5.17	Consider creating a primary care tool kit to address the specific care gap(s) targeted.	5.17.a	NCQA Kidney Health Toolkit Improving the Quality of Kidney Care[203]

> *We need to do a better job talking about kidney disease in communities where folks are more affected, at colleges, in high school, in middle school and even in elementary school—it's not too early to teach kids about their kidneys and how to keep them healthy.*
>
> ***Patrick O. Gee, PhD***
> *Kidney Transplant Patient*

STAGE OF CHANGE 6

Execute and Measure Your Impact.

	Change Ideas		Resources and Tools
6.1	Engage the practice staff in education regarding CKD assessment and management.	6.1.a	NKF Management Algorithm: How to Manage your CKD Patients—a tool that facilitates management of patients with or at risk for CKD[178]
		6.1.b	IPRO Kidney Choices Clinician App[204]
		6.1.c	NIDDK Kidney Disease for Health Professionals—clinical practice tools assist health care professionals in diagnosing and treating patients with kidney disease[205]
		6.1.d	AHRQ Create and Support High Functioning Care Teams to Deliver High-Quality Evidence-Based Care[170]
		6.1.e	AHRQ Tools and Resources for Practice Transformation and Quality Improvement[206]
		6.1.f	CDC Vital Signs: Decrease in Incidence of Diabetes-Related End-Stage Renal Disease among American Indians/Alaska Natives–United States, 1996–2013[77] [207]
6.2	Engage practice staff in the refinement and application of the implementation strategy in their own workflows.	6.2.a	Implementation Mapping: Using Intervention Mapping to Develop Implementation Strategies[78] [208]
	• RE-AIM (reach, effectiveness, adopt, implement, maintain)	6.2.b	RE-AIM Improving Public Health Relevance and Population Health Impact. Resources and Tools[162]
	• PDSA (plan, do, study, act)	6.2.c	IHI The Plan-Do-Study-Act (PDSA) Worksheet[163]
		6.2.d	AHRQ Health Literacy Universal Precautions Toolkit. Plan-Do-Study-Act (PDSA) Directions and Examples[164]
	• CFIR (consolidated framework for implementation research)	6.2.e	The updated Consolidated Framework for Implementation Research based on user feedback[79] [165]
		6.2.f	Consolidated Framework for Implementation Research[166]
6.3	Utilize EHR and claims data to illustrate CKD care among patients living with hypertension and/or diabetes in each care team's population.	6.3.a	NKF Chronic Kidney Disease Data Analysis Strategy–a concise overview of unrecognized CKD plus data mining parameters via CKD*intercept*™ Practice Assessment[115]
6.4	Ensure the care team receives ongoing performance feedback about the agreed upon CKD quality metrics/interventions.	6.4.a	AHRQ Do It Yourself Run Chart for Primary Care Practices[209]

> *The things that are measured and graded are always going to be the things that receive more attention.*
>
> ***Blake Cameron, MD, MBI***
> *Duke Health*

POPULATION HEALTH MANAGEMENT
Volume 25, Number 5, 2022

DOI: 10.1089/pop.2021.0112

Redesigning Kidney Disease Care to Improve Value Delivery

Titte R. Srinivas, MD, FAST,[1] Justin J. Coran, PhD, MPH,[1,2] Esther J. Thatcher, RN, PhD,[2] Bradley Patton, DO,[2] Brayden Dunn, PharmD,[2] Sandeep Palakodeti, MD, MPH,[2] Todd Zeiger, MD,[2] Brandi N. Dobbs, FNP-BC, MSN,[2] Valerie Reese, MEd,[2] Patrick Runnels, MD, MBA,[2] Nagaraju Sarabu, MD,[2] and Peter J. Pronovost, MD, PhD[1,2]

Abstract

This article describes the articulation, development, and deployment of a machine learning (ML) model-driven value solution for chronic kidney disease (CKD) in a health system. The ML model activated an electronic medical record (EMR) trigger that alerted CKD patients to seek primary care. Simultaneously, primary care physicians (PCPs) received an alert that a CKD patient needed an appointment. Using structured checklists, PCPs addressed and controlled comorbid conditions, reconciled drug dosing and choice to CKD stage, and ordered prespecified laboratory and imaging tests pertinent to CKD. After completion of checklist prescribed tasks, PCPs referred patients to nephrology. CKD patients had multiple comorbidities and ML recognition of CKD provided a facile insight into comorbid burden. Operational results of this program have exceeded expectations and the program is being expanded to the entire health system. This paradigm of ML-driven, checklist-enabled care can be used agnostic of EMR platform to deliver value in CKD through structured engagement of complexity in health systems.

Keywords: kidney, primary care, nephrology, machine learning, quality improvement

Introduction

Defects in care of patients with chronic kidney disease (CKD) and end-stage renal disease (ESRD) are highly prevalent, pervasive, and profoundly impact health care costs.[1–3] Defects in value have been defined as any barrier, error, or lapse in care that could result in a suboptimal outcome.[4] Financial incentives for patients with CKD prioritize pay for late-stage CKD and ESRD medical care, specifically in hemodialysis centers, rather than improving preventive care and slowing the progression of renal disease.[3] This neglect of upstream care of CKD that precedes ESRD is a foundational defect in care delivery that uncovers an opportunity to control comorbidity in primary care settings, optimize recognition of CKD, refer to nephrologists, reduce expensive acute care utilization, and optimize use of value-enhancing care such as home dialysis and transplantation.[5,6] This article describes a pilot project to develop and deploy a system of care for patients with CKD within a health system. Specifically, this article describes how informatics was used to identify patients with CKD at risk for high costs, connect such people to primary care and standardize their primary care and referral to nephrology, and from nephrology to transplant.

Background

In the United States, CKD affects 1 in 3 adults with diabetes (DM) and 1 in 5 adults with hypertension (HTN), affecting more than 10% of the population overall.[1] ESRD, a condition that will progress to death absent dialysis or transplantation, canonically follows CKD by many months to years. This prosodic progression from CKD to ESRD has been the focus of research and therapeutics in the field. In fact, most guidelines for CKD care focus on stalling progression of CKD, but most patients with CKD present with abrupt incident ESRD in acute care settings requiring urgent dialysis. Unfortunately, most of these patients usually have missed many opportunities to diagnose disease and delay disease progression, have multiple complications, and often start dialysis with a central venous catheter, a major risk factor for mortality.[1,3]

[1]Case Western Reserve University, Cleveland, Ohio, USA.
[2]University Hospitals, Cleveland, Ohio, USA.

Most patients with renal disease go years before they are diagnosed with CKD and have multiple associated comorbid conditions including many complications associated with DM, HTN, obesity, atherosclerosis, and heart failure (CHF).[7] Most patients with CKD receive medical care for multiple conditions from many providers without clinical recognition of CKD and the majority die before reaching ESRD.[7] Notably, 70% of the longitudinal total cost of care for CKD patients resides in missed opportunities to manage comorbid conditions.[1,7] Although 2 therapies for ESRD, namely home dialysis and transplantation, significantly improve value for patients with CKD, these therapies are used infrequently. This scenario is a direct consequence of perverse financial incentives in a fee-for-service reimbursement paradigm in the United States that under-incentivizes upstream care while over-incentivizing the use of in-center hemodialysis.[1,3] In-center hemodialysis is expensive, robs patients of an opportunity to earn a living wage, and drives up utilization costs.[1,3,8,9]

The authors have previously applied a framework to understand the impact and drivers of defects in their health system. Defects can be defined as ''anything clinically, operationally, or experientially that a provider would not want to happen, including in diagnosing, initiating treatment, adjusting treatment, nurturing therapeutic alliances at the individual provider and system level, and avoiding preventable service utilization.''[4] The authors' experience suggested solutions that allowed implementation of several tactical changes within their health system's accountable care organization (ACO) and employee health plan to drive value.[4] Using this framework, the authors first looked specifically for defects in CKD care that had clear, actionable solutions that could be implemented immediately. Second, simple checklists were designed and deployed that would promote facile implementation of best practices by default. Third, the checklists were pilot tested in a primary care provider (PCP) practice with the ultimate goal of developing a scalable model.

The goal of this paper is to describe: (1) an approach to uncovering defects in value in the care of CKD; (2) an analytic model to identify CKD patients at risk for high utilization; (3) a person-centered care process to manage patients with CKD; and (4) a pilot test of an intervention to partner nephrologists with PCPs to implement a CKD defects in value checklist. The first section describes the classification of defects in CKD care. The second section describes how an analytic operating system with visualization layer (ie, dashboard interface) was built to track, monitor, and act on these defects. With a focus on value, allowed medical spend in the authors' ACO was examined as a way to address patients with highest need that would be amenable to intervention. The third section describes a pilot in which insights from the data were used and an intervention was co-created with PCPs to eliminate defects and optimize care for patients with CKD.

Methods

Clinical setting

The inquiry and intervention were conducted in the University Hospitals (UH) ACO that serves the Greater Cleveland area and Northeast Ohio. UH is a super-regional health system that cares for more than 1.2 million patients – 580,000 of whom are in the UH ACO – annually through an integrated network of 10 acute care hospitals, more than 50 health centers and outpatient facilities, and 200 physician offices in 16 counties in Northeastern Ohio. Nearly two thirds of all UH patients rely on Medicare or Medicaid to pay for their care. This includes 146,000 Medicaid managed care patients, 320,000 commercially insured patients, 58,000 Medicare Advantage patients, and 59,000 Medicare Shared Savings Program patients. ACO patients were included in this study if they were ages 18 years or older, and had sufficient data to calculate 2019 total allowed medical spend.

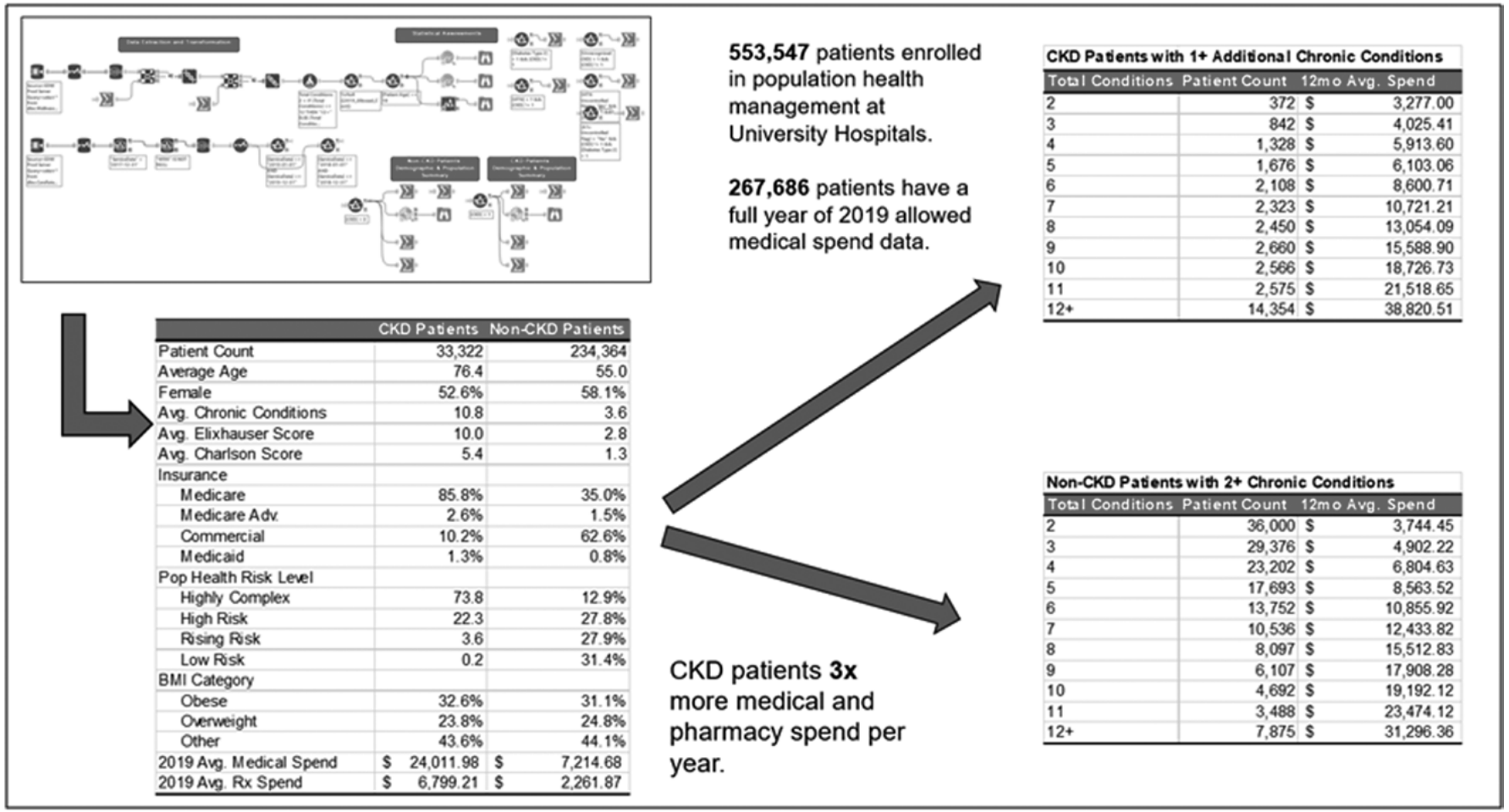
Data structure and machine learning model

The Enterprise Data Warehouse (EDW) was used to develop an operational construct for CKD by building a supervised machine learning algorithm with Alteryx Designer (Alteryx, Inc., Irvine, CA) and integrating the algorithm into the Power BI Reporting system to classify patients with known and unknown CKD and ESRD (Figure 1). A combination of laboratory values was used that yielded estimated glomerular filtration rates (eGFRs), clusters of comorbidity using International Classification of Diseases, Tenth Revision (ICD-10) codes, scheduling data, and Current Procedural Terminology (CPT) codes drawing on the work of Navaneethan et al.[10] Next examined was whether or not algorithmically defined CKD was accompanied by clinically recognized CKD as defined by both an eGFR value and ICD-10 code for CKD. Algorithmically, unrecognized CKD was defined as a patient with CKD identified from laboratory values without an ICD-10 for CKD. Data examined included: laboratory values, ICD-10 codes for comorbid conditions, and CPT and diagnosis-related group (DRG) codes to categorize both acute care and ambulatory utilization.[11,12] Further, completion of an annual wellness visit was used as a surrogate for the adequacy of preventive health care in the ambulatory setting.

The EDW centralizes the different clinical products belonging to Allscripts (Allscripts Healthcare, LLC, Chicago, IL) (ie, Touchworks, Sunrise) electronic medical record (EMR) system into one centralized 3-layer data lake. The clinical systems feeding data into the EDW also include the laboratory and pharmacy information systems, and scheduling and financial systems. In addition to the clinical and administrative data, data were incorporated from Ohio's Health Information Exchange, adjudicated claims, insurer member enrollment files, Ohio death records, and social determinants of health (mapped to ACO patients to facilitate population health management activities).

Key variables

Classification and cost of services in claims and EMR data. In the EMR and claims data, health care services were grouped by service date and classified as inpatient, emergency department (ED), or outpatient/ambulatory (OP). Out-of-network utilization was extracted from adjudicated claims data because UH's EMR can only collect data from in-network sources. Both in-network and out-of-network encounters were aggregated to calculate 90-day readmission rates. Wellness visits were defined based on CPT codes (G0438, G0402, G0439, 99385, 99386, 99387, 99391, 99392,



	CKD Patients	Non-CKD Patients
Patient Count	33,322	234,364
Average Age	76.4	55.0
Female	52.6%	58.1%
Avg. Chronic Conditions	10.8	3.6
Avg. Elixhauser Score	10.0	2.8
Avg. Charlson Score	5.4	1.3
Insurance		
Medicare	85.8%	35.0%
Medicare Adv.	2.6%	1.5%
Commercial	10.2%	62.6%
Medicaid	1.3%	0.8%
Pop Health Risk Level		
Highly Complex	73.8	12.9%
High Risk	22.3	27.8%
Rising Risk	3.6	27.9%
Low Risk	0.2	31.4%
BMI Category		
Obese	32.6%	31.1%
Overweight	23.8%	24.8%
Other	43.6%	44.1%
2019 Avg. Medical Spend	$ 24,011.98	$ 7,214.68
2019 Avg. Rx Spend	$ 6,799.21	$ 2,261.87

CKD Patients with 1+ Additional Chronic Conditions

Total Conditions	Patient Count	12mo Avg. Spend
2	372	$ 3,277.00
3	842	$ 4,025.41
4	1,328	$ 5,913.60
5	1,676	$ 6,103.06
6	2,108	$ 8,600.71
7	2,323	$ 10,721.21
8	2,450	$ 13,054.09
9	2,660	$ 15,588.90
10	2,566	$ 18,726.73
11	2,575	$ 21,518.65
12+	14,354	$ 38,820.51

Non-CKD Patients with 2+ Chronic Conditions

Total Conditions	Patient Count	12mo Avg. Spend
2	36,000	$ 3,744.45
3	29,376	$ 4,902.22
4	23,202	$ 6,804.63
5	17,693	$ 8,563.52
6	13,752	$ 10,855.92
7	10,536	$ 12,433.82
8	8,097	$ 15,512.83
9	6,107	$ 17,908.28
10	4,692	$ 19,192.12
11	3,488	$ 23,474.12
12+	7,875	$ 31,296.36

FIG. 1. Machine learning model for identifying patients with CKD. Data model on the left showing data sources and informatic build. Tables depict comorbid burden by presence or absence of CKD and by CKD stage as well as annual spend based on claims data. Avg, average; BMI, body mass index; CKD, chronic kidney disease; Rx, prescription.

99393, 99394, 99395, 99396, 99397, 99381, 99382, 99383, 99384, 99461). Allowed medical spend or the maximum reimbursement the member's health policy allows for a specific service was derived from adjudicated claims for 2019 services. The cost applied to hospital OP and ED visits included both hospital and physician services. Cost per visit was applied to each office, home health, or laboratory visit. OP dialysis services in patients without evidence of kidney transplant were excluded from ESRD costs because of significant underrepresentation in the source data, which do not include data from freestanding outpatient units.

Other study variables. Age, sex, race, and insurance program information were sourced from EMR data and verified for accuracy with payor enrollment files. A total of 50 comorbidities, defined by ICD-10 codes, were aggregated to produce an average chronic condition score. Key disease cohorts of comparison include patients with CKD, DM, HTN, CHF, stroke, and pulmonary disease. Certification of diagnosis had to occur in 2019, 2018, or 2017 to be included.

Mapping system defects, goals, and solutions

To identify and resolve defects in the care system, a team of subject matter experts was brought together, including PCPs, nephrologists, the population health team, care navigators, data scientists, and clinical pharmacists. In addition to classifying defects by subject matter experts, input from the data science team on costs attributable to these defects were incorporated where feasible. Defects and opportunities for intervention were classified under the following categories: (1) maintaining wellness in health, (2) getting well by managing disease or recovering from illness episode, and (3) sustaining recovery after acute decompensation (see Supplemental Data, available with the article online).

Next, the team was engaged in a solution-building exercise that yielded a mapping of defects in care to actionable clinical workflows. The team constructed a driver diagram to help visualize and converge on a deployable solution[9] (see Supplemental Data). The stated outcome goal in this diagram was to reduce the cost of care for patients with CKD and ESRD by 30% through decreased utilization of unplanned acute care. The key change component categories were: systems to recognize CKD, wellness and preventive care workflows, primary care workflows to refer and hand off patients, care navigation, inpatient disease-specific workflows, genetics and pharmacogenetics, dialysis access and education, and transplant referral.

The expert team then detailed these workflows for primary care and nephrology specialty practices (see Supplemental Data). For example, primary care workflows should incorporate systems to assess ageing-related eGFR changes versus true kidney disease, complete wellness services, manage CKD comorbidities, assess and manage psychosocial needs, and refer to specialists by protocol. Nephrology workflows should include disease-specific management and diagnostic testing, patient engagement with CKD education and goals of therapy, medical and social work preparedness for dialysis and/or transplant, and co-management protocols with the PCP.

These team-based system mapping exercises culminated in designing a pragmatic framework to guide patient-centered care. This framework (Figure 2) comprises 4 key processes: (1) identify patients at risk through informatics-based case-finding algorithms; (2) trigger EMR-based alerts to notify patients and providers to take action; (3) act to optimize team-based patient care in primary care and nephrology; and (4) learn continuously to improve data and clinical processes.

The CKD Checklist in Primary Care was developed as a quick-reference tool to implement the expert team's primary care recommendations into practice (Figure 3). The 1-page checklist structured goals of care for patients with CKD, including wellness care, managing comorbidities such as DM and HTN; assessments including frailty, cognition, and social support needs; and goals of care including advanced directives. A list of diagnostic testing is specified when the PCP is preparing a patient for nephrologist referral.

This framework and checklist were pilot tested in a site in the UH system with a co-located primary care practice, nephrologist, laboratory, radiology, pharmacy, and also a nearby aligned dialysis facility. A nephrologist was co-located at this practice location with a view to allowing unlimited access to consultation to the primary care teams. Proximity of a dialysis facility would allow facile referral for CKD education as well as ESRD modality planning. In this design the patient would have had age- and gender-appropriate health screenings completed in such a way that would make transplant evaluation and listing possible in an expedited time frame. This team approach relieved the PCP of the full burden of care. As examples, patient navigators facilitated interactions to promote patient and physician engagement. Pharmacists supported medication reviews and adjustments for eGFR. This design allowed patients and their families to access resources in a time-efficient manner that minimized lost time away from life and work. In sum, a patient-centered convergence of resources was designed that would optimize for the desired outcome of comorbidity management and planning for transitions of care related to advanced CKD in the ambulatory setting.

Results

The UH ACO population in this study included 267,829 adult patients in total, with a CKD cohort of 33,365 (Table 1). Age and racial characteristics are shown in Table 1. Average number of chronic conditions was higher in the CKD cohort compared with the overall sample; rates of each of the studied comorbid conditions were higher in the CKD cohort, including 97% with HTN and 86% with pulmonary disease. Ninety-day readmission rates and inpatient length of stay were higher in the CKD cohort as well.

Health care utilization and spend by CKD characteristic are described in Tables 2 and 3. Average number per patient of inpatient visits, 30-day readmissions, and ED visits all increased with CKD stage of disease (Table 2). Costs per patient were more than twice as high for patients with CKD ($24,011) than for patients with DM or HTN but without CKD (Table 3). Unrecognized CKD was noted in 9158 patients with average annual spend of $8199. Total medical spend for all CKD patients in the sample was more than $800 million.

Patients with CKD who had completed a wellness visit averaged $18,902 in annual medical spend vs. $25,457 among those who had not completed a wellness visit in the

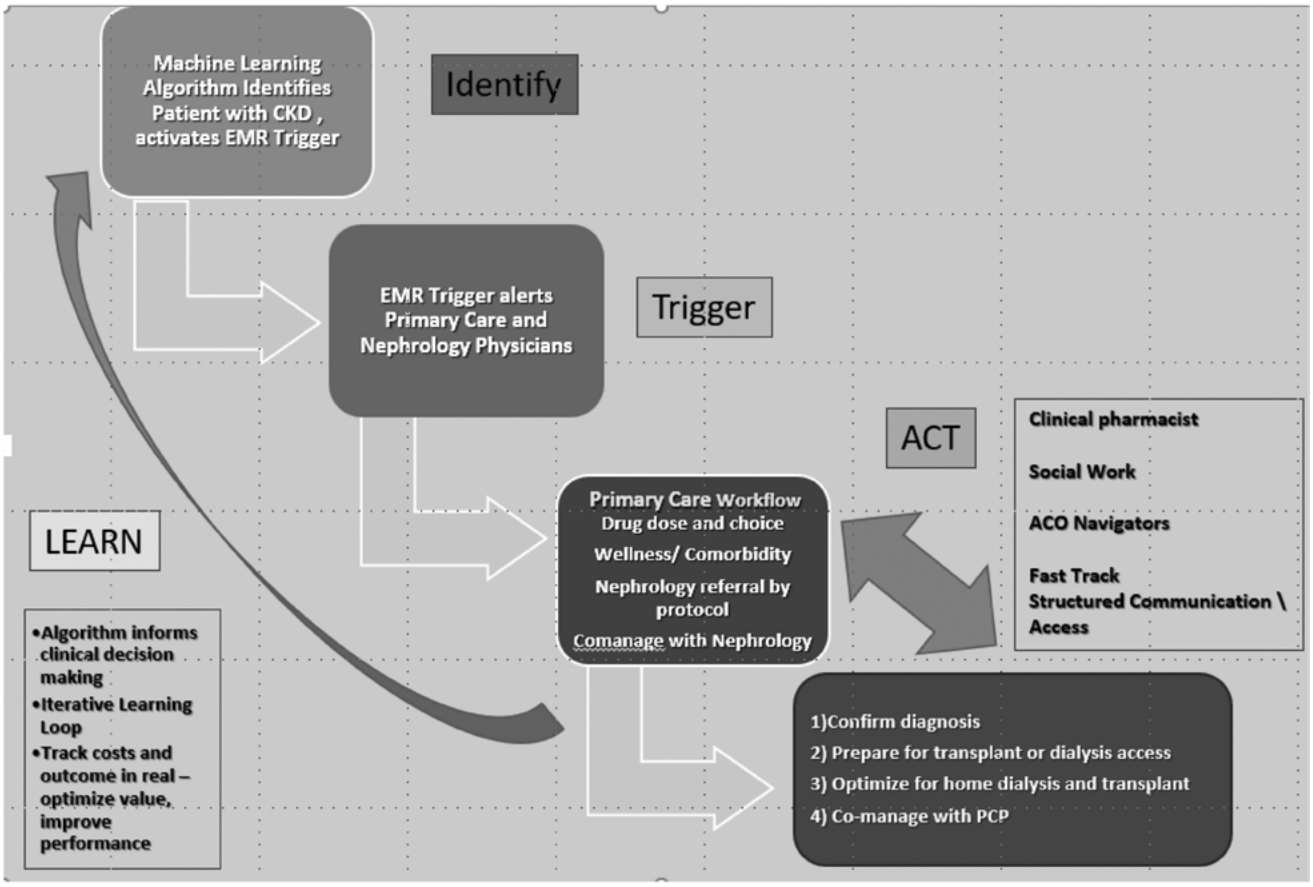


FIG. 2. Framework for improving CKD early identification and care. ACO, accountable care organization; CKD, chronic kidney disease; EMR, electronic medical record; PCP, primary care provider.

same year (data not shown). Among non-CKD patients, wellness visit completion was associated with an annual spend of $5583 vs. $8382 among those without wellness visit completion.

Pilot test results for the CKD checklist intervention were based on patients seen in a nephrology clinic after a referral from the pilot primary care site. Nineteen patients were included during the first 3 months despite a near complete lockdown on face-to-face visits during the pandemic (see Supplemental Data). Fifteen of the patients seen were between Stages 2 and 3b CKD. Fifteen patients had HTN, and 6 had DM. Actions taken in their care included medication adjustment for 5 patients and continued CKD monitoring for 13 patients. There also were 5 preemptive transplant referrals and 3 nonurgent dialysis starts in this time period from the pilot practice site.

Discussion

This study used a novel informatics-driven approach to identify and make visible defects in care for patients with CKD and to begin to eliminate those defects. Specifically, first, the data system was leveraged to obtain a data understanding of a disease state, CKD. The premise was that biochemically classified CKD is a lead measure that better triggers clinically relevant intervention and timely access to care than administrative data. Administrative data such as ICD-10 codes, DRGs, and claims data, which reflect products of clinical care that has already been delivered, are necessarily lag markers of CKD. Thus, the expert team combined traditional administrative data along with measures of eGFR to arrive at a CKD classifier with a view to maximize the chance of recognizing and managing patients with comorbidity. This approach differs from generation of lists of patients using claims data, diagnostic codes, or procedure codes as these measures are subject to the time constants of the revenue cycle. Using a biochemical anchor to the CKD classifier would allow better alignment of case finding with the time constants of care delivery. As the initial design of the model was iterated, the expert team came to understand that using traditional operator-intensive methods of generating patient lists using traditional statistical programming and analyses would not work given time constraints of clinical relevance and the diversity of data sources. The team also came to realize very quickly that the human resources could be used much more efficiently in directly enabling care delivery rather than serving rote reporting tasks that were largely irrelevant clinically.

Further, the health system had several clinical pathways in deployment. However, adherence to these was more in the breach than in compliance given the absence of an automated case-finding approach that triggered appropriate clinical actions. The health system also was not burdened by legacy reporting systems prior to the build of the data model

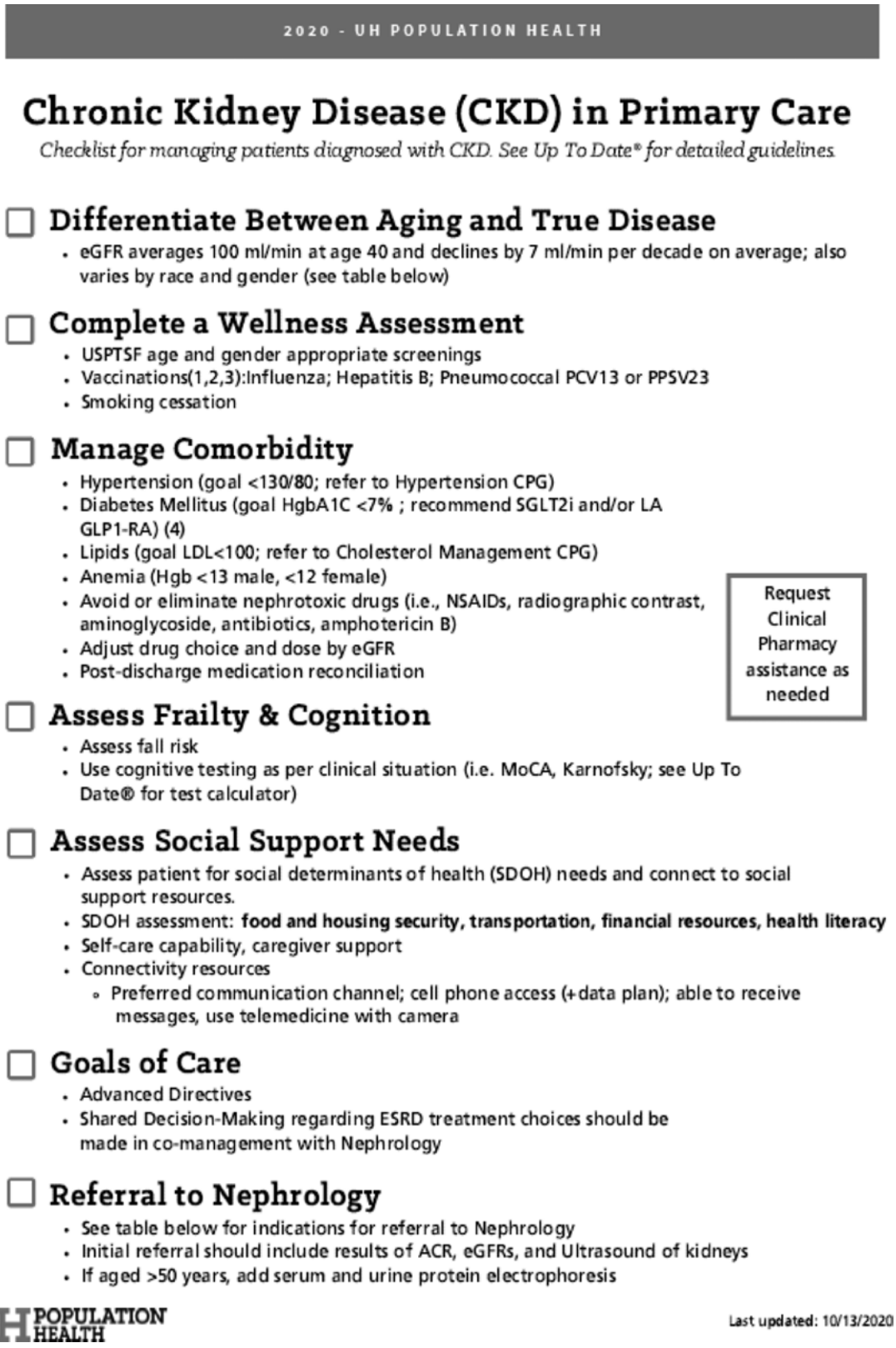


FIG. 3. CKD checklist in primary care. ACR, albumin-creatinine ratio; CKD, chronic kidney disease; CPG, clinical process guideline; eGFR, estimated glomerular filtration rate; ESRD, end-stage renal disease; LA GLP1-RA, long-acting glucagon-like peptide 1 receptor agonists; LDL, low-density lipoprotein; MoCA, Montreal Cognitive Assessment; NSAID, nonsteroidal anti-inflammatory drug; PCV13, 13-valent pneumococcal conjugate vaccine; PPSV23, 23-valent pneumococcal polysaccharide vaccine; SGLT2i, sodium/glucose cotransporter-2 inhibitors; USPSTF, US Preventive Services Task Force.

Table 1. Characteristics of the Study Population

	All patients	*CKD cohort*
Patient Count	267,829	33,365
Average Age	57.7	76.4
Gender		
Female	57.4%	52.6%
Male	42.6%	47.4%
Race		
White	80.4%	79.8%
Black	9.1%	13.1%
Other	10.5%	7.1%
2019 Readmission Rate, 90 Day	23.4%	32.3%
2019 Avg. Length of Stay per Admit	3.7	5.2
GFR Values - ACO 2019 Population		
Have GFR Value in Medical Record	63.3%	71.9%
No GFR Value in Medical Record	36.7%	28.1%
Avg. Chronic Conditions	4.5	10.8
% w/Diabetes	20.0%	49.3%
% w/Hypertension	44.5%	96.7%
% w/Heart Failure	12.5%	49.0%
% w/Stroke	14.1%	41.3%
% w/Pulmonary Disease	55.4%	85.9%

ACO, accountable care organization; Avg, average; CKD, chronic kidney disease; GFR, glomerular filtration rate.

and thus was well positioned for ab initio deployment of machine learning versus a more traditional approach of reporting whether or not care pathways were adhered to. As the approach was designed, the stakeholders strongly aligned around a collaborative care delivery structure moving forward rather than the stentorian pass-fail reporting of quality of the past.

Machine learning was used to make predictions around CKD as follows: identify patients within the system and classify them by comorbid burden and wellness completion. Data insights from machine learning were then used to trigger actions within the EMR (Figure 2).[13] Next, subject matter expert input was used in formulating clinical actions around the data insights with tactical, clinically deployable checklists and workflows. Preliminary observations show the promise of this approach while awaiting further evaluation of the efficacy of the intervention in driving outcomes. This is an area of active investigation as the initial success is iterated.

Notable findings that are likely generalizable to most health systems include:

Table 3. Health Care Spend by Patient Subgroups

	Patient count	*2019 Total medical spend*	*2019 Avg. medical spend*
CKD Patients	33,365	$ 800,127,188.73	$ 24,011.98
Unrecognized CKD	9158	$ 75,093,012.89	$ 8199.72
Diabetes w/o CKD	37,147	$ 430,591,480.72	$ 11,591.55
Hypertension w/o CKD	116,319	$ 1,171,385,932.25	$ 10,070.46

Avg, average; CKD, chronic kidney disease.

i) Leveraging knowledge that advancing CKD stages associates with comorbid clustering allows scripted person-centered care.

ii) Absence of wellness visits associates with increased medical spend across the board. Thus, wellness visits can be used as a point of value optimization.

iii) Structured attention to laboratory data, orders for imaging, and medication reconciliation can be used to optimize nephrology referral.

A recent publication from UCLA describes deployment of teams of subspecialists to deliver care for CKD patients with complex needs. However, this approach did not employ an automated detection and triggering method and also did not use standardized workflows or checklists.[6] Further, this approach somewhat disintermediates the PCP practice as the medical home of the patient, whereas in the approach described herein, the PCP practice remains the medical home of the patient.

The primary limitation of this work is the narrow time horizon of the inquiry and a limited scope of the first deployment. This approach is in the process of being generalized across the health system and a cluster randomized trial is being planned across the nephrology and primary care practices. Specifically, future lines of inquiry will focus on cardiorenal disease in Stage 4 and 5 CKD, linking the CKD data structure to the transplant data structure as well as the cost and billing structures. A further confounder of the ability to measure impact of the interventions on cost and acute care utilization was the disruption of access to care and steep increase in acute care utilization among CKD patients during the COVID-19 pandemic. The approach to solving for defects in care also is provider-centric and patients' perspectives on defects in care are being used during iterations.

Table 2. Health Care Utilization by Chronic Kidney Disease Stage

CKD stage	*Patient count*	*2019 avg. IP visits*	*2019 avg. 30 day readmits*	*2019 avg. ED visits*
CKD Stage 1 - Normal	234,364	0.08	0.01	0.36
CKD Stage 2 - Mild Loss	2776	0.40	0.05	1.05
CKD Stage 3a - Mild to Moderate	7065	0.39	0.05	1.09
CKD Stage 3b - Moderate to Severe	5106	0.46	0.05	1.20
CKD Stage 4 - Severe	2280	0.82	0.14	1.69
CKD Stage 5 - Kidney Failure	1244	1.12	0.22	2.18

Avg, average; CKD, chronic kidney disease; ED, emergency department; IP, inpatient.

Summarizing, at-risk patients with CKD were identified using the automated trigger. The algorithm identified patients with CKD stage 3 or above and sent an email to encourage patients to visit their PCPs. This email thus directly engaged patients. Simultaneously, a list of these patients was sent to their PCPs. A structured checklist for PCP management of patients was then used to help ensure that patients were receiving appropriate therapy for HTN and/or DM, that medication doses were based on eGFR, that comorbid conditions were addressed, that wellness measures were completed, and physiology (eg. blood pressure, blood glucose) was controlled. To increase referral to nephrology, the PCP visit was scripted to refer to nephrology and nephrology workup and documentation were standardized. This model also is envisaged to feed an iterative learning loop that would help improve performance in its future state (Figure 2). Results thus far within the system suggest that this model has worked in directing early-stage referrals of CKD cases from PCPs to nephrologists and that meaningful clinical actions such as medication dose and choice are being addressed as well as regimented monitoring of CKD. Based on this initial success, leadership of the primary care program has requested that this program be disseminated system-wide.

A path forward

This journey uncovered several avenues for value delivery in health systems based on optimizing care for patients with CKD using informatics as an accelerator of change. The first and foremost is to avoid the parochial trap that the medical care of the CKD patient revolves around kidney care. Rather, an opportunity was seen for a more secular approach:

i) Identifying CKD uncovers complexity and populations likely to incur higher medical spend. Wellness visits could provide an opportunity to ''make CKD visible'' in primary care settings through triggers based on the algorithm that was used to identify patients with CKD.

ii) Primary care workflows could be tailored to include optimization of wellness among CKD patients while retaining their place as the medical home for these patients through standardized workflows and simple checklists.

iii) Designing formal hardwired linkages within health systems between primary care practices and nephrology to optimize referral of CKD patients to nephrology and structured channels of communication.

iv) This first phase of deployment will then be followed by a drive toward zero defects in the care of the CKD patient.

Conclusion

The authors see this approach to machine learning-driven CKD care as a way to solve for value delivery in health care by using machine learning around CKD as a facile way to trawl for complexity in the population. CKD also uncovered defects in value. These defects in value are most often a consequence of the way the care system is organized, or fails to be organized, and are largely invisible to clinicians, whose focus is – unfortunately for the most part – transactional and reactive rather than relational and proactive. This approach would identify patients with CKD and comorbid clustering using a deterministic algorithm that would then be used to initiate an EMR-based trigger that would initiate actions in the primary care and nephrology setting either sequentially or simultaneously. These clinical actions are scripted to solve for ideal care delivery in the majority of clinical settings using clinically relevant, tactically facile checklists. Standardized care across the ambulatory continuum would then accrue savings by reducing expensive unplanned acute care utilization. Such a care delivery paradigm can be built with prescribed iterative learning that would sustain gains over time.

Authors' Contributions

Drs. Srinivas, Coran, Thatcher, Patton, Palakodeti, Zeiger, Sarabu, Pronovost: Conception, data acquisition, analysis, interpretation, drafting, revision, final approval, accountable for content. Dr. Dunn: Conception, analysis, interpretation, drafting, final approval, accountable for content. Ms. Dobbs: Conception, data acquisition, interpretation, drafting, final approval, accountable for content. Ms. Reese: Conception, data interpretation, drafting, final approval, accountable for content. Dr. Runnels: Conception, data acquisition, interpretation, drafting, revision, final approval, accountable for content. Drs. Srinivas, Palakodeti, Runnels, and Pronovost, and Ms. Reese: Obtained funding.

Author Disclosure Statement

The authors declare that there are no conflicts of interest.

Funding Information

This study was funded internally by the University Hospitals Accountable Care Organization.

Supplementary Material

Supplementary Data

References

1. Transitions of care in chronic kidney disease in United States Renal Data System. 2019 USRDS annual data report: epidemiology of kidney disease in the United States. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2019. https://www.usrds.org/media/2366/usrds-tcckd-2019-report.pdf Accessed February 13, 2021.
2. Wasse H, Speckman RA, Frankenfield DL, et al. Predictors of central venous catheter use at the initiation of hemodialysis. Semin Dial 2008;21:346–351.
3. Srinivas TR. Kidney transplant access in the Southeastern United States: the need for a top-down transformation. Am J Transplant 2014l;14:1506–1511.
4. Pronovost PJ, Urwin JW, Beck E, et al. Making a dent in the trillion-dollar problem: toward zero defects. NEJM Catal Innovations Care Delivery 2021. DOI: https://doi.org/10.1056-1064
5. Patzer RE, Pastan SO. Kidney transplant access in the Southeast: view from the bottom. Am J Transplant 2014: 14:1499–1505.
6. Gupta R, Skootsky SA, Kahn KL, et al. A system-wide population health value approach to reduce hospitalization among chronic kidney disease patients: an observational study. J Gen Intern Med 2021:36:1613–1621.

7. Honeycutt AA, Segel JE, et al. Medical costs of CKD in the Medicare population. J Am Soc Nephrol 2013;24:1478–1483.
8. Fissell RB, Srinivas T, Fatica R, et al. Pre-emptive renal transplant candidate survival, access to care and renal function at listing. Nephrol Dial Transplant 2012;27:3321–3329.
9. Cox M, Sandberg K. Modeling causal relationships in quality improvement. Curr Probl Pediatr Adolesc Health Care 2018;48:182–185.
10. Navaneethan SD, Jolly SE, Schold JD, et al. Development and validation of an electronic health record-based chronic kidney disease registry. Clin J Am Soc Nephrol 2011;6: 40–49.
11. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:373–383.
12. Elixhauser A, Steiner C, Harris Dr, et al. Comorbidity measures for use with administrative data. Med Care 1998; 36:8–27.
13. Srinivas TR, Taber DJ, Su Z, et al. Big data, predictive analytics, and quality improvement in kidney transplantation: a proof of concept. Am J Transplant 2017;17:671–681.

Address correspondence to:
Titte R. Srinivas, MD, FAST
Case Western Reserve University
10900 Euclid Avenue
Cleveland, OH 44106-7078
USA

E-mail: trsrinivas65@gmail.com

References

1. Delgado C, Baweja M, Crews DC et al. A unifying approach for GFR estimation: recommendations of the NKF-ASN Task Force on reassessing the inclusion of race in diagnosing kidney disease. *Am J Kidney Dis*. 79(2):268-288.
2. Genzen JR, Souers RJ, Pearson LN, et al. An update on reported adoption of 2021 CKD-EPI estimated glomerular filtration rate equations. *Clin Chem* 2023 Aug 10. Online ahead of print.
3. Cusick MM, Tisdal RL, Chertow GM et al. Population-wide screening for chronic kidney disease, a cost-effectiveness analysis. *Ann Intern Med* 2023 Jun;176(6):788-797.
4. Kidney Health Evaluation for Patients with Diabetes (KED). Kidney Health Evaluation for Patients with Diabetes–NCQA
5. Kidney Health Evaluation. https://ecqi.healthit.gov/ecqm/ec/2024/cms0951v2. Accessed 25September2023.
6. Kidney Disease: Improving Global Outcomes (KDIGO) Diabetes Work Group. KDIGO 2022 clinical practice guideline for diabetes management in chronic kidney disease. *Kidney Int*. 2022 Nov;102(5S):S1-S127.
7. Heerspink HJL, Stefansson BV, Correa-Rotter R et al. Dapagliflozin in patients with chronic kidney disease. *N Engl J Med*. 2020 Oct 8;383(15):1436-1446.
8. McMurray JJV, Solomon SC, Inzucchi SE et al. Dapagliflozin in patients with heart failure and reduced ejection fraction. *N Engl J Med*. 2019 Nov 21;381(21):1995-2008.
9. Packer M, Anker SD, Butler J et al. Cardiovascular and renal outcomes with empagliflozin in heart failure. *N Engl J Med*. 2020 Oct 8;383(15):1413-1424.
10. Anker SD, Butler J, Filippatos G et al. Empagliflozin in heart failure with a preserved ejection fraction. *N Engl J Med*. 2021 Oct 14;385(16):1451-1461.
11. Herrington WG, Staplin N, Wanner C et al. The EMPA-KIDNEY Collaborative. Empagliflozin in patients with chronic kidney disease. *N Engl J Med*. 2023 Jan 12;388(2):117-127.
12. Alfego D, Ennis J, Gillespie B et al. Chronic kidney disease testing among at-risk adults in the U.S. remains low: real-world evidence from a national laboratory database. *Diabetes Care*. 2021 Sept;44(9):2025-2032.
13. United States Renal Data System. www.usrds.org
14. CDC CKD Surveillance System. https://nccd.cdc.gov/CKD/
15. Jankowski J, Floege J, Fliser D et al. Cardiovascular disease in chronic kidney disease: pathophysiological insights and therapeutic options. Circulation. 2021 Mar 16;143(11):1157-1172.
16. Go AS, Chertow GM, Fan D et al. Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. N Engl J Med 2004 Sep 23;351(13):1296-305.
17. Nichols GA, Ustyugova A, Anouk DL et al. Health care costs by type of expenditure across eGFR stages among patients with and without diabetes, cardiovascular disease, and heart failure. *J Am Soc Nephrol*. 2020 Jul;31(7):1594–1601.
18. National Kidney Foundation. K/DOQI Clinical practice guidelines for chronic kidney disease: evaluation, classification and stratification. *Am J Kidney Dis* 2002;39:S1-S266.
19. Vassalotti JA, Centor, Turner BJ et al. Practical approach to detection and management of chronic kidney disease for the primary care clinician. *Am J Med* 2016 Feb;129(2):153-162.e7.
20. Whelton PK, Carey RM, Aronow WS et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on clinical practice guidelines. *Hypertension* 2018. 71(6): p. e13-e115.
21. Chobanian AV, Bakris GL, Black HR et al. Seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure. *Hypertension*. 2003;42:1206-1252.
22. James PA, Oparil S, Carter BL et al., 2014 evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the eighth joint national committee (JNC 8). *JAMA*. 2014. 311(5):507-520.
23. Taler SJ, Agarwal R, Bakris GL et al. KDOQI US commentary on the 2012 KDIGO clinical practice guideline for Management of Blood Pressure in CKD. *Am J Kidney Dis*. 2013;62(2):201-213.
24. KDOQI Clinical Practice Guideline for Diabetes and CKD: 2012 Update. *Am J Kidney Dis*. 2012 Nov;60(5):850-86.
25. Inker LA, Astor BC, Fox CH et al. KDOQI US commentary on the 2012 KDIGO clinical practice guideline for the evaluation and management of CKD. *Am J Kidney Dis*. 2014;63(5):713-735.
26. Friedewald, V.E., Bennett JS, Christo JP et al. Editor's consensus: selective and nonselective nonsteroidal anti-inflammatory drugs and cardiovascular risk. *Am J of Cardiol*, 2010. 106(6):873-884.
27. Leonard CE, Freeman CP, Newcomb CW et al., Proton pump inhibitors and traditional nonsteroidal anti-inflammatory drugs and the risk of acute interstitial nephritis and acute kidney injury. *Pharmacoepidemiol Drug Saf*, 2012. 21(11):1155-1172.
28. Academy of Nutrition and Dietetics. Chronic Kidney Disease (CKD) Evidence-Based Nutrition Practice Guideline. https://www.andeal.org/files/files/CKD/CKD2020_Comparison_Table_20200820.pdf. Accessed October 10, 2023.
29. Kramer H, Jimenez EY, Brommage D et al. Medical nutrition therapy for patients with non-dialysis dependent chronic kidney disease: barriers and solutions. *J Acad Nutr Diet*. 2018 Oct;118(10):1958-1965.
30. Chan MR, Dall AT, Fletcher KE, et al. Outcomes in Patients with Chronic Kidney Disease Referred Late to Nephrologists: A Meta-analysis. *Am J Med* 2007;120:1063-70.e2.
31. Vassalotti JA, DeVinney R, Lukasik S et al. CKD quality improvement intervention with PCMH integration: health plan results. *Am J Manag Care*. 2019 Nov 1;25(11):e326-e333.
32. Scholle SH, Ontad K, Hart A, Hwee T. Chronic kidney disease disparities: educational guide for primary care. Prepared for the Centers for Medicare and Medicaid Services (CMS) by the National Committee for Quality Assurance (NCQA). 2021 April:1-19.

33. Tummalapalli SL, Powe NR, Keyhani S. Trends in quality of care for patients with CKD in the United States. *Clin J Am Soc Nephrol*. 2019 Aug 7;14(8):1142-1150.
34. Norton J, Moxey-Mims MM, Eggers PW et al. Social determinants of racial disparities in CKD. *J Am Soc Nephrol*. 2016 Sep;27(9):2576-95.
35. Crews DC and Novick TK. Social determinants of CKD hotspots. *Semin Nephrol*. 2019 May;39(3):256-262.
36. Tucker KJ. Social justice as a tool to eliminate inequities in kidney disease. *Semin Nephrol*. 2021 May;41(3):203-210.
37. Crews DC, Pfaff T, Powe NR. Socioeconomic factors and racial disparities in kidney disease outcomes. *Semin Nephrol*. 2013 Sep;33(5):468-75.
38. Sevin C, Moore G, Shepherd J et al. Transforming care teams to provide the best possible patient-centered, collaborative care. *J Ambul Care Manage*. 2009 Jan-Mar;32(1):24-31.
39. Tuot DS and Powe NR. Chronic kidney disease in primary care: an opportunity for generalists. *J Gen Intern Med* 2011 Feb; 26(4):356–8.
40. Neumiller JJ, Shubrook JH, Manley T et al. Optimizing use of SGLT2 inhibitors and other evidence-based therapies to improve outcomes in patients with type 2 diabetes and chronic kidney disease: An opportunity for pharmacists. *Am J Health Syst Pharm*. 2022 Jan 1;79(1):e65-e70.
41. Strand MA, DiPietro MNA, Hall L et al. Pharmacy contributions to improved population health: expanding the public health roundtable. *Prev Chronic Dis* 2020 17:200350.
42. Norton JM, Kaltun A, Jurkovitz CT et al. Development and validation of a pragmatic electronic phenotype for CKD. *Clin J Am Soc Nephrol*. 2019 Sep 6;14(9):1306-1314.
43. Shang N, Khan A, Polubriaginof F et al. Medical records-based chronic kidney disease phenotype for clinical care and "big data" observational and genetic studies. *npj Digital Medicine* 2021 4:70.
44. van der Scheer JW, Woodward M, Ansari A et al. How to specify healthcare process improvements collaboratively using rapid, remote consensus-building: a framework and a case study of its application. *BMC Med Res Methodol*. 2021 21:103:1-16.
45. Moise N, Cene CW, Tabak RG et al. Leveraging implementation science for cardiovascular health equity: a scientific statement from the American Heart Association. *Circulation*. 2022;146:e260–e278.
46. ElSayed NA, Allepo G, Aroda VR et al. 11. Chronic kidney disease and risk management: standards of care in diabetes—2023. *Diabetes Care* 2023;46(Supplement_1):S191–S202.
47. Inker LA, Astor BC, Fox CH et al. KDOQI US Commentary on the 2012 KDIGO Clinical Practice Guideline for the Evaluation and Management of CKD. *Am J Kidney Dis*. 2014;63(5):713-735.
48. Handelsman Y, Anderson JE, Bakris G et al. DCRM Multispecialty Practice Recommendations for the management of diabetes, cardiorenal, and metabolic diseases. *J Diabetes Complications*. 2022;36(2):1-22.
49. Navaneethan SD, Zoungas S, Caramori ML et al. Diabetes management in chronic kidney disease: synopsis of the KDIGO 2022 clinical practice guideline update. *Ann Intern Med*. 2023;176:381-387.
50. KDIGO 2021 Clinical Practice Guideline for the Management of Blood Pressure in Chronic Kidney Disease. *Kidney International* 2021 99:S1–S87.
51. Taler SJ, Afarwal R, Bakris GL et al. KDOQI US commentary on the 2012 KDIGO clinical practice guideline for management of blood pressure in CKD. *Am J Kidney Dis*. 2013; Aug; 62(2):201–213.
52. de Boer IH, Khunti K, Sadusky T, et al. Diabetes management in chronic kidney disease: a consensus report by the American Diabetes Association (ADA) and Kidney Disease: Improving Global Outcomes (KDIGO). *Kidney Int*. 2022 Nov;102(5):974-989.
53. Yau K, Dharia A, Alrowiyti I et al. Prescribing SGLT2 inhibitors in patients with CKD: expanding indications and practical considerations. *Kidney Int Rep* (2022) 7,1463–1476.
54. Tuttle KR, Brosius FC, Cavender, MA et al. SGLT2 inhibition for CKD and cardiovascular disease in type 2 diabetes: report of a scientific workshop sponsored by the National Kidney Foundation. *Am J Kidney Dis*. 2021 Jan;77(1):94-109.
55. Arnett DK, Blumenthal RS, Albert MA et al. 2019 ACC/AHA guideline on the primary prevention of cardiovascular disease: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *J Am Coll Cardiol*. 2019 Sep, 74 (10) e177–e232.
56. Wanner C, Tonelli M and the Kidney Disease: Improving Global Outcomes (KDIGO) Lipid Guideline Development Work Group Members KDIGO Clinical Practice Guideline for Lipid Management in CKD: summary of recommendation statements and clinical approach to the patient. Kidney International (2014) 85, 1303–1309.
57. Ikizler TA, Burrowes JD, Byham-Gray LD et al. KDOQI clinical practice guideline for nutrition in CKD: 2020 update. *Am J Kidney Dis*. 2020;76(3)(suppl 1):S1-S107.
58. Pai AB. Keeping kidneys safe: The pharmacist's role in NSAID avoidance in high-risk patients. *J Am Pharm Assoc* (2003). 2015 Jan-Feb;55(1):e15-23.
59. Keohane DM, Dennehy T, Keohane KP et al. Reducing inappropriate non-steroidal anti-inflammatory prescription in primary care patients with chronic kidney disease. *Int J Health Care Qual Assur*. 2017 Aug 14;30(7):638-644.
60. Baker M and Perazella MA. NSAIDs in CKD: are they safe? *Am J Kidney Dis*. 2020 Oct;76(4):546-557.
61. Plantinga L, Grubbs V, Sarkar U et al. Nonsteroidal anti-inflammatory drug use among persons with chronic kidney disease in the United States. *Ann Fam Med*. 2011 Sep-Oct;9(5):423-30.
62. Tuot DS, Plantinga LC, Judd SE et al. Healthy behaviors, risk factor control and awareness of chronic kidney disease. *Am J Nephrol* (2013) 37 (2): 135–143.
63. Tangri N, Stevens LA, Griffith J et al. A predictive model for progression of chronic kidney disease to kidney failure. *JAMA* 2011 Apr 20;305(15):1553-9.
64. EH De Marchis, Brown E, Aceves BA et al. SCREEN Report: state of the science executive summary on social screening in healthcare settings. Summer 2022.
65. National Association of Community Health Centers, Inc., Association of Asian Pacific Community Health Organizations, and the Oregon Primary Care Association. March 2019.

66. Chronic Kidney Disease Prevention, Early Recognition, and Management. Department of Veterans Affairs, Veterans Health Administration, Washington, DC 20420. March 17, 2020.

67. Moulin JC, Dickson KS, Stadnick NA et al. Ten recommendations for using implementation frameworks in research and practice. *Implement Sci Commun*. 2020 1:42.

68. Kaplan HC and Walsh KE. Context in implementation science. *Pediatrics* 2022 (149);Supplement 3.

69. Waltz TJ, Powell BJ, Fernandez ME et al. Choosing implementation strategies to address contextual barriers: diversity in recommendations and future directions. *Implement Sci*. 2019 Apr 29;14(1):42.

70. Damschroder LJ, Reardon CM, Opra Widerquist MA et al. The updated consolidated framework for implementation research based on user feedback. *Implement Sci*. 2022 Oct 29: 2-16.

71. R. Rubin. It takes an average of 17 years for evidence to change practice-the burgeoning field of implementation science seeks to speed things up. Medical News & Perspectives. *JAMA* 2023;329(16):1333-1336.

72. Mendu ML, Ahmed S, Maron JK et al. Development of an electronic health record-based chronic kidney disease registry to promote population health management. *BMC Nephrol* 2019 20:72.

73. Litvin CB, Hyer M and Ornstein SM. Use of clinical decision support to improve primary care identification and management of chronic kidney disease (CKD). *J Am Board Fam Med*. 2016 Sep-Oct;29(5):604-12.

74. Mendu ML, Schneider LI, Aizer AA et al. Implementation of a CKD checklist for primary care providers. *Clin J Am Soc Nephrol*. 2014 Sep 5;9(9):1526-35.

75. The American Journal of Managed Care. Symposium Recap, April 2023.

76. Cutts T, Gunderson G, Carter D et al. From the Memphis model to the North Carolina way: lessons learned from emerging health system and faith community partnerships. *North Carolina Medical Journal* 78 (4): 267–72.

77. Bullock A, Burrows NR, Narva AS et al. Vital Signs: decrease in incidence of diabetes-related end-stage renal disease among American Indians/Alaska Natives—United States, 1996–2013. *MMWR* 2017 (66)1:26-32.

78. Fernandez ME, Ten Hoor GA, van Lieshout S et al. Implementation mapping: using intervention mapping to develop implementation strategies. *Front. Public Health* 2019 7:158.

79. Damschroder LJ, Reardon CM, Opra Widerquist MA et al. The updated consolidated framework for implementation research based on user feedback. *Implement Sci*. 2022 Oct 29:2-16.

URL Resources

80. https://www.kidney.org/CKDIntercept/chronic-kidney-disease-data-analysis-strategy
81. https://www.kidney.org/sites/default/files/6.22.2023_ckdintercept-practice-assessment_v.2.pdf
82. https://www.sonichealthcareusa.com/media/wcoi520n/33807-ckd-booklet-update_digital-spread-_ada.pdf
83. https://www.labcorp.com/data/diagnostic-assistant
84. https://www.ncqa.org/hedis/measures/kidney-health-evaluation-for-patients-with-diabetes/
85. https://www.aafp.org/family-physician/practice-and-career/getting-paid/coding/hierarchical-condition-category.html
86. https://cme.kidney.org/spa/courses/resource/2023-spring-clinical-meetings/event/home/posters/abstracts?abstractId=2633
87. https://www.cdc.gov/pcd/issues/2016/16_0221.htm
88. https://www.census.gov/programs-surveys/acs/data.html
89. https://www.ahrq.gov/sdoh/data-analytics/sdoh-data.html
90. https://data.cms.gov/tools/mapping-medicare-disparities-by-hospital
91. https://health.gov/healthypeople/objectives-and-data/browse-objectives/diabetes/increase-proportion-adults-diabetes-who-get-yearly-urinary-albumin-test-d-05
92. https://health.gov/healthypeople/objectives-and-data/browse-objectives/chronic-kidney-disease/increase-proportion-people-medicare-chronic-kidney-disease-who-get-recommended-tests-ckd-04
93. https://health.gov/healthypeople/objectives-and-data/browse-objectives/chronic-kidney-disease/increase-proportion-adults-chronic-kidney-disease-who-know-they-have-it-ckd-02
94. https://diabetesjournals.org/care/article/44/9/2025/138877/Chronic-Kidney-Disease-Testing-Among-At-Risk
95. https://pubmed.ncbi.nlm.nih.gov/31747237/
96. https://www.cms.gov/files/document/chronic-kidney-disease-disparities-educational-guide-primary-care.pdf
97. https://journals.lww.com/cjasn/fulltext/2019/08000/trends_in_quality_of_care_for_patients_with_ckd_in.8.aspx
98. https://journals.lww.com/jasn/fulltext/2016/09000/social_determinants_of_racial_disparities_in_ckd.8.aspx
99. https://www.seminarsinnephrology.org/article/S0270-9295(19)30009-9/fulltext
100. https://www.seminarsinnephrology.org/article/S0270-9295(21)00071-1/fulltext
101. https://www.seminarsinnephrology.org/article/S0270-9295(13)00085-5/fulltext
102. https://health.gov/healthypeople/priority-areas/health-equity-healthy-people-2030
103. https://intermountainnv.org/blog/the-benefit-of-interdisciplinary-teams-in-healthcare/
104. https://journals.lww.com/ambulatorycaremanagement/fulltext/2009/01000/transforming_care_teams_to_provide_the_best.5.aspx
105. https://link.springer.com/article/10.1007/s11606-011-1650-8
106. https://pubmed.ncbi.nlm.nih.gov/34185826/
107. https://www.cdc.gov/pcd/collections/Public_Health_and_Pharmacy.htm
108. https://cpesn.com/
109. https://www.kidney.org/content/laboratory-engagement-initiative-lei
110. https://journals.lww.com/cjasn/fulltext/2019/09000/development_and_validation_of_a_pragmatic.8.aspx
111. https://www.nature.com/articles/s41746-021-00428-1
112. https://phekb.org/phenotype/chronic-kidney-disease
113. https://www.kidney.org/NKF-Community-Health-Workers
114. https://www.amjmed.com/article/S0002-9343(15)00855-4/fulltext
115. https://www.kidney.org/CKDIntercept/chronic-kidney-disease-data-analysis-strategy
116. https://bmcmedresmethodol.biomedcentral.com/articles/10.1186/s12874-021-01288-9
117. https://www.ahajournals.org/doi/suppl/10.1161/CIR.0000000000001096
118. https://diabetesjournals.org/care/article/46/Supplement_1/S191/148040/11-Chronic-Kidney-Disease-and-Risk-Management
119. https://www.kidney-international.org/article/S0085-2538(22)00507-5/fulltext
120. https://www.ajkd.org/article/S0272-6386(14)00491-0/fulltext
121. https://www.sciencedirect.com/science/article/pii/S1056872721003251?via%3Dihub
122. https://www.acpjournals.org/doi/10.7326/M22-2904
123. https://www.ascp.org/content/docs/default-source/get-involved-pdfs/istp_choosingwisely/ascp-35-things-list_2020_final.pdf
124. https://www.healthquality.va.gov/guidelines/cd/ckd/index.asp
125. https://www.aafp.org/family-physician/patient-care/clinical-recommendations/all-clinical-recommendations/highbloodpressure.html
126. https://kdigo.org/wp-content/uploads/2016/10/KDIGO-2021-BP-GL.pdf
127. https://www.ajkd.org/article/S0272-6386(13)00680-X/fulltext
128. https://diabetesjournals.org/clinical/issue/41/1
129. https://www.niddk.nih.gov/health-information/professionals/clinical-tools-patient-management/diabetes/guiding-principles-care-people-risk-diabetes
130. https://www.kidney-international.org/article/S0085-2538(22)00634-2/fulltext
131. https://www.kireports.org/article/S2468-0249(22)01372-9/fulltext
132. https://www.ajkd.org/article/S0272-6386(20)30934-3/fulltext
133. https://www.jacc.org/doi/10.1016/j.jacc.2019.03.010?_ga=2.247198532.1331522468.1682105%20431-1735207651.1680541642

134. https://www.kidney-international.org/article/S0085-2538(15)56385-0/fulltext
135. https://www.ajkd.org/article/S0272-6386(20)30726-5/fulltext
136. https://www.japha.org/article/S1544-3191(15)30021-2/fulltext
137. https://pubmed.ncbi.nlm.nih.gov/28809591/
138. https://www.ajkd.org/article/S0272-6386(20)30724-1/fulltext
139. https://www.annfammed.org/content/9/5/423
140. https://karger.com/ajn/article/37/2/135/41361/Healthy-Behaviors-Risk-Factor-Control-and Awareness of Chronic Kidney Disease
141. https://kidneyfailurerisk.com/
142. https://jamanetwork.com/journals/jama/fullarticle/897102
143. https://www.cms.gov/files/document/zcodes-infographic.pdf
144. https://www.kidney.org/atoz/content/kidneydiscauses
145. https://health.gov/healthypeople/priority-areas/social-determinants-health
146. https://www.cms.gov/files/document/chronic-kidney-disease-disparities-educational-guide-primary-care.pdf
147. https://www.cdc.gov/nccdphp/dch/pdf/HealthEquityGuide.pdf
148. https://www.aafp.org/family-physician/patient-care/the-everyone-project/toolkit.html
149. https://www.ahrq.gov/sdoh/data-analytics.html
150. https://sirenetwork.ucsf.edu/tools-resources/resources/screen-report-state-science-social-screening-healthcare-settings
151. https://aapcho.org/wp-content/uploads/2021/02/NACHC_PRAPARE_ALL-Updated-8.24.20.pdf
152. https://confluence.hl7.org/display/GRAV/The%2BGravity%2BProject
153. https://www.nimhd.nih.gov/resources/phenx/
154. https://uniteus.com/
155. https://www.va.gov/vhapublications/ViewPublication.asp?pub_ID=8737
156. https://www.niddk.nih.gov/health-information/professionals/clinical-tools-patient-management/kidney-disease/identify-manage-patients/manage-ckd/collaborate-nephrologist
157. https://dihi.org/project/building-a-virtual-medical-neighborhood-for-chronic-kidney-disease-in-duke-primary-care/
158. https://implementationsciencecomms.biomedcentral.com/articles/10.1186/s43058-020-00023-7
159. https://www.fic.nih.gov/About/center-global-health-studies/neuroscience-implementation-toolkit/Pages/methodologies-frameworks.aspx
160. https://publications.aap.org/pediatrics/article/149/Supplement%203/e2020045948C/184818/Context-in-Implementation-Science?autologincheck=redirected
161. https://implementationscience.biomedcentral.com/articles/10.1186/s13012-019-0892-4
162. https://re-aim.org/resources-and-tools/
163. https://www.ihi.org/resources/Pages/Tools/PlanDoStudyActWorksheet.aspx
164. https://www.ahrq.gov/health-literacy/improve/precautions/tool2b.html
165. https://implementationscience.biomedcentral.com/articles/10.1186/s13012-022-01245-0
166. https://cfirguide.org/
167. https://www.aafp.org/family-physician/practice-and-career/managing-your-practice/quality-improvement-basics.html
168. https://www.acponline.org/practice-resources/quality-improvement-in-healthcare-acp-resources-and-programs
169. https://jamanetwork.com/journals/jama/article-abstract/2803716
170. https://www.ahrq.gov/evidencenow/tools/keydrivers/create-care-teams.html
171. https://archive.ahrq.gov/ncepcr/tools/transform-qi/index.html
172. https://www.ahrq.gov/evidencenow/tools/index.html
173. https://bmcnephrol.biomedcentral.com/articles/10.1186/s12882-019-1260-y
174. https://intermountainhealthcare.org/ckr-ext/Dcmnt?ncid=521395847
175. https://www.niddk.nih.gov/research-funding/research-programs/kidney-clinical-research-epidemiology/health-information-technology/development-electronic-ckd-care-plan?dkrd=hisce0104
176. https://cds.ahrq.gov/cdsconnect
177. https://www.kidney.org/sites/default/files/CKD-Decision-Support-Litvin.pdf
178. https://www.kidney.org/sites/default/files/02-10-6800_ABG_PCPI_Algorithm2.pdf
179. https://journals.lww.com/cjasn/fulltext/2014/09000/implementation_of_a_ckd_checklist_for_primary_care.7.aspx
180. https://ecqi.healthit.gov/ecqm/ec/2023/cms951v1
181. https://www.cms.gov/priorities/innovation/files/worksheets/ahcm-screeningtool.pdf
182. https://www.ahrq.gov/evidencenow/tools/social-needs-tool.html
183. https://uniteus.com/nowpow-login/
184. https://www.211.org/
185. https://www.auntbertha.com/widget/660x234?c=2F8BC5&d=connectva
186. https://www.sahfnet.org/
187. https://www.neighborworks.org/home
188. https://www.communityhousingpartners.org/
189. https://www.acponline.org/clinical-information/high-value-care/resources-for-clinicians/high-value-care-coordination-hvcc-toolkit
190. https://www.niddk.nih.gov/health-information/professionals/clinical-tools-patient-management/kidney-disease/identify-manage-patients/manage-ckd/collaborate-registered-dietitian?dkrd=hisce0071
191. https://www.niddk.nih.gov/health-information/professionals/education-cme?dkrd=hisce0076

193. https://www.ahrq.gov/ncepcr/care/coordination.html
194. https://www.kidney.org/kidney-basics
195. https://www.kidney.org/atoz/content/patient-education-brochures
196. https://www.kidney.org/atoz/content/patient-education-2-sided-flyers
197. https://kidneyschool.org/mods/
198. https://www.kidney.org/peers
199. https://www.niddk.nih.gov/health-information/community-health-outreach/family-reunion-kidney-health-guide
200. https://www.niddk.nih.gov/health-information/community-health-outreach/kidney-sundays-toolkit
201. https://cdn.sanity.io/files/0vv8moc6/ajmc/06014639d2784560873ae6cd3532a26bbeb07ac7.pdf/EBO_AJP1213_Seagen_ConferenceRecap_PDF.pdf
202. https://ncmedicaljournal.com/article/54879
203. https://www.ncqa.org/kidney-health-toolkit/
204. https://ckdmobileapps.ipro.org/
205. https://www.niddk.nih.gov/health-information/professionals/clinical-tools-patient-management/kidney-disease
206. https://archive.ahrq.gov/ncepcr/tools/transform-qi/index.html
207. https://www.cdc.gov/mmwr/volumes/66/wr/pdfs/mm6601e1.pdf
208. https://www.frontiersin.org/articles/10.3389/fpubh.2019.00158/full
209. https://www.ahrq.gov/evidencenow/tools/diy-run-chart.html