

Development of an EHR-based CKD Registry for Use in Clinical Research and Improvement of Patient Outcomes

Cleveland Clinic, Glickman Urological and Kidney Institute

Setting & Background

Lead Organization: Cleveland Clinic Health System

Key Partners: State Health Department (for mortality data)

Cleveland Clinic Structure & Organization: The Cleveland Clinic Health System is an integrated delivery network serving an estimated 1.5 million people. It is comprised of:

- Cleveland Clinic main hospital, with 1,400 beds;
- Eight community hospitals, and
- More than 90 outpatient care locations—18 full-service family health centers—in northern Ohio.

Patient services at Cleveland Clinic are delivered through institutes, each based around a single disease or organ system. Institutes combine medical and surgical services, along with research and education, under unified leadership. The Glickman Urological and Kidney Institute's has over 100 physicians and scientists that provided care to nearly 15,000 patients in 2013.

Target Population: Patients with CKD served by Cleveland Clinic

Electronic health record (EHR) platform: Cleveland Clinic uses an integrated ambulatory and inpatient EHR system with a common patient index (Epic, Epic Corp, Verona, WI). This system has been in use since 2002. Since 2009, ePrescription has been in use. EHR use is mandated for scheduling, order entry, documentation of progress notes, results, review, medication management, and provider/provider and provider/patient communication.

Data Sources: The primary source of data is the EHR (demographic, clinical, and laboratory). Other data sources include:

- ICD-9 codes – for CKD and other comorbid conditions;
- U.S. Renal Data System (USRDS) – for progression to end-stage renal disease (ESRD);
- Social Security Death Index; and
- State of Ohio mortality data.

Other HIT Specifications: Clinical Data Repository (Clarity [Oracle Database], Epic Systems, Verona, WI).

Time period: 2005 to present

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Introduction

Cleveland Clinic's EHR has been used to create and maintain a CKD registry with patients qualifying for inclusion since 2005 to the present. Initial funding for the registry was provided through an unrestricted educational grant to the Department of Nephrology and Hypertension. Later, an NIH Planning Grant (R34) and support from a local foundation provided support for the registry.

The registry includes demographic information, critical parameters, and outcome measurements for more than 95,000 patients and allows tracking of CKD management across the entire spectrum of care. Registry data form the basis for ongoing research projects and the clinic is initiating collaborative research projects with other institutions.

In development of the registry, the team focused on the EHR since it provides more reliable longitudinal data (containing data related to health care delivery such as physician visits, lab testing, screening procedures, etc.). In developing the registry the team developed and validated criteria to identify CKD patients.

The CKD registry was the first comprehensive EHR based disease-specific registry developed at the Cleveland Clinic. For members of the team—both clinicians and IT staff—it was an exciting process. Several of the original team members are still involved in the maintenance of the registry.

While the registry was developed to aid research activities, it is also supporting quality improvement activities. Each year, the Clinic releases an “Outcomes Book” that documents key clinical outcomes, by institute, and is designed as a tool for clinicians to provide transparency to patients. The Outcome Books are available at:

<https://my.clevelandclinic.org/about-cleveland-clinic/quality-patient-safety/treatment-outcomes>.

The registry has helped to support collaboration with other specialties within the Clinic, such as cardiology and pulmonary medicine.

The Institutional Review Board of the Cleveland Clinic Foundation approved the inception and ongoing use of this registry.

Methods

Registry Development

The main steps for developing and maintaining the registry included:

- Establishing and maintaining the team;
- Setting objectives;
- Determining rules and data elements;
- Validating data elements;
- Modifying data sources;
- Maintaining the registry; and
- Sustaining the registry (i.e., securing resources).

Establishing and Maintaining the Team

A multidisciplinary team developed the registry. Over the years, the team has met twice a month to discuss issues related to the registry, such as review of existing projects and planning for future projects. In addition to the weekly meetings, the team has held regular retreats where they address broader issues such as revising rules (i.e., data elements) and necessary modifications over time (e.g., integration of ICD-10).

While individual members have changed over time, the team continues to have members representing key elements within Cleveland Clinic:

- Nephrologists
- Primary care physicians (internists)
- eResearch Division (where electronic data warehouse is housed) – The division extracts clinical data from the EHR and helps clinical researchers develop databases for use in research
- Quantitative Health Sciences Research Data Center (statistical analysis)

Including internists in the design of the registry was critical since not all patients with CKD receive care from a nephrologist. In addition, the multidisciplinary approach helped to promote the registry within the institution. Team members went back to their peers and shared information about the registry.

Setting Objectives

The team identified objectives for the registry. The goal of the registry is to identify CKD patients earlier and systematically in order to develop programs for these patients. Data are also used for outcomes research and to create intervention programs to improve CKD care.

Determining Rules and Data Elements

To identify patients with CKD who were not receiving CKD care at Cleveland Clinic, the team focused on data elements related to GFR values and follow up.

Cleveland Clinic has an “opt in” policy for the handling of patient data. The Clinic has limitations on sharing of data outside of the institution. Raw data cannot be shared—only aggregated data is sharable.

The registry includes patients who have had at least one face-to-face outpatient encounter with a Clinic health care provider and:

- Had two outpatient estimated GFR values $<60 \text{ ml/min/1.73m}^2$ at least 90 days apart from January 1, 2005 to the present; and/or
- Were patients with International Classification of Diseases-9 (ICD-9) diagnosis codes for CKD, Polycystic kidney disease, glomerulonephritis, diabetic nephropathy, hypertensive nephrosclerosis, or renovascular disease from January 1, 2005 to the present.

Excluding patients:

- <18 years of age
- Already diagnosed with end-stage renal disease (ESRD) needing dialysis or renal transplant
- With serum creatinine $>20 \text{ mg/dl}$

Data Element	Description
Serum Creatinine	All outpatient serum creatinine measurements for the study population are performed in the same clinical laboratory, which uses integrated database management system—traceable samples to minimize calibration bias.
eGFR	eGFR is calculated using the recommended four-variable Modification of Diet in Renal Disease equation for all patients who had at least two outpatient serum creatinine values. Patients who meet the definition of CKD using the Chronic Kidney Disease Epidemiology Collaboration equation are also identified

Covariates	In order to understand the potential explanatory factors or covariates that may impact CKD and its outcomes additional data are extracted. These include data related to various covariates that can be broadly classified into the following data elements: demographics, comorbid conditions, medications, laboratory, imaging, and clinical measures.
Outcomes (Death/ESRD)	Initially the registry included data from the United States Renal Data System (USRDS) and the Social Security Death Index (SSDI) to identify patients who have progressed to ESRD and who had died. Acquiring cause-specific death data can be expensive. A major change in the registry was to pursue a relationship with the State Health Department to obtain mortality data. Ohio provides data to the CDC/National Death Index, and the USRDS also obtains mortality from the NDI. The Clinic was able to obtain data directly through the state. This relationship continues to this day.

Additional detail on the inclusion criteria are provided in [Development and Validation of an Electronic Health Record-Based Chronic Kidney Disease Registry, Clinical Journal of the American Society of Nephrology](#). Complete tables of [data elements](#) and [ICD-9 codes](#) are also included.

Validating Data Elements

Validation of the CKD registry against the EHR was performed in two stages. Two reviewers used various sections of the EHR such as problem list, physician notes, laboratory reports, and imaging results based on pre-specified validation criteria developed for the selected CKD registry conditions. Blind reviews were conducted using pre-specified validation criteria developed by an expert panel of nephrologists. Discussions were conducted with a third reviewer when discordance arose.

The diagnosis, inclusion criteria, and primary comorbidities included in the registry were validated against the EHR:

- Twenty (20) randomly selected charts were reviewed to ensure ICD-9 codes used as inclusion criteria in the CKD registry captured those patients with CKD who may or may not know they have abnormal eGFR.
- A total of 184 charts were reviewed to validate comorbid disease conditions (diabetes mellitus, hypertension, coronary artery disease, cerebrovascular disease, congestive heart failure, and hyper-lipidemia) included in the CKD registry.

Statistical Analysis

Unix SAS 9.4 (SAS Institute, Cary, NC) is used for all descriptive statistical analyses. Patients are classified using the Kidney Disease Outcomes and Quality Initiative (KDOQI) guidelines into various stages of CKD (stage 3 CKD, eGFR 30 to 59 ml/min per 1.73 m²; stage 4 CKD, eGFR 15 to 29 ml/min per 1.73 m²; stage 5 CKD, eGFR < 15 ml/min per 1.73 m²). Sensitivity and specificity were calculated to measure the accuracy of recording presence/absence of ICD-9 codes used for diagnosis related to kidney diseases and the six most important comorbid disease conditions. The kappa statistic to assess the extent of agreement between the administrative dataset derived from the EHR and actual EHR chart review was calculated. The kappa statistic was categorized into five groups: 0.81 to 1.00 (near perfect agreement), 0.61 to 0.80 (substantial agreement), 0.41 to 0.60 (moderate agreement), 0.21 to 0.40 (fair agreement), and <0.20 (poor agreement).

Substantial to near perfect agreement (≥ 0.61) was noted for all conditions except coronary artery disease and hypertension, which had moderate agreement (0.60 and 0.45 respectively). Both sensitivity and specificity were $>80\%$ in the majority of conditions, along with similarly high positive and negative predictive values, indicating that EHR-based identification of the conditions that were validated are reliable.

Modifying Data Sources

The registry originally included data from the United States Renal Data System (USRDS) and the Social Security Death Index (SSDI) to identify patients who have progressed to ESRD or who had died. A major change in the registry was to pursue a relationship with the state health department to obtain mortality data. Obtaining data from the state health department represents a significant cost savings.

Sustaining the Registry

To maintain the registry requires staff from both eResearch and the Quantitative Health Sciences Department. IT staff (approximately .5 FTE) ensure the flow of data into the registry and monitor data quality. Statistical analysts (approximately .5 – 1 FTE) provide ongoing statistical support. The registry is updated approximately every 3 months.

Data Storage

Demographic, clinical, and laboratory data from the EHR are stored in the Clarity Oracle Database. Data access is maintained by eResearch (Clarity, Epic Systems, Verona, WI). Data are extracted and loaded into the CKD Registry Oracle database which is managed in the clinic's Quantitative Health Sciences Department.

Results

The registry:

- **Includes over 95,000 CKD patients.**
- **Supports recruitment of patients for clinical trials.** Researchers can identify qualifying patients, their primary care providers, and the location where they receive care (to pursue recruitment). For example, 209 participants were recruited over a 14 month period for the NIH-sponsored Patient Navigator study (Jolly 2015) described below. Additionally, the registry has been used to recruit patients for the Chronic Renal Insufficiency Cohort (CRIC) Study and the Systolic Blood Pressure Intervention Trial (SPRINT).
- **Enables quality improvement efforts.** For example, the registry has been used to compare nurse practitioner and nephrologist led CKD care.
- **Enables innovative interventions targeting patients with CKD.** For example, Cleveland Clinic implemented a Patient Navigator program similar to those used in oncology. An ongoing study (Jolly 2015) is currently collecting data to explore the clinical impact of two interventions: 1) CKD Patient Navigator; and 2) use of an enhanced personal health record. The two interventions will be compared to usual care for CKD Stage 3b/4 in a randomized controlled trial using a factorial design. The results of this clinical trial will be available in Spring 2016.

Facilitators

- Participation of a multidisciplinary team from inception.
- Clinicians, IT staff, and statisticians learning to “speak the same language” through regular meetings and collaboration.

- Careful consideration of rules and data elements up front. The team stresses the importance of putting much thought into the establishment of rules. Even after a thoughtful process they realized later that the dataset did not include all the necessary data elements. It can be difficult to add these later in the process.
- Establishment and maintenance of beneficial partnerships (e.g., state health department).

Limitations

Limitations related to the CKD registry include:

- Misclassification of some patients as normal who have true kidney disease may occur if two serum creatinine levels are not measured.
- Registry patients were identified based on eGFR and ICD-9 diagnosis codes only; therefore, patients with stage 1 and 2 CKD, in the absence of documented kidney disease, were not included.
- Patients may seek care outside the Cleveland Clinic network resulting in missing or incomplete data in the registry.
- Although the registry contains details of when medications are prescribed and stopped by providers and medication reconciliation efforts at each encounter increase the accuracy, it is not possible to determine whether patients fill or adhere to these prescriptions.

Next Steps

The team has developed a registry of in-patient dialysis patients that captures all dialysis patients seen at various hospitals within the Cleveland Clinic Health System. The registry is used to track outcomes, such as readmissions and causes for readmissions. Information gleaned from the registry will be used to develop interventions.

Additional Resources

- **The Cleveland Clinic Glickman Urological and Kidney Institute Outcomes Book** summarizes surgical and medical trends and approaches, data on patient volume and outcomes, and a review of new technologies and innovations:
<https://my.clevelandclinic.org/ccf/media/Files/outcomes/2014/outcomes-guki.pdf>

References

Jolly SE, Navaneethan SD, Schold JD, Arrigain S, Konig V, Burrucker YK, Hyland J, Dann P, Tucky BH, Sharp JW, Nally JV. Development of a chronic kidney disease patient navigator program. *BMC Nephrol.* 2015 May 3;16:69. <http://www.ncbi.nlm.nih.gov/pubmed/26024966>

Navaneethan SD, Jolly SE, Schold JD, Arrigain S, Saupe W, Sharp J, Lyons J, Simon JF, Schreiber MJ, Jain A, Nally JV. Development and validation of an electronic health record-based chronic kidney disease registry. *Clin J Am Soc Nephrol.* 2011 Jan;6(1):40-9.
<http://www.ncbi.nlm.nih.gov/pubmed/21051745>

Navaneethan SD, Jolly SE, Sharp J, Jain A, Schold JD, Schreiber MJ, Nally JV. Electronic health records: a new tool to combat chronic kidney disease? *Clin Nephrol.* 2013 Mar;79(3):175-83.
<http://www.ncbi.nlm.nih.gov/pubmed/23320972>