

Development and Implementation of a Telenephrology Dashboard for Active Surveillance of Kidney Disease: A Quality Improvement Project

Melissa L Swee (✉ melissa-swee@uiowa.edu)

Iowa City VA Medical Center <https://orcid.org/0000-0002-1591-0862>

M. Lee Sanders

University of Iowa

Kantima Phisitkul

Iowa City VA Medical Center

George Bailey

Iowa City VA Medical Center

Angie Thumann

Iowa City VA Medical Center

Nikki Neuzil

Iowa City VA Medical Center

Bharat Kumar

Iowa City VA Medical Center

Amy MJ O'Shea

Iowa City VA Medical Center

Bradley S Dixon

Iowa City VA Medical Center

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Abstract

Background : Kidney disease accounts for more than 50 billion dollars in healthcare expenditures annually. Early detection and intervention may reduce the burden of disease. We describe a quality improvement project to develop a telenephrology dashboard that proactively monitors kidney disease. **Methods :** 184,000 Veterans within the Iowa City Veterans Affairs Health Care System were eligible for telenephrology consultation. The dashboard accessed the charts of 53,085 Veterans at risk for kidney disease. We utilized Lean-Six Sigma tools and principles and the Define-Measure-Analyze-Improve-Control Framework to develop and deploy a telenephrology dashboard in 4 community-based outpatient clinics (CBOCs). The primary measure was the number of days to complete consultation. Secondary measures included number of electronic consultations per month, distance and cost of Veteran travel saved, and number of steps for completion of consult. **Results :** The data of 1,384 Veterans at the 4 CBOCs were analyzed by the telenephrology dashboard, of which 459 generated telenephrology consults. The number of days to complete any type of consultation was unchanged (48.9 days in 2019, compared to 41.6 days in 2017). The average Veteran saved between \$21.60 to \$63.90 per trip to Iowa City. Between March 2019 and August 2019, there were 27.3 telenephrology consults per month. The number of steps needed to complete the consult request was decreased from 13 to 9. **Conclusions :** Utilization of the telenephrology dashboard system contributed to an increase in consultations completed through electronic means without decreasing face-to-face consults. Electronic consults now outnumber traditional face-to-face consultations at our institution. Telenephrology consultation improved early detection and identification of kidney disease and saved time and costs for Veterans in travel, but did not decrease the average number of days to complete consultation requests.

Background

Kidney disease is a major contributor to disease burden in the United States, affecting 30 million individuals,^[i] and accounting for more than 49 billion dollars per year in healthcare costs in the Medicare population alone.^[ii] Early detection of at-risk patients in primary care clinics and timely consultation with kidney specialists may potentially reduce this burden.^[iii] However, the lack of efficient coordination between primary care and nephrology clinics often leads to delays in care and missed opportunities for early intervention.

The development and utilization of dashboards may help to address this problem. In recent years, dashboards have been developed in several settings to pro-actively identify and manage conditions. Studies suggest that dashboards may help to improve adherence to quality guidelines and improve patient outcomes.^[iv] Because the practice of nephrology is largely dependent upon monitoring of laboratory results and vital signs, development of a dashboard for kidney diseases is an appealing quality improvement approach.

The Iowa City Veterans Affairs (VA) Health Care System is a member of the Veterans Affairs Midwest Health Care Network that serves more than 184,000 Veterans living in 50 counties spread throughout the

mostly rural areas of Eastern Iowa, Western Illinois, and Northern Missouri. While the hospital and specialized clinics, including Nephrology, are headquartered in Iowa City, there are also 10 community-based outpatient clinics (CBOCs) in Iowa and Illinois that deliver primary care.[v] When specialist services are required, patients are either referred to the clinics in Iowa City or receive care in the community outside of the VA system. This often poses problems for coordination of care between primary care practitioners and nephrologists. This quality improvement initiative aims to facilitate such coordination through the development of a dashboard.

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Methods

This study was submitted to the Institutional Review Board at the Iowa City Veterans Affairs Health Care System. As a Quality Improvement initiative, it was exempt from full review.

We utilized Lean Six Sigma principles and tools as well as the Define-Measure-Analyze-Improve-Control (DMAIC) Framework to structure our intervention (Figure 1).

Study Sites and Participants

This initiative took place at 4 CBOCs within the state of Iowa: Ottumwa, Quincy, Galesburg, and Dubuque. These 4 CBOCs have 23 primary care practitioners (PCPs), of which 9 participated in the quality improvement project. These 9 PCPs serve approximately 9000 patients, of which 93% live in rural or very rural areas. Like in most VA settings, the majority of patients are male (in this case, 97.4%). Patients eligible for telenephrology consultation had chronic kidney disease Stage 3b or above (eGFR < 45), acute kidney injury, hematuria, or proteinuria. Patients who were already seeing a non-VA nephrologist were

excluded, and those that were seeing a VA nephrologist were screened to determine if there was a new complication that warranted a telenephrology consultation.

Defining and Measuring the Problem

At the start of this initiative, we drafted a project charter outlining the aims, scope, participants, outcomes, and benchmarks for the project. A multidisciplinary core team of two nephrologists (KP and MLS), two PCPs (DC and MH), a quality improvement scholar (MS), two nephrology nurse coordinators (AT and NN), one PCP nurse coordinator (TB), a health informatics expert (GB), and the chief of medical service (BSD) was assembled. PCPs and nephrologists were consulted at every step of drafting the project charter and developing protocols.

The primary impact measure was the number of days between the PCP entering an order for any type of nephrology consult and the nephrologist completing a consult note. In addition to traditional face-to-face encounters, we also included e-consults, where PCPs enter a consult order and nephrologists review the order without contacting the patient, and Clinical Video Telehealth (CVT) appointments, where encounters between nephrologists and patients are conducted through video conferencing technology. Administrative data in the three months prior to the initiation of the project were used to determine the baseline.

Secondary measures included the number of telenephrology consults and the amount and cost of travel per Veteran. These were obtained through administrative data and the electronic health record. Baseline operations were also documented through the creation of a process map (Figure 2). This process map depicts the way in which patients with kidney disease come into contact with nephrologists.

Analysis of Data

We obtained data from three major sources: (1) the electronic health record, (2) administrative data, and (3) transcripts of group interviews.

The electronic health record was used to obtain patient data, including serum creatinine, estimated glomerular filtration rate (eGFR), urine blood, urine protein-to-creatinine ratio, urine microalbumin, and systolic blood pressure (SBP).

Administrative data were collected for certain outcomes, such as the number of days to complete the consult, demographic profiles of patients (location, age, sex, and stated ethnicity) and number of new face-to-face, electronic, and telenephrology consults.

Lastly, we conducted interviews with PCPs, nephrologists, case managers, and Veterans, which were transcribed and analyzed by MS and AT.

Voice of the Customer

The investigative team identified a set of four key stakeholders: PCPs, nephrologists, clinic case managers, and Veterans. Throughout each step of the process, we consulted with the four key stakeholders. Group interviews with PCPs, nephrologists, and clinical case managers revealed three themes: (1) delay in getting patients to clinic, (2) concerns about increased workload, and (3) concerns about losing autonomy.

With regards to Veterans, individual interviews were conducted by AT. Veterans voiced frustration at delays in coordinating care and in travel to Iowa City for specialty consultation.

Process Mapping

Based on these insights, the investigative team examined the process map to identify areas for improvement and drafted a future state map (Figure 2). Of the 13 steps leading to one of two outcomes, there were 6 steps that were deemed to be non-value added, and only 1 non-value-added step was deemed necessary. This enabled the team to focus on developing approaches and solutions that would reduce or eliminate these steps altogether, and therefore, streamline nephrology care into PCP clinics.

Improvement and Refinement of Processes

Future State Maps

These efforts culminated in the development of a future state map composed of 9 steps leading to one of two outcomes: consultation or no consultation. All six non-value-added steps from the current state map were eliminated, but one non-value-added step was introduced in the future state map.

Plan-Do-Study-Act Cycles

We structured our improvement phase into five Plan-Do-Study-Act (PDSA) cycles: (1) dashboard design and development, (2) deployment at the Ottumwa CBOC, (3) refinement of parameters for Acute Kidney Injury (AKI), (4) prioritization of subgroups for consultation, and (5) full deployment at the 4 CBOC's (Figure 3).

Cycle 1: Dashboard Design and Development

The dashboard was developed using an iterative process that cycled through (1) collection of user requirements, (2) development of dashboard prototypes, and (3) evaluation of the prototypes. First, the six individuals who would use the dashboard (MS, MLS, KP, AT, GB, and BD) were assembled to collectively brainstorm potential dashboard features, leading to a list of 8 proposed features.

To better evaluate priorities for development and evaluation, the quality improvement team used the Kano evaluation model to better categorize features as 'Must-Have,' 'Attractive,' 'Indifferent,' 'Questionable,' 'Reverse,' or 'One-Dimensional' (Figure 4).^[i] Due to the small sample size of users and high degree of agreement, further calculation of satisfaction and dissatisfaction coefficients were not deemed necessary.

'Must-Have' features included data tables for serum creatinine, urine blood, and urine protein, graphs for kidney function over time, incorporation of prediction models for development of CKD, and use of color to mark indicators. 'Attractive' features included filtering of values based on user selection, sorting lab values and ability to drill down to specific events in time. One 'Indifferent' feature was identified: customization of views based on user, and one 'Reverse' feature was noted: automatic notifications of lab changes to users.

The 'Must-Have' and 'Attractive' features were incorporated into draft versions of the dashboard. Incorporation of the 'Indifferent' feature was reserved as an option for the future but there was no demand for its subsequent incorporation.

Cycle 2: Implementation – Pilot Site

We piloted the dashboard at the Ottumwa CBOC, the most rural of the CBOCs (97.3%), for 3 months. We utilized point-of-care observations to ensure that the dashboard was working effectively and without technical problems. After 12 weeks, we reviewed the data and conducted group interviews with the nephrologists, PCPs, and case managers to identify areas of further improvement. The large volume of telenephrology requests suggested a need to refine parameters for AKI and drove the next PDSA cycle.

Cycle 3: Refinement of Parameters for AKI

Because 16.8% of dashboard hits resulted in telenephrology consults, the nephrologists and PCPs were concerned that the dashboard was too sensitive in picking up changes in eGFR. Therefore, the quality improvement team used the Delphi method to refine the parameters for AKI, from values of predicted eGFR below the confidence interval for the 95th percentile to a 70% prediction interval. This reduced the number of dashboard notifications for AKI from 251 to 53.

Cycle 4: Prioritization of Subgroups for Telenephrology Consultation

Similarly, due to the high volume of dashboard hits, the quality improvement team sought to prioritize those who would theoretically obtain the greatest benefit from early telenephrology consultation. Veterans with projected progression to end-stage kidney disease within 5 years, and those whose age < 85 were prioritized, although all patients, regardless of age and risk of end-stage kidney disease were evaluated for possible telenephrology consultation. This change in workflow did not objectively change the number of eligible consults but rather facilitated triage of consults when volume was high.

Cycle 5: Implementation at Multiple Sites

At month 10, the team began to sequentially expand the number of sites from 1 to 4, while continuing to collect data on the primary and secondary outcomes. A major concern was increasing the yield of the dashboard so that there was appropriate sensitivity of the telenephrology dashboard for generating telenephrology consults. The addition of new PCPs at other sites also provided opportunities to explore how the program can expand the scope to all 10 CBOCs within the Iowa City VA Health Care System.

Control Plan

In order to build on these successes, the team composed a control and sustainability plan. This control and sustainability plan outlined how the project would continue to evolve beyond the initial 12 months. This included celebration of the short-term wins and dissemination of our data. Additionally, we derived protocols for sustaining telenephrology consultations for nephrologists and case managers (Supplement).

[i]. Bellamkonda VR, Kumar R, Scanlan-Hanson LN, et al. Pilot Study of Kano "Attractive Quality" Techniques to Identify Change in Emergency Department Patient Experience. *Ann Emerg Med.* 2016 Nov;68(5):553-561.

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Results

Dashboard Development

Based on the results of the Kano Analysis, GB developed the telenephrology dashboard software. The 'Attractive' and 'Must-Have' features were incorporated, as shown in Figure 5. After two iterations, the dashboard was finalized and ready for use on March 2018. Since that time, the dashboard has been accessed daily, principally by the telenephrology case manager (AT).

Process Measures

We identified 6 steps that were non-value-added, of which only 1 was necessary. Based on these, we constructed a future state map and worked towards its realization.

The future state map reduces the number of steps for completion of consultation from 13 to 9. Notable steps that were eliminated included triage by a nephrologist, scheduling the patient, and Veteran travel to the Iowa City nephrology clinic.

Primary outcome:

Throughout the project, we continued to look at the number of days to completing the consultation request for all face-to-face, electronic, and telenephrology consult orders. There was a change in average time from 41.6 days in 2017 to 28.6 days in 2018 and 48.9 days in 2019 (to July 2019), but these changes were not statistically significant ($p=0.57$).

Secondary outcomes:

Veteran Travel Time and Cost

We saved 47,718 miles of travel for the 459 Veterans in total (mean: 108 miles; median: 100 miles). This amounted to \$21.60 to \$63.90 saved per Veteran, depending on the formula used by the Internal Revenue Service to calculate standardized miles.

Telenephrology Consultations

We tracked the numbers of telenephrology consults per month over the course of the 21 months. As Figure 6 illustrates, the number of telenephrology and other electronic consultation methods has consistently outpaced traditional face-to-face consultation since March 2018, when the team started to utilize the dashboard. Since that time, the system has been largely in control with special cause variation in four of these months. In all of these cases, the number of such electronic consultations has actually exceeded the upper control limit. As of July 2019, the majority of these electronic consultations are now telenephrology consults (55.7%). Over the last six months of the project (March to August 2019), the average number of consults was 27.3 per month.

Discussion

Multiple lines of evidence suggest that early detection and management of kidney disease can help to guide more appropriate preventative care, prevent the onset of end-stage kidney disease, and possibly lower healthcare costs.^{7,8} This quality improvement project helps to address this challenge through the creation of a dashboard for telenephrology consultation. Our experience has important implications for both PCPs and nephrologists as healthcare systems are pressed to improve value and minimizing waste.

First and foremost, we demonstrated how complex healthcare systems can directly integrate nephrologist care into primary care clinics in a way that is dynamic, synergistic, and responsive. There have been trends in the modern American healthcare system towards increasing specialization and separation of nephrologists from primary care. This separation poses a set of challenges for patients that may lead to delays in obtaining care.^{9,10} The collaborative process between nephrologists and PCPs that led to the creation of this dashboard is an example of how technology and quality improvement methodologies can be employed to offset the adverse effects of increasing specialization.

Secondly, we have developed a simple, scalable, and flexible dashboard system to monitor kidney disease among patients receiving primary care in the Iowa City Veterans Affairs healthcare system. Dashboards have long been promoted as a means to monitor conditions and diseases, but the quality of

a dashboard depends largely upon usability. By using a systematic method to evaluate user needs and desires, we have created a program that is more likely to be integrated into the clinical environment and associated workflows. As the program grows, this systematic method can be employed once again for its redesign.

Thirdly, we have developed software to engage in proactive surveillance of kidney health. The quality improvement team discovered that the dashboard was initially too sensitive for acute kidney injury to be a meaningful instrument for early detection and intervention. Rather, it required refinement of parameters in order to prioritize those who would gain the most benefit from early detection, monitoring, and intervention.

Lessons Learned for Other Institutions

We have been able to successfully implement this telenephrology consult system using the dashboard tool described above. Our investigative team has gleaned several insights from our experience that may be informative for other institutions aiming to develop similar dashboards and telenephrology consult systems.

Most importantly, it is vital to develop a multidisciplinary team that represents the interests of various stakeholders. In our case, we ensured that nephrologists and PCPs were incorporated as core team members. Similarly, we relied upon the expertise of nephrology and primary care case managers to understand the less visible back-office processes that govern consultation behavior. The involvement of the Chief of Medical Services as the project sponsor, was instrumental in marshalling the resources, time, and talent to ensure the success of the program.

Secondly, projects of this scale demand close coordination and proactive planning. The drafting and ratification of a project charter enabled team members to better understand their positions and responsibilities. Benchmarks for dashboard development and implementation permitted the team to remain committed to the task at hand. Beyond our team members, we coordinated closely with the individual clinics, advertising the availability of this service and sought feedback from PCPs at the forefront.

Thirdly, we utilized the Kano Model to understand users' needs with respect to dashboard design. The Kano Model is a systematic manner in which features can be categorized and prioritized for development. While our nephrologists prioritized certain features on their individual experiences, interests, and concerns, specialists from other fields may have other priorities. Therefore, using the Kano Model may help to bolster the flexibility of the intervention.

Limitations

Despite the potential of this dashboard system to engage in active surveillance of kidney disease in PCP clinics, there remain some important limitations.

First, it is unclear how generalizable and sustainable our findings are, since our project was implemented in only four clinics in the states of Iowa and Illinois. These clinics are predominantly rural in nature. As with all quality improvement projects, it is important to replicate findings in other settings, and we are currently pursuing this approach throughout the Iowa City Veterans Affairs Health Care System.

Secondly, our primary outcome of reducing the time to complete consultation was not met. The high variability is a major reason why we could not detect a change; additionally, the volume of new patients identified by the telenephrology dashboard system likely mitigated reductions in the time to complete consult requests. Yet there were other benefits of the telenephrology consult system, including improved workflow, early detection of certain kidney diseases, and savings in cost and time for Veterans. Therefore, even if consultations were not completed more rapidly, the intervention helped to reduce unwarranted waste for patients and practitioners.

Thirdly, the overarching larger impact on kidney health, i.e. progression to end-stage renal disease, has not yet been studied. We intend on continuing this project and collecting data to understand how better integration of nephrology into PCP clinics through the dashboard impacts the progression of chronic kidney disease and proteinuria over longer periods of time.

Conclusions

We were able to develop a system of actively monitoring kidney disease through a telenephrology dashboard system, and deploy it in 4 predominantly rural community-based outpatient clinics. Although it did not result in decreased time to complete consultation, it enabled a larger volume of Veterans to receive specialist expertise within the context of their PCP clinics. The majority of nephrology consultations at our center are now completed electronically, and the majority of these consults are telenephrology consults. Veterans saved an average of \$20.60 to \$63.90 per trip to the nephrology clinic. The quality improvement team continues to adapt this intervention for wider scale implementation in all 10 community-based outpatient clinics in the Iowa City Veterans Affairs Health Care System.

Abbreviations

CBOC: Community-based outpatient clinics

CVT: Clinical Video Telehealth

DMAIC: Define-Measure-Analyze-Improve-Control

eGFR: estimated glomerular filtration rate

PCP: Primary care provider

PDSA: Plan-Do-Study-Act

SBP: Systolic blood pressure

VA: Veterans Affairs

Declarations

Ethical approval and consent to participate: This manuscript reports data from a retrospective analysis of a quality improvement project. The project was submitted to the Institutional Review Board at the Iowa City Veterans Affairs Health Care System and waived the need for review. The study was determined exempt under the provisions of 45 CFR 46 Section 101(b) as per the United States Health Insurance Portability and Accountability Act.

Consent for publication: Not applicable

Availability of data and materials: Not applicable

Competing interests: Bradley S. Dixon serves on a Data Safety & Monitoring Board for a clinical trial for Humacyte, Inc.

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Authors' contributions: MS and MLS collected, analyzed and interpreted the data for quality improvement; MS, MLS, and BK were major contributors in writing the manuscript. AO, KP, and BD provided oversight in analyzing and interpreting the data. GB designed the dashboard implemented in this project. AT and NN collected data. All authors read and approved the final manuscript.

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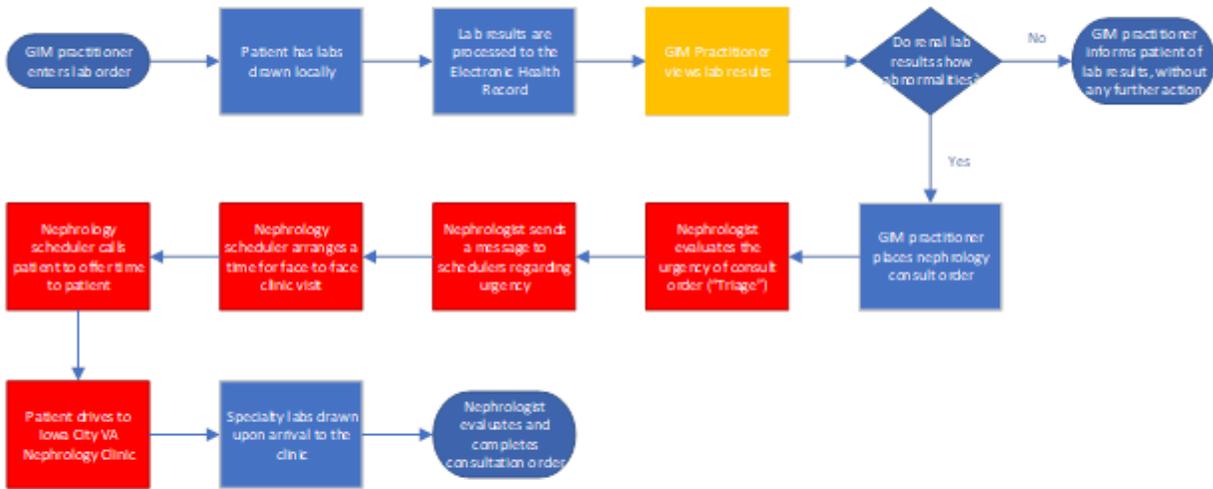
Figures

	Element of each step	Actions Performed by Core Investigators
Define	Problem statement	Project Charter was drafted, including a problem statement that articulated the background, specific needs, and aims of the project
	Goal statement	Articulated in the Charter: "Decrease number of days between the PCP entering an order for any type of nephrology consult and the nephrologist completing a consult note from 48.9 days to 30 days, by August 2019."
	Project scope	Articulated in the Charter: "This Lean Six Sigma project will take place 360 days from start to validated solutions"
	Identification of project sponsor	The Chief of Medical Services was identified and designed as the project sponsor
	Identification of process owner	The telenephrology Case Manager was identified and designated as the process owner
	Primary impact measure	Articulated in the Charter: "Number of days between primary care practitioner entering a consult and nephrologist performing chart review"
	Secondary impact measures	Travel time and costs saved by Veterans Number of telenephrology consults generated
Measure	Baseline operations	Chart review determined baseline number of days to completion of nephrology consultation Pre-Intervention Process Map
	Impact data	Project charter updated regularly based on performance
Analyze	Process mapping	Current process map from PCP entry of lab order to completion of consult order is shown in figure 2
	Voice of the customer	Veterans, PCPs, and Nephrology clinical staff (practitioners and case managers) interviewed Point-of-care observations performed
Improve	Future state maps	Future state map from PCP entry of lab order to completion of consult order is shown in figure 2
	Plan-Do-Study-Act cycles	Five PDSA cycles were performed
	Pilot results	Gaps between predicted and actual performance analyzed
Control	Development of a control plan	A control plan was drafted to summarize the process and take steps to ensure that the level of improvement is maintained and sustained
	Impact summary	A one-page impact summary was drafted with simplified language and diagrams for dissemination within the institution
	Recognition of work accomplished	Results of quality improvement project disseminated locally at institutional grand rounds and nationally at annual conferences Celebration of short-term wins

Figure 1

Overview of the Define-Measure-Analyze-Impact-Control (DMAIC) Framework. The Quality Improvement Team used the DMAIC Framework to guide the intervention.

Current Process Map



Future State Map

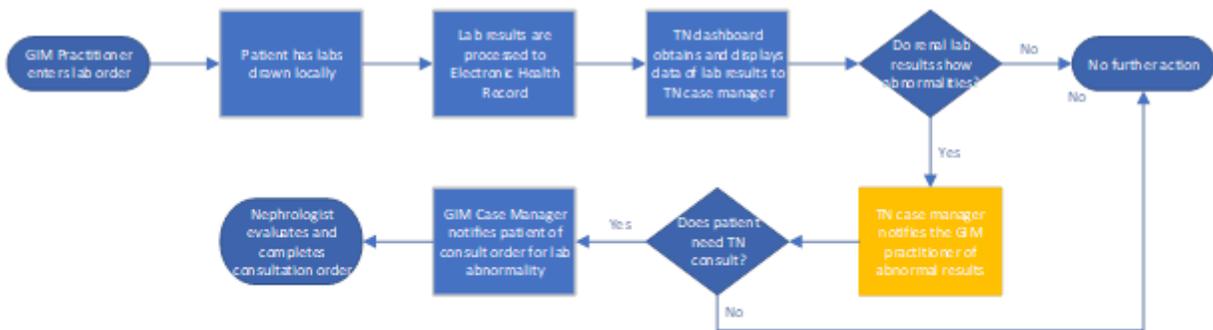


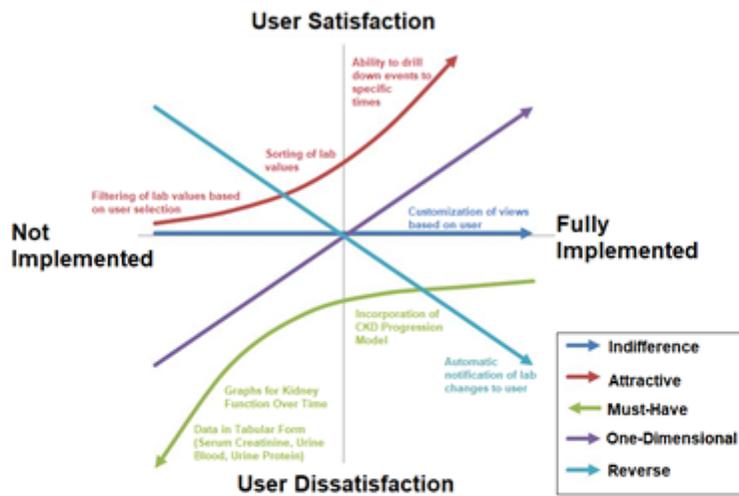
Figure 2

Current Process Map and Future State Map. Current process and future state maps were constructed. The current process map revealed 5 non-value-added unnecessary steps (shaded red) and 1 non-value added necessary step (shaded orange). These were eliminated as much as possible in the future state map.

		Cycle 1: Dashboard Creation	Cycle 2: Deployment at Ottumwa CBOC	Cycle 3: Refinement of Parameters for AKI	Cycle 4: Prioritization of Subgroups for Consultation	Cycle 5: Full Deployment at 4 CBOC's
		October 2017 – March 2018	April 2018 – June 2018	June 2018	June 2018	July 2018 – Current
Plan	Hypotheses	A telenephrology (TN) dashboard can be created based on user preferences for features	Deployment of the TN dashboard at Ottumwa will enable at least 15% of dashboard hits to be converted into TN consults	Changing the parameters for triggering TN consult for AKI will lead to a smaller pool of Veterans who are more likely to require intervention	Prioritizing younger veterans at greater risk of kidney disease is more likely to generate specific recommendations from TN consultation	Implementation of the TN dashboard will help to increase the percentage of consults completed within 30 days to 80%
	Intervention Plan	Kano Evaluation Model to characterize features	To utilize the dashboard to collect data from patients at Ottumwa through the EHR	Delphi method among the nephrologists to define parameters for AKI	Stratify patients by age and risk of progression of CKD	To implement the TN dashboard at 4 CBOC's
	Data Collection Plan	Brainstorm potential features for the dashboard Solicit preferences for desired features Apply Kano Evaluation Model	Solicit feedback from PCPs via the voice of customer Observe practitioner workflow Conduct chart reviews	Use Voice of the Customer for both PCPs and nephrologists Conduct chart reviews	Use Voice of the Customer for both PCPs and nephrologists Conduct chart reviews	Solicit feedback from PCPs via voice of the customer Observe practitioner workflow Conduct chart reviews
Do	Intervention	Develop a TN dashboard	Deployment of the TN dashboard at the Ottumwa CBOC	Changed the protocol for triggering TN consult for AKI	Patients in the youngest quartile in age and with the steepest decline in eGFR were prioritized for consultation	Implementation of the TN dashboard at the 4 CBOCs (Ottumwa, Galesburg, Quincy, and Dubuque)
Study	Data Summary & Analysis	Dashboard captures data from 53,085 Veterans in the Iowa City VA Health Care System 11,790 Veterans (22.2%) have evidence of Kidney Disease	The data of 298 Veterans were reviewed via the TN dashboard, of which 50 TN consults were conducted (16.8%).	During this time period, AKI's eligible for TN consultation reduced from 251 to 53.	Veterans with projected progression to End-Stage Kidney Disease within 5 years were more likely to need a TN consult	The data of 1 384 Veterans were reviewed via the TN dashboard, of which 459 generated TN consults (33.2%)
Act	Summarize & Document Findings	4 'Must-Be' features include: (1) Data tables (2) Graph display for CKD (3) CKD Progression Modeling (4) Color to mark indicators 3 'Attractive' features include: (1) Filtering of values (2) Sorting lab values (3) Drill down events by date	PCPs voice: Appreciation for pro-active stance regarding kidney disease Concerns about losing autonomy Nephrologists and PCPs voice concerns about increased workload	Nephrologists noted that the volume of TN consults due to potential AKI decreased. However, the number of TN consults remained stable. These patients were more likely to meet the definition of AKI per KDIGO.	Nephrologists and PCPs noted that TN consults appeared more likely to catch those that were at greatest risk for CKD progression. Although younger age was prioritized, Veterans of all ages were eligible for TN consult.	With a greater focus on patients most at risk for kidney disease, percentage of TN eligible consults being converted into TN consults increased from 16.8% in Ottumwa only to 33.2% in all 4 CBOCs.
	Define Next Steps	Deployment of the TN dashboard into a pilot site	Refine definitions of AKI	Prioritization of subgroups for consultation	Implementation at 4 CBOC's	Deployment throughout the entire Iowa City VA Health Care System

Figure 3

Overview of the Five Plan-Do-Study-Act Cycles. Five PDSA Cycles were undertaken by the Quality Improvement team.



		If we cannot incorporate this feature, how would you feel?				
		I like it that way	It must be that way	I am neutral	I can live with it that way	I dislike it that way
If we can incorporate this feature, how would you feel?	I like it that way	Questionable	Attractive	Attractive	Attractive	One-Dimensional
	It must be that way	Reverse	Indifferent	Indifferent	Indifferent	Must-Be
	I am neutral	Reverse	Indifferent	Indifferent	Indifferent	Must-Be
	I can live with it that way	Reverse	Indifferent	Indifferent	Indifferent	Must-Be
	I dislike it that way	Reverse	Reverse	Reverse	Reverse	Questionable

Figure 4

Kano Analysis of Eight Dashboard Features. Kano Analysis was utilized in order to understand which features should be incorporated into the Telenephrology dashboard.

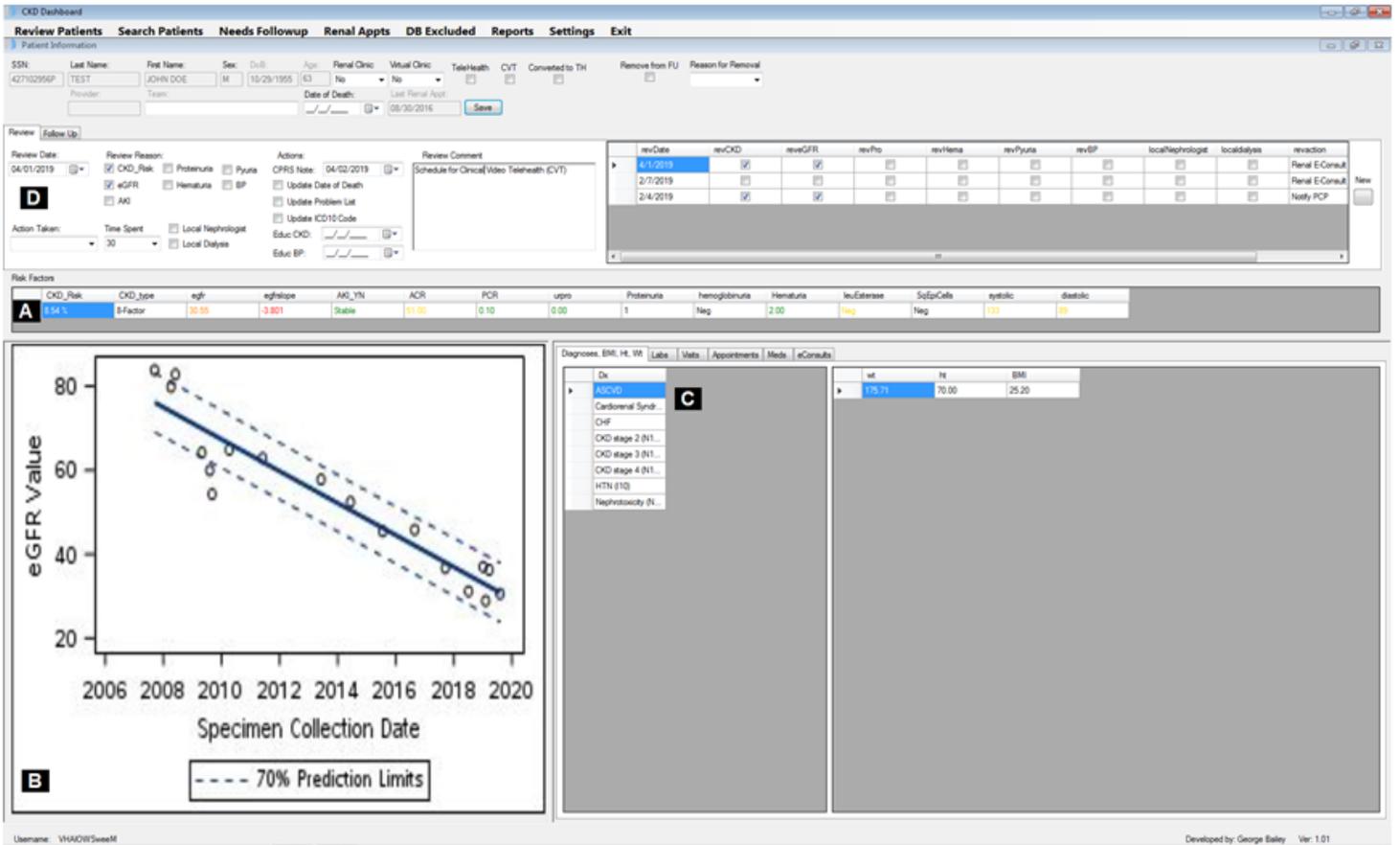


Figure 5

Features and Functionality of the Telenephrology Dashboard. The telenephrology dashboard software automatically updates and displays information from the Electronic Health Record. Once the Veteran is selected, the user will see this view. Features include dedicated windows for (A) risk factors coded by color [red denotes higher risk, green denotes lower risk], (B) graphical displays of laboratory data, and (C) associated clinical data. Once these data are reviewed, the user can enter comments and formulate a plan for further evaluation and management (D).

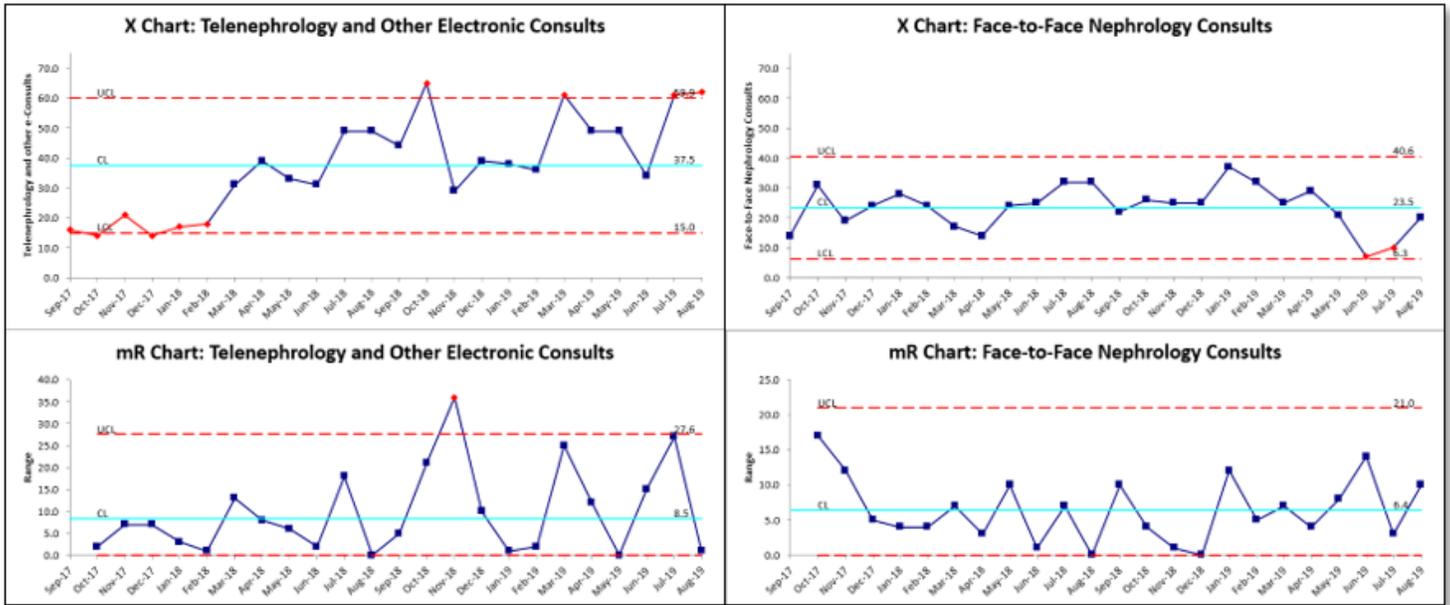


Figure 6

Run Charts (XmR) of Nephrology Consults between September 2017 and August 2019. The number of Telenephrology and other electronic consults has increased since utilization of the dashboard began in March 2018 (Panel A). The number of face-to-face consultations has remained mostly stable during this time (Panel B). Telenephrology and other electronic consults have consistently outpaced traditional face-to-face consults since March 2018.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [CurrentStateMapsSupplemental.pdf](#)