

 **Duke** Institute  
for Health Innovation

# 2017 **Impact**Report



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# Foreword

Dear Colleagues,

The Duke Institute for Health Innovation (DIHI) was established in 2013 as a platform to advance health and health care innovation at Duke Health and catalyze innovation in the clinical enterprise. Fiscal year 2017 was marked by a significant expansion in the breadth and scope of projects that were aligned more closely with the mission and goals of Duke Health as articulated in *Advancing Health Together*.

The accomplishments of DIHI and the many faculty, staff and students who have worked with the program over the past year are summarized below while a more robust description is presented in the accompanying report:

## **Platform for innovation at Duke Health:**

- Successfully deployed structured programs to source problems and innovations:
  - Annual RFA for innovation pilots and
  - Innovation Jam, a Shark Tank style investment program
- Engaged with faculty, staff and students from Duke Health and from Duke University on transdisciplinary projects and project implementation

## **Implementation and spread of the innovation portfolio:**

- Implemented over 40 innovation projects at Duke Health from primary care innovations to inpatient sepsis care using deep learning approaches
- Implemented and scaled over 60% of the innovation pilots
- Supported the translation of proven ideas into commercial opportunities since its inception

## **Innovation as a key differentiator for the clinical enterprise:**

- Advanced mobile app rapid prototyping driving innovative digital health apps in areas such as autism, cancer distress coaching and geo-fencing for clinical research
- Supported and advanced the work of clinicians and researchers in implementation sciences to develop new models of care

## **Academic output:**

- Demonstrated academic output through manuscripts, posters, publications and successful implementation of trainee-led, multidisciplinary projects
- Engaged the Duke School of Medicine through work with medical students during their third-year rotation
- Provided project implementation support and mentorship to undergraduate students and graduate students in statistics, engineering and computer science

We are grateful for the broad support for health innovation across Duke Health and Duke University as our ability to make significant progress on the goal of using innovation to create value for our patients, providers and community would not be possible without this enthusiastic and meaningful engagement. In the coming academic year, we look forward to additional opportunities for collaboration while continuing to harness the collective expertise of the Duke community for positive impacts on health and health care.

Sincerely,

**William Fulkerson, MD**

Executive Director for DIHI

Executive VP for Duke University Health System

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# Emergency Department Telehealth Program



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BRIEF  
DESCRIPTION

Development and implementation of a telehealth program at Duke University Hospital ED to reduce left without being seen (LWBS) and initiate patients' care faster.



PROBLEM

There is an increasing number of patients presenting to EDs around the country, leading to prolonged wait times, and, in turn, a higher percentage of patients leaving without being seen (LWBS). Addressing long wait times and high LWBS rates are of particular interest to patients, providers, and hospital administrators. For patients, LWBS leads to increased dissatisfaction as well as the potential for a poor outcome. For providers, there is dissatisfaction related to not being able to care for patients who present to the ED. Lastly, for hospitals, high LWBS rates lead to low patient satisfaction and decreased reimbursement. Addressing this problem requires a mechanism to accommodate the influx of patients that addresses the limited space, staffing constraints, and volume of patients coming to ED.



**"Duke using telemedicine to cut ER wait times."**

WRAL.COM March 15, 2017



SOLUTION

Implementation of a telehealth program at Duke University Hospital ED to allow ED providers to see patients remotely and quickly initiate patients' care soon after their arrival to the emergency department. Patients were brought to a room with a telehealth cart allowing them to briefly be seen by a provider to initiate their care. For the purposes of the pilot, a specific set of days and times were chosen during which telehealth would be offered. These dates and times were decided based on historical times of high waiting room volumes.

**Purpose:** To provide medical screening exams for patients and initiate their care while waiting for a room to become available.



## Outputs and metrics

- » **Patient satisfaction**
  - » Follow-up patient phone calls: 30% response rate
  - » Overall impression of Telehealth: -4.7/5
- » **Provider performance**
  - » Average number of patients seen per hour: 4
  - » This number has potential for improvement as processes become more streamlined and providers become more familiar with the technology
- » **Provider satisfaction**
  - » Improvement in overall impression of Telehealth from inception to completion of pilot
- » **LWBS rates**
  - » Prior to Telehealth (September 2016): 6.85%
  - » Telehealth days (Monday and Tuesday; October 2016, December 2016, January 2017, February 2017, March 2017): 8.48%
  - » Hard to quantify the impact of Telehealth on LWBS rates due multiple confounding factors

## Plans to scale

- » **Creating an on-call model in** which there is an on-call system on historically high-volume days that can be activated at broader times
  - » Provider is on-call from 11am-9pm on Monday and Tuesday, and are called in at times of surge volumes of patient arrivals, and would provide Telehealth services for a 4-hour block
- » **Expanding provider resource pool**
  - » Utilizing more providers in order to increase the coverage pool
  - » Creating an on-call model, in which providers would be paid an on-call rate, and when called in, paid a rate which would be a combination of hourly pay along with an RVU model based on performance of seeing patients and patient satisfaction.
- » **Limit use of ED nursing staff**
  - » Utilization of ED techs rather than nurses to help provider with assessment of patient. This helps to not use the scarce nursing resource in areas that can be managed by other staff.
  - » Use of other available nursing (ie. Life Flight nursing) to initiate IVs and draw blood work
- » **Expansion to Duke-affiliated outpatient clinics** (ie. Urgent Care, Primary care offices)
  - » Creation of a business entity within the Duke Health System (DHS) which would be comprised of a group of providers from Duke Hospital, Duke Regional Hospital and Duke Raleigh Hospital.
  - » This group would be responsible for seeing patients located at clinics/urgent cares and providing emergent consultation, and initiating care before patients arrive to the appropriate emergency department.
  - » Also can be used to direct patients from clinics to less busy emergency departments and ultimately decompressing busy departments.
- » **Expansion to Duke-Life Point Hospitals**
  - » Providing emergency department care remotely to facilities that have a shortage of providers.

# GI Virtual Concierge



TEAM

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BRIEF  
 DESCRIPTION

The GI Endoscopy Virtual Concierge leverages the patient flow tracking capability of the electronic health record to enable automated status notifications to patient caregivers.



PROBLEM

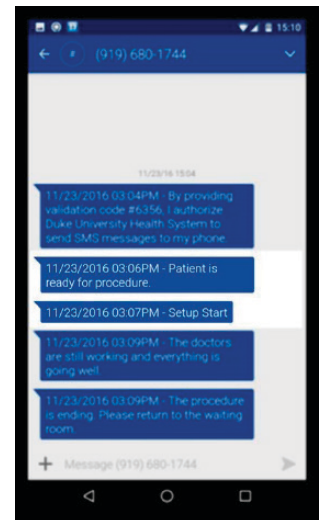
Patient caregivers often have to wait hours in the waiting rooms of Duke Endoscopy units and operating rooms without information on the progress of their loved ones through the surgical process. Existing technology uses restaurant pagers or status boards to notify caregivers when they are required to return to the waiting room, and this waiting period can be very stressful to caregivers.



SOLUTION

The GI Endoscopy Virtual Concierge leverages the patient flow tracking capability of the electronic health record to enable automated status notifications to patient caregivers. The tool pulls status updates from the Duke Epic platform to a secure server. From that server, the tool automatically and securely sends text messages to authorized caregiver phones. The clinical staff workflow is unchanged.

The goal of the DIHI funded project was to demonstrate the feasibility of automating messages to caregivers with each status change in GI endoscopy.

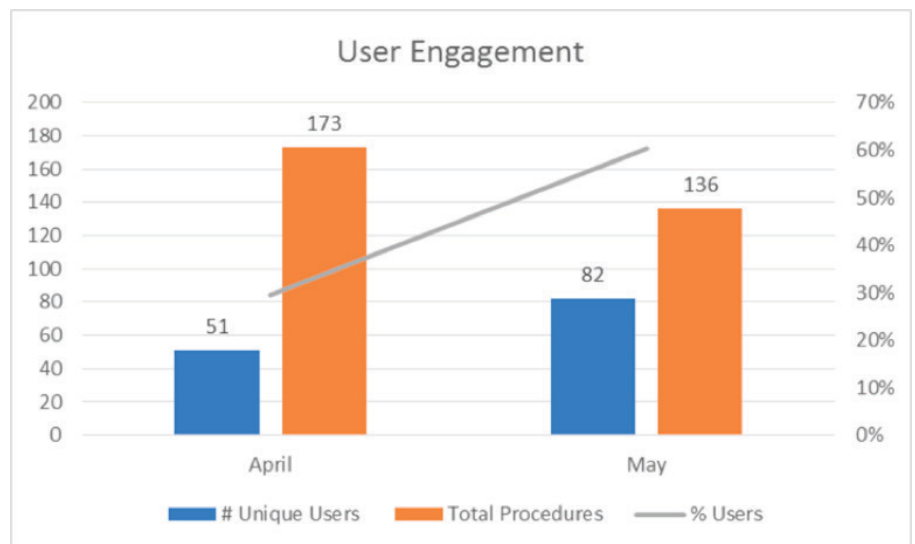


IMPACT

Concierge was implemented at Duke GI of Raleigh Endoscopy Unit March 2017.



User engagement increased from 29% in April to 60% of patients in May.



**Patient Satisfaction was highly favorable in a survey of users (N=46).**

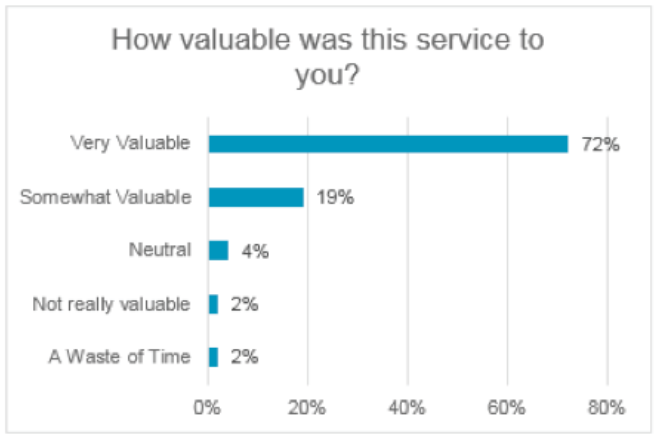
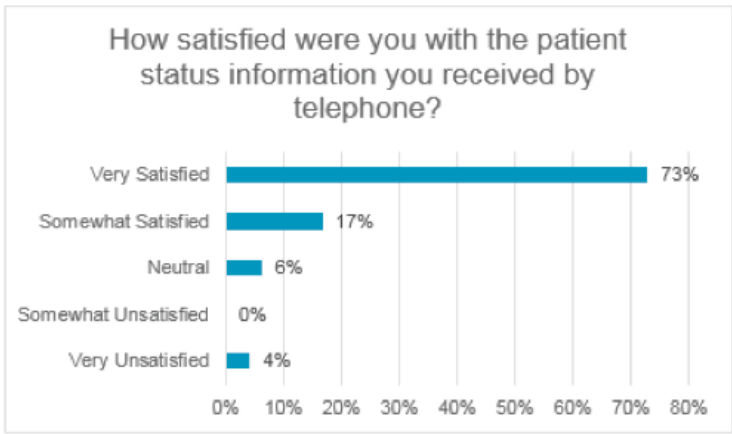
**98%** of patients would recommend the service again for their next procedure at Duke

**90%** of users were satisfied with the information they received

**91%** of users felt that the service was valuable

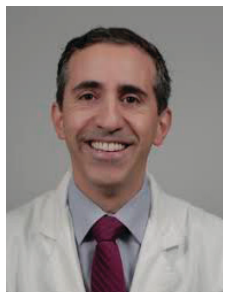
**Staff satisfaction was universally positive. Benefits of this service to staff included:**

- Decreased clinical staff times to contact family/drivers
- Improved communication of delays to patients
- Decreased the need for additional equipment (beepers/pagers)



» We have a phased plan for dissemination and scaling. Each phase requires transition of the platform to DHTS for operational oversight of the concierge service.

- Phase 1** – Dissemination to all Duke GI Endoscopy sites
- Phase 2** – Expansion to other Duke Ambulatory Surgical Centers
- Phase 3** – Expansion to Duke Operating Rooms



PI: Ziad Gellad, MD, MPH

# Improving Chronic Disease Management in DPC: Building a Virtual Medical Neighborhood



## TEAM

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## BRIEF DESCRIPTION

Application of a risk stratification algorithm to all Duke Primary Care patients in order to identify select Duke Primary Care (DPC) clinics that have relatively high CKD risk burden and/or Duke Connected Care (DCC) enrollment that could benefit most from an econsult program. Then, implementation of Duke Nephrology econsult program.



## PROBLEM

As health systems grow larger and demand for specialty care increases, it is becoming increasingly important to embrace efforts to reduce care fragmentation and enhance the primary care to specialty care interface. Referrals serve as the gateway to specialty care; however, with referrals doubling within the past decade, access to specialists continues to be a common barrier for both patients and PCPs. Patients often face long wait times, along with cost and travel burdens to see specialists, which contribute to poor patient satisfaction and outcomes. Barriers to access are especially a problem for patients with chronic diseases who suffer from increased rates of morbidity and mortality due to delayed referrals. PCPs may be forced to refer patients to out-of-network specialists with quicker access, which can in turn increase care fragmentation. When patients are seen by specialists, communication breakdowns still exist, which can result in duplicate diagnostic testing, polypharmacy, and confusion about conflicting care plans. For specialists, concerns also exist about the appropriateness of referrals and lack of pre-requisite workup.



## SOLUTION

As access to specialists becomes increasingly limited for patients and primary care providers (PCPs), health systems are seeking innovative solutions to improve specialty care access. Several stakeholders from Duke University Health System leadership, nephrology, primary care, and health informatics, convened to develop a Nephrology eConsult program. The program contributors designed an eConsult workflow embedded within Epic that would use existing functionality for ordering, documentation, and messaging.

Using the "E-Communication to Nephrology" order, PCPs have the option to request remote evaluation and management recommendations from a Duke Nephrology provider based on chart review, without a face-to-face visit. Nephrology is ideally suited for an eConsult model since timely nephrology referral is crucial for patients with high-risk chronic kidney disease (CKD), and yet many new patients referred to nephrology have low-risk CKD and do not require in-person specialist visits. Our quality improvement study sought to characterize the demand for nephrology and identify the areas where eConsults could most improve the referral process.

We hypothesized that eConsults would promote closing the specialty referral loop, reduce nephrology care wait times, and increase referral completion rates for patients within our primary care network.





From July 2016 to March 2017, 80 eConsults were submitted to Duke Nephrology for 78 patients. These eConsults were placed by 21 Duke Primary Care providers at 4 pilot clinic sites and 1 Duke endocrinologist, who served as an Epic physician builder who helped with the program launch. In these 4 pilot clinics, **32.2% of referrals placed to nephrology were eConsults**, following program implementation. All of the eConsults received were completed during the study period.

- » The time for eConsult note completion was approximately 10 to 18 minutes, as measured by the nephrologist. The median response time for eConsults was one day; 45% were completed on the same day and 80% were completed within 2 days.
- » The nephrologist did not recommend a face-to-face visit for 67.5% of patients. For the 32.5% of patients for whom a face-to-face specialist visit was recommended, wait times and visit outcomes were measured. The median wait time was 40 days (compared to the 61-day median appointment wait times for traditional Nephrology referrals).
- » Approximately three quarters (73.1%) of the visits were completed, 15.4% were canceled, 7.7% were scheduled, and 3.8% were no shows (**Figure 1**). The 26 in-person visits were scheduled among 8 different Duke Nephrology providers. An appointment status and wait time were available for all in-person visits that followed an eConsult.

E-Consults significantly improved closing of the specialty referral loop, increased referral completion rates, and reduced nephrology care wait times.

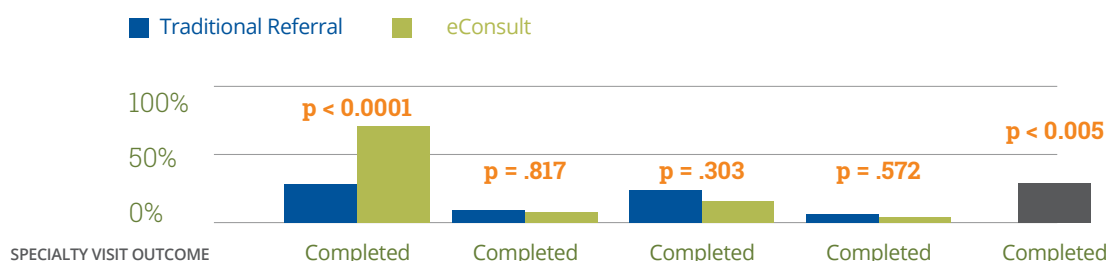
#### We sent an online survey to measure PCP satisfaction at the end of the pilot.

- » A majority (86.6%) of the PCPs who responded rated their overall satisfaction with the program as a 9 or 10 out of 10 (“highly satisfied”) and 100% were “extremely likely” to continue using eConsults.
- » Similarly, a majority (80%) of PCPs indicated that they would have sent an ambulatory referral to nephrology with or without additional diagnostics prior to referral for most patients for whom they submitted eConsults.
- » The remaining 13.3% of PCPs indicated that they would have simply managed the patient in primary care, and 6.6% would have contacted a nephrologist via phone, email, or staff message.

#### PCPs were asked to provide free text about the biggest benefits of using eConsults.

- » A majority (78.6%) said that the quick turnaround time by the nephrologist was the biggest benefit (“Timeliness of consults and ability to handle “simple” issues without a formal consult”; “Speed and ease of consult, quick response”).
- » The remaining 21.4% described the efficiency for providers and patients as the greatest benefit (“Efficiency for provider and patient; triage of referrals--PCPs not always sure when to refer to nephrology”; “Patients do not have to travel to Duke for evaluation”).
- » Recommendations about how to improve the program included using eConsults for follow-up specialist visits and making eConsults available to all primary care practices and other specialties. The other specialties included rheumatology, neurology, cardiology, gastroenterology, endocrinology, and dermatology, along with several other specialties.

**Figure 1. Specialty visit outcomes following eConsult vs traditional referral**



**Other outputs:**

- » Our work was presented at the 12th Annual Duke Health Patient Safety and Quality Conference (March 23, 2017) and the 2017 Annual Scientific Session of the North Carolina Chapter of the American College of Physicians (February 24, 2017).
- » We will also be submitting a manuscript to the Journal of Telemedicine and Telecare entitled "Keeping Care Connected: E-Consultation Program Improves Access to Nephrology Care."

Although a financial model for eConsult reimbursement has not yet been created, department leadership in other specialties, including Urology and Rheumatology, have begun discussing how to implement an eConsult program for their patient populations, who have similar challenges compared to those referred to Nephrology. These specialties are likely to pilot the next eConsult programs at Duke, so much discussion has taken place about how to best structure those pilots, taking into consideration the limitations of the nephrology pilot (i.e. having one specialist reviewer and a small sample size of primary care clinics and patients).

Various eConsult platforms have been considered and could allow for more widespread implementation of eConsults.

**DukeHealth**  
 Priscille Schettini, BS; Kevin Shah, MD, MBA; Melissa Machtoff; John...  
 Hayden Bosworth, PhD; Blake Cameron, MD, MBI

**BACKGROUND**

- Referrals are the gateway to specialty care
- Many obstacles exist: long wait times for specialist appointments, high no-show rates, cost and travel burden for patients
- Many clinical questions do not require face-to-face specialist visits
- Electronic consultations (eConsults) are a method for specialists to provide input based on patient chart review without a face-to-face visit

**PROCESS CHANGES**

**Enhanced Referral Pathway**

```

    graph TD
        PCP[PCP] -- "PCP requests specialist advice" --> E[eConsult submitted through EPIC order]
        E --> S[Specialist provides recommendations labs, imaging, medications]
        S --> PCP
        E -.-> F[If needed, specialist requests face-to-face patient visit]
        F --> SV[Specialty Visit]
    
```

**Traditional Referral Pathway**

```

    graph TD
        PCP --> SV[Specialty Visit]
    
```

**INTERVENTION**

- Nephrology eConsult program deployed to 3 Duke Primary Care (DPC) clinics in July 2016
- 18 Primary Care Providers (PCPs) submitted 67 eConsults to Duke Nephrology
- eConsults were compared to traditional Nephrology referrals from July-Dec 2016 (N=502)

**REFERRAL TURNAROUND TIME**

Pathway	Mean Wait Time
Traditional Referrals	54 days
eConsults	1 day

p<0.0001

**REFERRAL COMPLETION RATE**

Pathway	Completion Rate
Traditional Referrals	35.9%
eConsults	100.0%

p<0.0001

**Specialty Visit Outcomes Following eConsults vs Traditional Referrals**

	eConsults N=22	Traditional Referrals N=502	P-value
Median Wait Time	38 days	56 days	p=.207
Completion Rate	59%	36%	p=.027
No-Show Rate	0%	5%	p=.294
No Reported Status Rate	0%	28%	p=.003

# A Three-Pronged Approach to Reducing HIV Transmission through Pre-Exposure Prophylaxis (PrEP)



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## BRIEF DESCRIPTION

Development of a three-pronged program to decrease HIV transmission and increase awareness in the Duke and Durham community, including:

1. Creation of a dedicated Duke PrEP clinic at Duke Medical center
2. Educational promotion
3. Community outreach



## PROBLEM

HIV infection remains a serious public health concern, especially amongst blacks, young people and men who have sex with men (MSM) whereby incidence rates continue to rise. North Carolina has one of the highest diagnosis rates of all states and Durham County ranks third highest in HIV incidence of all 100 NC counties. PrEP, or pre-exposure prophylaxis, has been shown to be more than 90% efficacious in preventing HIV transmission. PrEP entails giving Truvada once daily to persons at high-risk. Unfortunately, there is a lack of awareness about PrEP, and for that reason, uptake has been slow.



## SOLUTION

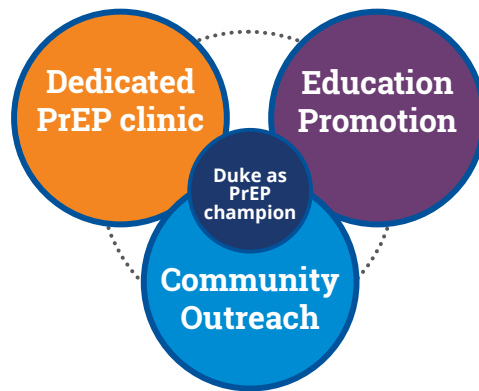
We proposed a novel method of combining a dedicated PrEP clinic at Duke Medical Center with education promotion and community outreach to truly mitigate HIV transmission in our community.



## IMPACT

### Dedicated PrEP Clinic

- » The Duke PrEP Clinic was officially established in January 2016. The clinic takes an integrated approach to HIV prevention, with two social workers and two pharmacy support staff to assist with risk behavior counseling and enrollment in patient assistance programs, respectively. We have evaluated 106 patients for PrEP services (approximately 42.3% black, 43.5% white, 77% MSM).
- » The Duke PrEP Clinic Web Page was established, with a link to an associated blog site. (<https://www.dukehealth.org/locations/duke-prep-clinic-hiv-prevention>).
- » Referral templates and Smartset in Maestro: A referral system was created in Maestro Care for the PrEP Clinic (Ambulatory Referral to HIV Prevention [PrEP] [HIV]).
- » Communications: Duke PrEP Clinic fliers have been widely distributed. The Duke PrEP Clinic was listed on national websites including the PrEP Locator Page ([preplocator.org](http://preplocator.org)) and North Carolina AIDS Training and Education Center. Additionally, advertising campaigns have included promotion of the clinic on social networking sites and apps as well as on the Durham transportation system buses.



## Educational promotion

- » **PrEP Toolkit**- A comprehensive educational toolkit was created to educate providers in the Duke community. The toolkit included a PrEP training video for Duke Primary Care providers that is available on the Duke Intranet. Additionally, a “PrEP Primer” was created for distribution to Primary Care Providers.
- » **Onsite trainings** across Duke Primary Care- 26 onsite trainings to-date for primary care providers. To assess our efforts, we distributed a repeat survey to assess PrEP knowledge, prescribing patterns, and feedback on our initiative. The survey showed that the numbers of Duke PCPs who prescribed PrEP increased from 17% in October 2015 to 33% 12 months later.

## Community Outreach

- » **An extensive marketing campaign** has been developed and implemented with advertisements on Durham County bus system, and via social media including on multiple dating websites targeting MSM. We hold monthly meetings with our community stakeholders including Triangle Empowerment Center, El Centro Hispano, CAARE Inc, Durham County Health Department and NC State Health Department. College campus outreach has included NCA&T and NCCU.
- » We have helped **host/sponsor at least 10 community events** including: Shades of Pride, Pride Day, PrEP Naked Rainbow Affair, Thicker than Blood Film Screening, a Barber Shop Event, PrEP Easter Egg Hunt, PrEP Poetry Slam, a Community Board meeting among others.

## We have submitted three grant proposals, including:

1. NIH R34, May 2017, entitled *Increasing PrEP Uptake among Black MSM in the South* (funding mechanism: PA-17-103: Strengthening the HIV Pre-Exposure Prophylaxis (PrEP) Care Continuum through Behavioral, Social, and Implementation Science)
2. CFAR supplement, May 2017, entitled *Preventing HIV during the Opioid Epidemic: PrEP for People Who Inject Drugs* (funding mechanism: CFAR Supplement Announcement in HVI/AIDS-FY 2017), and
3. NIH K23, May 2017, entitled *mHealth Peer Support to Reduce Rates of STIs in Black MSM PrEP Users* (funding mechanism: PA-14-049).

## We have two manuscripts that have recently been accepted for publication:

4. *An Educational Initiative in Response to Identified PrEP Prescribing Needs Among PCPs in the Southern U.S.* [In Press, AIDS Care]
5. *Partnerships between a University-Affiliated Clinic and Community Based Organizations to Reach Black Men who have Sex with Men for PrEP Care* [In Press, Journal of Acquired Immunodeficiency Syndrome].

We plan to continue to expand the Duke PrEP Clinic, working closely with our stakeholders in the community who help promote our clinic and identify persons at greatest risk for HIV including young, black MSM.

Additionally, we are considering the use of a mobile unit (van) which would help us access populations who are difficult to reach. We will continue to offer trainings to Primary Care providers including Family Practice, Internal Medicine, Ob-GYN, and Pediatrics.



# Comprehensive Cardiac Device Safety System



## TEAM

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**DIHI:**  
Will Ellaissi, MBA, MHA



## BRIEF DESCRIPTION

Creation of a “single source of truth” for device information in Cardiology



## PROBLEM

There was no reliable way to track implantable electrophysiology (EP) devices at Duke and even less reliable methods for managing patients with legacy devices (those implanted before Epic went live). This made it difficult to execute device recalls.



## SOLUTION

We identified a “single source of truth” which was the Epic Implant Log. This functionality already existed within Epic and was being used by other therapeutic areas to varying degrees. In addition, implants as of 2011 were already being recorded in this database. However, this left out two important categories of device patients:

- 1) those with devices implanted before Epic went live
- 2) those who had devices implanted at other institutions but are followed at Duke.

These groups are not insignificant and all device patients are potentially subject to recalls.

Existing data from the historical database as well as data from device manufacturers was used to try and populate the implant log with all relevant implant information for Duke patients.



Emily Zeitler, MD



## IMPACT

First, we examined the implant log data capabilities and made changes based on the specific requirements for recording EP implant information. We also made changes to the implant log to make it more clinically useful. For example, functionality was added to indicate when the implant log had been reviewed and verified since implant information can change.

Next, historical Duke implant patients were identified and the data were converted for upload into the Implant Log. Ongoing work is needed to upload implant information for patients implanted outside of Duke since implant information is nonstandardized.

Next, we developed a report that can generate a list of patients with a specific device. This would be a critically helpful function in the case of a recall. This reporting feature is available for use.

# Duke Children's Complex Care Service – Mobile Complex Care Plans



## TEAM

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## BRIEF DESCRIPTION

Implementing a mobile complex care plan for provider and patient's guardians to coordinate care approaches.



## PROBLEM

Children with medical complexity (CMC) are the most medically fragile and costly pediatric population, and many of these CMC require frequent, prolonged hospitalizations. CMC with high hospital utilization (HHU) can benefit from value-based models that deliver efficient inpatient care and extend outside hospital walls to seamlessly coordinate care across the inpatient/outpatient (IP/OP) continuum.



PI: David Ming, MD



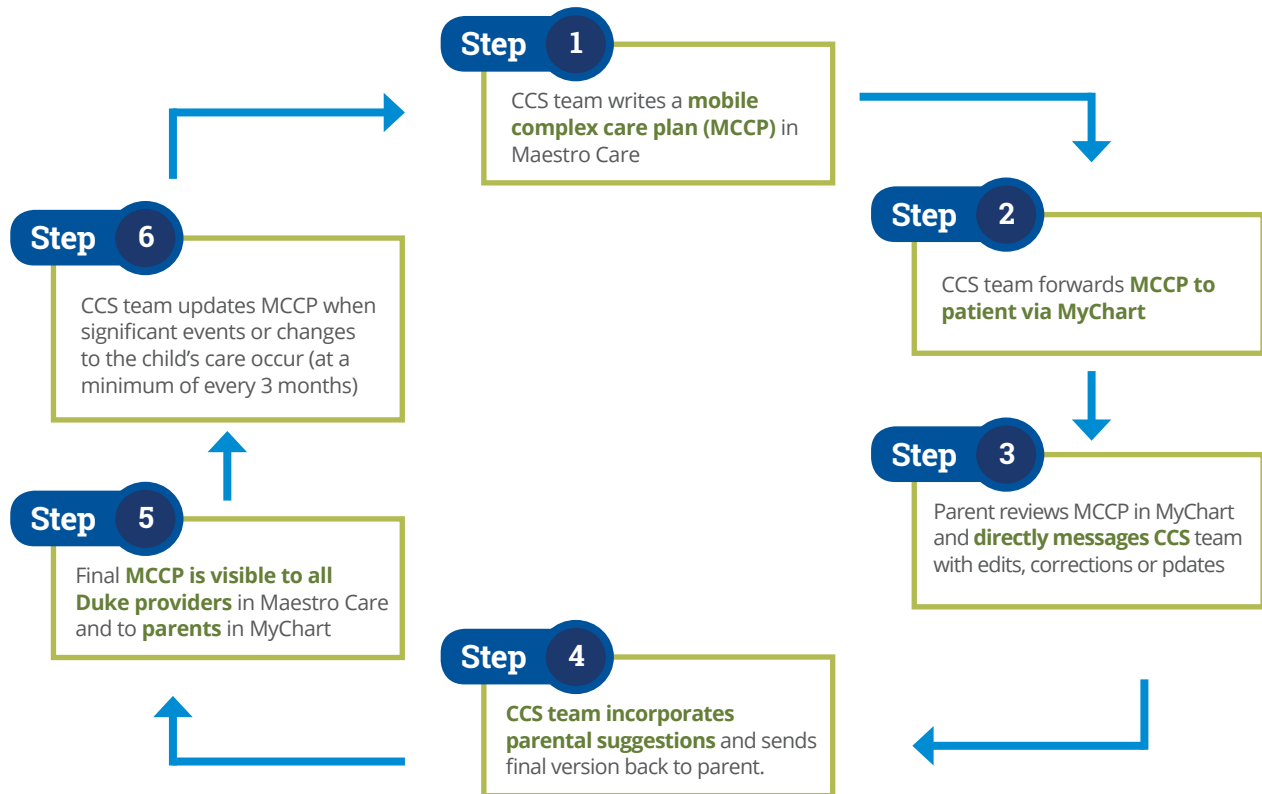
## SOLUTION

We developed and implemented a pilot project for mobile complex care plans (MCCPs) with bidirectional secure communication between CCS providers and parents. The goals of the MCCP platform were to improve efficiency of overall care for Duke's growing population of CMC and empower parents of CMC to actively engage in the development of care plans that follow their children across episodes of care.

The primary aims of the MCCP project were: 1) to improve parent engagement and 2) to improve the parent experience. Essential features of the MCCP platform included (Figure 1):

- 1. Read-only copy of the most updated care plan.** This feature allowed families to directly view electronic copies of the MCCP online (via My Chart), and print hard copies of the MCCP to share with other care team members as needed (e.g., out-of-network PCP without access to Epic).
- 2. Enhanced bi-directional communication/messaging for between-visit contacts.** This feature leveraged existing EHR tools such as InBasket and MyChart to allow families to directly message the CCS team with real-time updates (e.g., clinical status, medication changes, etc.) that could then be efficiently incorporated into the MCCP.
- 3. Continued integration with Maestro Care.** To maintain clinical relevance and visibility, care plans continued to live in the EHR.
- 4. Pre-visit planning questionnaires.** This bi-directional communication system for real-time updates from parents allowed them to directly communicate their most pressing concerns before upcoming clinic visits.

Figure 1:



IMPACT

### I. FEASIBILITY

- 60 patients enrolled in CCS (as of 3/22/17)
- 72% (n=43) of all CCS patients were eligible to receive MCCPs
- 88% (n=38) of eligible patients received an MCCP
- 93 unique MCCPs sent by CCS team between 9/1/16 – 3/22/17
- Mean MCCPs per patient = 2.4 (range 1-6)

### II. PARENT ENGAGEMENT

- 66% (n=25) of parents of eligible patients who received a MCCP opened/reviewed it online (surrogate for parental engagement)
- 52% (n=13) who opened/reviewed MCCP online sent a follow-up message back to CCS team (highest level of parental engagement)

### III. CARE COORDINATION QUALITY

- CCS response time to parental follow-up messages regarding MCCP = 2.18 hours (IQR 0.3-15.6)

# Cancer Distress Coach Mobile App



## TEAM

Sophia Smith, PhD, MSW  
Cristy Van Sant  
Tony Sung, MD

Bridget Koontz, MD  
Eric Kuhn, MD  
Jon O'Donnell, MD

DIHI:  
Mike Revoir  
Jamie Daniel

Krista Whalen  
Michael Gao  
Callie Berkowitz



## BRIEF DESCRIPTION

Development of Cancer Distress Coach, a mobile application for iOS and Android devices that delivers cognitive-based therapies for patients, survivors, and caregivers experiencing symptoms of post-traumatic stress related to a cancer diagnosis.



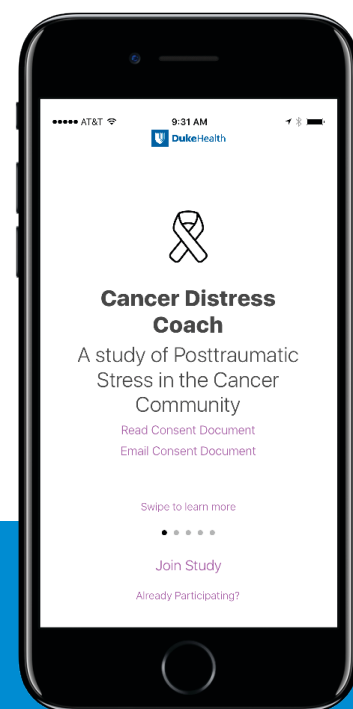
## PROBLEM

Cancer survivors frequently suffer from persistent or worsening symptoms of posttraumatic stress disorder many years following diagnosis and treatment. Symptoms are often unaddressed and impact quality of life.



## SOLUTION

Develop and test a mobile app, Cancer Distress Coach, to help users manage their symptoms of cancer-related PTSD. Data are currently being collected.



## IMPACT

The app is currently available in the App Store and on Google Play.

### With success, there is potential to expand the app:

- » Develop multiple language functionality (e.g., Spanish, French)
- » Develop caregiver-specific content
- » Submitted R01 in October 2017

### Invited Presentations, International

- » **Smith, S.K.** Quality of life and posttraumatic stress disorder symptoms among lymphoma patients. Plenary presentation, Canadian Conference on Lymphoproliferative Disorders (CCOLD), Lake Louise, Alberta, Canada, March 24, 2017.

### Invited Presentations, National

- » **Smith, S.K.** Cancer Distress Coach Development Cycle. Webinar, Cigna Specialty Care Learning Collaborative, September 27, 2017.

### Invited Presentations, Regional/Local

- » **Smith, S.K.** Invited Keynote Speaker, Michigan Society of Hematology Oncology Great Lakes Cancer Nursing Conference, Troy, Michigan, October 20, 2016.
- » **Smith, S.K.** Lymphoma as a Trauma and PTSD. Hematology/Oncology Grand Rounds, Duke Cancer Institute, Durham, NC, July 14, 2017.
- » **Smith, S.K.** Evolution of the Cancer Distress Coach App to Manage Stress in Cancer Survivors, Duke Center for Applied Genomics & Precision Medicine, Durham, NC, September 14, 2017.
- » **Smith, S.K.** Responding to Cancer-related Trauma. Cancer Symposium, North Carolina Area Health Education Centers Program (AHEC), Rocky Mount, NC, October 19, 2017.
- » Berkowitz, C., & **Smith, S.K.** DIHI Innovation Project: Cancer Distress Coach RCT. Duke Mobile App Gateway Conference, Durham, NC, October 19, 2017.



# Novel PSA Screening Algorithm



## TEAM

Thomas Polascik, MD  
Raj Gupta, MD  
John Anderson, MD, MPH  
Kevin P. Shah, MD, MBA

**DIHI:**  
Will Ellaissi, MBA, MHA  
Malhar P. Patel



## BRIEF DESCRIPTION

Integration of a novel, evidence-based PSA screening algorithm into the electronic health record (EHR), in order to better identify patients at risk for prostate cancer.



## PROBLEM

In 2012, the US Preventive Services Task Force (USPSTF) issued the lowest recommendation grade (grade D) to PSA screening stating that the risks outweigh the benefits due to over-diagnosis and overtreatment. However, the USPSTF recommendation did not account for populations at high-risk for prostate cancer such as African-American men and those with a positive family history. In aggregate, these disparate recommendations led to increased confusion and variation in primary care provider

practice around prostate cancer screening.

In response to these challenges, the Duke Cancer Institute's Prostate Cancer Working Group designed a novel evidence-based PSA screening algorithm. This algorithm helps to standardize Duke's approach to prostate cancer screening and evaluation, and was tailored to the needs of the North Carolina male population that includes more than 20-30% African American men. However, it was still necessary to inform and educate primary care physicians (PCPs) of the new algorithm and to facilitate its seamless implementation and utilization within the electronic health record.



PI: Thomas Polascik, MD



## SOLUTION

**Inclusion of the novel PSA screening algorithm into the EHR** in a manner that prompts PCPs to consider PSA screening when willing patients present with certain parameters (age, race etc). The EHR also includes a link to the full algorithm that PCPs can use in real-time during the visit. **Educational presentations at numerous Duke-affiliated PCP clinics.** During these educational sessions, PCPs received information on the rationale behind the new PSA algorithm, who the men are who will benefit most, and how it should be implemented.



## IMPACT

First, Duke Urology has provided education around this algorithm, and prostate cancer screening more broadly, to various Duke-affiliated PCP clinics and primary care leadership. Second, the the new algorithm was implemented into the EHR in February 2017. A patient's PSA status and whether a PSA is due is embedded within the "Health Maintenance" tab and driven based upon the algorithm.

In addition, PSA laboratory results now include age specific information about interpreting the PSA values, in accordance with the algorithm.

Finally, Duke Urology has expanded access for patients with an elevated PSA. In the past, PCPs expressed concern regarding adequate Urology access for patients who screen positive. To provide appropriate access to specialty referral through the DCI convened a focused group of MDs and APPs who would evaluate patients with elevated PSA.

Additionally, an Advanced Practice Provider dedicated to elevated PSA referrals was recently hired.

- » The algorithm is fully implemented in the EHR and live for all Duke primary care providers. The project is currently being expanded to Duke Raleigh under the supervision of Dr. Thomas Longo and Dr. Thomas Polascik.
- » There is the possibility to also make this available to some of the private practices who operate out of Durham Regional Hospital depending on alliances/partnerships within the Duke Health system.

# Project CALM –Confusion Avoidance Led by Music



## TEAM

Heidi White, MD, MHS, Med, CMD  
Neema Sharda, MD  
Emily Mattoon  
Loretta Matters, RN  
Shelley McDonald, DO, PhD  
Christy Cassas, MSN  
Richard Sloane, MPH  
**DIHI:** Krista Whalen



## BRIEF DESCRIPTION

Development and implementation of a personalized music program that targets patients who are at high-risk for developing delirium and seen in the Perioperative Optimization for Senior Health (POSH) clinic at Duke.



## PROBLEM

Delirium prevention in the post-operative setting is an important aim in the geriatric population. The etiology of delirium is multifactorial. Age, uncontrolled pain, changes in medications (such as the addition of pain medication) and dementia are common contributing factors. Among older surgical patients, the risk for delirium ranges from 10 to more than 50 percent. Those who develop delirium experience prolonged hospitalizations, functional and cognitive decline, high mortality and high risk for institutionalization. This geriatric syndrome is associated with astounding costs and clinical ramifications, and it is imperative that we continue to explore non-conventional methods for delirium prevention.



## SOLUTION

Findings of a recent meta-analysis suggest that music should be offered as a way to help alleviate post-operative pain and anxiety, and potentially reduce incident delirium. In particular, personalized music that is played through headphones without distractions has the power to capture the patient's full attention and trigger positive emotions associated with past memories.

We developed and implemented Confusion Avoidance Led by Music (CALM), a program. The program is available to patients seen in the POSH (Perioperative Optimization for Senior Health) clinic, a pre-operative evaluation clinic for complex geriatric patients preparing for elective surgical procedures. Patients seen in the clinic have multiple co-morbidities, cognitive impairment, mood disturbances, and limited mobility. All of these factors increase their risk for delirium and thus made them ideal candidates for the intervention.

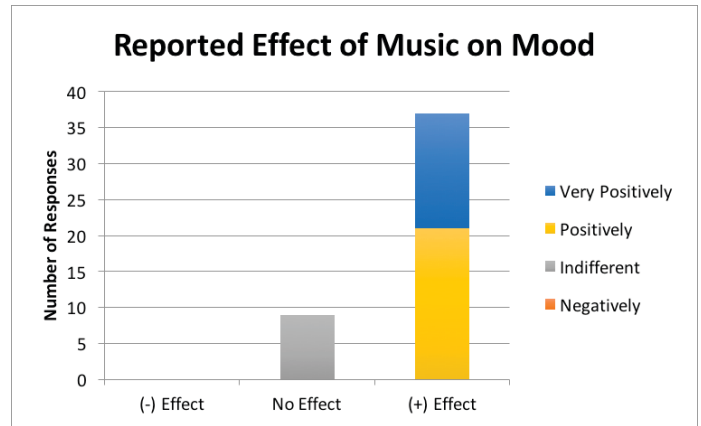
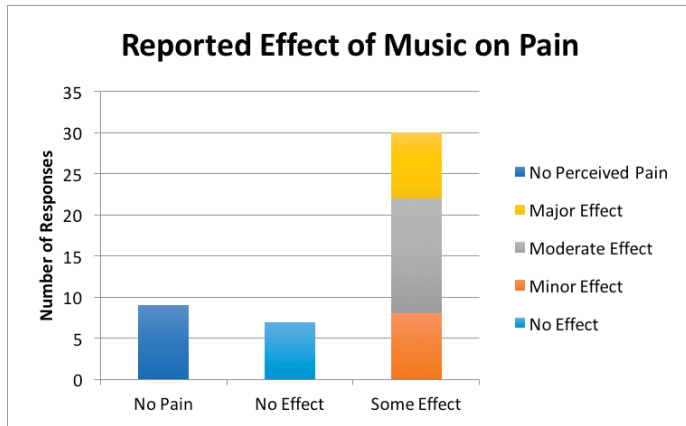
### THE MUSIC INTERVENTION INCLUDED THE FOLLOWING KEY COMPONENTS:

- » **Completion of a music preference questionnaire.** During the clinic visit, the patient was seen by a member of the project team. Patients and their families were introduced to the therapeutic benefits of music for pain and anxiety reduction. Then, the patient or a family member completed a music interest questionnaire, which included questions regarding past experiences with music and music preferences.
- » **Delivery of device to patient post-surgery.** A project team member delivered the iPod and headphones to patient on post-operative day one, with music personalized for the patient, based on their responses from the music preference questionnaire.
- » **Pre-discharge patient and caregiver experience surveys using REDCap.** A research database was set up to solicit the patients' impressions of the music program.
- » **Music as medicine.** By connecting with interdisciplinary professionals across Duke, including those in recreational therapy, Arts and Health at Duke, stress management, and nursing on 2100, 2200, 2300, and 4100, we hope to continue to promote music as adjunct therapy for patients and to integrate music into the culture of patient care at Duke University Hospital.



The majority of CALM patients reported positive effects of music listening on pain perception and mood. Illustrative comments included:

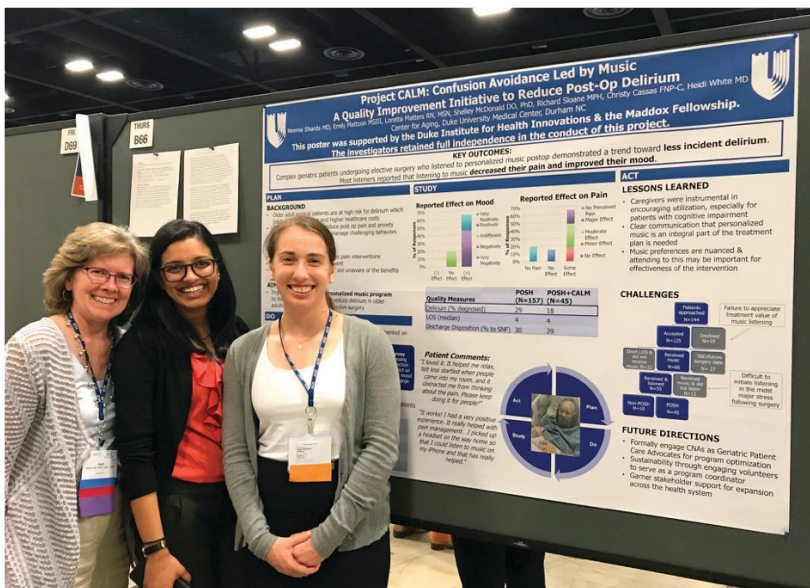
## CALM Survey Results



Among POSH patients, there is a trend towards less incident delirium for patients in CALM despite more patients having cognitive impairment. This supports a potential clinical benefit of personalized music.

In comparison to POSH patients, non-POSH patients' incident delirium is low & they are less likely to be discharged to a facility. This is likely due to better health status (younger), more social support (married), and decreased recognition of delirium.

- » We created a volunteer position that will serve as the personalized music program coordinator to continue the program with Clinic 1J staff, volunteers, unit staff on 2100, 2300, and 4100, and the inpatient geriatric service, including the POSH nurse practitioner.
- » In a collaboration with the Duke Nurses for Improving Care for Health System Elders (NICHE) program, personalized music will be offered to patients outside of the POSH program by making iPods available on unit-specific "delirium carts." Part of a rapid improvement event at Duke University Hospital, Duke Raleigh Hospital and Duke Regional Hospital, iPods on these carts will be distributed to patients at the discretion of the nurses and nursing assistants. The teaching module will be incorporated into the Duke NICHE Geriatric Patient Care Advocate pilot program for CNAs for CNAs to effectively utilize personalized music on their respective units across Duke.



### Posters presented at:

- » Duke Center for Aging Research Retreat
- » North Carolina College of Physicians Meeting
- » American Geriatric Society Annual Meeting; Awarded Best QI Poster

# Highly-Individualized, Dedicated Onsite Care at the Duke Outpatient Clinic (DOC)



## TEAM

Alex Cho, MD, MBA  
Laurie Germino, RN  
Lynn Bowlby, MD  
Patrick Hemming, MD, MPH  
Marigny Bratcher, RN

Dinah Harris  
Lisa Lowe-Hall, MHA  
Brenda Mutisya, RN  
Amy Pollak

**DIHI:**  
Krista Whalen  
Michael Gao  
Mark Sendak, MD, MPP



## BRIEF DESCRIPTION

Development of a highly individualized dedicated onsite care program (HIDOC) at the DOC, whereby high-utilizing patients seen at the DOC are availed a higher-level of care than typical in primary care, to reduce daytime DUH ED visits by high-utilizing DOC patients.



## PROBLEM

A highly successful initial clinic redesign at the DOC has led to substantial reductions in ED visits resulting in hospitalization. However, there remains a large (but addressable) number of visits by DOC primary care patients to the DUH ED that occur during hours when the DOC would be available to care for these patients (n= 665 in FY15). Many of these visits (1 in 4) result in inpatient admission (n = 175), many of which are potentially avoidable with substitution of intensive primary care.

**High cost of care for DOC patients admitted to the ED.** At an average cost of \$7,800, these admissions resulted in \$1.4M in direct costs in FY15, not to mention any opportunity cost when the hospital is at capacity.

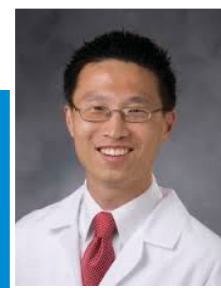
**DOC patients visiting the ED for higher-level complaints.** A big part of the challenge is that the case mix for these visits has shifted from over half being lower-level visits for basically ambulatory complaints, to the vast majority (4 in 5) being higher-level visits requiring a significantly higher level of care – which the clinic is less prepared to manage.

**Excess daytime ED visits to DUH by DOC patients during week, when clinic was open.** Vast majority (85%) of these visits, however, required treatments and/or were at an acuity level not normally handled in a primary care clinic setting.



## SOLUTION

Development of new HIDOC (Highly Individualized Dedicated Onsite Care) program at DOC, a targeted program whereby patients seen by providers at the DOC are availed higher-level services than are typically offered in primary care.



PI: Alex Cho, MD, MBA

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**The program includes the following key components:**

**Analytic visualization platform:**

Use of an analytic platform to identify the top five complaints for which patients visit DUH ED and patients that would benefit from the HIDOC program.

**Care guidelines:**

A multidisciplinary team at the DOC worked together to develop care guidelines and menu of services for treatment of shortness of breath, chest and abdominal pain in the absence of trauma.

**Treatment nurse (RN):**

serves as the bedside “treatment nurse” for patients seen in the acute illness care model, while, at other times, is responsible for clinic-based care management of the high-need DOC patients enrolled in the model.

**MD supervision:**

Additional attending staffing will be required to supervise the APP and resident provider in the acute illness care model; and time protected to support the development of acute illness care guidelines for the clinic, as well as individualized care plans for patients selected for the pilot.

**Advanced Practice Provider (APP):**

The clinician “on point” for managing the acute episode, with same-day availability “built-in” to her schedule.



Laurie Germino, RN, serves as the treatment nurse for HIDOC



IMPACT

Successful establishment of working prototype of HIDOC team (bedside RN/care manager, APP, MD leader and in-clinic coverage, supported by addition of pharmacy assistant plus other clinic resources), and suitable acute treatment space.

Commitment from DUH for MD support needed to make walk-in HIDOC access and proactive MD involvement in care management possible on a daily basis. Parallel commitment secured from PDC to support APP attached to HIDOC team.

“Soft” launch began in March 2017; now ramped up to ongoing caseload of 8 with more referrals in queue and acute treatment space and support available to clinic at-large daily.

**HIDOC formally launched as standing service in July 2017.**

# Duke Pillbox and Endocrine Dashboard



TEAM

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Bradi Granger, RN, PhD  
Beury Derstine, PharmD  
Courtney Powell  
Lynecia Cooper  
Joe Abate

DIHI:  
Krista Whalen  
Michael Gao



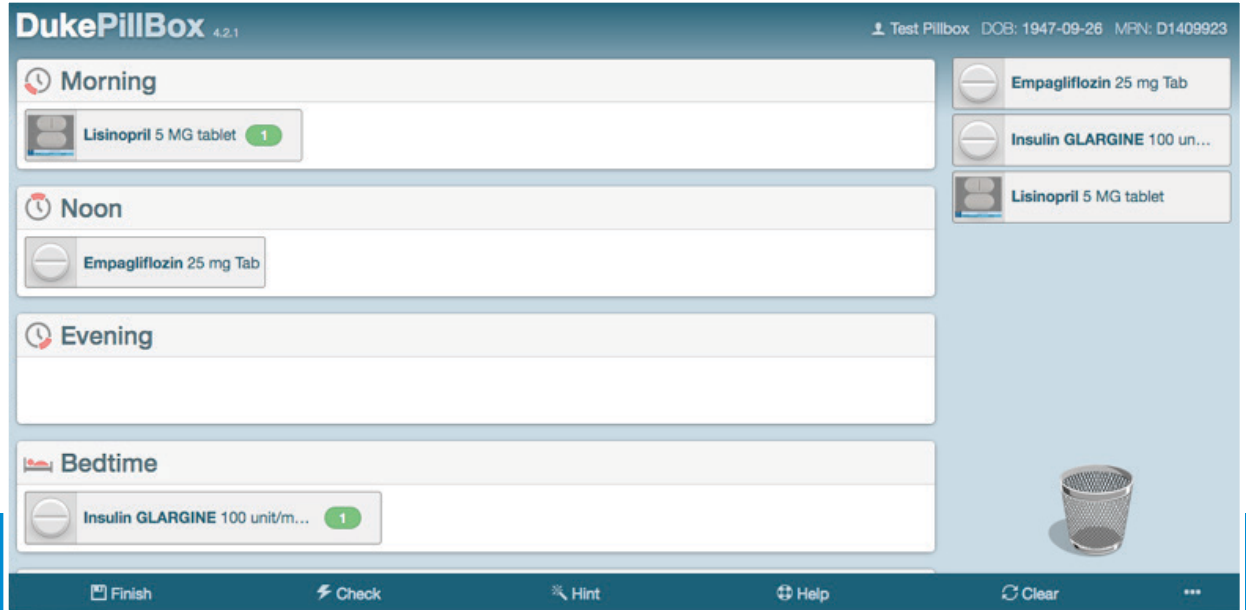
BRIEF  
DESCRIPTION

Implementation of a Maestro-integrated pillbox amongst Duke patients with diabetes mellitus (DM) and blood pressure (BP) above goal to improve medication adherence and control of hypertension.



PROBLEM

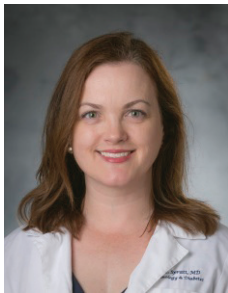
1. Diabetes mellitus (DM) **affects 12% of adult Americans** and is the primary cause of renal failure, non-traumatic amputation, and blindness.
2. A major problem in treatment of a chronic condition is **medication adherence**, with estimate that patients with DM take only 50% of prescribed drugs.
3. We aim to **improve medication adherence and control of hypertension** among patients with DM by implementing a Pill Box tool integrated within our EHR
  - Providers use Dashboard to identify DM patients and BP above goal
  - Offer patients the use of the electronic Duke Pill Box



SOLUTION

Using the healthy planet dashboard, we can identify over 900 diabetes patients in the Endocrine Division have uncontrolled blood pressure (greater than 140/90).

Using the healthy planet dashboard in Maestro Care, we launched reporting work bench reports to identify patients with uncontrolled blood pressure, used the bulk messaging feature available in reporting workbench, and offered them the use of the Duke PillBox which is an electronic, interactive pillbox that contains patient medication listed according to time of day.



Co-PI: Susan Spratt, MD and Bradi Granger, PhD, MSN, RN

**The pillbox could be deployed to any Duke medical population struggling with medication adherence.**



**Pillbox launched in April 2017. Data collection is ongoing.**

- Identified & analyzed baseline population of patients with diabetes and uncontrolled hypertension via Endocrine dashboard
- Designed Epic Smart Phrase with BPA that places Pillbox link in Mychart.
- Designed and created link in MyChart to access Pill Box via SMART on FHIR
- Improved how insulin displayed in PillBox
- Placed Pillbox link to MyChart in Production environment of Maestro Care
- Initiated recruitment via bulk MyChart messaging using the dashboards Endocrine providers

**Other outputs:**

- Epic User Group Meeting presentation in Verona, WI in September 2017
- HL7 FHIR Roundtable presentation at Duke in March 2017

**The project is currently underway and in the recruitment phase. Upon successful completion:**

- » The pillbox could be deployed to any Duke medical population struggling with medication adherence.
- » Opportunity to improve the functionality of the MyChart Duke PillBox version by enhancing its functionality to include:
  - o Add photographs for all pills and injectables
  - o Add indication for medication
  - o Add side effects of medications
  - o Add a way to indicated whether medication was taken or not and if not why

# Palliative Care Planner (PCplanner) – App Designed to Improve Palliative Care Integration in Duke Intensive Care Units



TEAM

Christopher Cox, MD  
DIHI:  
Will ElLaissi, MBA, MHA



BRIEF  
DESCRIPTION

Enhance the communication between palliative care and ICU attendings in order to more efficiently decide which patients would benefit most from palliative care.



PROBLEM

Patients, their families, and their providers have unmet palliative care needs in the ICU. Critically ill patients and their families have difficult end of life decisions to make, and often don't know what to expect. However, there are many barriers to integrating palliative care efficiently in an ICU setting.

**Staffing limitations:** Recent epidemiological studies report that up to 35% of all ICU admissions met at least one validated 'trigger' criteria for a palliative care consultation. Therefore, if an academic medical center implemented a palliative care trigger system in adult ICUs, over 1,500 additional annual palliative care consults could be expected—an infeasible task.

**Technological challenges:** Using the electronic health records, it is difficult to identify patients who may benefit the most from a palliative care consult.

**Social challenges:** There are concerns that ICU staff would be hesitant to fully support a trigger system unless they were able to approve the appropriateness of a palliative care consult.



SOLUTION

Develop a set of measures which would trigger a daily report of patients who are candidates for palliative care consultations. We would then initiate a palliative care consult and collect patient needs, desires, and offer general education video to patients about the value of palliative care.



PI: Christopher Cox, MD

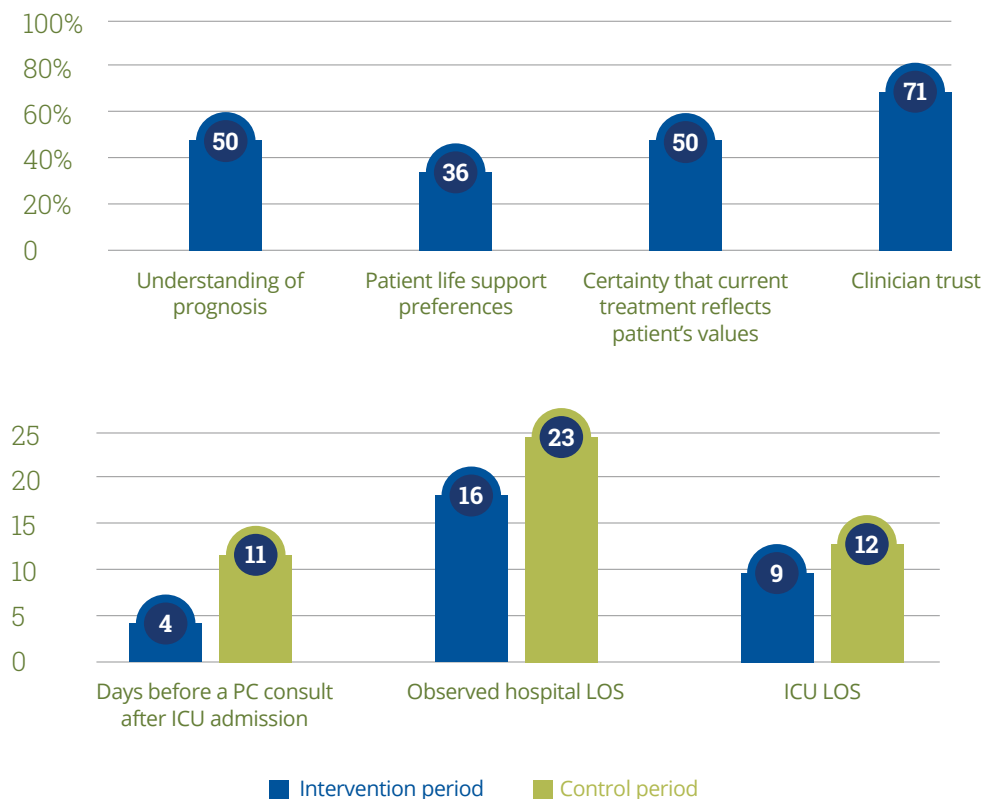


IMPACT

PCplanner (Palliative Care Planner) was successfully developed to screen for ICU patients meeting any of six palliative care consultation 'triggers,' to alert palliative care specialists to the consult request, and to allow families to self-report their palliative care needs. Application of triggers among 191 consecutive medical and surgical ICU patients over a two-week period revealed a high sensitivity (95%) compared to prospective manual chart review.



### Increase over pre-intervention ratings



In comparison to the control period, intervention group palliative care consultation occurred sooner after ICU admission (4d vs. 11d), with decreases observed in hospital LOS (17.1d vs 23.3d) and ICU LOS (9.2d vs 12.1d). Control mortality was 79% with nearly all dying in the ICU, while intervention group mortality was 46%, with 23% transferred to inpatient hospice and 15% to home hospice.

- » We have had positive impact in improving patient satisfaction and their engagement in care plans.
- » There was a decrease in LOS in both hospital and ICU as well as a decrease in in-hospital mortality. Upon full implementation of FHIR, Duke Health can activate palliative care alerts in real-time.
- » Increased awareness in nurses for palliative care opportunities.
- » Data and analytics framework put in place for palliative care by this pilot will reduce time and cost

#### Publications

- » Palliative Care Planner (pcplanner): A Pilot Study To Eval in "Health Services Highlights in Critical Care"  
[http://www.atsjournals.org/doi/pdf/10.1164/ajrccm-conference.2017.195.1\\_MeetingAbstracts.A7559](http://www.atsjournals.org/doi/pdf/10.1164/ajrccm-conference.2017.195.1_MeetingAbstracts.A7559)

# Implementation of a Surgeon-Led Operative Checklist



TEAM

Paul Mosca, MD, PhD, MBA  
Sabino Zani, MD  
Kara Penne, ANP  
Samantha Kwan Verruto, PA-C  
Trey Sinyard, MD, MBA  
Adam Brys, MD

**DIHI:**

Will ELLaissi, MBA, MHA



BRIEF  
DESCRIPTION

Implementing intra-operative checklists in wide excision of a melanoma and laparoscopic partial hepatectomy



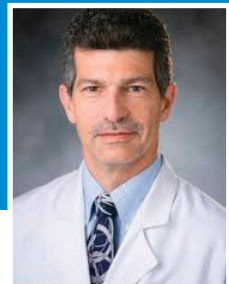
PROBLEM

The OR is among the most dangerous places in any hospital. It is estimated that each year anywhere from 100,000 to 440,000 patients admitted to a hospital are affected by a preventable medical error that contributes to their death and as many as two-thirds of such adverse events may be associated with surgical care. In the operating room, communication, teamwork, and coordination of processes are of variable quality, potentially compromising patient safety.



SOLUTION

Implement a procedure-specific, team-based, intraoperative checklist displayed via computer monitor in the OR.



PI: Paul Mosca, MD, PhD, MBA



IMPACT

The primary endpoints of this project were:

**Feasibility** as measured by checklist completion

**Impact** on operating room (OR) communication, teamwork, and safety as measured by pre- and post- intervention questionnaires.

Over the course of the study period, the intra-operative checklist was implemented in 25 cases (21—wide local excision with sentinel lymph node biopsy, 4—partial hepatectomy).

---

**Among 61 completed pre-intervention surveys**, 100% of nurses and 87% of physicians agree that communication among OR personnel should be improved. All nurses and 84% of physicians agree that surgeons should be more engaged in patient safety processes. Lastly, the majority of nurses and physicians feel empowered to voice their concern about patient safety in the OR.

**Among 41 completed post-surveys**, 28 people did not participate in any surgeries where the checklist was implemented. Overall, the perception of communication, teamwork, and patient safety are comparable between the checklist and no checklist group.

- » Demonstrated feasibility of checklist implementation in OR and impact on communication among OR teams.
- » Initiated a culture of safety discussion in the OR through the role and use of checklist.
- » Resulted in a sponsored research and collaboration with 3si/Downing Health Technologies for further study of standardized, step-based intra-operative checklist utilization.
- » Substantial opportunity for intellectual property development and commercialization of checklist protocols designed by Duke surgery faculty.



# IMPACT Model: Transforming Depression Care Management in Duke Medicine: The Collaborative Care Approach



## TEAM

Marvin Swartz, MD  
Natasha Cunningham, MD  
Terry Ervin, RN  
John Anderson, MD  
Elizabeth Long, MBA  
Christina Crosby  
Ed Cooner, MD  
**DIHI:**  
Will Ellaissi, MHA, MBA



## BRIEF DESCRIPTION

Performing PHQ2 and subsequent PHQ9 on all patients that are having an annual visit or are in the primary care clinic for a post-hospital discharge visit. Based on the PHQ9 score, patients are connected to care management and virtually rounded on by a med/psych attending.



## PROBLEM

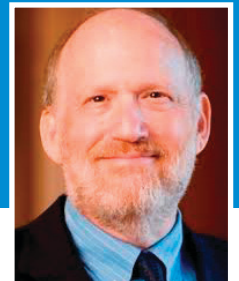
Primary care providers increasingly serve as the de facto mental health system in the US. Patient preference, stigma, insurance discrimination and the shortage of psychiatrists have all contributed to this shift in the locus of care.

As a result, the majority of prescriptions for psychotropic medications are written in primary care settings. However resource constraints, lack of time and gaps in training all limit the effectiveness of behavioral health care in primary care. Efforts to integrate mental health treatment in primary care, while garnering significant attention, have been less than successful and can be linked to inadequate use of evidence-based models of behavioral health-primary care integration.



## SOLUTION

We leveraged DukeWell care managers to work with participating pilot practices in implementing a telephonic depression care protocol for patients diagnosed with depression. This intervention was done in the following DPC clinics: (a) Hillsborough and (b) Sutton Station.



PI: Marvin Swartz, MD



## IMPACT

Through implementation, we saw that the care manager we funded to perform the care management function was able to serve 2.5 DPC clinics. At these clinics:

**6,837**  
patients screened

**269**  
patients screened positive as having a PHQ score >9

**169**  
patients were referred to the program

**139**  
patients enrolled in the program

## The IMPACT model showed the following results:

55%: response rate for those enrolled (response defined as a reduction to PHQ9 score)

27: remission rate for those enrolled (PHQ9 score dropped below 5)

### PROCESS OUTCOMES

	Roll out date	# Screened	# Positive (PHQ > 9)	# Referred	# Enrolled
<b>Sutton Station</b>	5/20/2015	5640	144 (2.6%)	133	86
<b>Hillsborough</b>	12/3/2015	1197	125 (10.4%)	68	53

Over 6700 patients were screened for depression.  
169 patients were referred to the intervention and 139 were enrolled.

### CLINICAL OUTCOMES

PHQ-9 Scores of Patients with at least 1 positive intervention score (N = 60)	
<b>Score at Referral (Mean)</b>	17 (Moderately Severe Depression)
<b>Hillsborough</b>	9 (Mid Depression)

### DUKE IMPACT OUTCOMES COMPARED TO TRIAL DATA (UNUTZER 2002)

	Duke IMPACT	Unutzer IMPACT RCT	
	Intervention (N = 60)	Intervention (N = 906)	Usual Care (N = 895)
<b>Response *</b>	55%	45%	19%
<b>Remission **</b>	27%	25%	8.3%

\* 50% reduction in PHQ-9/SCL-20 score

\*\* PHQ-9 < 5 or SCL-20 < 0.5

- » 30% of patients enrolled in IMPACT model of care went into remission
- » Implementation and scaling of Population Health approach to mental health
- » Duke Primary Care scaled this model from just 2.5 clinics to the network of primary care practices. DPC hired Terry Ervin from DukeWell to sit within DPC to offer IMPACT (now referred to collaborative care for depression) resources to our patients.
- » Currently, Terry Ervin is accepting referrals from 8 practices with plans to scale to all 26.

# Diabetes Management: The Next Generation



TEAM

Matthew Crowley, MD  
Megan Oakes  
Nicole Jelesoff, MD  
Hayden Bosworth, PhD

Dave D'Alessio, MD  
Dev Sangvai, MD  
Alex Cho, MD  
Kevin Shah, MD

Lynn Bowlby, MD  
Mohammed Shahsahebi, MD  
**DIHI:**  
Will ElLaissi, MBA, MHA



BRIEF  
DESCRIPTION

Combine tele-monitoring, medication management, and self-management support to help improve diabetes control for Duke Primary Care patients with “persistent poorly-controlled diabetes mellitus” of hemoglobin A1c (HbA1c) >8.5%.



PROBLEM

**The burden of poor diabetes control:** Over 29 million Americans, or 9% of the U.S. population, have diabetes. Diabetes is:  
1) the leading cause of blindness, renal failure, and non-traumatic limb amputation;  
2) a major risk factor for heart disease and stroke; and  
3) responsible for a two-fold increase in mortality risk.

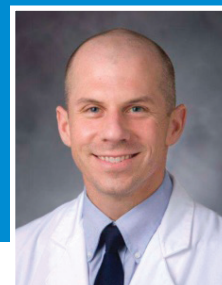
**Persistent poorly-controlled diabetes (PPDM):** Within organizations like Duke University Health System (DUHS), most patients maintaining poor diabetes control do so despite receiving clinical diabetes care.

**The need for effective approaches to PPDM:** Health services research (HSR) interventions utilize telemedicine and eHealth delivery strategies to move care beyond the typical clinic setting and facilitate frequent patient-provider contact.



SOLUTION

Develop and evaluate an Epic-integrated, DUHS-tailored telemedicine intervention for high-risk patients with PPDM. The program consists of telemonitoring, self-management support, and physician-guided medication management.



PI: Matthew Crowley, MD



IMPACT

HbA1c improved by a statistically non-significant 0.23% among engaged patients by the end of the observation period, far less than the 1.0% versus usual care (and 1.9% among engaged patients) we saw in our VA work.

We also gathered valuable formative data to guide refinement and future implementation of Epic-integrated, telemedicine-based diabetes care within DUHS.

- » Identified reasons and opportunities for improving care pathways for uncontrolled diabetic patients
- » Developed two innovative, Epic-integrated platforms for delivering telemedicine care within DUHS.



# Implementation of a Novel Duke-Specific Early Warning System to Detect and Treat Sepsis



## TEAM

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## BRIEF DESCRIPTION

We have developed a Duke-specific deep learning model that will leverage real-time EHR data to improve detection and treatment of sepsis in the hospital.



## PROBLEM

Sepsis is a clinical condition that is common, dangerous, and expensive. Nationally, patients diagnosed with sepsis have a 28% mortality rate, and sepsis constitutes the single greatest cost to Medicare for inpatient hospitalizations. Early detection and treatment of sepsis is key to improving clinical outcomes. However, sepsis is poorly understood at a pathophysiologic level, and as a result, the condition is difficult for clinicians to diagnose and treat effectively.



## SOLUTION

In addition to the deep learning model, we have developed a software infrastructure that includes:

1. EHR data cleaning and processing scripts
2. A pre-launch model optimization, workflow, and evaluation planning tool
3. A dashboard user interface to display information on high-risk patients, facilitate the clinical workflow, and monitor the delivery of sepsis treatment bundle elements
4. A quality improvement tool to track key performance and utilization metrics in real-time, and facilitate continuous improvement.



## IMPACT

### Outputs and metrics

During our implementation pilot, which is set to begin in fall 2017, we will assess the impact of our system on shifting key clinical metrics like percentage of sepsis patients with all elements of the 3hr and 6hr surviving sepsis campaign bundles delivered successfully, the time between sepsis diagnosis and administration of antibiotics, ICU utilization, and mortality.

We are building the infrastructure and capabilities that will allow Duke Health to sustainably and rapidly develop, deploy, evaluate, and scale machine learning models in the inpatient setting. We have thoughtfully designed a software infrastructure so that it can easily support all stages of future inpatient machine learning projects.

Similarly, we have carefully developed a flexible deep learning model so that in just days to weeks, it can be quickly retrained to predict onset of other inpatient events like death and cardiogenic shock.

In addition, we have published multiple papers in top machine learning journals, and have been accepted to present at several machine learning conferences. There is substantial opportunity to publish some of our pre-pilot work in clinical journals. Furthermore, we intend to publish the results of a clinical trial that we are designing as part of our pilot.



PI: Cara O'Brien, MD

# Integrating Remote Wireless Technology to Reduce CHF & COPD Readmissions



## TEAM

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## BRIEF DESCRIPTION

The 21st Century Six Minute Walk aims to modernize under-utilized traditional office-based performance tests by providing COPD and CHF patients with wearables that transmit the patients' daily step count passively to the EHR and creating patient-specific alerts for early warning signs.



## PROBLEM

Readmission rates for heart failure (HF) and chronic obstructive pulmonary disease (COPD) remain high. Heart failure and COPD represent significant burdens to patients, providers, and payers. Heart failure is the leading cause of hospital readmission among older patients in the United States. Hospitals have responded to these incentives by developing strategies to reduce readmission rates such as early physician follow-up within 7 days of discharge. Despite implementation of strategies to reduce readmissions after a hospitalization for HF, 30-day readmission rates remain at 20-25%, and the 1-year mortality rate after a HF hospitalization remains unchanged at 20-25%. No intervention has been proven to improve rates of COPD readmissions.

**We saw the digital divide first-hand through this project and committed to ensuring that apps are created on both iOS and Android platforms**



## SOLUTION

The proposed solution was to equip patients admitted with COPD or CHF with a step counter and configure their iOS devices to transmit their daily step counts to Epic. In parallel the team administered a brief daily survey of symptoms to complement the step count information. This capability could potentially be built into a MyChart survey following a successful pilot. The team hoped to demonstrate feasibility of such a care pathway, reliable transmission of data, acceptability to patients and providers, and begin to understand if this data could be useful for identifying readmission risk.





IMPACT

Patients generally used smartphones (approximately 85% of patients screened), mirroring national trends (see pew internet survey and others), however these were overwhelmingly Android devices (approximately 90%). This also reflects national trends; the iOS has a minority of the market in the US, and Android phones are favored by the less economically advantaged. Internationally, Android has >80% of the smartphone market.

85%

patients generally use smart phones

90%

phones were Android devices

The HealthKit integration works only with iOS at present, so we piloted a workaround using loaner iOS devices. We then found a number of patients who lacked reliable access to home wireless internet (see pew internet survey). The loaner strategy initially worked, however abruptly stopped working after an update to MyChart was pushed out.

With the above strategies, in the targeted patient population, post-discharge monitoring is promising but not yet feasible. We were limited by low penetrance of iOS devices in our population, no compatible solution for Android, a lack of home IT infrastructure, and potential instability of existing solutions.

- » We have learned about the promises and limitations of mHealth infrastructure at Duke. While Duke has some cutting-edge capabilities, scale is currently limited chiefly due to reliance on the iOS devices.
- » DHI/Duke is investing in Android platform capabilities to improve impact on broader Duke Health patient population.
- » Evidence shows that devices paired with communication (data plans) must be provided for success in implementing digital interventions. Loaner strategy with data plan should be deployed while expanding to android.
- » While COPD and CHF are big-impact disease states, future pilots should target more engaged/captive patient populations, such as hematologic malignancies, heart or lung transplant. These patients are more connected to the health system already, more engaged, and may be more likely to be able to successfully participate in a digital health programs.

# CALYPSO: Machine Learning for Assessing & Managing Surgical Outcomes



TEAM

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BRIEF  
DESCRIPTION

Building statistical models and using machine learning principles to predict the absolute and relative risks of surgical complications for specific patients.



PROBLEM

Preventable surgical complications, which accounts for 15% of all surgical procedures performed, continue to have significant negative impact on patients' quality of life, surgeons' reimbursement, and health systems' cost of care. However, current risk assessment methods practiced by surgeons are almost entirely subjective. Even objective tools such as the American College of Surgeon's Risk Calculator creates too much burden for the surgeon to use on every patient.

Published analyses of Medicare costs of inpatient surgery demonstrate that payments for the index hospitalization usually account for the majority of increased payments (Birkmeyer, Annals of Surgery, 2012). Yet, in spite of great progress in data analytic techniques, the "risk space" for post-operative outcomes is poorly explored. Unmanaged variability in post-operative outcomes leads to preventable morbidity and mortality for the patient, economic cost to society, with complications potentially multiplying the cost of a procedure by a factor of five (Vonlanthen, Annals of Surgery, 2011).



PI: Erich Huang, MD, PhD



SOLUTION

We propose that machine learning—class discovery and predictive modeling techniques—provide the analytic tool set for understanding and managing post-operative outcomes by allowing practitioners to better understand variables they can and cannot control and providing a predictive and quantitative basis for optimizing surgical and post-surgical management.

**The solution created a comprehensive computing and risk stratification platform for:**

1. predicting risk of surgical complications
2. tailoring interventions to the individual patient, and
3. improving surgical outcomes through best practice measures

## Essential for implementing such management is a platform that enables:

1. Rigorously analyzing the many variables that contribute to surgical outcomes
2. Melding these variables into risk stratification models
3. Deploying these models with provider-friendly interfaces
4. Designing data-driven interventions

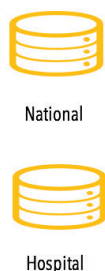
Such a platform represents the key for effectively using research and operational data to scalably enhance the effectiveness and efficiency of peri-operative interventions throughout the health system. **CALYPSO (Clinical Analytic & Learning Platform in Surgical Outcomes)** is a platform for employing machine learning strategies to identify higher-order relationships in local data and national databases such as NSQIP and ERAS, that facilitates transfer learning between such datasets, and provides the means to operationalize insights via “predictive models as a service” within the Health System.



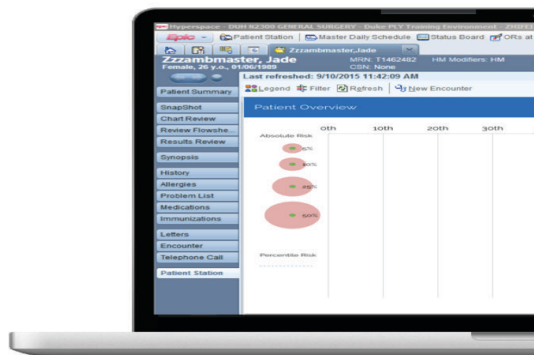
The team developed a highly predictive model using novel methodology, leveraging both national NSQIP (National Surgery Quality Improvement Program) and Duke surgical data. This model was built off of 4 million national records. The model also predicts on 11 clinical outcomes (wound infections, dvt, etc.). The team designed and created an engaging user interface to deliver prediction results and interventions to the end-users.

The team also completed a companion pilot study (funded through the DIHI Innovation Jam by the Department of Surgery as well as additional funding from Kevin Sowers) for measuring patients’ 30-day complication outcomes while using our platform. In this study we rounded on 200 patients and data is currently being analyzed. The team is working with Duke Health Technology Systems and Epic on product integration.

- » The innovative risk prediction model has been deployed on daily rounding of surgical patients
- » Follow-on funding by Department of Surgery and Kevin Sowers (DUH).
- » An IDF was filed with the Office of Licensing and Ventures.
- » A company was created, KelaHealth, which is in the final stages of negotiation with OLV on licensure. Angel investors engaged.
- » Academic: 2 oral presentations at national conferences, 1 publication, and awaiting second publication.



**CALYPSO**  
Machine Learning



# Duke Connected Care: Chronic Kidney Disease Care Improvement Project



TEAM

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BRIEF  
DESCRIPTION

Use of validated statistical models on Duke data to predict the rate of decompensation for patients with Chronic Kidney Disease (CKD) while also creating a novel model of team-based care called Population Rounding™.



PROBLEM

Chronic kidney disease (CKD) is both a consequence of progressive chronic disease and important comorbidity with prognostic significance in its own right. Within the 45,000 patients who comprise the Medicare Shared Savings Program (MSSP) population attributed to Duke Connected Care (DCC), over 400 are already on dialysis and another 4,573 are designated as having kidney failure.

**The cost to Medicare for a patient with end-stage renal disease (ESRD) in the DCC-attributed population is approximately \$60,000 a year; which, although lower than the national ACO average, is still almost 7 times higher than the cost of the average attributed MSSP patient.**

There is a need, however, for better population health analytics to help target the efforts of limited personnel and design effective interventions. There are also clear limits to the use of claims data or clinical data alone for the purpose of identification of high-risk patients. On one hand, complications or stage of chronic diseases are inconsistently coded, and commercially available tools to predict readmission risk from claims data alone are inherently limited. On the other hand, information from episodes of care that take place outside Duke is not currently captured and pushed to DEDUCE or Clarity, from which it can be extracted, nor are compiled pharmacy records (of prescriptions filled, etc.) readily available. Finally, available visualizations of patient populations are limited to relatively few dimensions.

**PI: Genie Komives, MD**



SOLUTION

The CKD initiative deployed predictive models and a series of flags and filters that use administrative claims and EHR-based clinical data to produce reports of beneficiaries at high risk of rapid CKD progression and complications. A multidisciplinary care team comprising a nephrologist, care coordinator, primary care physician (PCP), pharmacist and others reviewed these reports and selected interventions to mitigate these risks. Interventions included virtual consultation and coordination with the PCP and care team, scheduling of formal nephrologist consults, changes to medications and the plan of care and counseling.

Care coordinators reviewed 450 higher risk patients, and either recommended or executed changes to the plan of care for 120 of these patients. The remainder are monitored to ensure plans of care adopt to patient risk, by for example, maintaining regular appointments with a nephrologist. The remaining 38 patients were deceased. The PharmD reviewed medications for high risk beneficiaries, and engaged sixteen beneficiaries and their PCPs to improve medication management. The initiative developed proprietary software and filed an invention disclosure form with the Office of Licensing and Ventures.

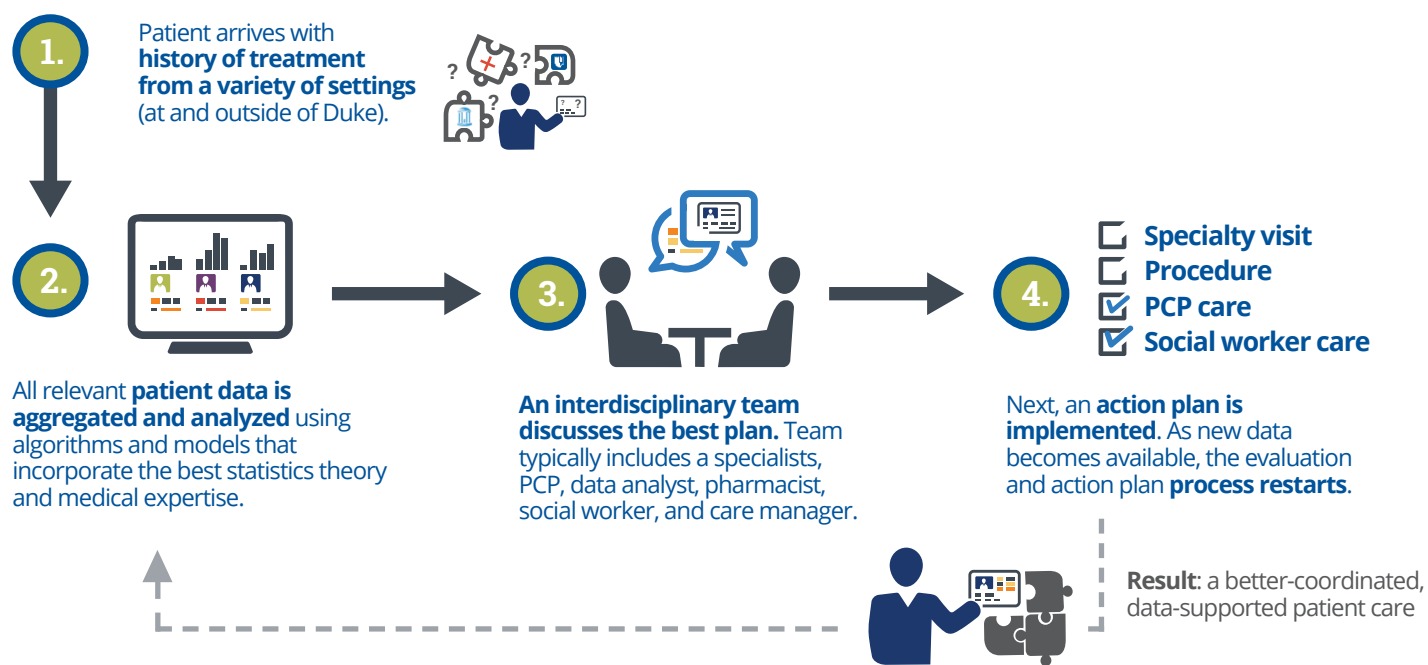
The predictive model and multidisciplinary care team improved operational efficiency, expanding capacity to serve more Medicare CKD patients. The model quickly and accurately identifies patient risks, compared to lengthier manual reviews. The coordination team can access and review reports, and interventions are quickly aligned and monitored for individual beneficiaries.



IMPACT

The **Population Rounding™** approach showed the following outcomes:

- » Delayed progression of CKD through more timely identification and intervention of risks and complications
  - » Increased rate of pre-dialysis nephrology care and early transplant evaluation
  - » Lowered rate of emergency (catheter-based) initiation of dialysis
  - » Increased rate of home-based dialysis modalities (e.g., peritoneal dialysis) at initiation
- Other outcomes included the validation of a data-driven population rounding workflow that is generalizable to other chronic conditions and can be translated to other populations



- » A new Population Health management model, Population Rounding™ has been created.
- » The CKD program will serve non-Medicare populations, and support a tighter interface (e.g., e-consults) between PCPs and nephrologists for lower-risk CKD patients.
- » Population Rounding™ has scaled to other clinical groups (a) endocrine (b) palliative care.
- » Similar predictive models are under development to efficiently serve other diagnostic groups and produce better outcomes.
- » With funding from NIH, DIHI has created an economic model to show the impact that this new approach, Population Rounding™ can have for both patients and the health system.
- » New IP for proprietary software has been filed with OLV.
- » Several academic posters and publications in Machine learning Conferences and Internal Medicine summits.

# A Novel Mobile Health Intervention to Improve Health and Quality of Life Outcomes for Patients with Sickle Cell Disease



TEAM

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Lindsay Anderson, MA  
Sarah Leonard, MD



BRIEF  
DESCRIPTION

Capturing video “selfies” of pediatric patients with sickle cell disease to enhance medication adherence, education and engagement.



PROBLEM

Patient health management in the context of chronic illness is often characterized by poor adherence to complex daily treatment regimens, which limits the overall effectiveness of treatment. Mobile health technology has the potential to increase patient adherence, facilitate patient-provider communication, and improve disease knowledge, thereby enhancing health management for patients with chronic diseases such as sickle cell disease (SCD) for better health outcomes. SCD is an inherited blood disorder that affects 1 in 400 to 500 African American newborns in the U.S. annually. Associated complications in SCD include vaso-occlusion, pain crises, organ damage, high risk of stroke, neuropsychological sequelae, and low quality of life. Given these complications, SCD requires a high level of comprehensive care for acute and chronic health management.



PI: Nirmish Shah, MD

Despite clear recommendations for optimum health outcomes, adherence to prescribed medication and health management regimens is typically low to moderate, but has been reported as low as 12% based on pharmacy refill data. Cited barriers to adherence in SCD include resource constraints (e.g., unable to attend clinic visits or travel to refill prescription), poor provider-patient communication, and lack of disease knowledge.

Additionally, SCD as a group is an underserved clinical population, and in the context of broader racial health disparities, continues to be underrepresented in clinical research. As a result, available adherence statistics for SCD are inconsistent and largely dependent upon the informant; thus, tools that facilitate more accurate compliance tracking are also an important initiative to optimize clinical monitoring.





#### SOLUTION

We used a self-developed mobile application to teach patients about the importance of taking their medications, record 'selfie' videos to document they took their medications, and receive encouragement videos from the provider team. This solution has fully integrated (a) patient education, (b) provider communication, (c) intensive intervention and training for medication compliance, (d) symptom tracking and intervention monitoring, and (e) increased self-efficacy for independent health management, into a single user-friendly mobile application.



#### IMPACT

Patients and caregivers endorsed high levels of acceptance, ease of use, and satisfaction with the intensive training program. Participants demonstrated significant increases in Medication Possession Ratio ( $p < 0.001$ ) and sustained improvements in disease knowledge ( $p < 0.001$ ).

Compared to non-adherent youth, adherent participants demonstrated significant decreases in pain ( $p < 0.05$ ) and caregiver burden ( $p < 0.05$ ). Children who were adherent reported quality of life and overall SCD-related functioning at a clinically-significant higher level when compared to those who were non-adherent ( $p < 0.05$ ).

**Importantly, patients who had at least 1 entry in the app had a 77% compliance rate to record and take their medications, much higher than historical rates.**

- » The mobile app is being enhanced to support iOS and Android, and to be used for a study at Ohio State University to have additional patients use the same methodology and validate it at another institution in a randomized controlled trial
- » Intensive training programs can be expanded to other chronic illness populations
- » This approach is scalable to other disease areas
- » 2 papers in write up stages.

# Duke Health Innovation Jam



Duke Health Innovation Jam is a “Shark Tank style” event for Duke faculty, staff, trainees, and students to pitch their novel health-related innovations to leaders across Duke for potential investment in their idea. This is a mechanism by which Duke Health translates commercially-viable ideas and products into market.

Since the event’s start, three companies have formed as a result of the Jam:



- » **InnAVasc:** Jeff Lawson and Shawn Gage  
*A medical device company that designs and develops products for vascular and hemodialysis access*
  - \$2.9M raised through DAN and MedBlue
  - Working through regulatory approval process



- » **kēlaHealth:** Erich Huang, Katherine Heller, Jeff Sun  
*Analytics / machine learning platform to optimize surgical outcomes*
  - STTR funding \$225K (NOA anytime), NC IDEA matching -\$65K
  - Final due diligence at Duke Angel Network & a seed-stage fund
  - Another likely angel investment (Greenbox ventures)



- » **SCANSLATED:** Ryan Short, Nick Befera, Raj Gondalia  
*Software platform transforms technical radiology report into a diagrammatic, simple document to enhance patient comprehension and engagement*
  - Acquired ~4M radiology reports for training and testing machine learning algorithms
  - Finalist in the SIIM 2017 Innovation Challenge





# Academic Output & Publications

1. Machine Learning in Health @ NIPS: *Transfer Learning via Sparse Latent Factor Analysis to Improve Prediction of Surgical Outcomes*
2. Machine Learning in Health Care: *CALYPSO: Precision Medicine at Point-Of-Care Management of Surgical Complications*
3. International Society for Bayesian Analysis: *Transfer Learning via Latent Factor Analysis to Improve Prediction of Surgical Outcomes*
4. Uncertainty and Artificial Intelligence: *Scalable Joint Modeling of Longitudinal and Point Process Data for Disease Trajectory Prediction and Improving Management of Chronic Kidney Disease*
5. UAI 2016 Workshop on Bayesian Applications: *Scalable Joint Modeling of Longitudinal and Point Process Data for Disease Trajectory Prediction and Improving Management of Chronic Kidney Disease*
6. International Society for Bayesian Analysis: *Scalable Joint Modeling of Longitudinal and Point Process Data for Disease Trajectory Prediction and Improving Management of Chronic Kidney Disease*
7. Bayesian Young Statisticians Meeting: *Scalable Joint Modeling of Longitudinal and Point Process Data for Disease Trajectory Prediction and Improving Management of Chronic Kidney Disease*
8. Machine Learning in Health Care: *Scalable Modeling of Multivariate Longitudinal Data for Prediction of Chronic Kidney Disease Progression*
9. Society for General Internal Medicine (SGIM) 2016: *Developing a Data-Driven Workflow for Population Health Rounding*
10. American Medical Informatics Association (AMIA): *Rationale and Design for the Duke Connected Care Predictive Modeling Pilot with a Medicare Shared Savings Program Population*
11. American Medical Informatics Association (AMIA): *Guiding Principles for the Duke Connected Care Predictive Modeling Pilot*
12. 34th International Conference on Machine Learning, 2017: *Accurate and Timely Real-Time Prediction of Sepsis Using an End-to-end Multitask Gaussian Process RNN Classifier*
13. The Institute for Operations Research and the Management Sciences, 2017 Optimizing Operations and Outcomes Conference (Informs Healthcare 2017): *Accurate And Timely Real-time Prediction Of Sepsis Using An End-to-end Multitask Gaussian Process Rnn Classifier*
14. 2017 Society of General Internal Medicine (SGIM) Annual Meeting: *Closing the Specialty Referral Loop: An Imperative for a Resilient Primary Care Network (oral)*
15. 2017 Annual Scientific Session of the American College of Physicians (ACP): *Closing the Specialty Referral Loop: Are Referrals from Primary Care to Specialists Actually Completed? (poster)*
16. 12th Annual Duke Health Patient Safety and Quality Conference: *E-Consultation Program Improves Access to Nephrology Care (poster)*
17. 12th Annual Duke Health Patient Safety and Quality Conference: *What Happens to a Referral?: Life-Cycle Analysis of Referrals from Duke Primary Care to Duke Specialty (poster)*
18. 2017 Annual Scientific Session of the North Carolina Chapter of American College of Physicians (NC ACP): *Improving Access to Nephrology Care through an E-Consultation Program (poster)*
19. 2017 Annual Scientific Session of the North Carolina Chapter of American College of Physicians (NC ACP): *Closing the Specialty Referral Loop: Are Referrals from Primary Care to Specialists Actually Completed? (poster)*

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