Improving Health Information Exchange Utilization in an Emergency Department

Anna Schoenbaum

University of Maryland

Doctor of Nursing Practice Scholarly Project Proposal

Dedication

I wish to dedicate this scholarly project to my family, friends and colleagues. Their love and support inspires me each day. To my husband and best friend, Geoff, who has been my rock and biggest support. I am eternally grateful to have such a loving, caring, and encouraging husband. To my sons, Joseph and Ansel, who touches me daily and reminds me the importance of family, enjoying the little things, and making memories. To my parents, who brought us to the U.S. for a better life with bountiful opportunities, and has always been there for me. To my sister, Ruth, who is always there to listen and offers words of encouragement. To my close friends and running partners, who have been patient with my absences in body and mind due to deadlines, projects, and papers. To my classmate, Michelle, who was a true blessing in getting through the program together. To my colleagues, who helped me along the way. To all of you, thank you for being a part of my DNP journey. Thank you so much for your support and encouragement. I could not have made it through this program without you. I thank you and love you dearly

Anna
2016

Acknowledgements

I would like to acknowledge my committee for their guidance, encouragement, and support over the course of my scholarly project. First, I would like to thank my Chair, Dr. Charlotte Seckman for her support, guidance and recommendations. From the very beginning of my program, Dr. Seckman's advice and mentorship guided me in planning my coursework, practicums, and this scholarly project. I would also like to thank Dr. Mark Kelemen, who introduced to me to the leaders at the Chesapeake Regional Information System for our Patients (CRISP). It expanded my healthcare knowledge, offered new experiences, and developed new relationships. I would like to thank Dr. Kimmith Jones, whose was a part of my early nursing career and now a part of my committee. Dr. Jones has a passion for advancing knowledge and I appreciate his support while I was navigating through the program.

I would also acknowledge the target hospital and provider champion, Dr. Klein for supporting the project. I would like to thank Ryan Bramble (CRISP), Tony DeCusatis (CRISP), Darryl Waters (UMMS), Ryan Chu (Epic), Eric Frohmader (Epic), and most importantly, Paul Thompson (UMMS) for their technical expertise in the implementation of the CRISP HIE button and PDMP. I would like to thank Dr. Dan Lemkin (UMMS), Johnross Famisan (CRISP), Denvil Ruan (CRISP), and Neils Lutterrodt (CRISP) for their help and support. I would like to acknowledge Jon Burn (UMMS) and Brian Cassel (UMMS) for their support with the implementation.

Lastly, I would like to acknowledge the leaders and staff of the CRISP for their support and opening their doors to me. Specifically, I would like to thank David Horrocks and Cheryl B. Jones for an incredible experience.

Anna
2016

Abstract

Background: The healthcare industry is under pressure to improve the health of populations, enhance the patient experience, and lower cost across the continuum of care. Care coordination is the catalyst for improving interoperability in health data sharing especially in the emergency departments (EDs) where 136 million patients visit annually. Health information exchanges (HIEs) provide a longitudinal data record on patients, which can promote care coordination . The Prescription Drug Monitoring Program (PDMP), which is a separate database of the patient's history of prescribed and dispensed controlled substance drugs, is not always included in the HIE. The patient's prescription history is critical in delivery of care; therefore, it is recommended PDMP with HIE's. The state of Maryland offers a HIE called CRISP. In January 2016, the target hospital ED implemented an embedded link in their electronic health record (EHR) to provide direct access to CRISP; however, access to the PDMP was not offered.

Purpose: The purpose of this scholarly project was to develop, implement, and evaluate the impact of having HIE/PDMP data accessible in the EHR for ED providers.

Methods: A health information technology innovation project was conducted mid-May to August 2016 in the ED of a 300-bed community hospital. The implementation involved PDMP registration; technical development to display PDMP when launching CRISP HIE button within the EHR; and training/communication. Data were collected pre-post HIE/PDMP implementation related to utilization, readmission, lab, imaging, and narcotic prescribing rates.

Results: Findings indicated HIE utilization three months post PDMP implementation (M=238) was higher than the three months pre PDMP (M= 90.75). CRISP HIE registration of ED providers increased from 34% to 100%. Of the CRISP button users, HIE usage increased significantly with the PDMP implementation (M=33.83 to M=78.88, t (22) = -7.75, p <.001). A significant main effect of the CRISP HIE button indicated that access to the system changed narcotic prescription ordering at ED discharge ($F_{(1, 23)}$ = 30.583, p < .001) and narcotic ordering during the ED visit ($F_{(1, 23)}$ = 182.230, p < .001). There were no main effects or any interactions involving PDMP.

Conclusion: Through streamlining PDMP registration, access, and clinical workflow, this scholarly project increased HIE/PDMP usage, which may potentially improve care coordination and patient outcomes. This project supports the need for technology advancement to improve accessing and viewing HIE/PDMP data.

Improving Health Information Exchange Utilization in an Emergency Department

Background

The healthcare industry is under pressure to improve the health of populations, enhance the patient experience, and lower cost across the continuum of care (The Office of the National Coordinator [ONC] for Health Information Technology, 2015). In response to this pressure, the healthcare landscape is transitioning to a delivery model where healthcare organizations and providers are held accountable to coordinate care for their patients. Care coordination is the "deliberate organization" of managing patient care and the catalyst for improving interoperability in health data sharing (McDonald, Sundaram, Bravata, et al., 2007; ONC, 2015). Care coordination is particularly important in emergency departments (EDs) where 136 million patients visit annually without warning and care must be orchestrated in an efficient, effective, and appropriate manner (Centers for Disease Control and Prevention, 2011). Furthermore, 13 to 27% of ED visits are potentially avoidable, and 40% of patients who frequently visit the ED have data in multiple facilities (Weinick, Burns, & Mehrotra, 2010; Finnell, Overhage, & Grannis, 2011). For this reason, the use of health information exchanges (HIEs) can promote care coordination among high utilizers with complex physical, behavioral, social needs especially in the ED. HIE is a longitudinal data record on each patient (i.e., clinical notes, radiology, and lab results), which can be automatically shared across healthcare organizations; however, access to HIE does not always include data found in a Prescription Drug Monitoring Program (PDMP) (Mastrian, McGonigle, & Farcus, 2014). The PDMP is a separate database of the patient's history of controlled dangerous substances (CDS) prescribed and dispensed (ONC, & Substance Abuse and Mental Health Services Administration [SAMHSA], 2012). The patient's prescription history is critical in caring for patients with complex illnesses and drug seeking

behaviors; therefore, the ONC has recommended linking the PDMP with HIEs (ONC & SAMHSA, 2012). Having access to HIE data plus the PDMP in the electronic health record (EHR) provides ED practitioners with a more comprehensive picture of the patient's profile for better care coordination (ONC, 2015).

Care coordination is a top initiative at an acute care community hospital especially in the ED. The ED in this study is one of the busiest in Maryland. Having the right information for patients at the right time is necessary to make good clinical decisions providing a continuity of care. The state of Maryland offers a HIE called the Chesapeake Regional Information System for Our Patients (CRISP). The HIE monthly usage rate in this ED is 1-5% per ED visits (CRISP, 2015). This low rate is congruent with the evidence found in the literaturewhere investigators found HIE access rates by ED practitioners to be 2-24% (Rudin, Motala, Goldzweig, & Shekelle, 2014). Similarly, access to PDMP is low (ONC & SAMHSA, 2012). There is clear evidence to support an increase in HIE usage and user acceptance when technology integrates with a provider's workflow (Thorn, Carter, & Bailey, 2014). Therefore, in January 2016, the target ED implemented an embedded link in their electronic health record (EHR) to provide direct access to CRISP; however, access to the PDMP was not offered. Today, PDMP access is cumbersome; therefore, providers do not frequently access it. The purpose of this scholarly project was to develop, implement, and evaluate the impact of having HIE/PDMP data accessible in the EHR for ED providers. The potential significance of the project was to improve care coordination and provide safer prescribing with anticipated outcomes of increasing HIE and PDMP utilization, reducing readmissions, and decreasing the prescription of narcotic orders.

Theoretical framework

DeLone and McLean's updated Information Systems (IS) Success model (2003) was the theoretical framework selected to guide the implementation of the PDMP in the EHR. The updated IS Success model provides a comprehensive framework for conceptualizing and operationalizing information systems' effectiveness (DeLone & McLane, 2003). For practice and behavior change to occur, the updated IS Success model evaluates six dimensions: system quality, information quality, service quality, system use/usage intentions, user satisfaction, and net system benefits (DeLone & McLane, 2003). System quality is described as technical success, information quality is described as semantic success, and service quality is described as customer support to the user (DeLone & McLane, 2003). Once the quality components are in place, effectiveness can be separated into three categories: 1) "intention to use/usage," 2) "user satisfaction," and 3) "net benefits" (DeLone & McLane, 2003). The "intention to use/usage" considers how the data are being used; "user satisfaction" is how the users like the intervention; and "net benefits" are a positive or negative outcome depending on the other dimensions of success (DeLone & McLane, 2003).

Applying DeLone and McLean's (2003) model to this scholarly project was pivotal in the implementation. Appendix H provides an illustration of the six dimensions to guide this project. To establish a quality system, it is important to have a solid understanding of the practitioners' workflow in the emergency department and how the EHR and HIE are currently used. It is also important to understand the EHR and HIE vendor system capabilities and limitations to develop a quality system and workflow. Next, information quality needs to be considered in guiding the interoperability of sharing data. With this in mind, the organization must adhere to the interoperability standards and exchange protocols for HIE established by the

Office of the National Coordinator (ONC) for Health Information Technology (ONC, 2015). Additionally, service quality needs to be considered in the implementation. For instance, it is important for hardware, network, and software to be continuously tested and maintained so the connections are reliable. With system implementations, users expect the technology department to be responsive to any technical issues. Therefore, a support plan was needed for the implementation. Lastly, the "intention to use/usage," "user satisfaction/acceptance," and "benefits" need to be considered in the usage report. By applying the updated IS Success model, it ensures a quality technical solution with a good support structure is implemented, which leads to increase use, higher user satisfaction, and positive outcomes (DeLone & McLean, 2003).

Literature Review

A literature review was performed to investigate the evidence of HIE and PDMP usage in the emergency department. Due to the rapid changes in federal and state policies and the advancement in technology, published HIE and PDMP studies are limited. Searches were conducted using PubMed and CINAHL with 198 articles retrieved, which was narrowed to 11 publications based on relevance and study design. Due to the paucity of the impact of HIE and PDMP literature, the review will begin with care transitions then expand on the importance and benefits of HIE and the PDMP. Next, the review will discuss the barriers to using HIE and the PDMP. Finally, the review will conclude with current recommendations to improve HIE and the PDMP.

Care Transitions

Having the HIE and PDMP tools easily accessible in a fast paced ED environment is key, especially when patients have data at multiple institutions. By examining automated query-based transmission of patient documentation, researchers found that care transitions from one

facility to another facility occurred in 28% of total encounters. The findings indicated 41% of consent patients had encounters supported by automated query-based HIE system. Of these patients, more than 70% of these patients had more than two visits and 41% visited multiple facilities (Campion, Vest, Ancker, & Kaushal, 2013). The study is significant as it concludes many patients have data at different healthcare organizations and highlights the need for data sharing through the HIE and the PDMP. A limitation of the study was that patient transition measurement was counted if the transfers occurred between the facilities in the study and not outside to other facilities. Another weakness of the study was due to inconsistency of transmission of patient care summary documents within the facility-to-facility transfers; therefore, not all accounts of hospital admissions and/or clinic visits may have been captured. More research is needed to better understand how frequently and why patients visit multiple institutions.

Benefits

The literature confirms the benefits of HIE are to improve quality of care, reduce admissions and reduce costs (Carr et al., 2013; Frisse et al., 2012; Rudin et al., 2014). Carr et al., (2013) examined the use of HIE and the use of health services for ED patients. Results showed that 86.7% of surveyed providers claimed that HIE improved the quality of care (Carr et al., 2013) especially in managing chronic patients in multiple institutions (Frisse et al., 2012). Rudin et al., (2014) systematic review findings indicated access to HIE data can improve the quality of care by decreasing duplicate tests, and reducing unnecessary admissions, which can lead to cost savings. One of the studies found HIE access correlated with a decrease in hospital admissions (Frisse et al., 2012). For example, a hospital used a Web portal to access HIE was associated with a decrease in hospital admissions (OR 0.27; 95% CI 0.21- 0.35; $p<0.001$); while another

hospital using HIE print summaries was also associated with a decrease in hospital admissions (OR 0.47; 95% CI 0.40 - 0.57; p<0.001) (Frisse et al., 2012). This study also demonstrated HIE access significantly decreased the number of laboratory and diagnostic imagining tests ordered, which resulted in an annual cost savings of $1.1 million (Frisse et al., 2012). Similarly, Carr's (2013) findings indicated that patients with HIE information had a cost savings of $2,699.77 per hospitalization. Although using HIE has been shown to improve care, reduce admissions, and decrease costs, the studies were weak in quantifying clinical outcomes.

Likewise, access to prescription data via PDMP allows for better care delivery (ONC & SAMHSA, 2012). For instance, a significant study conducted by the ONC & SAMHSA (2012) showed that 82% of practitioners found PDMP data valuable for clinical use especially for those communities who are seeing an increase in opioid misuse and addiction. Notably, 72% of prescribers indicated that the PDMP data provided new information, which altered their prescribing pattern by 58% (ONC & SAMHSA, 2012). Specifically, there was a reduction in the number of prescriptions written and the number of pills prescribed (ONC & SAMHSA, 2012). Equally, Rathlev et al. (2016) found PDMP "pushed" alerts were associated with a decrease in opioids prescribed to patients with opioid use disorder and high utilizers of the ED. Researchers conducted a randomized control study comparing the proportion of morphine (mg) received by the care plan alert group (4.5% to 2.9%) to the usual care group (15.7% to 25.7%) during the study period (Rathlev et al., 2016). There was an 89% proportional prescribed change pre-period to post- period in the care plan alert group compared to the usual care group (OR .11 [95% CI[0.01-0.092]; p=0.04) (Rathlev et al., 2016). The literature reviewed above is testimony to the benefits of HIE and the PDMP to improving the quality of care and reducing the cost of healthcare (Carr et al., 2013; ONC & SAMHSA, 2012).

Barriers

Despite the benefits of HIE and PDMP, EDs often fail to adopt these information systems. The literature suggests two key barriers. First, evidence indicates that practitioners tend not to use HIE and the PDMP due to the lack of access. The lack of access to HIE and PDMP is often due to a lack of knowledge and difficulties with the enrollment process. Rudin et al. (2014) noted that some practitioners were not aware of their HIE or how to access it. Similarly, investigators found approximately 25% reported no knowledge of HIE or did not have access to their state's PDMP (Perrone, DeRoos & Nelson, 2012). Consequently, practitioners did not obtain access to HIE and PDMP due to the complexity of the registration process (Greenwood-Ericksen et al., 2015; Thorn et al., 2014). Another study revealed that practitioners stopped using HIE and the PDMP because access to the website was cumbersome. Practitioners often forgot usernames and passwords, which were difficult to recover (Greenwood-Ericksen et al., 2015). Second, much of the literature uniformly suggests the major barrier to using the HIE and the PDMP was the lack of integration between the systems (Carr et al., 2013; Perrone, DeRoos & Nelson, 2012; Rudin et al., 2014; Thorn et al., 2014). Specifically, accessing portals outside the EHR and having multiple log-ins were major deterrents (Perrone, DeRoos & Nelson, 2012; ONC & SAMHSA, 2012). In Poon et al. (2015), investigators compared the time and number of clicks required to review one patient's record in the external PDMP system to perform three computer-based tasks in the EHR used in the ED. Results showed the PDMP task took significantly longer time to complete than the three EHR tasks.

Recommendations

The literature claims that the use of technology increases as the systems are integrated with provider's workflow and acceptance increases when the technical solution provides better patient care (Thorn et al., 2014; ONC & SAMHSA, 2012). Therefore, to promote HIE and PDMP usage in the ED, researchers recommend the integration of the HIE, PDMP and the EHR (Greenwood-Ericksen et al., 2015; ONC & SAMHSA, 2012; Rathlev et al., 2016). Three distinct changes have been offered to facilitate adoption of the HIE and the PDMP in the EHR: 1) streamline the log-on procedure; 2) automatically enroll practitioners in HIE and the PDMP; and 3) automate queries for patient health information and prescription history (Campion, Vest, Ancker, & Kaushal, 2016; Greenwood-Ericksen et al., 2015). The evidence suggests 97% of the surveyed practitioners felt accessing PDMP inside the EHR was easier than doing it outside (ONC & SAMHSA, 2012). This difference in user satisfaction reflected the use of a single log on procedure and the elimination of the need for a separate enrollment in the EHR. In addition, the automatic queries increased usage as access to PDMP was incorporated into the ED providers' workflow (ONC & SAMHSA, 2012).

Discussion

The literature review included 11 publications: five HIE and six PDMP studies. The literature review addressed care transitions, the barriers to adoption, benefits in using the systems, and recommendations for increase adoption for better care coordination. The studies were appraised on the level and quality of evidence (see Appendix A-E). The strength of evidence ranged from level II to level VII, with the majority of the studies rating a level VI due to the nature of the study. The quality of evidence ranged from good to low due to the study design, limited or no statistical data, and limited generalizability. The level II study was

conducted by Rathlev et al. (2016). Their randomized control trial (RCT) found pushed "care plan" alerts demonstrated a change in opioid prescribing. The strength of this level II study was based on the conceptualization of the design, methods used, and outcomes. The level III studies had a quasi-experimental design that looked at PDMP use, but their methods were different. Baehren et al. (2010) surveyed ED providers while they were caring for their patients (before and after using HIE). Poon et al. (2015) looked at PDMP usability by mixed methods. Despite the different methods, the use of PDMP altered prescribing behavior. The level IV study was a HIE access case control conducted by Frisse et al. (2011). The findings indicated low HIE usage but when HIE was used, HIE was noted to be useful and cost effective. This study's strength was due to the well-developed conceptualization design and large sample size. However, low HIE usage may have been contributed to a lack of integration of the HIE into the EHR. The level V systematic review study conducted by Rudin et al. (2014) is significant due to the large number of publications reviewed. Interestingly, the authors found an overall low quality of HIE research studies due to the small sample size, poor design and inconclusive outcomes. The level VI studies accounted for the majority of this literature reviewed. These studies revealed that HIE and/or PDMP uniformly provided value in care delivery, but the evidence varied per study (Campion et al., 2013; Carr et al., 2013; Perrone et al., 2012; ONC & SAMHSA, 2012; & Thorn et al., 2014). Lastly, the Level VII study was an expert panel publication with their recommendations for PDMP. While the recommendations of the experts were extensive, the evidence behind the recommendations was limited and/or withheld.

In summary, the HIE and PDMP literature are limited in the strength of evidence; however, the methods used and the findings will be helpful in translating evidence into

practice. Importantly, there is evidence that HIE and PDMP improves care delivery, reduces admissions, and reduces costs (Baehren et al., 2010; Carr et al., 2013; Frisse et al., 2012). Moreover, the literature overwhelmingly suggests that HIE and PDMP need to be easily accessible by integrating it into the practitioner's workflow (Carr et al., 2013; Greenwood-Ericksen et. al, 2015; ONC & SAMHSA, 2012; Rathlev et al., 2016; Rudin et al., 2014). Recent studies advocate for data to be easily viewable at the right time especially for high frequency ED patients (Greenwood-Ericksen et. al, 2015; Rathlev et. al, 2016). To promote efficient information sharing and address fragmented workflows, it is important to consider the evidence of integrating HIE and PDMP data.

Methods

Project Design, Setting, and Subjects

The project design was a healthcare innovation to make the PDMP accessible in the EHR for ED providers in a community hospital with a pre and post data collection. The patient's dispensed CDS prescription history displayed in two ways: 1) by clicking on the CRISP HIE button, the Maryland PDMP appears in the CRISP clinical view and 2) by clicking on the interstate PDMP tab, the PDMP dispensed drugs in Virginia, West Virginia, Connecticut, and Arkansas displayed. The following information also displayed: drug name, date filled, pharmacy, script, prescription number, refills remaining, total refills, payment method, and state.

The project was conducted in the ED of a 300 plus bed acute care community hospital. This ED is known to be one of the busiest EDs in the state of Maryland with over 100,000 ED visits and 80% of admissions coming through the ED. At the beginning of the study, the sample size was 62 ED providers, which was composed of board certified emergency medicine physicians, nurse practitioners, and physician assistants. Inclusion criteria included all employed licensed

ED providers (full and part time) and practitioners noted with a primary specialty as emergency medicine in CRISP database. Exclusion criteria included practitioners' secondary specialty as emergency medicine.

Implementation Plan

The project was implemented in five phases based on an adapted version of the DeLone and McLane's model (2003): 1) system quality; 2) information quality; 3) services quality; 4) implementation, and 5) data collection and analysis. The implementation plan is illustrated in Appendix F. Phase one involved current workflow assessment of the ED practitioners, how the HIE and EHR system are used, and the technical capabilities of the systems. With a better understanding of the clinical needs and technical requirements, the project was presented and approved by the enterprise-wide physician and pharmacy user groups. Next, two workgroups were formed: 1) clinical, and 2) technical. The clinical workgroup involved physician champions, IT analysts, and the project lead that provided decisions on workflows. The technical workgroup was comprised of representatives from CRISP, the EHR vendor, IT analyst and the project lead.

Phase two involved building and testing to ensure system and information quality. The build in the EHR and CRISP involved technical configuration by CRISP and IT. Testing requires different forms of measures: 1) unit testing of the CRISP HIE button functionality; 2) testing within the different EHR application modules per user role; 3) testing the integrated workflow; and 4) regression testing to ensure other workflows were not impacted. Testing involved both workgroups.

Phase three involved training and communication to ensure service quality. The training plan included the following tactics: 1) a tip sheet about PDMP (Appendix I); 2) a training video about

the CRISP PDMP posted on the intranet site and tip sheet; and 3) an email communication sent by the provider champion. Phase four involved the implementation of the PDMP display in the EHR. This phase involved the actual use of the HIE and PDMP. The practitioner logged into the EHR using a secured username and password. Once in the EHR, the provider searched for the patient. The practitioner accessed CRISP by clicking on the CRISP HIE button. PDMP data appeared in the CRISP clinical view. By clicking on the CRISP HIE button, the CRISP database recorded the provider accessing the HIE. With the HIE/PDMP information and assessment of the patient, the practitioner prescribed treatment (i.e., medications, labs, and diagnostic tests) and determined to admit or discharge the patient. Discharging a patient from the ED involved discharge instructions and possibly prescriptions. During this phase, a support plan was in place to assist with technical and workflow issues. Multiple debriefing session(s) were held post implementation with CRISP, physician champions, application teams and help desk staff. Phase five involved data collection and analysis. System quality, information quality and services quality will be reflected in the HIE usage data. The variables, steps for data collection, and data analysis are outlined below.

Protection of Human Subjects

An application for exempt review was submitted to the University of Maryland Baltimore (UMB) Institutional Review Board for a Non-Human Subjects Research (NHSR) determination. Non-Human Subjects determination was received on May 11, 2016 (see Appendix J). The data collected was protected by filtering out patient and provider identifiers. Only authorized data analysts have access to the databases. Only the project leader had access to the study data which was stored in a password protected file on a secure server.

Data Collection and Data Analysis

Data were collected from three databases: 1) the hospital credentialing database; 2) the CRISP databases (includes reports); and 3) the hospital EHR database. Data were collected for the time periods: Pre PDMP (January- April 2016) and Post PDMP (May-August 2016). Data extracted from the hospital credentialing system included the number of employed providers, type of licensed providers (medical doctor, nurse practitioner, and physician assistant), age, and years of service at the target hospital. Data extracted from CRISP included the HIE usage rate, number of ED visits, inpatient admissions, and readmissions. Variable definitions are in Appendix G. Data extracted from the hospital EHR database provided ED visits from January to August 2016. The patient data included the date of admission, the physician of record, the ED treatments ordered during the ED visit (narcotics, CBC, CMP or BMP, CXR, CT scan, and MRI) and narcotic prescriptions written at ED discharge.

Descriptive statistical procedures and measures of central tendencies (mean, median, mode) were used to describe and analyze the sample. To determine the CRISP HIE and PDMP utilization rate, data analysis was conducted utilizing descriptive statistics, measures of central tendencies, paired t-test statistics, and two-factor analysis of variances (ANOVA). Descriptive statistics were also used to analysis the overall CRISP HIE usage by all providers (PAs, MD/DOs, and NPs). A paired t-test was conducted to measure the HIE utilization Pre/Post PDMP.

To answer the clinical question, does HIE and PDMP change physician behavior, a two-factor analysis of variance (ANOVA) was conducted on the influence of two independent variables (CRISP HIE button and Pre/Post PDMP). The use of CRISP HIE button included two levels, comparing use and nonuse Pre PDMP (January to April) and Post PDMP (May to August)

implementation. The analysis examined the effect of providers ordering behavior with those who used the CRISP HIE button Pre/Post PDMP implementation and those who did not use the CRISP HIE button. Finally, to explore if HIE and PDMP had an impact care coordination, a descriptive statistical procedure was used to evaluate readmission rates Pre/Post PDMP implementation. Hospital discharge, readmission rate, and unadjusted inpatient readmission rate were analyzed. Excel and the statistical program, Statistica 12, were used to conduct analysis.

Results

At the time of the PDMP implementation, 62 providers worked in the ED. ED providers consisted of 31 PAs (50%), 29 MD/DOs (47%), and two CRNPs (3%). The mean age of the providers was 40.95 (SD=20) years old with the majority being females (females= 65%; males= 35%). Years of employment ranged from less than 1 year to 29 years (M= 7.98, median= 7.00, mode= 1.00, SD=6.94). See Table 1 for demographics.

Table 1
Demographic characteristics of study group prior to DMP

Baseline characteristics (n=62 providers)				
	n	%		
Licensure				
MD/DO	29	47%		
PA	31	50%		
CRNP	2	3%		
Gender				
Females	40	65%		
Males	22	35%		
	Mean	Median	Mode	SD
Age (years)	40.95	39	35	9.9
Years of employment	7.98	7	1	6.94

Findings indicated overall HIE utilization by ED providers (PAs, MD/DOs, and NPs) via the CRISP HIE button three months Post PDMP implementation (M=238) was higher than the three months Pre PDMP (M=90.75). Prior to the implementation, 34% of ED providers were

registered with CRISP; with the implementation, subsequently, 100% of providers were registered with CRISP and the Maryland Department of Health and Mental Hygiene for PDMP access. Findings also revealed CRISP HIE button usage increased significantly after the PDMP implementation (M=119.33 to M=231.33, t (2) = -15.79, p <.001). There was an increased spike during the month of the PDMP implementation, followed by a slight decrease the following months. See Figure 1 for the CRISP HIE button usage rate.

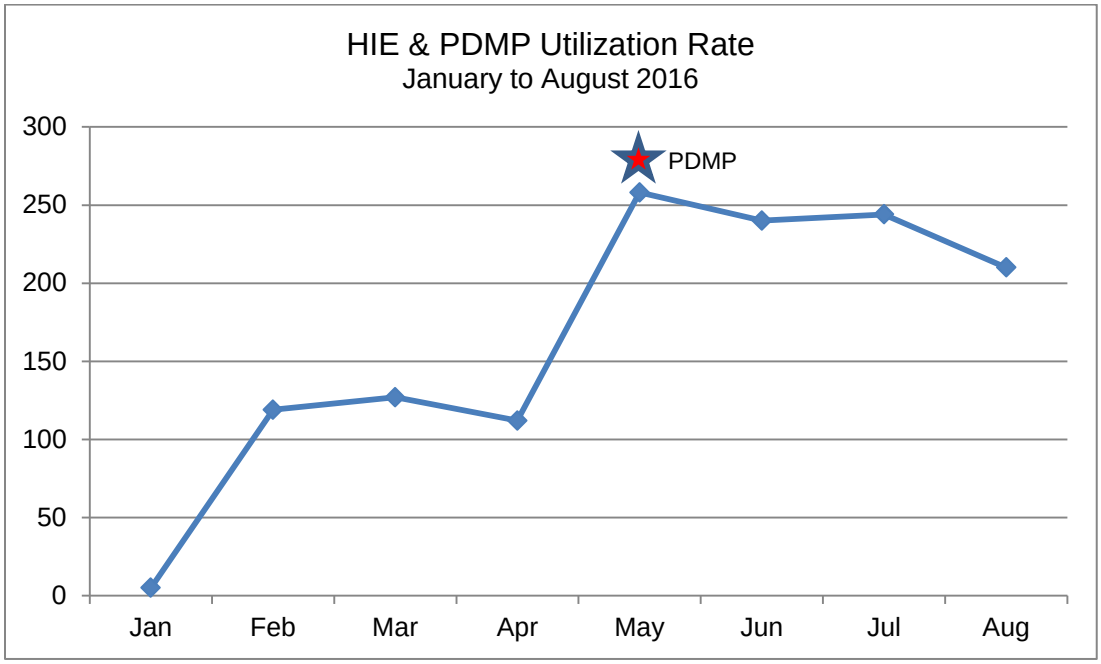


Figure 1. Monthly HIE utilization rate before/after PDMP implementation on May 17, 2016

The EHR data included 63,312 registered ED visits from January to August 2016. These ED visits were linked to the CRISP HIE button usage data. The ED visits were narrowed to 53,554 ED visits based on 24 ED physicians, employed January to August 2016, who were users of the EHR, CRISP HIE, and PDMP. Five physicians were removed from the sample due to infrequent use of the EHR or departure from the organization during the study. NPs and PAs were also removed from the sample due to the difficulty of matching providers to ED encounters when the

provider was not listed as the admitting physician. Similar to the early findings, the ED physicians (n=24) revealed a significant increase CRISP button usage with the PDMP implementation (M=33.83 to M=78.88, t (22) = -7.75, p <.001).

To test whether the use of the CRISP HIE and the facilitation of its use by the PDMP implementation changed physician behavior, the study monitored the narcotic prescribing rate (number of narcotic prescription/orders per patient visit in the ED). Findings revealed a significant main effect of the CRISP HIE button ($F_{(1, 23)}$ = 30.583, p < .001), indicating that access to the system changed narcotic prescription ordering behavior at ED discharge (see Table 2). Importantly, there was no main effect or interaction with Pre/Post PDMP ($F_{(1, 23)}$ = 0.026, p = 0.87). Thus, the effect of the CRISP usage did not depend on the use of PDMP. Interestingly, the results indicated a significant main effect of the CRISP HIE button ($F_{(1, 23)}$ = 182.230, p < .001), indicating a narcotic order rate increase when CRISP was used during an ED visits (see Table 2). In this case, there was also a significant main effect of PDMP ($F_{(1, 23)}$ = 7.953, p = 0.010), suggesting that ease of use also facilitated ordering of narcotics during the visits.

Five other ED treatment orders were evaluated Pre/Post PDMP, which included: CBC, CMP or BMP, CXR, CT scan and MRI. Findings on all five datasets revealed a significant main effect of the CRISP HIE button (ranging from an F ratio of $F_{(1,23)}$ = 24.923, p < .001 to an F ratio of $F_{(1,23)}$ = 10.679, p < .001$F_{(1,23)}$ = 0.983, p = 0.332), indicating that access to the system changed ordering behavior. Ordering of CBC, CMP or BMP, CXR, CT scan, and MRI occurred more frequent when the CRISP HIE was used . Again, there were no main effects or any interactions involving PDMP. Thus, the effects of the CRISP HIE button did not seem to depend on whether or not PDMP was in effect. Test of between- subject effects for lab orders during ED visits are shown in Table 3 and imaging orders in Table 4.

Table 2. Two-factor ANOVA

Source	SS	df	MS	F	p
Dependent variable: Narcotic prescriptions at ED discharge					
CRISP HIE button	.158	1	.158	30.583	<.001*
	.119	23	.005		
PDMP	.000	1	.000	.026	.873
	.077	23	.003		
CRISP HIE use*PDMP	.004	1	.004	1.387	.251
	.062	23	.003		
Dependent variable: Narcotics orders during ED visit					
CRISP HIE button	.818	1	.818	182.230	<.001*
	.103	23	.004		
PDMP	.031	1	.031	7.953	.010**
	.090	23	.004		
CRISP HIE use*PDMP	.003	1	.003	.535	.472
	.119	23	.005		

*Statistical significance at least at p≤ 0.001 level **Statistically significance at least at p≤ 0.01

Table 3. Two-factor ANOVA

Source	SS	df	MS	F	p
Dependent variable: CBC orders					
CRISP HIE button	.112	1	.112	16.695	<.001*
	.155	23	.007		
PDMP	.017	1	.017	3.005	.096
	.134	23	.006		
CRISP HIE use*PDMP	.001	1	.001	.164	.689
	.114	23	.005		
Dependent variable: BMP & CMP orders					
CRISP HIE button	.126	1	.126	17.749	<.001*
	.164	23	.007		
PDMP	.013	1	.013	2.334	.140
	.132	23	.006		
CRISP HIE use*PDMP	.002	1	.002	.377	.545
	.115	23	.005		

*Statistical significance at least at p≤ 0.001 level

Table 4. Two-factor ANOVA

Source	SS	df	MS	F	P
Dependent variable: CXR orders					
CRISP HIE button	.077	1	.077	14.722	.001*
	.121	23	.005		
PDMP	.008	1	.008	1.377	.253
	.137	23	.006		
CRISP HIE use*PDMP	.002	1	.002	0.603	0.445
	.073	23	.003		
Dependent variable: CT scan orders					
CRISP HIE button	.125	1	.125	24.923	<.001*
	.115	23	.005		
PDMP	.004	1	.004	0.983	.332
	.099	23	.004		
CRISP HIE use*PDMP	.000	1	.000	0.114	.739
	.098	23	.004		
Dependent variable: MRI orders					
CRISP HIE button	.010	1	.010	10.679	<.001*
	.022	23	.001		
PDMP	.001	1	.001	.442	.513
	.027	23	.001		
CRISP HIE use*PDMP	.002	1	.002	1.332	.260
	.026	23	.001		

*Statistical significance at least at p≤ 0.001 level

Findings of the hospital data revealed readmissions rates decreased after the PDMP implementation (M=192.75 to M=170.50). The readmission rate decreased from 14.64% to 12.58%. See Figure 2 for the unadjusted inpatient readmit rate from January to August 2016, which did not factor case-mix data.

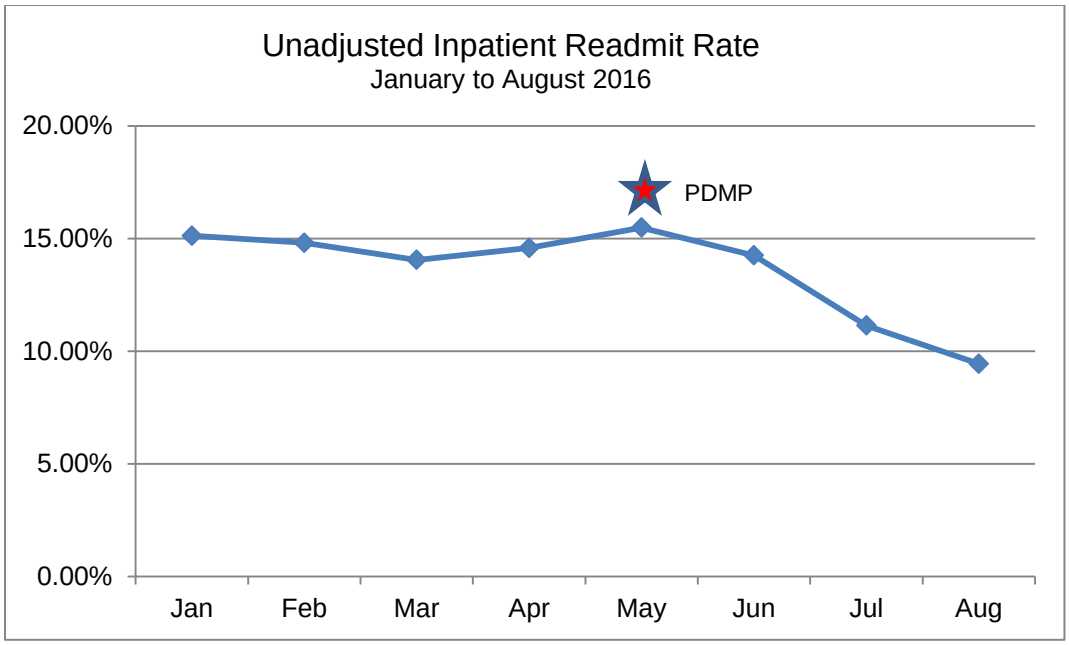


Figure 2. Unadjusted Inpatient Readmission Rate.
PDMP implementation took place May 17, 2016. Findings of the hospital data revealed a decrease in readmission rate from 14.64% to 12.58%.

Discussion

The purpose of this healthcare innovation was to develop, implement, and evaluate the impact of having HIE/PDMP data accessible in the EHR for ED providers. A better understanding of the HIE usage will serve to inform organizational leadership and aid the responsiveness to the barriers and facilitators of the technical initiatives.

This project examined the difference between ED providers, those who used the CRISP HIE button pre/post PDMP implementation and those who did not use the CRISP HIE button. The PDMP was designed to evaluate the narcotic ordering practices during the ED visits and at discharge. The study has shown with the PDMP implementation, there was a significant increase in the CRISP HIE button utilization. Streamlining the CRISP and PDMP registration and access process was able to unblock the barriers in using HIE. Adding the CRISP HIE button and PDMP in the HER may have influenced the ordering behavior in the ED.

The study demonstrated that the use of the CRISP HIE button affected the narcotics, laboratory, and diagnostic imaging test prescribing during an ED visit, and writing narcotic prescriptions at ED discharge. The study also demonstrated an increase in narcotic ordering with the use of the CRISP HIE button and Post PDMP implementation. The resultant behavior of the providers may have directly related to the complexity of the patients and the need for HIE patient data to treat patients, especially when ordering narcotics.

The encouraging findings indicated access to the patient's comprehensive HIE data, especially when it includes the controlled dispensed substance data, may have contributed to the increase utilization of the CRISP HIE button. The implementation of the CRISP button with PDMP may have contributed to the decrease in the hospital readmission rate. The finding that HIE is beneficial in care coordination is consistent with previous research, along with the perception of streamlining providers workflow will most certainly increase adoption as the result of the innovative technology (Carr et al., 2013; Frisse et al., 2012; Rudin et al., 2014).

While findings showed an increase of HIE usage rate, the study failed to demonstrate if the HIE and PDMP data were helpful and if it altered the ED providers' narcotic ordering practice. In addition, the CRISP button continued to have technical issues, which could have influenced the CRISP HIE button usage. The types of patients admitted to the ED are cyclic and a short-term study would not capture the seasonality of the patient population. A longitudinal study would strengthen the analysis.

Implementation Challenges

With every implementation, there are issues. On May 17, there were issues with CRISP HIE button turning on the PDMP access, which was corrected the following day. With the PDMP

implementation, the issues were combined with the CRISP HIE button plus PDMP since PDMP relies on the infrastructure of CRISP HIE button. The implementation challenges can be categorized into two groups: 1) provision of users, and 2) technical issues. The implementation challenges are outlined in Table 6.

The biggest implementation challenge was the provisioning of the user roles. Since the provisioning of the EHR and the CRISP HIE button process was previously established, the PDMP user provisioning process was incorporated into the existing processes. However, due to the urgency of the project and the lack of provider's CDS license in the EHR system, a short and long-term plan was needed. The short-term plan included user data extraction from medical staff office credentialing systems since there were no interfaces for CDS license numbers for providers. The long-term plan is to include the CDS license field in the EHR access form as a required field, but also add the CDS license number in the hospital credentialing system interface message. Since the clinical pharmacists do not have a CDS license number, a process was established to add the hospital CDS license number for the clinical pharmacists. Due to the high volume of user loading, CRISP experienced technical and resource issues in adding PDMP access to the CRISP HIE button users. Unless the project leader received an email or helpdesk ticket, it was difficult to know if all providers had CRISP and PDMP access.

Other technical challenges included the bulk cross match of patient data. CRISP was aware of this issue and has a strategy in place to upgrade their system in the December timeframe, at which time CRISP will recompare all records to each other in what is called a "bulk cross match." CRISP believed this process would create some linkages that may have been previously in error and should reduce the duplicate rate. Currently, CRISP's Master Patient Index (MPI), a unique patient identifier, currently receives data from several data sources that

contain insufficient demographic data to match with another record. These records create duplicate identities in the MPI every time (i.e., reference labs). CRISP is working with these data sources to increase the amount of demographic information included in the messages so that they begin to link with records. All these improvements will provide better patient matching for clinical data, such as the PDMP.

Table 6. Implementation Challenges

	Description	Action
PDMP Access		
Provisioning Users	• Not all users had access to CRISP HIE button and/or PDMP due to no CDS license number	• Added CDS license number in interface message from credentialing system • Added required field to hospital user access form
Technical		
CRISP HIE Slowness	• Direct correlation between slowness and the amount of incoming data • CRISP has increased its data input significantly, recently adding a number of CCD sources.	• Added resources to CRISP infrastructure
Patients in CRISP	• Duplicate patients not found by MRN search	• CRISP system upgrade planned for late fall. CRISP will recompare all records to each other in what is called a “bulk cross match.”

Conclusion

With the heightened focus on care coordination, healthcare organizations are being held accountable to decrease readmission rates, improve the quality of care, and lower the cost of care. It becomes necessary to build and deliver effective solutions that enhance patient care through the innovative use of technology. This scholarly project streamlined access to HIE and the PDMP, which increased the CRISP HIE utilization. The increase in use of CRISP HIE and PDMP may contribute in improving care coordination and patient outcomes. This project supports the need for technology advancement to improve accessing and viewing HIE/PDMP

data. Future plans include the implementation of PDMP Application Programming Interface (API) to push patient's dispensed controlled substance data rather than launching a CRISP HIE button.

References

Agency for Healthcare Research and Quality (2015). Retrieved from http://hcupnet.ahrq.gov/HCUPnet.app/Methods-HCUPnet%20readmissions.pdf

Baehren, D. F., Marco, C. A., Droz, D. E., Sinha, S., Callan, E. M., & Akpunonu, P. (2010). A statewide prescription monitoring program affects emergency department prescribing behaviors. *Annals of Emergency Medicine, 56*(1), 19-23.e3. doi:http://dx.doi.org.proxy-hs.researchport.umd.edu/10.1016/j.annemergmed.2009.12.011

Carr, C. M., Gilman, C. S., Krywko, D. M., Moore, H. E., Walker, B. J., & Saef, S. H. (2014). Observational study and estimate of cost savings from use of a health information exchange in an academic emergency department. *The Journal of Emergency Medicine, 46*(2), 250-256.doi:10.1016/j.jemermed.2013.05.068

Campion, T. R., Vest, J. R., Ancker, J. S., & Kaushal, R. (2013). Patient encounters and care transitions in one community supported by automated query-based health information exchange. *American Medical Informatics Association Annual Symposium Proceedings,* 175-84.

Centers for Disease Control and Prevention (2011). National Hospital Ambulatory Medical Care Survey: 2011 Emergency Department Summary Tables. Retrieved from http://www.cdc.gov/nchs/data/ahcd/nhamcs_emergency/2011_ed_web_tables.pdf

Centers for Medicare and Medicaid Services (2015); Retrieved from https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Readmissions-Reduction-Program.html

Chesapeake Regional Information for Our Patients (2015). CRISP Monthly Reports March 2015 (CRISP Report March 2015). Retrieved

from: http://mhcc.maryland.gov/mhcc/pages/hit/hit_hie/documents/HIE_CRISP_Mon_Rpt_20150301.pdf

DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean Model of Information Systems Success: A Ten-Year Update. *Journal of Management Information Systems*, *19*(4), 9-30.

Greenwood-Ericksen, M. B., Poon, S. J., Nelson, L. S., Weiner, S. G., & Schuur, J. D. (2015). Best practices for prescription drug monitoring programs in the emergency department setting: Results of an expert panel. *Annals of Emergency Medicine.* Advance online publication. doi:http://dx.doi.org.proxy-hs.researchport.umd.edu/10.1016/j.annemergmed.2015.10.019

Grove S. (2007). *Statistics for health care research: A practical workbook*. St. Louis, MO: Elsevier.

Fincham, J. E. (2008). Response rates and responsiveness for surveys, standards, and the *Journal*. *American Journal of Pharmaceutical Education*, *72*(2), 43.

Finnell, J.T., Overhage, J.M, & Grannis, S., (2011). All health is not local: an evaluation of the distribution of emergency department care delivered in Indiana. *Proceedings of the American Medical Informatics Association Annual Symposium*, 109-416.

Frisse, M. E., Johnson, K. B., Hui, N., Davison, C. L., Gadd, C. S., Unertl, K. M., & ... Qingxia, C. (2012). The financial impact of health information exchange on emergency department care. *Journal of the American Medical Informatics Association*, *19*(3), 328-333. doi:10.1136/amiajnl-2011-000394

Mastrian, K.G., McGonigle, D., & Farcus, N. (2012). Ethical applications of informatics. In D. McGonigle & K.G. Mastrian (Eds). *Nursing informatics and the foundation of knowledge* (2nd ed., pp. 69-88). Burlington, MA: Jones and Bartlett.

McDonald, K. M., Sundaram, V.M, Bravata, D.M., Lin, N., Kraft, S., McKinnon, M., … Owens, D.K. (2007). Care coordination. In K.G. Shojania, K.M. McDonald, R.M. Wachter, & D.K. Owens (Eds). *Closing the quality gap: A critical analysis of quality improvement strategies*. (Agency for Healthcare Research and Quality [AHRQ] Publication No. 04[07]-0051-7. pp.33-139). Rockville, MD: AHRQ.

Newhouse, R.P. (2006). Examining the support for evidence-based nursing practice. Journal of Nursing Administration, 36(7-8), 337-40.

Melnyk, B.M., Fineout-Overholt, E. (2011). *Evidence-based practice in nursing & healthcare: A guide to best practice* (2nd ed.). New York: Lippincott, Williams & Wilkins.

Perrone, J., DeRoos, F. J., & Nelson, L. S. (2012). Prescribing practices, knowledge, and use of Prescription Drug Monitoring Programs (PDMP) by a National Sample of Medical Toxicologists, 2012. *Journal of Medical Toxicology*, *8*(4), 341–352. http://doi.org.proxy-hs.researchport.umd.edu/10.1007/s13181-012-0250-2

Poon, S., Greenwood-Ericksen, M., Gish, R., Neri, P., Takhar, S., Schuur, J., & Landman, A. (2015). Usability of the Massachusetts Prescription Drug Monitoring Program in the emergency department: a mixed methods study. *Annals of Emergency Medicine*, *66*(Supplement). doi:10.1016/j.annemergmed.2015.07.282

Rathlev, N., Almomen, R., Deutsch, A., Smithline, H., Li, H., & Visintainer, P. (2016). Randomized controlled trial of electronic care plan alerts and resource utilization by high frequency emergency department users with opioid use disorder. *Western Journal of*

Emergency Medicine, *17*(1). doi: 10.5811/westjem.2015.11.28319. uciem_westjem_28319

Rudin, R. S., Motala, A., Goldzweig, C. L., & Shekelle, P. G. (2014). Usage and effect of health information exchange. *Annals of Internal Medicine, 161*(11), 803-811. doi:10.7326/M14-0877

The Office of the National Coordinator. (2015). Federal *Health IT Strategic Plan 2015-2020.* Retrieved from: https://www.healthit.gov/sites/default/files/9-5-federalhealthitstratplanfinal_0.pdf

The Office of the National Coordinator for Health Information Technology, & Substance Abuse and Mental Health Services Administration (2012). *Integration an emergency department with a Prescription Drug Monitoring Program: A pilot study*. McLean, VA.

Thorn, S. A., Carter, M. A., & Bailey, J. E. (2014). The practice of emergency medicine/original research: Emergency physicians' perspectives on their use of health information exchange. *Annals of Emergency Medicine, 63*(3), 329-337. doi:10.1016/j.annemergmed.2013.09.024

Weinick, R.M., Burns, R.M., & Mehrotra, A. (2010). How many emergency department visits could be managed at urgent care centers and retail clinics? *Health Affairs 29*(9):1630-6. doi: 10.1377/hlthaff.2009.0748.

Appendix A

Melnyk & Fineout-Overholt Rating and Grading Scale

Melnyk & Fineout-Overholt (2011) Rating and Grading Scales for Hierarchy of Evidence Key

Level of the Evidence	Type of the Evidence
I (1)	Evidence from systematic review, meta-analysis of all relevant randomized controlled trails (RCTs), or practice-guidelines based on systematic review of RCTs.
II (2)	Evidence obtained from well-designed RCT
III (3)	Evidence obtained from well-designed controlled trials without randomization
IV (4)	Evidence from well-designed case-control and cohort studies
V (5)	Evidence from systematic reviews of descriptive and qualitative studies
VI (6)	Evidence from a single descriptive or qualitative study
VII (7)	Evidence from the opinion of authorities and/or reports of expert committees

Appendix B

Quality Rating Scheme Table

Quality Rating Scheme Key (Newhouse et al., 2007)

Quality Rating Scheme Key		
Rating Scale	Rating Level	Description
A	High	Consistent results with sufficient sample Adequate control Definitive conclusions Consistent recommendations based on extensive literature review
B	Good	Reasonably consistent results with sufficient sample Some control Fairly definitive conclusions Reasonably consistent recommendations based on fairly comprehensive literature review
C	Low/major flaw	Little evidence with insufficient sample size No control Inconsistent results Conclusions cannot be drawn.

Appendix C

Summary of Literature Review with Level of Evidence and Quality Rating Table

Author, Year	Study Design & Objectives	Sample (N)	Outcomes Studied (how measured)	Results	Level & Quality Rating
Baehren, D. F., Marco, C. A., Droz, D. E., Sinha, S., Callan, E. M., & Akpunonu, P., 2010	Prospective quasi-experimental study To monitor controlled substance prescriptions within Ohio	N=179 participants	• After examining patient, providers were surveyed by research assistant on the likelihood of using HIE and likelihood of writing prescription for controlled substance. HIE data (intervention) was presented to provider. Providers surveyed again to see if there was a change in prescription and other questions. • Primary outcome measure: change in opioid prescription • Secondary outcome measures: change in clinical management, (# of prescriptions, # of prescribing physicians)	• Providers changed clinical management in 41% (N=74) of cases • 61% resulted in fewer or no opioid medications prescribed than originally planned in altered management • 39% resulted in more opioid medication than previously planned • Summary: use of PDMP data frequently altered prescribing practice for patients with nontraumatic pain in the ED • Delay in HIE PDMP data (up to 3 weeks)	III B

Author, Year	Study Design & Objectives	Sample (N)	Outcomes Studied (how measured)	Results	Level & Quality Rating
Campion, T. R., Vest, J. R., Ancker, J. S., Kaushal, R., & the HITEC Investigators, 2013	Nonexperimental Descriptive, cross-sectional study To describe the extent to which an automated query-based HIE system that transmitted summary of care documents to healthcare facilities in one community supported patient encounters & care transitions.	N=81,687 patients During the 23-month study period,	• Measured the extent to which automated query-based HIE supported patient encounters & care transitions in one community • The final data set contained transmissions representing 145,668 unique patient encounters • Looked at patients with encounters vs. without encounters	• 41% of patients (n=13,685) visited two or more facilities which accounted for 68% of total encounters. Of total encounters, 28% of patients (n=40,828) had care transitions from one facility to another. • Automated query-based HIE- supports care transitions; provides efficient information sharing; addresses fragmented care • Manual directed exchange requires providers to remember to initiate query transmission to seek information. Remembering is a barrier. • Automated transmission avoids many of the potential workflow, health care practice, human errors involved in data transmission	VI B

Author, Year	Study Design & Objectives	Sample (N)	Outcomes Studied (how measured)	Results	Level & Quality Rating
Carr, C. M., Gilman, C. S., Krywko, D. M., Moore, H. E., Walker, B. J., & Saef, S. H., 2014	Nonexperimental Qualitative study (surveyed providers) To investigate the ability of an HIE to decrease health services use for emergency department (ED) patients.	N=138 surveys All ED clinicians eligible to participate August-December. At an urban academic ED	• Provider were invited to participate in the survey when the HIE was accessed by a "pop-up" window. Survey was voluntary and anonymous. • The survey measured perception of HIE avoided use of hospital resources, improved quality of care, & reduced LOS. The cost savings of the avoided use was estimated by multiplying # of services clinicians completing survey reported avoided through use of the HIE by the costs of services • Patient visits with HIE access vs. patient visits without HIE access	• Practitioners HIE usage is low- 5.39% of these encounters • HIE benefits - avoided duplicate studies, consultations & admissions • 86.7 % of survey response stated HIE improved care • Summary: Patients with HIE access were found to have avoided unnecessary tests, a decrease in hospital admissions & a total cost savings of $283,477.67 ($2699.77 per patient with HIE information). • Physicians reported opinion state that the value of HIE saved time (81%; 120 min.8 minutes) & improved care delivery. Improved care delivery was not defined. • Prescriptions were avoided in 12 patients (5%) • The use of HIE was low, possibly due to a separate HIE icon outside the EHR.	VI C

Author, Year	Study Design & Objectives	Sample (N)	Outcomes Studied (how measured)	Results	Level & Quality Rating
Frisse, M. E., Johnson, K. B., Hui, N., Davison, C. L., Gadd, C. S., Unertl, K. M., & ... Qingxia, C., 2012	Nonexperimental Case control study To examine the financial impact health information exchange (HIE) in emergency departments (EDs)	N=31,596 participants 13 month period All major EDs in Memphis, TN	• HIE access encounter records were matched with encounter records without HIE access. • Outcomes studied: ED-originated hospital admissions, admissions for observation, lab testing, diagnostic imagining test • Used logistic regression models	• HIE accessed was low- 6.8% • One of the EDs-accessing HIE data via Web portal-associated with a decrease in hospital admissions (adjusted odds ratio (OR) ¼0.27; p<0001). • Other ED: relying more on print summaries, HIE access was associated with a decrease in hospital admissions (OR¼0.48; p<0001) and statistically significant decreases in head CT use, body CT use, and laboratory test ordering. • HIE access was associated with cost savings - $19 million • HIE helpful in managing non-urgent chronic patients seen in other institutions • Authors point out that access to HIE was not integrated into EHR.	IV B

Author, Year	Study Design & Objectives	Sample (N)	Outcomes Studied (how measured)	Results	Level & Quality Rating
Greenwood-Ericksen, M. B., Poon, S. J., Nelson, L. S., Weiner, S. G., & Schuur, J. D., 2015	Nonexperimental Expert panel To generate the framework for discussion & identification of best practices for prescription drug monitoring program design, & a policy review of state policies & regulations of PDMP	N=42 characteristics & state policy	• Few participants conducted system literature; others reviewed policies • Nominal group technique method used to achieve consensus to recommend best practice	• Current format of PDMP-poor design, delayed reporting, poor procedure for enrollment, burdensome log-in process • Best Practices for PDMP in ED: 18 policy recommendations: enrollment should be mandatory, automatic processes to mitigate the workload; registration should be open to all prescribers; delegates should have access to prescription drug monitoring program to alleviate work flow burdens; PDMP data should be pushed into hospital EHRs; mandatory PDMP review; mandatory for patients receiving opioid prescriptions; the PDMP content standardization with timely updates; states should interstate data sharing.	VII C

Author, Year	Study Design & Objectives	Sample (N)	Outcomes Studied (how measured)	Results	Level & Quality Rating
Perrone, J., DeRoos, F. J., & Nelson, L. S., 2012	Nonexperimetal Qualitative study To assess the circumstances and details prescribing practices for opioids, knowledge, and use of PDMPs.	N=205 providers 2 month period (reminders sent at 3 and 6 week period)	• Survey sent via email to American College of Medical Toxicology (ACMT) members. Consent obtained. Anonymous survey. • Results collated and reported in aggregated using Excel (Microsoft Office Excel 2003). Descriptive statistics were used.	• 46 % survey response rate; respondents from 34 states and the District of Columbia. • opioids in ED, usually prescription is for less than 7 days (85.6%) except with patients with cancer pain • Approximately 25 % reported no knowledge of or did not have access to their state's PDMP • 80.4% of providers prescribe • Barriers to use included time and complexity required to access relevant information • Generally aware of PDMPs, although many were unaware of or not using their state-based PDMPs when prescribing opioids in clinical practice • 20 % of respondents indicated that the PDMP frequently altered their prescribing	VI C

Author, Year	Study Design & Objectives	Sample (N)	Outcomes Studied (how measured)	Results	Level & Quality Rating
Poon, S., Greenwood-Ericksen, M., Gish, R., Neri, P., Takhar, S., Schuur, J., & Landman, A., 2015	Quasi-experimental Qualitative and quantitative (mixed method) To evaluate the usability of the Massachusetts (MA) PDMP by emergency medicine providers (EPs)	N= 20 Emergency Providers	• Usability research software program, Morae; used webcam on a computer in the ED to record user interactions with the system • Compared the time & number of clicks required to review one patient's record in the PDMP to 3 other commonly performed computer-based tasks in the ED • Performed semi-structured interviews and analyzed participant responses	• PDMP task took a longer time to complete with greater mouse clicks to complete than the 3 other tasks • 4 main themes on PDMP usability: difficulty accessing PDMP; cumbersome to acquire patient med history information within the PDMP; non-intuitive display of patient medication history information within the PDMP; perceived value of the PDMP despite an inefficient interface • Poor workflow: processes of gaining access, logging in, & using PDMP is complex • Authors recommend PDMP to be integrated within the hospital's EHR to decrease the time and complexity of accessing another system. Improve prescription data display	III C

Author, Year	Study Design & Objectives	Sample (N)	Outcomes Studied (how measured)	Results	Level & Quality Rating
Rathlev, N., Almomen, R., Deutsch, A., Smithline, H., Li, H. & Visintainer, P., 2016	Randomized, control trial non-blinded, two-group parallel study 1) opioid use disorder 2) high frequency ED use To measure changes in opioid prescribing and administration practices, total charges and other resource utilization using electronic alerts	N= 40 patients (care plan and usual care group)	• Used REDCap electronic data capture tools • Compared changes in: 1) opioid meds • Prescribed to patients; 2) total medical charges; 3) number of ED visits; 4) number of ED visits with advanced radiographic imaging studies; 5) number of inpatient admissions	• The “care plan” group demonstrated 89% greater proportional change in morphine mg equivalents prescribed over than the “usual care” group. • Not statistically significant in opioids administered during ED visits & inpatient admissions • Reduction in charges for both groups by 50% • No reduction in total number of ED visits, ED visits with advanced imaging (CT or MRI) & inpatient admissions.	II B

Author, Year	Study Design & Objectives	Sample (N)	Outcomes Studied (how measured)	Results	Level & Quality Rating
Rudin, R.S., Motala, A., Goldzweig, C., & Shekelle, P., 2014	Systematic literature review To evaluate evidence of the use & effect of HIE on clinical care.	N= 1314 N= 597 abstracts N=85 data synthesis (from 2003-2014)	• PRISMA (Preferred Reporting Items from Systematic Reviews & Meta- Analysis) guidelines • Search Methods: • PubMed, Web of Science, the Cochrane Databases, & gray literature • Article retrieved: Hypothesis testing: 12; Usage: 12; Sustainability & adoption: 17; Advanced HIE: 8; Attitude & barriers: 38	• Overall evidence supports HIE access by providers is low • Supports an effect of HIE use on reduced costs in the ED • HIE usage in less than 10% of patient encounters. • 25% of existing HIE organizations consider themselves financially stable • Providers, patients, & other stakeholders consider HIE to be valuable • Barriers: technical & workflow issues, costs, & privacy concerns; interoperable challenges • Reduction in repeated tests, hospital readmissions, & costs	V C

Author, Year	Study Design & Objectives	Sample (N)	Outcomes Studied (how measured)	Results	Level & Quality Rating
The Office of the National Coordinator for Health Information Technology, & Substance Abuse and Mental Health Services Administration, 2012	Non-experimental Longitudinal Study July 9, 2012 & ended on August 9, 2012 To demonstrate value of Health Information Technology connectivity by making PDMP available and streamlining system access of PDMP	N=674 data reports	• Viewed PDMP data reports • Prescribers had option of entering notes into the system to describe their response to the data & provided these notes 243 times	• 97% of the notes provided, prescribers indicated that the integration was easier to use than the external portal • 82% indicated that the PDMP data was valuable for clinical use • Providers altered planned prescribing pattern- 58% reduced prescriptions written or number of pills; 7% increased prescriptions written or number of pills • 28% prescriber indicated that the PDMP data caused no change in planned prescribing patterns. • 72% prescribers indicated that the PDMP data provided new/unaware information	VI C

Author, Year	Study Design & Objectives	Sample (N)	Outcomes Studied (how measured)	Results	Level & Quality Rating
Thorn, S. A., Carter, M. A., & Bailey, J. E., 2014	Nonexperimental Qualitative study Unstructured interviews using grounded theory principles To explore ED providers' perception of HIE	N=15 physicians	• Data collected from unstructured interviews (face to face) • The interviews were audio recorded, transcribed, & analyzed with MAXODA software. Probe questions were asked (i.e., tell me about your experience with HIE). • Data analysis with initial & focused coding. Comparative analysis conducted.	• Usage of health information exchange was low. • Accessing the HIE was noted to interrupt their workflows & was not user friendly. Specifically, the factors that influenced HIE utilization were environmental constraints, timing, & inconsistent privileges. • Provided value in clinical decisions but opinions varied. • Biggest deterrents were the difficulty in accessing HIE & the missing data in the HIE. • ED providers need to participate in the design of the HIE systems & EHRs so accessing health information can be incorporated into their daily workflows	VI C

Melnyk & Fineout-Overholt Rating and Grading Scales, 2011

Appendix D

Summary of Literature Review with Quality Rating Table

Author, year	Study objective/ intervention or exposures compared	Strengths	Weaknesses	Quality Rating
Baehren, D. F., Marco, C. A., Droz, D. E., Sinha, S., Callan, E. M., & Akpunonu, P., 2010	To monitor controlled substance prescriptions within Ohio	• Literature Review: Good • Design: conceptualization was well developed; good method when randomization is impractical; • Sample: convenience, large sample • Sampling: inclusion/exclusion criteria defined • Measure: reasonable consistent results • Analysis: the study provided before and after intervention measures; fairly definitive conclusions	• Survey Design/Response: Twenty patients were eliminated from the study because of incomplete data collection • No power analysis noted • No operational definitions noted • Framework: survey conducted by trained medical students (there could be lack of consistency- reliability); the number of patients treated by each physician is not the same (not balanced); single institution • Bias: lead physician is also the lead author of published paper; self-reporting	B

Author, year	Study objective/ intervention or exposures compared	Strengths	Weaknesses	Quality Rating
Campion, T. R., Vest, J. R., Ancker, J. S., Kaushal, R., & the HITEC Investigators, 2013	To describe the extent to which an automated query-based HIE system that transmitted summary of care documents to healthcare facilities in one community supported patient encounters & care transitions.	• Literature Review: Good, thorough • Sample: Large sample; clearly defined inclusion/exclusion criteria • Operational definitions are clear • Data collection: obtained large amounts of data • Analysis: data analysis of large population at specific point in time; reasonably consistent results with good tables; ability to aggregate data of the unique encounters over time by transition • Outcomes: synthesis of data well stated in tables and graphs (multiple outcomes were studied)	• Design: during study period query based transmission to the hospital were not available until the final week of the month 17 • Sampling: does not represent the whole population; limits generalization • Data collection does not take into consideration the cause and effect of variables which makes it difficult for identify associations • Measurement: does not address how and why providers use or do not use query-based HIE. Overly conservative in measuring automated query-based HIE- limitations in patient care summary transmission due to technical and workflow issues. • Outcomes: only measure one point in time; odds ratio not stated.	B

Author, year	Study objective/ intervention or exposures compared	Strengths	Weaknesses	Quality Rating
Carr, C. M., Gilman, C. S., Krywko, D. M., Moore, H. E., Walker, B. J., & Saef, S. H., 2014	To investigate the ability of an HIE to decrease health services use for emergency department (ED) patients.	• Literature review: concise • Tool: used REDcap software- reliable and validated • Methods: this section could have been better organized but the methods of the survey and estimates of avoided services were explained • Measure: instrument concise; survey instrument available online; inclusion and exclusion criteria • Data representation: Pie charts were clear and nicely presented	• Design: subjective reports by clinicians; voluntary • Framework: participants opinion; selection bias; the Hawthorne effect; due to anonymous survey, the researchers were unable to detect the number of surveys completed by individual providers • Sampling technique: voluntary • Sample: small (minimal data set)- (strong likelihood of Type II error); one institution- limited generalization • Outcomes: only measure one point in time	C

Author, year	Study objective/ intervention or exposures compared	Strengths	Weaknesses	Quality Rating
Frisse, M. E., Johnson, K. B., Hui, N., Davison, C. L., Gadd, C. S., Unertl, K. M., & ... Qingxia, C., 2012	To examine the financial impact health information exchange (HIE) in emergency departments (EDs)	• Literature Review: Good • Operational definition present • Sampling: Large sample; did not allow for clustering effect • Measure: matched every HIE access encounter record with a matched no-HIE access record; time duration- over 13 month period which captures a full calendar year; used instruments with established reliability and validity (generalized estimating equitation) • Analysis: study protocol clearly articulated; used logistic regression analysis performed • Outcomes- fairly definitive conclusions • Data representation: nicely presented (diagrams and tables clear and concise)	• Design: provider clustering effects was not accounted for, therefore, it may have affected standard error and confidence interval; variation in providers intent of using HIE was measured comprehensively • Sampling technique: 12 hospitals sampled in southern state; limited generalization; variation in when HIE is used (types of patients) • Analysis: HIE use was low due to lack of integration with EHR; retrospective analysis does not take into variables that might have taken place at the time of the study. • Results: Results may be confounded by other variables not considered part of the study	B

Author, year	Study objective/ intervention or exposures compared	Strengths	Weaknesses	Quality Rating
Greenwood-Ericksen, M. B., Poon, S. J., Nelson, L. S., Weiner, S. G., & Schuur, J. D., 2015	To generate the framework for discussion & identification of best practices for prescription drug monitoring program design, & a policy review of state policies & regulations of PDMP	• Sampling: adequate for systematic review; participants considered experts in their area • Operational definitions listed • Methods: consensus process stated • Measure: reasonable consistent results • Outcomes: strong recommendations by reliable sources with extensive knowledge or ability based on research, experience, and/or occupation in the prescription drug-monitoring program. Recommendations for best practice are supported by literature reviews, policies; and technical capabilities.	• Literature review: lacks detailed information about literature and policies reviewed • Sample: no numbers on the literature and policies reviewed • Sampling technique: expert panel affiliated with an academic institution; not community setting; limited generalization; only includes expert panel view (no other disciplines) • Method: no detail on systematic literature review and policy review process • Measures: lacks quantitative or qualitative data and no statistical analysis • Analysis of literature review was not present	C

Author, year	Study objective/ intervention or exposures compared	Strengths	Weaknesses	Quality Rating
Perrone, J., DeRoos, F. J., & Nelson, L. S., 2012	To assess the circumstances and details prescribing practices for opioids, knowledge, and use of PDMPs.	• Literature Review: Adequate • Sampling: Large sample; community and academic representation • Inclusion criteria – all physician board certified in medical toxicology or currently fellow in training program • No exclusion criteria • Operational definitions clear • Measure: assessed the respondents' frequency and patterns of opioid prescribing and their understanding and use of their state's PDMP; survey included which was helpful; survey offered free text field to allow participants to provide their own unique context • Analysis: responses to survey presented clearly	• Design: response rate to each question does not equal the total number of respondents • No power analysis • Survey reliability & validity weak. Validated by pilot through colleagues with iterative adjustment. • Framework: no control group • Sampling technique: varied but not all representation from all states • No exclusion criteria • Difficult to classify physician's responses based on the functionality of their state's PDMP • Response rate was 46% (according to Fincham [2008], survey response rates of approximately 60% should be expected) • Analysis- no statistical evidence presented in article	C

Author, year	Study objective/ intervention or exposures compared	Strengths	Weaknesses	Quality Rating
Poon, S., Greenwood-Ericksen, M., Gish, R., Neri, P., Takhar, S., Schuur, J., & Landman, A., 2015	To evaluate the usability of the Massachusetts (MA) PDMP by emergency medicine providers (EPs)	• Literature Review: Adequate • Sampling technique: recruited ED board certified ED providers and ED physician assistants; voluntary; blinded to study purpose • Method for usability testing: clear with detailed script • Measure: used web camera to measure number of clicks to get to HIE and other tasks; consistent research assistant performed all testing for consistency • Analysis: correlation statistics made between users and tasks, and participant-rated difficulty and frequency. Post hoc analysis used. In addition, three investigators analyzed transcript of interviews using constant comparative method. • Outcomes- reasonable consistent results	• Sampling: small size (strong likelihood of Type II error); sample decreased from 20 to 17 due to no access to PDMP which is an important finding; limited generalization due to sample size, specific MA PDMP proprietary • Sampling technique: subjective; bias-association between perceived task difficulty and reported frequency • Measure: technical difficulties may have skewed to capture testing sessions • Analysis: participants required prompts and assistance to complete the tasks which could have impacted the time and clicks; researchers included two participants into the sample that were unable to complete tasks even with prompts and assistance	C

Author, year	Study objective/ intervention or exposures compared	Strengths	Weaknesses	Quality Rating
Rathlev, N., Almomen, R., Deutsch, A., Smithline, H., Li, H. & Visintainer, P., 2016	To measure changes in opioid prescribing and administration practices, total charges and other resource utilization using electronic alerts	• Literature Review: Adequate • Design: well developed conceptualization; adequate control • Sampling: clearly explains on random selection process of using electronic tracking of participants with four or more ED visits in previous 12 months to identify care plans; used hospital registration and accounting system; clearly defined inclusion/exclusion criteria; control group • Operational definition clear • Methods: very detailed; clear in explaining methodology used • Analysis: conducted univariable comparison at baseline using Fisher's exact test for categorical variables and Wilcoxon rank-sum tests for continuous variables • Outcomes: consistent results; conclusion can be associated with decrease in opioid prescription; 89% change in "care plan group" compared to "usual care group."	• Sample: small size (strong likelihood of Type II error) • No power analysis noted • Sampling: limited sites (3 hospitals); limited generalization; considered pilot • Methods: inability to track patients not in the region of the study • Outcomes: pilot results; no longer term statistics	B

Author, year	Study objective/ intervention or exposures compared	Strengths	Weaknesses	Quality Rating
Rudin, R.S., Motala, A., Goldzweig, C., & Shekelle, P., 2014	To evaluate evidence of the use & effect of HIE on clinical care.	• Literature Review: Good • Design: conceptualization was well developed • Theoretical Framework used • Sample: Large sample; clearly defined inclusion/ exclusion criteria • Methodology: Extraction was duplicative; method clearly articulated • Clearly represented results text & in table	• Design: limited to evaluations that appeared in publication or gray literature • Methodology: published articles had methodological issues with study • Sampling technique: the development with HIEs have advanced dramatically since 2003. Too broad range for search dates.	C
The Office of the National Coordinator for Health Information Technology, & Substance Abuse and Mental Health Services Administration, 2012	To demonstrate value of Health Information Technology connectivity by making PDMP available and streamlining system access of PDMP	• Literature Review: limited • Hypotheses and intended impacts clearly stated (i.e., ease of use; fit with workflow; technical impact; clinical impact; driver of adoption; optimization factors) • Operational definitions are clear • Analysis: outlined clearly • Measure: fairly definitive conclusions • Outcomes:	• Sampling: limited provider participation; limited generalization • No power analysis • Bias: one of the participant is a researcher and an active ED provider and has published HIE articles • Method: all providers in study were given access to PDMP; training was not indicated with PDMP access; query of PDMP data was limited to one PDMP system • Analysis: limited analysis; no table provided • Outcomes: more descriptive statistics noted in article would have been valuable • The timeline of implementation would have been helpful	C

Author, year	Study objective/ intervention or exposures compared	Strengths	Weaknesses	Quality Rating
Thorn, S. A., Carter, M. A., & Bailey, J. E., 2014	To explore ED providers' perception of HIE	• Design; Qualitative study to identify themes (thematic saturation) • Literature Review: adequate • Theoretical Framework: used grounded theory; authors stated a theoretical sampling was used in selecting participants • Methodology: one researcher conducted interview for consistency; MAXODA 10, qualitative software used • Analysis: initial & focused coding; comparative analysis	• Design: authors classified as observational study but there were no observations, only interview observations; • Sample: cross sectional; one geographic area & one HIE (generalization) which limits generalization • Framework: unstructured and open ended questions leads to researcher interpretation • Sampling: small convenience sample (strong likelihood of Type II error) • Sampling technique: 4 urban hospitals (2 of 4 hospital EDs had not implemented electronic documentation) • Analysis: coding of interpretive data of open ended question by another author may lead to inconsistency • Outcomes: difficult to synthesize HIE usage rate data due to study framework	C

Appendix E

Summary of Evidence Table

Level of Evidence	Number of Studies	Summary of Findings	Overall Quality
2	1	• Rathlev et al. (2016) • The randomized control trial (RCT) suggested that the push "care plan" and the "usual care" group had decrease in opioid utilization. The "care plan" demonstrated 89% change in morphine prescription. No change in charges. No change in number of ED visits, ED visits with imagining tests or inpatient admissions.	• B • RCT was a well-designed study, however, the small sample size limits generalizability. Overall, the study showed pushed "care plan" alerts demonstrated a change in clinical management on opioid prescribing.
3	2	• Baehren et al. (2010) • Poon et al. (2015) • Both quasi-experimental study looked providers using PDMP with similar findings that the use of PDMP altered prescribing behavior. • Baehren et al. (2010) surveyed providers twice as they were caring for patients in the ED (before/after they access the HIE/PDMP). • Poon et al. (2015) looked at usability of the current PDMP system (mixed method), counted number of clicks.	• B-C • Conceptualization was well developed; good designed study when randomization is impractical; findings may be applied to other subjects and settings; researchers tried to control survey variables; conducted prospectively which understand the independent variables as they occur. Studies showed reasonable consistent results with before and after intervention. • Limitation in Poon et al. (2015) study due to small sample size but Baehren et al. (2010) study had good sample size.

Level of Evidence	Number of Studies	Summary of Findings	Overall Quality
4	1	• Frisse et al., (2011) • Nonexperimental, case control looked financial impact of HIE used in the ED. Study demonstrated HIE was helpful in managing non-urgent chronic patients seen in other institutions. • While HIE accessed was low- 6.8%, study found that EDs-accessing HIE data via Web portal was associated with a decrease in hospital admissions (adjusted odds ratio (OR) ¼0.27; p<0001). • Other ED: relying more on print summaries, HIE access was associated with a decrease in hospital admissions (OR¼0.48; p<0001) and statistically significant decreases in head CT use, body CT use, and laboratory test ordering. • HIE access was associated with cost savings - $19 million	• This study strength was due to the well-developed conceptualization and large sample size. The study showed low HIE usage but when HIE was used, HIE was noted to be useful with cost savings. HIE use was low due to lack of integration with EHR.

Level of Evidence	Number of Studies	Summary of Findings	Overall Quality
5	1	• Rudin et al. (2014) • One study performed a systematic review. • Hypothesis-testing studies supports an effect of HIE and cost savings • Direct evidence that HIEs were used by providers but generally showed usage in less than 10% of patient encounters. • 17 studies of sustainability -approximately 25% of existing HIE organizations noted to be financially stable. • 38 studies about attitudes and barriers showed that providers, patients, and other stakeholders consider HIE to be valuable; barriers include technical and workflow issues, costs, and privacy concerns.	• C • Extensive systematic review over 11 year time period; article retrieved- Hypothesis testing: 12; Usage: 12; Sustainability & adoption: 17; Advanced HIE: 8; Attitude & barriers: 38 • Data extraction was duplicative • The strength of the study was the extensive literature reviewed; however, technology and policies change rapidly and results of study five years ago may no longer be relevant.

Level of Evidence	Number of Studies	Summary of Findings	Overall Quality
6	5	• Campion et al. (2013); Carr et al.(2013); Perrone et al., (2012); ONC et al., (2012); Thorn et al., (2014) • Three studies focused on HIE and two studies focused on PDMP • All studies identified the need for easier workflow and the need for integration with HIE, PDMP and the hospital EHR • Measurement of each study was different • Two indicated that after review of the PDMP data, providers changed clinical management • Two study revealed that patients had data in multiple institutions • Studies found HIE avoids duplicate tests • One study measured time while other studies reported time savings • One study found cost savings with HIE use • All studies identified barriers- similar themes arose (access to complex; enrollment; interruption)	• B-C. • The studies revealed that HIE and/or PDMP uniformly provided value in care delivery but the evidence varied per study. • Studies identified barriers in using HIE and PDMP. • The differences of the studies is the instrument used were not the same • One cross-sectional- design involving data collection at defined time; difficult to obtain variable is the cause and the effect; contains individual level data. • Three qualitative- design without control limits causal or predictive ability; threats to external validity (time, place and person); • One of the study (Perrone et al. (2012) used a weak valid and reliable instrument • Two longitudinal study- correlational research; no interference with subject; good for vast amounts of data

Level of Evidence	Number of Studies	Summary of Findings	Overall Quality
7	1	• Greenwood-Ericksen et al. (2015) • This expert panel study provided best practice recommendations from a panel of experts in their field. • 18 Recommendations published after performing systematic review and policy review on PDMP best practices. • Barriers identified which were consistent with other evidence. Recommendations were also consistent with other evidence.	• C • The strength of the study was the expert panel's recommendations were aligned with the other PDMP literature reviewed for this scholarly project. The limitation of the study was due to the nonscientific approach or not mentioned in the publication (no framework provided).

Appendix F

Implementation Plan

Goal: Improve HIE utilization by making the PDMP accessible in the EHR for ED providers

Approach: Using the DeLone and McLane framework develop an implementation plan for making PDMP available in the CRISP Single Sign-On clinical view. The objectives will be to sustain the PDMP accessibility to providers by 1) streamlining the log-on procedure; 2) automatically enroll practitioners in HIE and the PDMP; and 3) automate queries for patient health information and prescription.

Action Tasks	Responsibility Date	Evaluation Plan
Phase One		
Assess knowledge needs		
Conduct assessment- ED provider knowledge, ED provider workflow and use of HIE (includes gap analysis)	Project leader, analyst Feb 2016	Current state and gap analysis to be shared with key stakeholders (hospital and CRISP leaders)
Conduct assessment- technical capabilities of EMR and PDMP	Project leader, CRISP integration, analyst Feb 2016	Same as above
Identify resources and form workgroups (clinical and technical)	Project leader Feb 2016	Resource hours to be calculated and shared
Propose and obtain approval project to UMMS user groups		Approval noted in meeting minutes
Project approval by physician user group	Project leader Mar 2016	
Project approval by pharmacy user group	Project leader Mar 2016	
User role approval by EMR access committee		
Conduct workflow discussion- (i.e., identify users, workflows)	Project leader, analyst Feb 2016	Future state workflow to be shared with respective key stakeholders
Conduct technical requirements meetings (i.e., user matching; patient matching)	Project leader, CRISP integration, analyst Feb 2016	

Phase Two		
Adapt knowledge to local context		
Perform cultural assessment	Project leader Feb 2016	Review results to identify any issues or concerns; share any issues with key stakeholders.
Build and configure in system- PDMP display	CRISP integration, analyst Mar 2016	Review Request for Change (RFC) documentation, which will include system build and encompasses different types of the testing (i.e., users, unit testing, application, integrated, regression). Request for change will be sign off by key stakeholders.
Identify and configure user roles	Project leader, analysts Mar 2016	
Testing		
Unit testing- CRISP HIE button/ PDMP	CRISP integration, analyst Apr 2016	
Application testing	CRISP integration, analyst Apr 2016	
Integrated testing of users and workflow	CRISP integration, analysts Apr 2016	
Regression testing	CRISP integration, analysts Apr 2016	
Complete change management request for change	Apr 2016	
Assess barriers for knowledge use		
Identify, document and assess barriers and/or risks	Project leader Apr 2016	Communicate any barriers and/or risks to key stakeholders
Develop training and communication plan	Project leader Apr 2016	Use existing communication vehicle + physician champion to communicate to peers
Phase Four		

Implementation of PDMP display	Project leader, CRISP integration, analysts, 5/17/2016	Communicate implementation to key stakeholders
Execute support plan	Project leader, CRISP integration, analysts 5/17/2016	Communicate to application teams on implementation and support plan
Monitor knowledge use		
Document/track all project issues and risks	Project leader 5/17/2016	Monitor implementation. Share post implementation issues with respective application teams and key stakeholders
Hold debriefing session if applicable	Project leader, analysts 5/17/2016	
Document technical lesson learned from application teams	Project leader, CRISP integration, analysts 5/30/2016	
Phase Five		
Evaluate outcomes		Share results with key stakeholders and application teams
Request for data extraction	Project leader May 2016	
Collect data	Project leader Jun 2016	
Analyze Data	Project leader Sep 2016	
Document overall lessons learned	Project leader Nov 2016	
Sustain knowledge use		Disseminate findings with key stakeholders.
Develop dissemination plan (CRISP leaders, hospital leaders, other hospital committees, journal, local/national conferences)	Project leader Dec 2016	

Appendix G

Variable Measurement Table

Variable	Measurement
ED Visits	Number of patient registration events to be admitted to the ED.
Inpatient Visits	Number of patient registration events to be admitted to the hospital
Readmission	Number of patients readmitted within 30 days following a discharge divided by the total number of discharges (Agency for Healthcare Research and Quality, 2015)
Unadjusted readmission rate	The number of stays with at least one subsequent hospital stay within 30 days divided by the total number of hospital stays between January and November, not adjusted for case-mix index
HIE/PDMP utilization via CRISP HIE button	Number of CRISP HIE button launches to view the CRISP patient clinical view/PDMP
ED providers employed	Number of providers employed to work in the ED
ED providers types	Different provider types (medical doctor, nurse practitioner and physician assistants)
Narcotic prescribing rate	An instruction written by licensed independent practitioner that authorizes a patient to be provided a controlled substance. Number of ED visits with prescription narcotics ordered at ED discharge.
Orders- medications	Number of ED visits with narcotic orders during an ED visit.
Orders- lab	Number of ED visits with the following orders : Complete blood count (CBC) during an ED visit Comprehensive metabolic panel (CMP) during an ED visit Basic metabolic panel (BMP) during an ED visit
Orders- imaging	Number of ED visit with an imaging tests ordered during ED visit (CXR, CT scan, and MRI)

Note. Abbreviations: ED, emergency department; CRISP, Chesapeake Regional Information for Our Patients; PDMP, Prescription Drug Monitoring Program.

Appendix H

Access PDMP Implementation Model

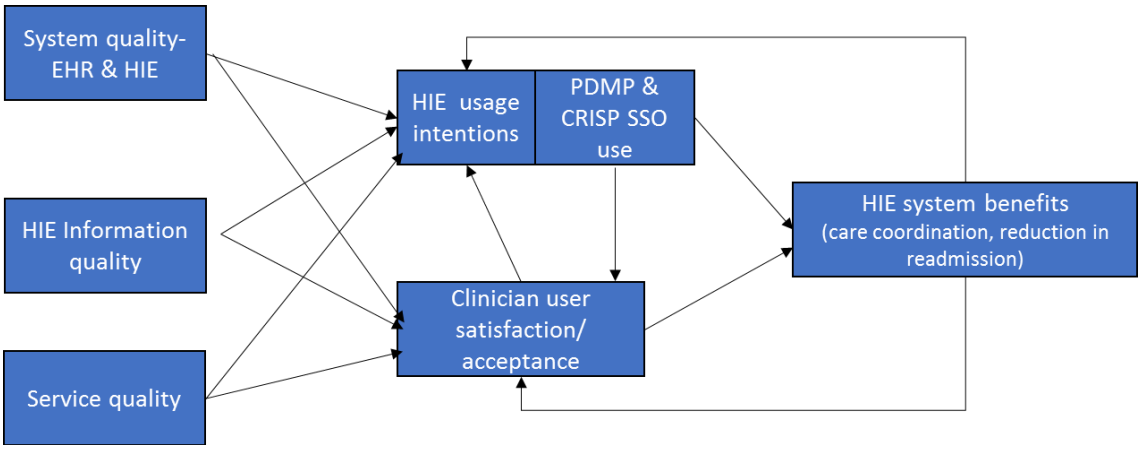


Figure 1. Access PDMP implementation model. From "The DeLone and McLean Model of Information Systems Success: A Ten-Year Update," by W.H. DeLone & E.R. McLean, 2003, *Journal of Management Information Systems*, 19(4), p. 9-30. Adapted with permission.

Appendix I

PDMP Tip Sheet Page 1

UNIVERSITY OF MARYLAND MEDICAL SYSTEM
PORTFOLIO

Tip Sheet
Inpatient & Ambulatory

PDMP Available in CRISP View in Epic

FACILITY:	UMMS
ROLE:	Providers, Case Managers, Pharmacists

Providers and Pharmacist can now view Maryland Prescription Drug Monitoring Program (PDMP) via the CRISP button inside of EPIC.

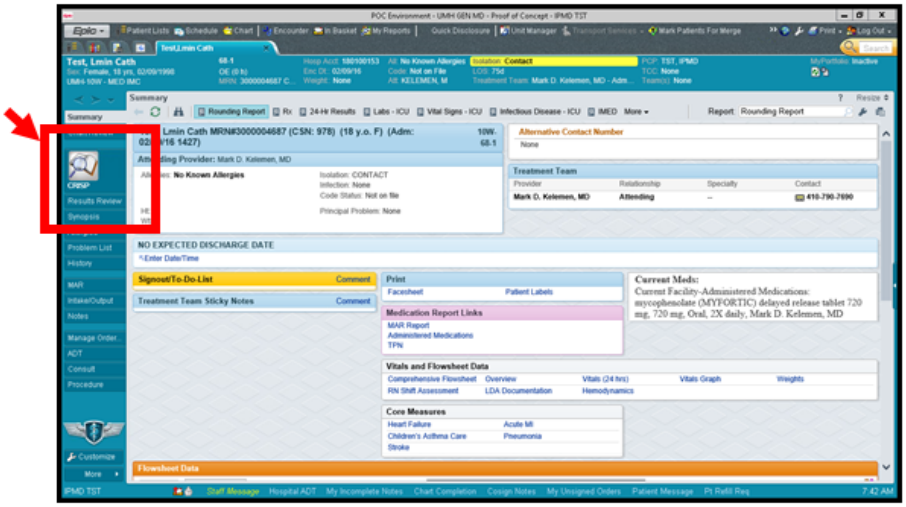
- On May 17, authorized licensed providers and pharmacists can view PDMP when you access the CRISP button in Epic. The PDMP contains controlled dangerous substances Schedule II-IV dispensed to Maryland patients. Users with access to view Maryland PDMP will also see an "Interstate PDMP" tab. By clicking on the Interstate PDMP tab, other state data is automatically searched and displayed.
- For more information about PDMP, here is a video link on the CRISP website. https://crisphealth.org/CRISP-HIE-SERVICES/Prescription-Drug-Monitoring-Program-PDMP

Benefits of PDMP

- Provides controlled drug substance data for safer prescribing
- Securely access CRISP and PDMP data without leaving Epic
- Eliminates 5 steps from the usual process to access PDMP and CRISP information

Access PDMP and CRISP Patient Information

1. To access your particular patient's information in Epic, select **CRISP**



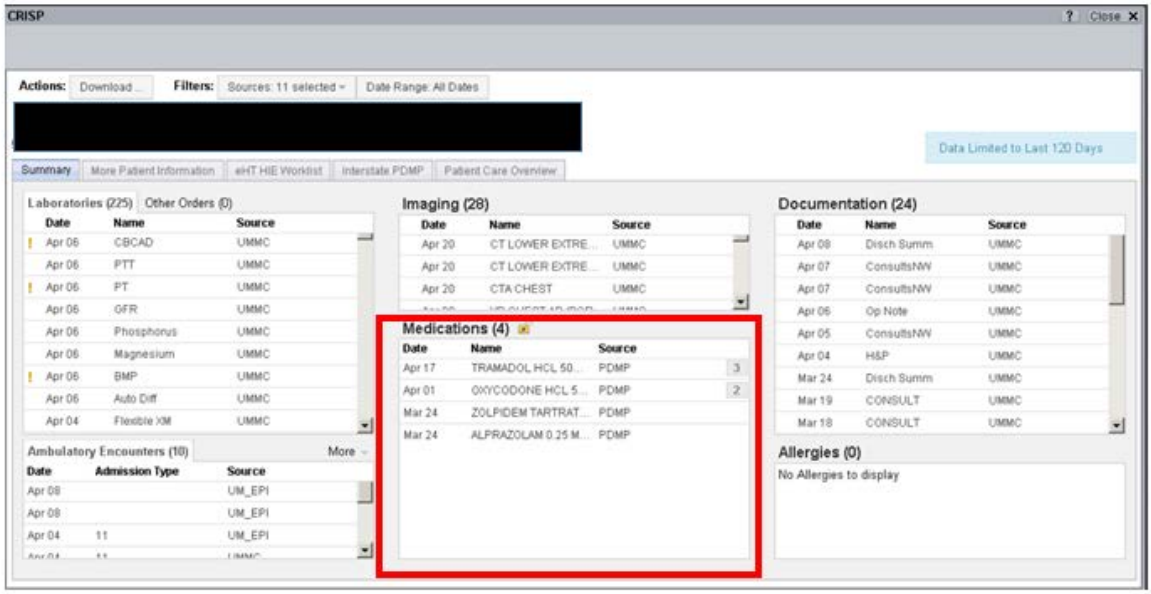
2. The Medications pane will display PDMP if the patient has CDS prescriptions.

Appendix I

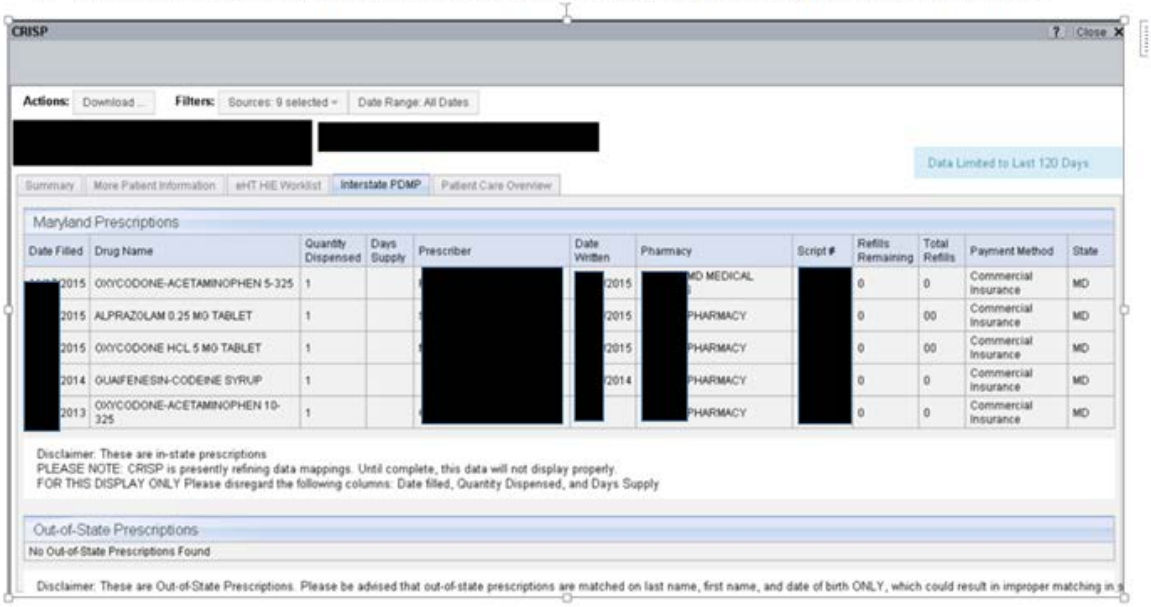
PDMP Tip Sheet Page 2

PDMP Available in CRISP View in Epic

UNIVERSITY OF MARYLAND MEDICAL SYSTEM PORTFOLIO



3. You can also select the Interstate Tab to view CDS prescriptions dispensed in other states.



Appendix J

Institutional Review Board Approval

From: CICERO@som.umaryland.edu [CICERO@som.umaryland.edu]
Sent: Wednesday, May 11, 2016 4:44 PM
To: Schoenbaum, Anna
Subject: Research is Not Human Subjects Research

Not Human Subjects Research (NHSR) Confirmed
To: Anna Schoenbaum
Link: HP-00069551 <https://cicero.umaryland.edu/CICERO/Rooms/DisplayPages
/LayoutInitial?Container=com.webridge.entity.Entity[OID[98AC18C95D3F394D9CDD445A4AEB48CC]]>
Description:

An IRB Analyst has reviewed the information provided and has determined that the project meets the definition of Not Human Subjects Research (NHSR). IRB oversight is not required and no further actions are required.

Submission Title: Health Information Exchange

POC: Charlotte Seckman

Please contact the HRPO at 410-706-5037 or HRPO@umaryland.edu <mailto:HRPO@umaryland.edu?Subject=CIERO:%20Question%20From%20User> if you have any questions.

Warning: This is a private message intended specifically for the above named receiver. If you are not the named receiver, or believe that you may have received this email in error, please forward it to cicero-help@som.umary