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Sara Jane Dever RDH Date

A Feasibility Evaluation Study for Linking Electronic Health to Dental Records

By

Sara Jane Dever RDH

Degree to be awarded: MPH

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A Feasibility Evaluation Study for Linking Electronic Health to Dental Records

By

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B.S. in Dental Hygiene

University of Michigan, Ann Arbor

1999

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An abstract of a thesis submitted to the faculty of the Rollins School of Public Health of Emory University in partial fulfillment of the requirements for the degree of Master of Public Health in the Executive MPH Program 2017

Abstract

A Feasibility Evaluation Study for Linking Electronic Health to Dental Records

By

Sara Jane Dever RDH

Background: Large volumes of patients lacking dental insurance and financial resources are presenting to emergency department settings for dental treatment, creating significant public health issues and increased expenses. Emergency department physicians and private-practice dentists lack timely, accessible communication. The data exchange between electronic health and dental records exist separately between medical and dental providers in the private-sector, and need to harmonize for effective communication and improved treatment options.

Purpose: To assess the feasibility of linking electronic health records in Grady Memorial Hospital's Emergency Department, to electronic dental records at private-practice dentists in metro Atlanta, Georgia.

Methods: A systematic literature review was conducted to explore current electronic health and dental record systems, public health policies, and interoperability standards for systems integration. Questionnaires were developed, and interviews were conducted with subject matter experts from emergency health care, private-practice dentistry, and electronic health and dental software technology. Expert opinions and requirements were gathered for linking electronic health records to electronic dental records.

Results: Oral health disparities would be reduced, access to dental care would increase, costs of care would be reduced, and improved treatment options would occur. Systems integration is technologically feasible through data linkage via a patient identifier, and interoperability is supported through a query-based and pushed-based approach. It is not feasible based on financial and policy considerations.

Conclusions: Further government mandates and polices with incentives extending beyond Meaningful Use needs to occur before linking electronic health records to dental records will occur in the private-sector.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACA	Affordable Care Act
ADA®	American Dental Association®
ADA® SCDI	American Dental Association® Standards Committee on Dental-Informatics
ANSI	American National Standards Institute
ARRA	American Recovery and Reinvestment Act
CDA®	Clinical Document Architecture®
CDT	Current Dental Terminology
CHCS	Composite Health Care System
CMS	Centers for Medicare and Medicaid
COHRI	Consortium for Oral Health-Related Informatics
DICOM®	Digital Imaging and Communications in Medicine®
DDS	Dental Diagnostic System (EZCodes)
DoD	Department of Defense
ED	Emergency Department
EDR	Electronic Dental Record
EHR	Electronic Health Record
EP	Eligible Professional
FHIR®	Fast Healthcare Interoperability Resource®
FQHC	Federally Qualified Health Center
HIPAA	Health Insurance Portability and Accountability Act of 1996

HIT	Health Information Technology
HITECH	Health Information Technology for Economic and Clinical Health Act
HITSP	Health Information Technology Standards Panel
HL7®	Health Level 7®
HL7® V3®	HL7 Version 3®
HTTPS	Hypertext Transfer Protocol
ICD	International Classification of Diseases
IHS	Indian Health Service
IRB	Institutional Review Board
IT	Information Technology
JSON	JavaScript Object Notation
LOINC®	Logical Observation Identifiers Names and Codes®
MU	Meaningful Use
OAuth	Open Authorization
REST	Representational State Transfer
ROI	Return on Investment
RPMS	Resource and Patient Management System
SDO	Standards Development Organization
SME	Subject Matter Expert
SNODENT	Systemized Nomenclature of Dentistry
SNOMED	Systemized Nomenclature of Medicine
SNOMED-CT	Systemized Nomenclature of Medicine Clinical Terms
UCSF	University of California San Francisco

UTHealth	University of Texas Health Science Center at Houston
VHA	Veteran's Health Administration
VistA	Veteran's Administration and Technology Architecture
XML	Extensible Markup Language

Chapter I: Introduction

Introduction and Rationale

Oral health is essential to the general well-being of individuals and population health (Alsumait et al., 2015; Griffin, Jones, Brunson, Griffin, & Bailey, 2012; Patrick et al., 2006; Sanders, Slade, Lim, & Reisine, 2009). The most common, chronic, and preventable diseases from childhood to adulthood begin inside the mouth (Griffin et al., 2012; Sheiham, 2005). Within public health practice, it is increasingly recognized that oral health is related to systemic health (Igari, Kudo, Toyofuku, Inoue, & Iwai, 2014), and patients that lack access and financial resources to oral health care, represent significant public health issues and increased expenses (Davis, Deinard, & Maiga, 2010; Seu, Hall, & Moy, 2006; B. C. Sun et al., 2015). Of particular interest, are the large volume of patients who present to emergency department (ED) settings for dental treatment (H. H. Lee, Lewis, Saltzman, & Starks, 2012; C. W. Lewis, McKinney, Lee, Melbye, & Rue, 2015; Seu et al., 2006), that if left untreated, can lead to other ongoing chronic health conditions (Lamster, Lalla, Borgnakke, & Taylor, 2008).

At Grady Memorial Hospital in Atlanta, Georgia, their ED is facing challenges of overcrowding, a growing volume of patients with unnecessary long length-of-stay and wait times, the presence of patients with non-urgent medical conditions (40%), and shrinking rates of reimbursement of Medicaid, Medicare, and commercial health insurance (Atallah & Lee, 2014). Adding to this burden, their ED averages 70 to 105 non-traumatic dental emergencies per week (Reznick, 2012), and for the state of Georgia, approximately 60,000 ED visits for non-traumatic dental emergencies, costing the tax

payers an additional $23 million per year (Reznick, 2012; Seu et al., 2006). Grady Hospital's ED situation is not unique. Across the United States, ED visits associated with non-traumatic dental problems has increasingly become a problematic and expensive public health burden (Davis et al., 2010; H. H. Lee et al., 2012; C. Lewis, Lynch, & Johnston, 2003; Tomar, Carden, Dodd, Catalanotto, & Herndon, 2016).

The purpose of this study is to determine the feasibility of linking electronic health records (EHR) to electronic dental records (EDR) in Grady Memorial Hospital's ED to private practice dentists in metro Atlanta, Georgia. As outlined below, by integrating health and dental records, overall patient outcomes may improve, and the costs associated with overall patient care may be significantly reduced.

Patient Populations

To help set a context for this feasibility study, it is important to provide an understanding of oral health relative to various patient populations. Research shows that poor oral health significantly impacts overall quality of life and general health of various populations in different ways (Griffin et al., 2012). Poor oral health can affect nutrition due to difficulty with eating food (Rosenoer & Sheiham, 1995; Sarita, Witter, Kreulen, Van't Hof, & Creugers, 2003), quality of life can be impacted due to pain from dental problems causing poor sleep outcomes (Slade, Foy, Shugars, Phillips, & White, 2004), and failure to prevent or control the progression of oral diseases can lead to other oral and systemic health outcomes (Lamster et al., 2008; Li, Kolltveit, Tronstad, & Olsen, 2000). Research shows that certain infections that arise in the mouth, particularly periodontal disease and tooth infections, are related to systemic conditions such as diabetes (Lamster

et al., 2008; Leite, Marlow, & Fernandes, 2013), heart disease (de Oliveira, Watt, & Hamer, 2010; Li et al., 2000), respiratory disease (Li et al., 2000; Pace & McCullough, 2010; Sjogren, Nilsson, Forsell, Johansson, & Hoogstraate, 2008), adverse pregnancy outcomes ("Committee Opinion No. 569: oral health care during pregnancy and through the lifespan," 2013; George et al., 2010; Igari et al., 2014), and many others (HHS, 2000).

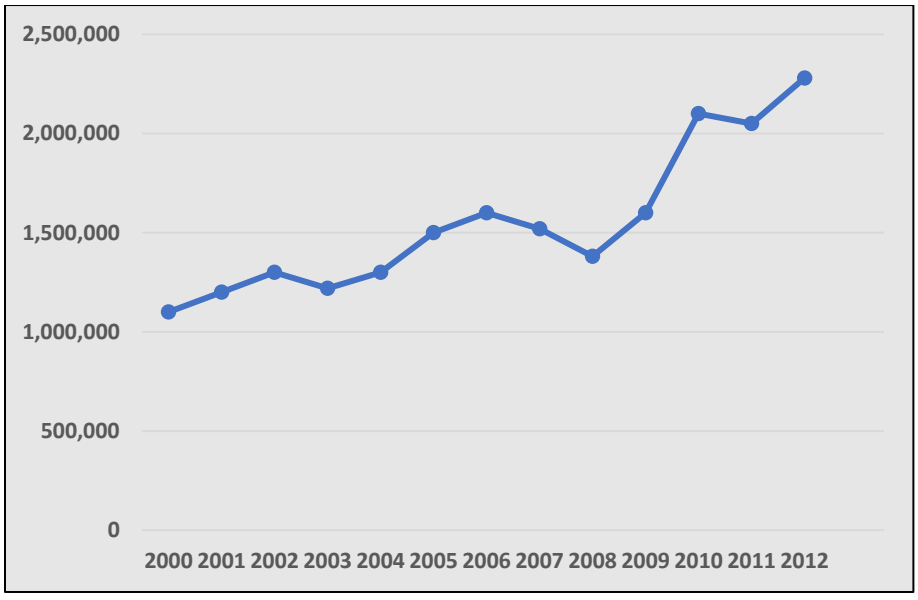
Oral health measures have improved dramatically over the years, however, disparities in oral health continue to be a significant public health issue affecting low-income and minority populations (J. Y. Lee & Divaris, 2014; Malecki et al., 2015). Examples include: 1) African-American and Hispanics have higher rates of tooth-loss and untreated dental caries, compared to non-Hispanic Whites (Feinberg, 2015); 2) Pregnant women in lower socioeconomic groups have lower rates of dental care and higher rates of gingivitis (Steinberg, 1999), and those on Medicaid were 24 to 53% less likely than privately-insured to receive oral health care (Gaffield, Gilbert, Malvitz, & Romaguera, 2001); and, 3) Children and adolescents of certain lower socioeconomic groups tend to have higher rates of dental caries (Dye et al., 2007), and adults and seniors of lower socioeconomic groups are more frequently afflicted with dental caries, periodontal disease, and oral cancer (Feinberg, 2015).

Types of available care and cost to patients today are systemic health care done by medical providers, and oral health care done by dental providers. Disparities in the United States (U.S.) health care system occur due to cultural, economic, and political factors (Patrick et al., 2006). Many patients either lack access to care, or have limited dental insurance coverage and cannot afford the out-of-pocket costs for dental care (B. C. Sun et al., 2015). Medicare does not cover dental health care unless it is connected to a

medical procedure (Patton, White, & Field, 2001), and Medicaid offers limited dental coverage for adults with less dentists participating (Nasseh, Vujicic, & Yarbrough, 2014). Patients that lack adequate dental insurance or the financial resources turn to ED settings for dental treatment that does not always provide lasting relief (Strock, 2013). The number of dental-related visits to the ED has been an increasing problem nationwide (H. H. Lee et al., 2012; C. Lewis et al., 2003; Tomar et al., 2016). Figure 1 below illustrates the number of dental-related ED visits from 2000 to 2012. Looking at the number of visits per year since 2000, there is a steady, persistent increasing trend from approximately 1.1 million in 2000, to 2.28 million in 2012.

Figure 1

Nationwide Dental-Related Emergency Department Visits: 2000 to 2012



Source: National Hospital Ambulatory Medical Care Survey, NCHS 2000 to 2012

Furthermore, many of the ED patients return multiple times for the same dental problem (Okunseri, Pajewski, Jackson, & Szabo, 2011) because hospital ED settings are only providing temporary relief for such patients with the prescribing of antibiotics and opiate pain medication (L. A. Cohen & Manski, 2006; Hocker et al., 2012), and not treating the underlying problem. Most ED settings are not staffed with dentists, and ED physicians have limited dental training from medical school (Leonard A. Cohen, 2013), therefore, creating a "revolving door" of high rates of repeat visits (Pajewski & Okunseri, 2014; Trikhacheva et al., 2015), and 39% of patients return to the ED for the same dental-related problem (Strock, 2013) leading to higher health care costs (Davis et al., 2010).

Patient Medical and Dental Records

Medical records are used to support all aspects of patient medical care within medical facilities (Yarmohammadian, Raeisi, Tavakoli, & Nansa, 2010), and dental records are used to support all aspects of patient dental care within dental facilities (Charangowda, 2010). Record keeping is used to support decision making, guide performance improvement (Yarmohammadian et al., 2010), and for patient safety and legal purposes (Devadiga, 2014; van Melle, Erkelens, van Stel, de Wit, & Zwart, 2016). Patient records consist of many elements that include written notes, prescription information, health history, laboratory information, and many others (Charangowda, 2010). Patient records are used to document the patient's treatment, and be used to assess the quality of care the patient is receiving (Platt & Yewe-Dyer, 1995). Accurate record keeping is essential to patient care in medicine and dentistry.

Current Status of Patient Records

The health care and dental care system originated with paper records for patients and have been moving forward with electronic records. From the beginning of modern health care, medical records and dental records have existed separately, is no longer sustainable in today's health care system, and need to harmonize for improved provider communication and better patient outcomes (Din & Powell, 2008). Currently, EHRs and EDRs are in place all over the U.S., and the adoption of such records continues to rise (Leigh & Harris, 2011; T. K. L. Schleyer et al., 2013), however, the exchange of data exists separately in the private sector (DesRoches et al., 2008; Jha et al., 2009). Oral health needs to be integrated into the medical community and part of the health care system with timely, accessible information readily available between medical and dental providers.

Review of the Literature

To support this study, a systematic literature review was conducted. This review included primarily peer-reviewed journal articles including government publications, technical journals, and gray-literature published over the past 16 years using the keywords shown below in Table 1. The review produced 66 articles. These articles were grouped and classified into the following discussion categories: 1) Public Sector; 2) Private Sector; 3) Medical-Dental Integration Programs; 4) Interoperability and Data Standards; 5) EHR/EDR Interoperability and Barriers; 6) Linking Systems and Research; 7) Fast Healthcare Interoperability Resource® (FHIR®); 8) Patient Barriers to Dental Care; and 9) Conclusion.

Table 1

Key Words Utilized for Systematic Review from 2001 to 2017

Data Standards	Indian Health Service
Dental Informatics	Interoperability
Dentistry and Emergency Departments	Meaningful Use
DICOM®	Medical-Dental Integration
Electronic Dental Records	Oral Health and Systemic Health
Electronic Health Records	Oral Health Disparities
FHIR®	SNODENT
Health Disparities	SNOMED
HL7®	Veteran's Health Administration

Public Sector

A fully integrated health information technology (HIT) system that links EHRs to EDRs is not a new concept. The U.S. Department of Defense (DoD), Veteran's Health Administration (VHA) and Indian Health Service (IHS) are areas where a fully integrated health system exists. The DoD uses an industry-wide medical and dental information system that produces, manages, and provides a 24-hour-secure online-access system to such records known as Composite Health Care System (CHCS). CHCS allows providers worldwide to perform effectively a wide range of requests and services such as issue prescriptions, record diagnosis and treatment codes, request radiology exams, and other functions (Charles, Harmon, & Jordan, 2005). The VHA developed an EHR information

system known as the Veteran's Administration and Technology Architecture (VistA) over 27 years ago (Byrne et al., 2010) that consists of over 180 applications for clinical, financial, administrative, and infrastructure needs into a single, common database allowing all veteran-related care including health and dental to be shared between the providers (Charles et al., 2005; D'Avolio et al., 2012). The IHS uses a platform known as Resource and Patient Management System (RPMS), that is like VistA, which contains clinical and administrative information for the health care facilities involved. The hardware configurations are flexible, contain over 60 software applications, and contain network communication components for supporting the entire system. This integrated HIT system is used at approximately 400 IHS, Tribal, and urban Indian health locations across the country (Sequist, Cullen, & Acton, 2011; Sequist et al., 2007).

Private Sector

In contrast to the public sector, the private sector has been much slower in adopting a fully interoperable health information system (DesRoches et al., 2008; Jha et al., 2009). Electronic health systems come with complexities, complications, and high costs involved. Political and financial measures have been put into place to reduce such issues and to facilitate the adoption of a national health infrastructure. In 2009, President Barack Obama signed into law the American Recovery and Reinvestment Act (ARRA) and the Health Information Technology for Economic and Clinical Health Act (HITECH). The focus of ARRA and HITECH was to give the Centers for Medicare and Medicaid (CMS) authority to provide financial reimbursement incentives for eligible professionals (EP) and hospitals to adopt widespread EHR technology information. The widespread EHR technology needs to be exchanged in a 'meaningful' understandable

way to improve the quality, safety, and efficiency of patient care in the U.S. (Blumenthal & Tavenner, 2010; Marcotte et al., 2012; Steinbrook, 2009). Meaningful Use (MU) is a three-stage process with final stage beginning in fiscal year 2017 (CMS.gov, 2017; Griskewicz, 2015) with the goal to improve quality, safety, efficiency, and reduce health disparities. Stage-two was the first to incorporate oral health measures.

Medical-Dental Integration Programs

There are pilot programs and early intervention programs in place throughout the U.S. in the attempt to integrate oral health into systemic health care. Some hospital ED settings in the U.S. have developed referral-based pilot programs for patients that demonstrate a financial need and are referred to volunteer dentists. Referred patients receive treatment for dental care and provide community services as a payment for the dental care received. Other ED settings are working with state and local dental societies to reduce preventable-dental visits to the hospital ED by providing tooth extractions on-site to patients who are unable to receive care through the dental safety net. A local dental society recruits the volunteer dentists; the goal is to eliminate visits to the ED for the same dental problem, and reduce ED visits for dental pain and infections. Some participating hospitals have seen a reduction for dental-related visits by as much as 70% with potentially saving the state millions in Medicaid dollars (Strock, 2013). Other collaboration efforts are in place for integrating dentistry into primary care (Bernstein et al., 2016; Wysen, Hennessy, Lieberman, Garland, & Johnson, 2004), efforts in integrating medical and dental care for increasing physician education in oral health (Leonard A. Cohen, 2013), bridging psychiatry with dentistry (Bathla, Chandna, Mehta, & Grover, 2015) and many other integration measures.

Interoperability and Data Standards

Adoption of EHRs by hospital EPs have increased significantly from 2006 to 2011. In 2011, 84% of hospital ED settings adopted the usage of EHRs and 50% of federally qualified health centers (FQHC) adopted EDRs (Leigh & Harris, 2011). Approximately 74% of private-practice and approximately 78% of group-practice dental providers were using a computer-based system to manage patient clinical information, and demonstrated that the trend towards increased EHR adoption was continuing (T. Schleyer et al., 2013). The ability to share such health information between providers, organizations, and patients is one of the promised benefits for the adoption of EHRs throughout the U.S. and worldwide (HealthIT.gov, 2014), however, the sharing of health information cannot take place without a standard way of communicating the health data. The true benefit from adopting a national EHR infrastructure will come from achieving interoperability. Interoperability is the sharing of accurate health information between organizations and patients in an understandable, readable format (Bhartiya, Mehrotra, & Girdhar, 2016). For the information or health data to be interoperable, the structured data that is stored in one EHR vendor's product would need to communicate and be understandable in another vendor's product. A diagnosis code for example hypertension or dental caries, would mean the same across all vendors and would be associated with hypertension or dental caries and not some other condition like diabetes, or periodontal disease. Interoperability requires data standards to define protocols and other features of health data. The Health Information Technology Standards Panel (HITSP) was formed for harmonizing and integrating health standards (HITSP, 2009). Such standards consist of an industry-wide agreement or framework on models, principals, and rules about the

data involved. For the data to be usable, those systems must "talk" the same language and codes from one system must be mapped to the codes from the other system. While anyone can combine data from multiple systems in place, if the data is not mapped in a specific way, the data cannot be unlocked (Bensen, 2012). MU has stipulated that EHRs must contain structured data standards. Health Level 7® (HL7®), Systemized Nomenclature of Medicine Clinical Terms (SNOMED-CT), Logical Observation Identifiers Names and Codes (LOINC®), International Classification of Diseases (ICD), and Clinical Document Architecture® (CDA®) have been identified as some of the many required standards for implementation of EHRs (HHS, 2010).

EHR/EDR Interoperability and Barriers

Barriers exist for EHR to EDR implementation. Standards development can take three or more years before adoption, and the organization of health informatics standards development changes frequently and are complex. The standards developers consist of volunteers who meet three times per year, work long hours, and the work done are in small committee meetings, then presented to a much larger group to gain a consensus (Bensen, 2010). Health data standards are not only more complex than commonly used web standards (Grieve, 2011), they are also subject to licensing issues that increase costs and slowdown adoption. Another problem that has come from standards are numerous siloed systems with private proprietary interfaces; thus, making interoperability more difficult (Bensen, 2012; Herzlinger, Seltzer, & Gaynor, 2013; T. K. L. Schleyer et al., 2013). The systems that are currently in use are also too complex for standards alone and are requiring new skill sets and training that are limited, and lack practical implementation guidelines in a real-world setting (Mohan et al., 2014). Different

computer systems also store data differently, and vendors may have newer or outdated versions of the information technology (IT) (T. K. L. Schleyer et al., 2013).

The barriers between linking medical and dental records data have also included different coding standards for medical and dental diagnoses, different patient identifiers used by dentists and physicians, and record systems that are inconsistent (Rudman, Hart-Hester, Jones, Caputo, & Madison, 2010; Theis et al., 2010; Weatherspoon & Chattopadhyay, 2013). Medicine uses a standardized terminology known as ICD, however, ICD codes are underused in dentistry (Weatherspoon & Chattopadhyay, 2013) because they are mainly used for billing purposes and do not contain enough oral health terms (Reed et al., 2015). Only select states in the U.S. have Medicaid reporting requirements regarding ICD codes for dentistry and it is not known at this time if private dental plans will require diagnosis codes on all claims in the future utilizing ICD (ADA.org, 2017c). Throughout the years, organizations have developed other standardized terminologies for dentistry (Kalenderian et al., 2011; White et al., 2011). In 2009, a workgroup of members of the Consortium for Oral Health-Related Informatics (COHRI) attempted to address this gap by developing a new standardized coding system for dentistry known as EZCodes terminology (Kalenderian et al., 2011), later renamed Dental Diagnostic System (DDS). DDS which were incorporated into an EHR has been developed as an interface terminology (Rosenbloom, Miller, Johnson, Elkin, & Brown, 2006) which is easy to use, and has sufficient detail to document everyday dental diagnoses. The DDS terminology is continuously being updated and refined, and has recently been mapped to ICD and SNOMED (Kalenderian et al., 2016). One study shows positive attitudes towards adoption of DDS among dental providers (Ramoni et al.,

2015) and current dental students (Reed et al., 2015). It is also more flexible because it contains entire complex terms such as localized chronic moderate periodontitis so the user does not need to create a term by clicking on individual concepts (Reed et al., 2015). Most dentists, however, use Current Dental Terminology (CDT) which is a five-digit alpha-numeric system for reporting dental services maintained by the American Dental Association® (ADA®), and are updated every five years (Weatherspoon & Chattopadhyay, 2013). The CDT became a standard Health Insurance Portability and Accountability Act (HIPAA) of 1996 code set in 2000 and is now required to be used when submitting a HIPAA standard electronic dental claim for outpatient dental procedures (ADA.org, 2017b).

In an effort to increase interoperability, the ADA® and the ADA®'s Standards Committee on Dental Informatics (ADA® SCDI) joined forces with HL7® in order to enhance coordination between medical and dental care providers (HL7, 2009). Systemized Nomenclature of Dentistry (SNODENT) became embedded into SNOMED-CT and CDT with over 8,000 terms (Ramoni et al., 2015). It is now used as a standard terminology with HITECH and MU incentives program, does not require special programming languages, and combines dental content developed by the ADA® with relevant SNOMED-CT content. All the new content is integrated into SNOMED-CT and all SNODENT concepts have SNOMED-CT identifiers. The recording of clinical data through SNODENT also enables the consistent retrieval, transmission, and analysis of data from patient records across health care systems, and provides a standardized way to represent clinical oral health descriptions captured by dentists. SNODENT standards map to health-related classifications and coding arrangements used in the U.S. such as

ICD and CDT (ADA, 2014). The ADA® is accredited as a Standards Development Organization (SDO) through the American National Standards Institute (ANSI).

Linking Systems and Research

The first EHR-EDR largest and centralized data repository named BigMouth was developed within these four dental schools participating in the COHRI; the University of Texas Health Science Center at Houston (UTHealth), Tufts University, the University of California San Francisco (UCSF) and Harvard University. This multi-stakeholder involvement developed this data governance framework for encouraging data sharing, researching measures on evidence-based dentistry, and studying other health-related conditions associated within the mouth. DDS was used to map the diagnoses, and CDT was used to map all procedure codes. BigMouth was successfully launched in 2012 with data on 1.1 million patients which has allowed researchers to study medical and dental conditions, and has been made available to users at contributing institutions (Walji et al., 2014). Prior to the launch of BigMouth, the current research methodology was to extract data from insurance companies for studying evidence-based dentistry (Leake & Werneck, 2005; Pahel, Rozier, & Stearns, 2010), but that had limitations because many adult patients lack dental insurance or have limited dental coverage.

In a study done in Colombia, the informatics project showed that HL7® Version 3® (HL7® V3®) and CDA® standard could be used to integrate EDR information and dental x-ray imaging through Digital Imaging and Communication in Medicine® (DICOM®). The clinical document includes information from different sources into a final dental document record. The CDA® document is useful for dental and non-dental

organizations. With regards to interoperability, it showed it could be integrated into the patient's EHR, and could support improved treatment decisions in dentistry for patients (Abril-Gonzalez, Portilla, & Jaramillo-Mejia, 2017). DICOM® is the standard in medicine in which x-ray images or other medical information between computers are shared. Since 1996, dentistry began the involvement in adopting DICOM® standards. Digital systems and DICOM® imaging standards have been adopted in some fields of dentistry that include orthodontics, oral surgery, oral medicine, implants, and are being utilized in hospital and dental school settings (Draenert et al., 2010; Jyothikiran, Shanthara, Subbiah, & Thomas, 2014). No documentation could be found regarding general dentistry.

For research purposes, one study linked dental and medical records through administrative data of a large dental carrier and an integrated health plan to conduct an observational study of diabetes and periodontal disease (Theis et al., 2010). Another study done that linked EDR data by mapping dental data elements into a cancer registry found that using EDR data is beneficial for research purposes, and future work will be used for clinical research studies on a variety of topics (Liu, Acharya, Alai, & Schleyer, 2013).

Fast Healthcare Interoperability Resource® (FHIR®)

FHIR® under HL7® is the new data standard that combines the best features of HL7® while being easy to implement, and also fast (HL7.org, 2017b). The FHIR® standard can be used independently, or be used with other existing standards (HL7.org, 2017a). The basic building blocks of FHIR® is a "resource" which have a wide range of

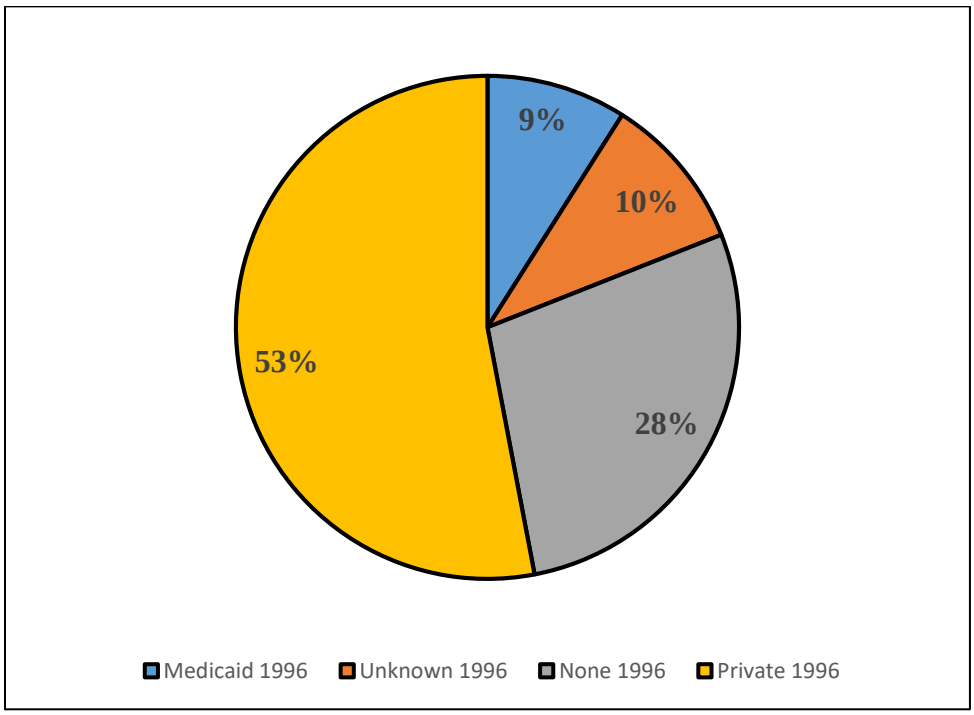
uses for clinical content such as care plans and diagnostic information. Resources define the basic units of exchange for clinical information (HL7.org, 2017a) such as family history and care plans (HIMSS, 2015), and define the exchangeable information in an understandable way; hence, interoperability. FHIR® builds documents from a set of resources that either by themselves, or when combined satisfy most use-cases at a lower price compared to existing alternatives (Solbrig et al., 2017). FHIR® is "open-sourced"; thus, available to everyone, not just moneyed vendors. It is based on Representational State Transfer (REST) (Yates et al., 2015) which makes implementation and usage much easier and quicker because there is much less data traffic (Franz, Schuler, & Krauss, 2015), and can be used for other resources such as mobile applications and cloud computing (Andry, Wan, & Nicholson, 2011; Khalilia et al., 2015). FHIR® can be used with data standards such as DICOM® (Clunie et al., 2016), CDA® (Mandl et al., 2012) and HL7® (Franz et al., 2015). Additionally, FHIR® supports other web-standards such as Hypertext Transfer Protocol (HTTPS), Extensible Markup Language (XML), JavaScript Object Notation (JSON) (Solbrig et al., 2017) and Open Authorization (OAuth) (Bloomfield Jr, Polo-Wood, Mandel, & Mandl, 2017).

Patient Barriers to Dental Care

The cost of dental care and lack of dental insurance is often the main reason why patients do not seek care at dental offices, and little has changed from 1996 to 2010 (GAO, 2013). Figure 2 and 3 below shows dental insurance coverage status in 1996 and 2010 in patients possessing either Medicaid, private insurance, no insurance, and unknown. Figure 2 and 3 below depicts little improvements have been made in increasing coverage between the years 1996 through 2010.

Figure 2

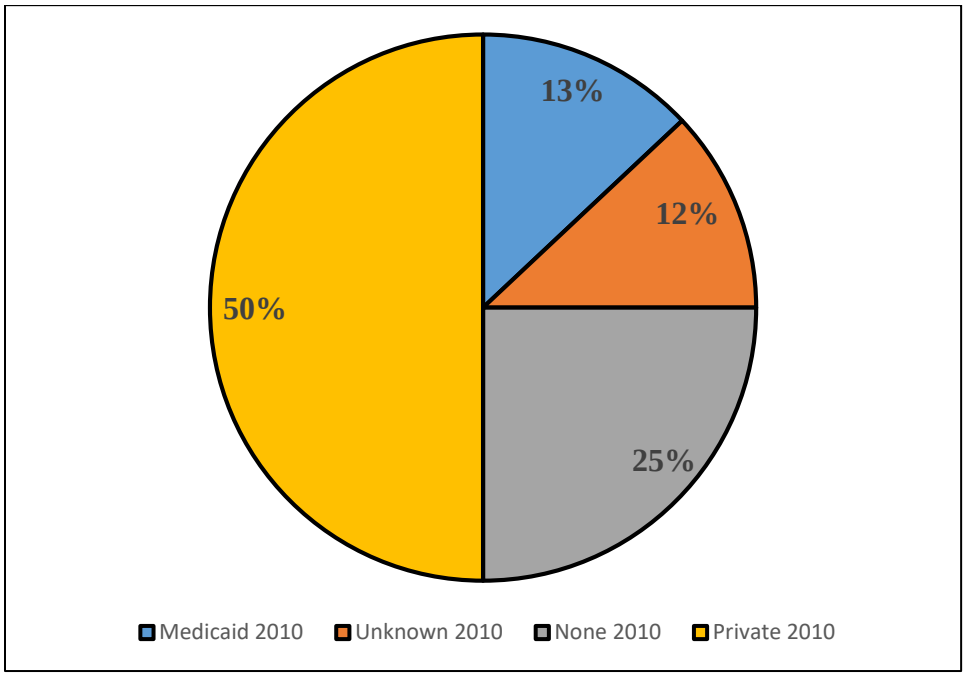
Dental Insurance Coverage Status: 1996



Source: GAO Analysis Data of HHS (GAO, 2013)

Figure 3

Dental Insurance Coverage Status: 2010



Source: GAO Analysis Data of HHS (GAO, 2013)

Furthermore, publicly-financed reimbursement programs for oral health care provide limited benefits for adults. Medicare covers preventive services but not in oral health. For Medicare to cover oral health services, it must be related to a medical procedure done in a hospital setting (Patton et al., 2001). Under the Patient Protection and Affordable Care Act (ACA) of 2010, Medicaid does cover emergency-related dental procedures for low-income adults, however, only 28 states and the District of Columbia (D.C.) (ADA.org, 2013) cover enrolled adults for dental care that is deemed medically necessary (Kaiser, 2012). Finding dentists that participates in Medicare (Waldman, Truhlar, & Perlman, 2005) and Medicaid is also a challenge due to low reimbursement rates (Logan,

Catalanotto, Guo, Marks, & Dharamsi, 2015; Logan, Guo, Dodd, Seleski, & Catalanotto, 2014). No information could be found how many dentists are currently participating in MU.

Conclusion

Based upon a systematic review of the literature, the linkages between oral health and systemic health are well-established in science, however, the integration of dental and medical practice information lags. Organizations, public and private have been working towards medical-dental electronic integration systems, however, there appears to be several barriers. The feasibility of this integration needs to be assessed systematically along several dimensions. Both medical and dental providers must be willing to adopt an integrated system to achieve health, and oral health equity. This can potentially be done using newly implemented data standards, data mapping techniques, and other federal legislation put into place for furthering the adoption and implementation of EHRs and EDRs. For a national EHR-EDR integration system to be put into place, this will be a multi-level approach with numerous participators that is beyond the scope of this research project. As society continues to move towards electronic health care in general, there may be no other option but to fully integrate all areas of health care, which includes dentistry.

Problem Statement

Research has shown that oral health and systemic health are related. There is a lack of timely electronic exchange of data between medical and dental providers in emergency department settings that creates sub-optimal patient outcomes, and has created

a growing public health expense burden. The feasibility of sharing data between providers needs to be explored. The knowledge gap of limited research of the feasibility of linking electronic health records to electronic dental records in the private sector needs addressing through this thesis project for determining the practicality in today's world.

Purpose Statement

The purpose of this research was to determine the feasibility of linking electronic health records in a hospital emergency department to electronic dental records at private practice dentists. This thesis project gathered requirements for linking the two systems, and other questions such as perceived value of systems integration, potential costs and benefits, and potential risks based upon interviews with subject matter experts.

Research Questions

1. Is it feasible to link Grady Hospital's Emergency Department electronic health records to the electronic dental records of Atlanta private-practice dentists?
2. Is there a practical and cost-effective solution for linking Grady Hospital Emergency Department's electronic health records to electronic dental records at Atlanta private-practice dentists?
3. What technologies, incentives, or assistance are needed for Atlanta medical and dental providers to link their electronic health records and electronic dental records together?
4. Can better patient care decisions result from linking electronic health records to electronic dental records?

5. Can oral health disparities be lowered by linking electronic health records to electronic dental records?

Significance Statement

In the U.S., dental providers consist mainly as independent, private, and small business-owners that do not routinely share electronic health and dental information back and forth between medical providers (Song, Liu, Abromitis, & Schleyer, 2013; St. Sauver et al., 2017). Medical and dental records data involve data capturing, storage, processing, exchange, integration, and interpretation of data from diverse systems. The existing EHR and EDR systems store large amounts of medical and dental records independently in various formats. The structural differences could be due to different storage devices, databases, data types, and attributes. The semantic differences may be due to different vocabularies, different languages, standards, and coding differences. The lack of the needed information exchange between medical and dental providers is due to separate EHR systems that are not interoperable. The problem with separate EHR systems that are not interoperable leads to poor communication between medical and dental providers, and duplication and inconsistency between the medical and dental record (Rudman et al., 2010). Other barriers make coordination of medical and dental integration and care difficult and slow (Din & Powell, 2008, 2009). Medical and dental providers that may have an interest to interoperate their systems do not have the information on the feasibility of integration due to limited available data on systems linkage in the private sector. With the implementation of the latest data standard FHIR®, other web-based standards, and data mapping techniques available today, data integration and harmonization may be an achievable process in the private sector.

Dental information is valuable to overall patient care because oral health and systemic health are related. Not only would linking such records be potentially beneficial to dental professionals, it could also be beneficial to medical professionals and patients as well (Din & Powell, 2008). This could potentially increase timeliness of communication, better treatment plans for patients, and lower other unforeseen medical-dental adverse reactions. A large portion of patient information gathered in dental offices can potentially be used to improve patient care and generate new public health knowledge (Liu et al., 2013). Patients and public health could truly benefit from this integration system. As health information technology progresses, this integration would potentially need to take place on a local, state, and national level in the very near future. For oral health to be integrated into the health care system and for patients to receive improved access to care, public health may need an informatics solution to improve population health.

Definition of Terms

adverse pregnancy outcome- Complications which include preterm delivery, delivery of low-birth weight, and high blood pressure with high amounts of protein in the urine (Paquette, 2006).

Affordable Care Act- Provides Americans with better health security by putting in place health insurance reforms that will expand coverage, hold insurance companies accountable, lower health care costs, guarantee more insurance choice, and enhance quality of care for all Americans (Medicaid.gov, n.d.).

American Dental Association® (ADA®)- Founded in 1859, this non-profit organization is the nation's largest dental association, representing more than 161,000 members, is the leading source for oral health information for dentists and patients, and is committed to the improvement of oral health to the public (ADA.org, 2017a).

American Dental Association® Standards Committee on Dental Informatics (ADA® SCDI)- Develops informatics standards and technical reports to assist the dental profession with hardware and software selection, digital photography, interoperability, data security, and more. They also interact with other entities involved in the development of health informatics standards (ADA.org, 2017g).

American National Standards Institute (ANSI)- Engaged in accreditation and assessing the competence of organizations conformance to standards (ANSI.org, 2017).

American Recovery and Reinvestment Act of 2009 (ARRA)- Signed by President Barack Obama in 2009, was an economic stimulus package and a joint effort through the Office of the National Coordinator for Health Information Technology (ONC) and Centers for Medicare and Medicaid (CMS) giving eligible professionals (EP) financial incentives for adopting health information technology standards through Meaningful Use (MU) and Health Information Technology for Economic and Clinical Health (HITECH) Act (CDC.gov, 2017).

Centers for Medicare and Medicaid (CMS)- A government agency that provides health coverage to more than 100 million people through Medicare, Medicaid, and Children's Health Insurance Program (CHIP) and Health Insurance Marketplace. The CMS seeks to strengthen and modernize the Nation's health care system, to provide access to high quality care, and improved health at lower costs (USA.gov, n.d.).

Clinical Document Architecture® (CDA®)- A document markup standard that specifies the structure and data language for clinical documents for the purpose of exchange between health care providers and patients, and can be used for a discharge summary, imaging report, physical report, and many others (HL7.org, 2007-2017a).

Composite Health Care System (CHCS)- A comprehensive medical informatics system designed, developed, and deployed by Science Applications International Corporation (SAIC) for use by all United States Department of Defense (DoD) military health care facilities (Openhealthnews.com, 2011-2016).

Consortium for Oral Health-Related Informatics (COHRI)- Formed in 2007 during a user's group meeting of dental schools who used the same EHR platform (axiUm), the Tufts University School of Dental Medicine had proposed the idea to form a consortium to share data to facilitate clinical research in dentistry. The vision is to link resources for better research and patient care. Their mission is create, standardize, and integrate data using electronic health records, cooperate with other health institutions to share data and many others (COHRI.org, 2013).

Current Dental Terminology (CDT)- A coding system used for the purpose to achieve uniformity, consistency, and specificity in accurately documenting dental treatment, provide efficient processing of dental claims, and to populate an EHR (ADA.org, 2017d).

dental caries- Known as a cavity or tooth decay, it is decomposition of a tooth (ADA.org, 2017e); Permanently damaged areas of the hard surfaces of teeth that develop into tiny openings, or holes also known as cavities. These are caused by a combination of

factors including bacteria, frequent snacking, sugary drinks, and not cleaning teeth well (Mayo, 1998-2017).

dental infection (abscess)- An inflammatory reaction to the nerve of the tooth from bacteria characterized by slow, or rapid onset, pain, tenderness, pus formation, and swelling of the associated tissues (ADA.org, 2017e).

dental providers- Any person duly licensed as a doctor of dental surgery (DDS) or, doctor of dental medicine (DMD) practicing within the authority of his/her license, which include dental specialists (Delta, 2015), and may also include registered dental hygienists (RDH) practicing within his/her license, and provide oral and health education, preventative, and periodontal care to dental patients.

dental safety net- Comprised of providers, payment programs, and facilities that provide clinical, nonclinical and support services which includes Medicaid, State Children's Health Insurance Program (SCHIP), federally qualified health centers (FQHC), school-based centers, academic dental institutions, and many other involved entities (ADEA, 2014).

Department of Defense (DoD)- Mission is to provide the military forces needed to deter war and to protect the security of the United States (Defense.gov, n.d.).

Digital Imaging and Communications in Medicine® (DICOM®)- The international standard for medical images and related information defines the formats for medical images that can be exchanged with the data and quality necessary for clinical use. It is used with x-ray's, CT, MRI, ultrasound, and other images (DICOM.org, n.d.).

disparities- A health difference that is closely linked with social, economic, and/or environmental disadvantage. Adversely affects groups of people who have

systemically experienced greater obstacles to health, based on their racial or ethnic group, religion, socioeconomic status, gender, age, mental health, and other factors (Carter-Pokras, 2002; HHS, 2008).

electronic dental record (EDR)- The dental equivalent to the electronic health record used by dental professionals, that contains the dental and treatment history of patients in one practice, or a large group with multiple dentists (AAO, 2012).

electronic health record (EHR)- Electronic version of a patient's medical history that is maintained by the provider over time, and may include all the key administrative and clinical data, relevant to that persons care under a provider including demographics, progress notes, medications, past medical history, and many others (CMS.gov, 2012a).

eligible professional (EP)- Under Medicare EHR incentive payments include: Doctor of Medicine (MD) or Osteopathy (DO), Doctor of Dental Surgery or Medicine (DDS) or (DMD), Doctor of Podiatry (DPM), Doctor of Optometry (OD), and Chiropractor (DC).

Under Medicaid EHR incentive payments include: Physicians primarily MD's and DO's, nurse practitioners (NP), certified mid-wife, DDS or DMD and physician assistant (PA) who provides services at FQHC or Rural Health Clinics lead by a physician (CMS.gov, 2012b).

emergency department (ED)- The department of a hospital responsible for the provision of medical and surgical care to patients arriving at the hospital in need of immediate care. The emergency department can also be called the emergency room (ER) (MedicineNet.com, 1996-2017a).

Extensible Markup Language (XML)- A web-based language, used in a flexible way to create information formats and electronically share structured data via the public internet as well as corporate networks (TechTarget.com, 2001-2017).

Fast Healthcare Interoperability Resource® (FHIR®)- Data standard for describing data formats and elements known as resources and an Application Programming Interface (API) for exchanging electronic health records. Aims to simplify implementation without sacrificing data integrity (HL7.org/fhir, 2015).

feasibility study- Tests the viability of an idea, a project, or even a new business. The goal is to place emphasis on potential problems that could occur if a project is pursued and determine if, after all significant factors are considered, the project should be pursued. Feasibility studies also allow a business to address where and how it will operate, potential obstacles, competition, and the funding needed to get the business up and running (investopedia.com, 2017).

federally qualified health centers (FQHC)- Qualify for funding under Section 330 of the Public Health Service Act (PHS), qualify for enhanced reimbursement from Medicare and Medicaid, serve underserved populations, offer services on a sliding scale and provide comprehensive services such as preventive health, dental, mental health, substance abuse, transportation services, hospitality, and specialty care (FQHC.org, n.d.).

gingivitis- Inflammation of the gums characterized by redness and swelling, caused by a bacterial infection (perio.org, 2017).

harmonization (harmonize)- Refers to all efforts to combine data from different sources and provides users with a comparable view of data from different studies (icpsr.umich.edu, 2017).

health equity- Enabling everyone the opportunity to achieve their highest level of health (APHA.org, 2017).

Health Information Technology for Economic and Clinical Health Act (HITECH)- Enacted as part of the American Recovery and Reinvestment Act (ARRA) of 2009, this act was signed into law on February 17, 2009, to promote the adoption and meaningful use of health information technology. Subtitle D of the HITECH Act addresses the privacy and security concerns associated with the electronic transmission of health information, in part, through several provisions that strengthens the civil and criminal enforcement of the HIPAA rules (Bernstein et al., 2016; HHS.org, 2009).

Health Information Technology Standards Panel (HITSP)- Established in 2005 under US Department of Health and Human Services (HHS) to achieve a widely accepted and useful set of standards specifically to enable and support widespread interoperability among health care software applications, as they will interact in a local, regional and national health information network for the United States (Bensen, 2010; HITSP, 2009).

Health Insurance Portability and Accountability Act of 1996 (HIPAA)- Implemented by the US Department of Health and Human Services (HHS), the Privacy Rule, address the use and disclosure of individuals health information – Protected Health Information (PHI) by organizations subject to the Privacy Rule called covered entities, as well as standards for individuals privacy rights to understand and control how their health information is used (HHS, 2003).

Health Level 7® (HL7®)- Provides a framework (and related standards) for the exchange, integration, sharing, and retrieval of electronic health information. These standards define how information is packaged and communicated from one party to

another, setting the language, structure and data types required for seamless integration between systems. HL7® standards support clinical practice and the management, delivery, evaluation of health services, and are recognized as the most commonly used standards in the world (HL7.org, 2007-2017b).

Health Level 7® Version 3 (HL7® V3®)- Updated data standard of HL7® has more complexity and the aim is to support all health care workflows, versus HL7® Version 2® (HL7® V2®) which is less complex, and has the aim to support all hospital workflows (Spronk, 2011).

Hypertext Transfer Protocol (HTTPS)- Set of rules for transferring files such as text, graphic, images, sound, video, and other multimedia files on the World Wide Web (TechTarget.com, 2000-2017a).

Indian Health Service (IHS)- An agency within the Department of Health and Human Services (HHS) that is responsible for providing federal health services to American Indians and Alaska Natives (IHS.gov, n.d.-a).

ineffective treatment options- Treatment that is not beneficial to the patient (Veatch & Spicer, 1992).

integration- Act of bringing together smaller components into a single system that functions as one. For an IT project, it refers to the end result of a process that aims to bring together different subsystems so that the data contained in each becomes part of a larger, more comprehensive system that easily shares data as needed (TechTarget.com, 2000-2017b)

interface technology- Where two separate parts of a computer system exchange information. The exchange can be between software and hardware (Engineers, 2000).

International Classification of Diseases (ICD)- Developed in 1893 and entrusted by World Health Organization (WHO), it is used for diagnosis of diseases, disorders, injuries, and other related health conditions, used for sharing and comparing health information between hospitals, and providers for monitoring the incidence and prevalence of diseases, observing reimbursement trends, and keeping track of safety and quality guidelines (WHO.org, 2017).

interoperability- The ability of different information technology systems and software applications to communicate, exchange data, and use the information that has been exchanged (HIMSS, 2010).

JavaScript Object Notation (JSON)- A data standard that contains light-weight data-interchange format that is easy for humans to read and write, and easy for machines to parse and generate (JSON.org, n.d.).

Logical Observation Identifiers Names and Codes® (LOINC®)- Developed to provide standards for identifying clinical information in electronic reports, provides a set of universal names and ID codes for identifying laboratory and clinical test results with Health Level 7 ®and other standards (LOINC.org, 1994-2017).

mapping (data)- Involves "matching" to enable software and systems to meaningfully exchange patient information, reimbursement claims, outcomes reporting, and other data (McBride, Gilder, Davis, & Fenton, 2006).

Meaningful Use (MU)- Under the American for Recovery and Reinvestment Act (ARRA) of 2009, the Health Information Technology and Clinical Health (HITECH) Act, proposed the use of certified electronic health records to be used in a meaningful way, ensuring EHR technology is connected in a manner that provides for the electronic

exchange of health information to improve the quality of care. To encourage widespread adoption of EHR technology, Centers for Medicare and Medicaid (CMS) can provide financial incentives to eligible professionals who demonstrate 'meaningful use' of EHR technology (CDC.gov, 2017; CMS, 2010).

Medicaid- A federal assistance program established as Title XIX under the Social Security Act of 1965 which provides payment for medical care for certain low-income individuals and families. It is funded jointly by the state and federal government, and administered by the state (ADA.org, 2017e).

medical providers- A doctor of medicine (MD) or doctor of osteopathy (DO), registered nurses (RN), nurse practitioners (NP) and physician assistants (PA) (Dictionary, 2003-2017).

Medicare- A federal insurance program enacted in 1965 as Title XVIII of the Social Security Act that provides certain inpatient hospital services and physician services for all person's age 65 and older, and for eligible disabled individuals. This program is administered through the Centers for Medicare and Medicaid (CMS) (ADA.org, 2017e).

non-traumatic dental problem- Problems associated with dental pain and oral disease caused by caries, inflammation of the pulp (nerve) and periodontal (gum) disease (B. Sun, M.D. M.P.P. & Chi, 2014).

Open Authorization (OAuth)- An open protocol to allow secure authorization in a simple and standard method from web, mobile and desktop applications (OAuth.net, n.d.).

open-sourced- A program in which the source code is available to the general public for use and/or modification from its original design free of charge (Beal, 2017).

opiate pain medication- Medication used to treat moderate to severe pain that do not respond well to other pain medications. Examples are codeine, hydrocodone, oxycodone, morphine, and others (WebMD.com, 2015-2017).

oral cancer- Cancer that forms in the oral cavity (mouth) or the oropharynx (part of the throat at the back of the mouth) (Cancer.gov, n.d.).

oral health- A functional, structural, aesthetic, physiologic, and psychosocial state of well-being in the mouth that is essential to an individual's general health and quality of life (ADA.org, 2017b).

oral health equity- Health equity is achieved when every person has the opportunity to attain his or her full health potential, and no one is disadvantaged from achieving this potential due to social circumstances (CDC.gov, 2015). Oral health equity, is health equity pertaining to the mouth.

patient identifier- Any alphanumeric code used to uniquely identify a patient within a health register or a health records system (Segen, 2012).

periodontal disease- Inflammatory disease that affects the soft and hard structures that support the teeth; the gum tissue pulls away from the tooth and supporting gum tissues are destroyed; bone can be lost, and the teeth can loosen or eventually fall out (perio.org, 2017).

protocols- A set of special rules that specify interactions between communicating systems (TechTarget.com, 2000-2017c).

Representational State Transfer (REST)- A way of achieving interoperability between computer systems on the internet. It is based on a set of principles that describe how networked resources are defined and addressed. REST is a style of software architecture as opposed to a set of standards (Service-architecture.com, 2000-2017).

Resource and Patient Management System (RPMS)- Developed and designed specifically for Indian health care and is used daily in hundreds of Indian health care locations. Utilizes clinical, administrative, and infrastructure needs of the Indian health care organizations (IHS.gov, n.d.-b).

siloed systems- A silo is any management system that is unable to operate with any other system, it is closed off from other systems which creates an environment of individual and disparate systems within an organization. These occur because they typically do not share the same priorities, goals, or tools, so they operate as individual business units (Webopedia.com, 2017).

standards (data)- A document, established by a consensus, and approved by a recognized body, that provides, for common and repeated use, rules, guidelines, or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in each context. Apart from product standards, other examples include: test methods, codes of practice, guideline standards and management systems standards (ISO, n.d.).

Standards Development Organizations (SDO)- Entities that develop, coordinate, revise, amend, interpret, or otherwise maintain standards that address the interests of users outside the SDO. In the United States, there are several hundred SDOs that which are coordinated by the National Standards Body (NSB)- the American National Standards

Institute (ANSI). SDOs are accredited by ANSI to develop standards using open and transparent processes (PHDSC.org, 2017).

subject matter expert (SME)- A person with a bona fide expert knowledge about what it takes to do a particular job (OPM.gov, n.d.).

systemic health- Health affecting the entire body (MedicineNet.com, 1996-2017b).

Systemized Nomenclature of Dentistry (SNODENT)- An official subset of SNOMED-CT, is designed for use in the electronic environment for electronic health and dental records. The intended purpose is to provide standardized terms for describing dental disease, capture clinical detail and patient characteristics, permit analysis of patient care services and outcomes, and to be interoperable with EHRs and EDRs (ADA.org, 2017f).

Systemized Nomenclature of Medicine (SNOMED)- Enables providers and electronic medical records to communicate in a common language, thus increasing the quality of patient care across many different provider specialties (Ware, 2013).

Systemized Nomenclature of Medicine Clinical Terms (SNOMED-CT)- A suite of designated standards for use in the U.S. Federal Government systems for the electronic exchange of clinical health information and is also a required standard in interoperability specifications of the U.S. Healthcare Information Technology Standards Panel (HITSP) (Nlm.nih.gov, 2017).

use-cases- A software and system engineering term that describes how a user uses a system to accomplish a goal. Acts as a software modeling technique that defines

features to be implemented and resolving of errors that may be encountered (Techopedia.com, 2017).

Veteran's Administration and Technology Architecture (VistA)- A robust electronic health record system, designed and developed to support a high-quality medical care environment for the military veterans of the United States. The VistA system is used in hundreds of Veteran's Administration centers and outpatient clinics across the country (WorldVista.org, 2000-2017).

Veteran's Health Administration (VHA)- The largest integrated health care system in the United States, providing care at 1,245 health care facilities, including 170 VA Medical Centers and 1,065 outpatient sites of care of varying complexity (VHA outpatient clinics), serving more than 9 million enrolled Veterans each year (VA.gov, 2017).

Chapter II: Methodology

Introduction

The purpose of this chapter is to describe the methodology, data types, and approach used to assess the feasibility of linking electronic health records (EHR) in Grady Hospital's Emergency Department (ED) to electronic dental records (EDR) at private-practice dentists in metro Atlanta, Georgia. Research has shown that oral health and systemic health are related (Igari et al., 2014; Lamster et al., 2008). There is a lack of timely electronic exchange of data between medical providers in ED settings and private-practice dentists that creates sub-optimal patient outcomes, and has created a growing public health expense burden (Davis et al., 2010; H. H. Lee et al., 2012; C. Lewis et al., 2003; Tomar et al., 2016). The feasibility of sharing data between medical and dental providers needs to be explored. The knowledge gap of limited research of the feasibility of linking EHRs to EDRs in the private sector needs addressing through this thesis project for determining the practicality in today's world. The following five research questions were studied for the purposes of this thesis project.

1. Is it feasible to link Grady Hospital's Emergency Department electronic health records to the electronic dental records of Atlanta private-practice dentists?
2. Is there a practical and cost-effective solution for linking Grady Hospital Emergency Department's electronic health records to electronic dental records at Atlanta private-practice dentists?

3. What technologies, incentives, or assistance are needed for Atlanta medical and dental providers to link their electronic health records and electronic dental records together?
4. Can better patient care decisions result from linking electronic health records to electronic dental records?
5. Can oral health disparities be lowered by linking electronic health records to electronic dental records?

Method

The methodology for this feasibility study consisted of the following four elements:

1. A systematic literature review to identify the key considerations of policies, barriers, disparities, data standards, and interoperability measures documented in the literature which should be included as considerations for assessing the feasibility of benefits, costs, requirements, and considerations. The literature review was also utilized to inform the overall methodology of this project.
2. An interview with an emergency department physician considered a subject matter expert at Grady Memorial Hospital in Atlanta, Georgia.
3. Interviews with two private-practice dentists considered subject matter experts in metro Atlanta, Georgia.
4. An interview with a technology-vendor employee representing an electronic health and electronic dental record software organization.

Each of these areas of expertise are grouped, and the methodology approach and procedures utilized are discussed in detail below.

Data Types and Descriptions

Subject Matter Experts

Participants in this study included four subject matter experts (SME) that were interviewed to gain their expert opinions on the feasibility of linking EHRs to EDRs. Participants included three males and one female, all were a minimum age of 18, and a maximum age of 50. Race was not asked or taken into consideration for the purposes of this project. Educational background ranged from bachelor's degree to doctorate degrees. All participants were employed full-time within the organization they represented, work-experience in the industry was a minimum of four years, and maximum of 20 years. All participants in this study voluntarily participated. Participants were recruited through professional referrals, professional affiliations, and the technology participant of the EHR company was assigned by the company based on company position and current knowledge of EHR and EDR software. All participants represented experts from ED health care, private-practice dentistry, and health care and dental technology software systems.

Project Design

The research design of this study was a feasibility evaluation study to assess the feasibility of linking EHRs to EDRs by gaining expert opinions from industry SMEs. After obtaining verbal consent, questions were asked that involved requirements, perceived value of linking EHRs to EDRs, current state of integration and willingness to adopt the linkage of the two systems, and other questions included potential costs, benefits, and potential risks involved in systems integration.

Procedures

Participants were instructed prior to the interviews that the purpose of the interview was to gain expert opinion of the feasibility of linking EHRs to EDRs. Verbal consent was obtained prior to the interview to participate in the study, no deception was used, and participants were informed about confidentiality of their information. Each interview took about one hour to conduct, no personal health information (PHI) was accessed or reported, no private patient information or records were viewed, and the study was exempt from institutional review board (IRB) procedures. Participants were thanked at the end of the interviews for their time, and letters were sent thanking them for their participation.

Instruments

Interviews were conducted via telephone or in-person, and information was recorded via pen and paper. Interviews were conducted one-on-one, and no patients or other employees were present during the interview.

Analysis

A questionnaire was developed to conduct the interviews based upon the areas of expertise per SME. Questions involved many considerations including requirements for integration and other questions such as perceived value of systems integration, potential costs, benefits, and risks involved. Other questions involved the current functionality and purpose of the EHR and EDR software, the data types that is transmitted, and current state of integration. A full list of interview questions for each SME is listed in Appendix A.

Emergency department physician. During the interview, the SME was asked questions on perceived value and usefulness of linking the two systems, what types of information would be useful to be transmitted back and forth, the type of workflow of the ED regarding non-traumatic dental emergencies, the amount of the patients seen per week, and percentage of patients that return for the same dental problem. Other questions include potential benefits to ED dental patients, benefits to medical and dental care in general, and if their ED would be willing to adopt this integration. Key questions and answers are listed below in Table 2.

Table 2:

Questions and Answers from Emergency Department Physician

Emergency department physician questions	Emergency department physician answers
What electronic health record software system does your hospital use?	*"Epic® is what our emergency department uses, I do not know what our oral surgery clinic uses though."*
If you had an electronic system that linked electronic health records to electronic dental records to Atlanta dentists to perform treatment and have timely	*"Yes, having access to patients' medications, antibiotics, toothaches, and dental history would improve medical and dental health, help reduce emergency department wait times, and would improve communication barriers between medical and dental providers."*

communication back and forth, would it be useful to you? How?	
How would a system like this benefit you and your hospital?	*"If it was currently available in our hospital, it would benefit us because we currently do not have a detailed dental history from the patient and do not know when they last saw a dentist. I would be interested in knowing if the patient has healthy teeth and a healthy mouth prior to assessment. Dental health is often overlooked by medical doctors and issues with the teeth affect patients medically."*
Describe the current workflow of the emergency department regarding non-traumatic dental emergencies.	*"There is quite a few, we give pain medications, antibiotics, refer them to a dental clinic outside of the hospital if there is no evidence of an abscess. If there is an abscess, we refer them to our oral surgery clinic."*
Do these patients slow down the workflow of the emergency	*"Yes, each non-traumatic dental patient takes time away from other patients needing true*

department that needs attending to true emergencies? Why?	*emergencies. For seeing 50 patients, it probably takes away four hours of total care away from other patients."*
How many of these patients are repeat patients?	*"Between three to five percent."*
Do you as a physician think this system would help reduce emergency department wait time and improve treatment overall?	*"I think every little bit would help, however I think if people had more access to dental care and better health literacy, perhaps less patients would show up to the emergency department for dental treatment to begin with."*
You mentioned your emergency department refers patients to affordable dental clinics. Why do you think patients are showing up to the emergency department instead of seeking care to a dental office first?	*"Many of these patients' lack health literacy and their solution is to come to the emergency department for care. I think if an educational program could be developed, or some type of informatics solution that would enable patients to seek care to an affordable dental clinic instead of an emergency department. That would significantly help this problem."*

Do you think Grady would be willing to invest in this type of system financially?	*"I think it could help reduce costs by keeping people out of the emergency department, but I am not convinced on the return on investment. Grady Administrators would need to see a detailed study and details on return on investment before they would be willing to purchase this type of system. Until patients are better educated, I think they will continue to seek care in the emergency department, so no, I do not think Grady would invest in this system right now."*
What requirements do you think would be necessary for your emergency department to adopt this system?	*"I think if government officials could come with a way to incentivize the systems which would include mandates, tax breaks, and other measures to keep costs down, that would be a good place to start."*
Do you think this technology would lower health and oral health disparities?	*"Yes, patients in general are pinching pennies due to insurance or lack thereof, and with the Affordable Care Act repealing, that could*

	increase. I think this system could potentially help to increase access to care and would improve communication between medical and dental providers."
Overall, what is your perceived value of linking electronic health records to electronic dental records?	*"I think it is a great idea, but think the out-of-pocket costs would be too high."*
What other barriers do you see that would prevent your hospital from adopting this integration system?	*"I think this integration would significantly improve access to care, help improve communication problems between medical and dental providers, and overall, think it is a great idea that needs to be done. But based on my knowledge of costs of electronic health records, I think the potential out-of-pocket costs for the hospital, and patients not being able to afford the dental care is what would be significant barriers to linking electronic health records to electronic dental records."*

What about open-sourced electronic health records?	*"Even with those types, they are not free and there are still many costs and people involved in migrating the data, so no, even that I do not think would be an option right now."*

Dentists in metro, Atlanta. The two SMEs were asked questions that involved the number of patients they see per day, what types of dental procedures their practice currently performs, would their practice be willing to adopt the system if made available, and what requirements would they like to see take place for integration. Other questions include potential benefits to dental patients, and medical and dental care in general. Key questions and answers are listed below in Table 3 for the first dentist interviewed, and Table 4 for the second dentist interviewed.

Table 3:

Questions and Answers from Private-Practice Dentist in Atlanta #1

Atlanta dentist #1 questions	**Atlanta dentist #1 answers**
What digital electronic dental record system does your practice use?	*"Eaglesoft® Version 16."*

What is your perceived value of linking electronic health records data to electronic dental records data?	*"I think it would be very valuable to patient care, systemic issues, medications, allergies and other pertinent patient information could be communicated back and forth between medical and dental providers."*
Would you be willing to adopt this system and be a participator with Grady Hospital's Emergency Department for linking electronic health records data to your electronic dental records data?	*"Yes, I am willing to see all patients referred from all physicians that need dental care. The patients would need to verify that we accept their insurance, and if we do not, then they would be charged our cash prices."*
Do you think seeing patients referred from Grady would help increase your practice revenue or patient amount?	*"No, our established practice schedule is booked out several weeks in advance, and our second practice that is open part-time is continuing to grow with full schedules on our open days."*

What are the out-of-pocket costs you would be willing to spend on the linking systems?	*"I would be willing to spend at most $3,000 for the linking of the two data systems, if it costs more than that, then no."*
What would need to take place for you to adopt the system integration?	*"If it cost more than $3,000, then government mandates, incentives to adopt the systems linking, perhaps $10,000 or more in incentives to link the data."*
Do you currently accept Medicaid or Medicare patients? Why not?	*"We do see Medicaid patients at our other location, but are currently phasing Medicaid out because the reimbursement is so low, we cannot afford to continue accepting that insurance and provide the quality care that we think our patients deserve. We do not accept Medicare because the reimbursements are too low and complicated to provide the care we want to our patients."*

Do you think this technology would reduce communication problems between physicians and dentists?	*"Yes, by the way a dentist or physician considers doing procedures, the information could be clearer, could prevent treatment mistakes, and could be used as an excellent tool for better treatment of dental and medical patients."*
If this system was made available, how could this better inform treatment decisions?	*"It could make treatment decisions easier, including dental and medical surgical procedures more precise, patient medical conditions could be monitored more closely such as blood glucose, medication interactions, and many other medical-dental treatment decisions could be considered."*
Do you think this system would lower oral health disparities?	*"Yes, the information transmitted back and forth could reduce health care and dental spending expenditures on visits to doctors, referrals could be more consistent and quicker, and medical and dental health*

	overall could become more affordable with this type of technology."

Table 4:

Questions and Answers from Private-Practice Dentist in Atlanta #2

Atlanta dentist #2 questions	**Atlanta dentist #2 answers**
What digital electronic dental record system does your practice use?	*"Dentrix® G5."*
What is your perceived value of linking electronic health record data to electronic dental record data?	*"Although I think it sounds like a great idea, I am not convinced it is something that I would want to do. I do not like the idea of patient information being transmitted back and forth or being accessed in a large database. I am concerned about security issues, HIPAA problems, and other headaches to have to deal with on top of what we already are dealing with regarding electronic dental records,*

	electronic insurance claims, and other issues."
Would you be willing to adopt this system and be a participator with Grady Hospital's Emergency Department for linking electronic health records data to your electronic dental records data?	*"No, I am really interested in performing family and cosmetic dentistry only. I refer most of my oral surgery and endodontic cases out to specialists, and I also think having an electronic referral system in place would add an extra expense and burden to our practice. So, I do not think the return on investment would be worth it."*
What would need to take place for you to adopt the system integration?	*"I think I would consider changing my mind if dentists could bill out medical insurance for dental procedures referred by physicians. Currently, the dental insurance industry has its problems that needs changing too; we deal with deductibles, waiting periods, missing tooth clauses, maximum per year amounts which, for a good insurance, might pay $1,500 to $2,000 maximum per year, which might restore one tooth if the patient needs a buildup*

	and a crown, so if we could start billing medical insurances for referred patients from physicians, then that would maybe be an option."
Do you currently accept Medicaid or Medicare patients? Why not?	*"No, the reimbursement for both insurances are too low. We do not feel we can provide the quality of care we want to our patients and accept those insurances."*
If this system was made available, how could this better inform treatment decisions?	*"Although I am not fully convinced it could. When I have questions, or need information from a physician about a patient, I prefer to speak to that physician because I have questions I need detailed answers to. I do not think I could get the information I need about a patient's medical condition from accessing it from a computer system or database; there is nothing like direct communication. I do not have that many patients that are so medically compromised that I need to speak to a*

	physician, but when I do, I prefer to get clarification from speaking to their physician."
Do you think this system would lower oral health disparities?	*"Yes, I think it could help increase access to care in areas of Georgia where there are limited dentists available by locating providers and increasing access to needed care that may not be available."*

Electronic health record technology employee. The SME was asked questions that assessed current technology capability on linking EHRs to EDRs, what information is transmitted between both software systems, what interface requirements there are, web standards, data standards, and languages involved, and how interoperability is supported. Other questions included potential costs, risks, and timeline for implementation. Key questions and answers are listed below in Table 5.

Table 5:

Questions and Answers from Electronic Health Record Software Technical Employee

Electronic health record technology employee questions	**Electronic health record technology employee answers**
I am aware of your organization's electronic health record and electronic dental record software. Do these have the capability to talk to each other back and forth?	*"Yes, it has the capability so that medical and dental providers can access health and dental information. Patient charts, patient notes, radiographs, demographics, provider information, and any other documentation needed to be sent between medical and dental providers can be easily shared as their own operating system."*
Do your software products have the capability to talk to other electronic dental record software vendors such as Dentrix® or Eaglesoft®?	*"Yes, any non-Epic® organization can interface with other vendors. If an organization has that vendor and wants to link Epic® with Dentrix® or Eaglesoft®, it can be done and would share the same types of patient information back and forth."*

Please provide a high-level overview of how the information is transmitted and how it can talk to each other.	*"An interface is set-up and pieces of each of database are mapped to the other database, and a patient identifier is used and recognized at each other for the linkage of the systems."*
How is interoperability supported?	*"It is a query-based and push-based approach."*
What type of data standards are currently being used in your system?	*"We utilize data standards like SNOMED, HL7® v2®, DICOM®, FHIR®, CDA ®, and other web services."*
What about SNODENT?	*"It can support SNODENT but may need importing into the system, and would require an additional license in terms of the software."*
How many users can the systems support at one time?	*"An infinite amount per that hardware capability."*

Are there any risks or problems you see occurring with linking both systems?	*"Interfaces are messy, setting up interfaces usually has problems, information exchange is not as smooth and may require additional mitigation to resolve the issues."*
How much does it cost to implement this type of system linkage?	*"I have no idea, it is usually on a case-by-case basis, but due to private company information, I cannot share that type of information publicly."*
Approximately how much time would it require to build this type of system?	*"I do not know, again, it is a case-by-case basis."*
How much labor would be required?	*"I do not know, again, it is a case-by-case basis, a team would need to be put together to determine all the factors and elements involved."*

Can you tell me the total cost for an emergency department to implement this system?	*"I cannot release that information, that is private company information."*
Can you tell me the total cost for a dental office to implement this system?	*"I cannot release that information either, that is private company information."*
How would an organization be able to go about linking their health data to their dental data if they currently had Epic® and wanted to link to Dentrix® or Eaglesoft®? What would be the process if they wanted to move forward with it?	*"They would need to contact our organization and we would assemble a team for them and provide a plan that includes a timeline, costs and other factors and would work with their existing electronic dental record software to map the data and integrate the systems."*

Chapter III: Results

Introduction

The purpose of this chapter is to describe the results of the methodology to assess the feasibility of linking electronic health records (EHR) in Grady Hospital's Emergency Department (ED) to electronic dental records (EDR) at private-practice dentists in metro Atlanta, Georgia. Research has shown that oral health and systemic health are related (Igari et al., 2014; Lamster et al., 2008). There is a lack of timely electronic exchange of data between medical and dental providers in ED settings that creates sub-optimal patient outcomes, and has created a growing public health expense burden (Davis et al., 2010; H. H. Lee et al., 2012; C. Lewis et al., 2003; Tomar et al., 2016). The feasibility of sharing data between providers needs to be explored. The knowledge gap of limited research of the feasibility of linking EHRs to EDRs in the private sector needs addressing through this thesis project for determining the practicality in today's world. The following five research questions were explored, and synthesis of expert opinions are reported below in Table 6.

1. Is it feasible to link Grady Hospital's Emergency Department electronic health records to the electronic dental records of Atlanta private-practice dentists?
2. Is there a practical and cost-effective solution for linking Grady Hospital Emergency Department's electronic health records to electronic dental records at Atlanta private-practice dentists?

3. What technologies, incentives, or assistance are needed for Atlanta medical and dental providers to link their electronic health records and electronic dental records together?
4. Can better patient care decisions result from linking electronic health records to electronic dental records?
5. Can oral health disparities be lowered by linking electronic health records to electronic dental records?

Key Findings

Table 6:

Research Questions and Synthesis of Expert Opinions of the Project

Research questions	Synthesis of expert opinions
1. Is it feasible to link Grady Hospital Emergency Department electronic health records to the electronic dental records of Atlanta private-practice dentists?	• No, it is not feasible to link Grady's Emergency Department's electronic health records to electronic dental records at private-practice dentists in Atlanta, Georgia. • The technology is currently available, however, it is not feasible to do based on financial and policy considerations.

2. Is there a practical and cost-effective solution for linking Grady Hospital Emergency Department's electronic health records to electronic dental records at Atlanta private-practice dentists?	• No, there are too many complexities with health and dental insurance such as lack of coverage, deductibles, waiting periods, out-of-pocket costs, and others. • No, because there is also a lack of available funding and financial resources to link the systems together. • There is also a lack of policies put into place making data systems integration not practical, or cost-effective.
3. What technologies, incentives, or assistance are needed for Atlanta medical and dental providers to link their electronic health records and electronic dental records together?	• Further government mandates for expanding access to dental care, allowing dentists to bill medical insurance for dental care referred by medical providers, and increasing dental insurance reimbursements and benefits.

	• Other incentives such as tax breaks and reimbursements that extend beyond Meaningful Use, and up to $10,000 or more is needed for systems integration.
4. Can better patient care decisions result from linking electronic health records to electronic dental records?	• Yes, it would create better patient decisions. More information would be available, treatment decisions would be easier and more effective, surgical procedures would go smoother, and the monitoring of glucose, medications, patient health outcomes, and other conditions could be overseen more effectively. • Direct conversations between dentists and physicians regarding patient care, however, appears to also be continually needed because electronic exchange still has its limitations; dentists that have questions that are not answered in the patient's electronic medical chart would

	need addressing by directly speaking with the physician.
5. Can oral health disparities be lowered by linking electronic health records to electronic dental records?	• Yes, it would help increase access to dental care, help locate participating dentists, and would overall lower health care and dental care costs by making them more affordable currently, and in the future.

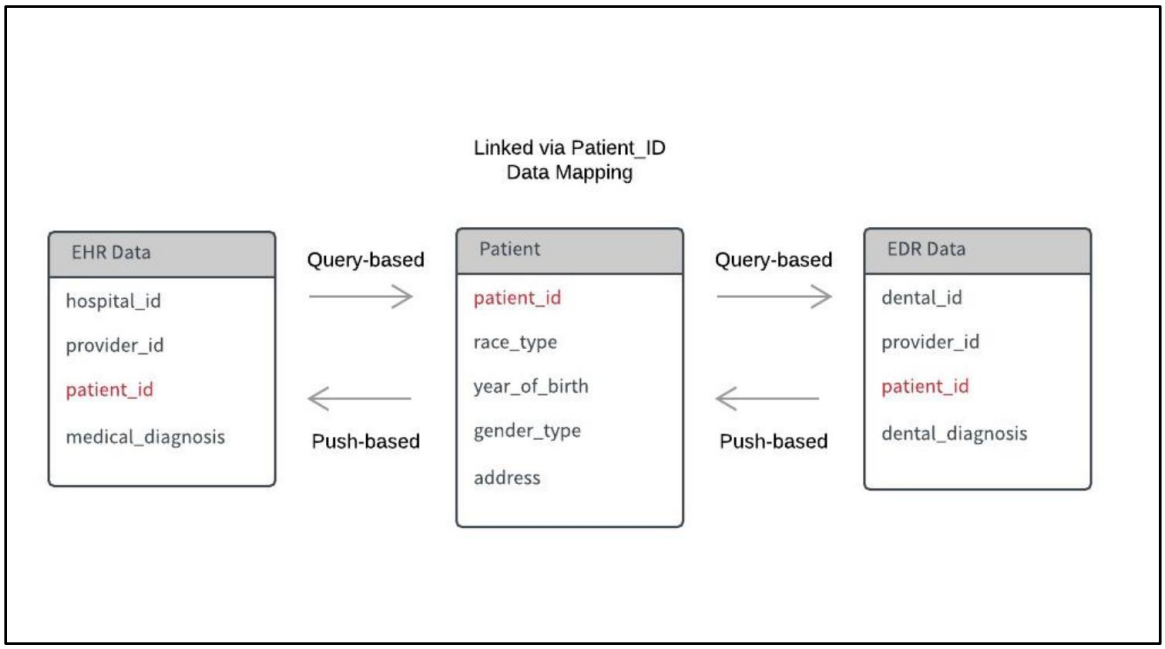
Other Findings

Based upon information gathered from the subject matter expert (SME) from the EHR company, linking EHRs to EDRs electronically is technologically feasible, data is connected through data mapping and linked via a patient identifier. Interoperability can be supported through a query-based, and push-based approach. Data standards such as Health Level 7® (HL7®), Clinical Data Architecture® (CDA®), and Systemized Nomenclature of Medicine (SNOMED), Fast Healthcare Interoperability Resource® (FHIR®) and Digital Imaging and Communications in Medicine® (DICOM®) is also used for interoperability. Systemized Nomenclature of Dentistry (SNODENT) can be used, however, it requires importing into the system with additional licensing terms and fees

for support. Figure 4 below depicts a high-level overview of electronic health and dental record systems linkage.

Figure 4

Data Mapping Via Patient Identifier



Research also found that Grady Hospital's ED currently has a very effective dental referral system in place. Patients that present to the ED for non-traumatic dental problems are either referred to Grady's Oral Surgery Clinic for the treatment of dental infections and extractions, and the remaining patients are referred to dental clinics that perform dental treatment on a sliding scale. Many of the patients that present to the ED for dental problems lack health literacy and the financial resources to pay for treatment. Referring such patients to low-cost dental clinics appears to be a cost-effective solution for the patients and cost-saving solution for Grady's ED. Patients that return to Grady's ED are between three to five percent, therefore, it was concluded that Grady currently has

an effective solution in place, and linking their EHRs to private-practice EDRs would not be a cost-effective and practical solution for Grady, or private-practice dentists. Further policy measures would need to be put into practice before moving forward with systems integration.

Summary

Based on the research, there are patient benefits for linking EHRs to EDRs. Oral health disparities would be lowered, provider communication would improve, and better patient treatment decisions could potentially arise from linking the data sources. From a technology standpoint, linking the data sources is feasible and interoperability can be supported. Although linking the data would improve patient outcomes and provider communication, it appears to have its limitations due to indirect provider communication that may be required. From a feasibility standpoint, however, there continues to be many barriers that makes linking EHRs to EDRs in this study not currently practical, and further measures on a policy standpoint needs to be implemented prior to linking these data sources.

Chapter IV: Key Findings and Discussion

Introduction

This chapter reviews and summarizes key factors of this study and discusses how this study contributes to the body of knowledge of public health informatics regarding the feasibility of linking electronic health records (EHR) to electronic dental records (EDR) in the private sector. Research has shown that oral health and systemic health are related (Igari et al., 2014; Lamster et al., 2008). There is a lack of timely electronic exchange of data between medical and dental providers in emergency department (ED) settings that creates sub-optimal patient outcomes, and has created a growing public health expense burden (Davis et al., 2010; H. H. Lee et al., 2012; C. Lewis et al., 2003; Tomar et al., 2016). The feasibility of sharing data between providers needs to be explored. The knowledge gap of limited research of the feasibility of linking EHRs to EDRs in the private sector needs addressing through this thesis project for determining the practicality in today's world. The following five research questions were explored.

1. Is it feasible to link Grady Hospital's Emergency Department electronic health records to the electronic dental records of Atlanta private-practice dentists?
2. Is there a practical and cost-effective solution for linking Grady Hospital Emergency Department's electronic health records to electronic dental records at Atlanta private-practice dentists?
3. What technologies, incentives, or assistance are needed for Atlanta medical and dental providers to link their electronic health records and electronic dental records together?

4. Can better patient care decisions result from linking electronic health records to electronic dental records?
5. Can oral health disparities be lowered by linking electronic health records to electronic dental records?

Summary of Project

This study involved assessing the feasibility of linking of EHRs to EDRs in the private sector. A systematic literature review was conducted to gain an understanding of the history of EHRs and EDRs in the U.S. with policies put into place, current fully integrated electronic systems in health care and dental care, interoperability measures and barriers, the links between systemic health and oral health, data standards and interoperability, medical and dental integration programs, and patient barriers to adequate dental care. Subject matter experts (SME) were interviewed from areas of emergency health care, private-practice dental care and electronic health and dental technology to gain their expert opinions on the feasibility of linking EHRs in Grady's ED to EDRs in private-practice dentists, in metro Atlanta, Georgia. Requirements were gathered for data linking, potential benefits, risks, and costs, perceived value of systems linkage, and other measures needed for moving forward. Limited research exists on the feasibility of linking EHRs to EDRs in private-practice dentistry and research discusses the need for linking the two data sources together. Research also discusses the link between oral health and systemic health (Igari et al., 2014; Lamster et al., 2008), and linking the data between medical and dental providers would benefit many areas of health care (Din & Powell, 2008).

It was concluded that interoperability can be achieved and supported through data mapping and linking a patient identifier between electronic health and dental records. Data standards such as Health Level 7® (HL7®), Clinical Document Architecture® (CDA®), Fast Healthcare Interoperability Resource® (FHIR®), Digital Imaging and Communications in Medicine® (DICOM®), Systemized Nomenclature of Medicine (SNOMED) and Systemized Nomenclature of Dentistry (SNODENT), along with a query-based and push-based approach for linking the data. Oral health disparities would be improved through overall reduced costs of medical and dental care, provider communication would be improved, and potentially increased access to dental care through locating available dentists. Dentists would continue to require direct communication with medical providers when questions regarding a patient's medical condition came about that was not available in the patient's electronic chart. Although it is technologically feasible to link the data sources, it is not currently feasible on a financial and policy standpoint. There continues to be limited funding and available resources from the areas of health care, dental care, and patient populations, that integrating the data would not be cost effective or practical. Further policies put into place for expanding dental coverage, allowing dental providers to bill medical insurance for patients referred by physicians, and other reimbursement measures extending beyond Meaningful Use (MU) would be required for health care and dental care to be willing to adopt the systems integration. Lastly, it was also concluded until patients acquire increased health literacy, they will continue to seek care in ED settings instead of initially seeking care at dental offices.

Implications

Public health has identified the need for increasing access to oral health care and others have identified the need for integrating medical and dental data into one interoperable system. Oral health and systemic health are related, many diseases that begin inside mouth contribute to other health conditions. Linking health records to dental records electronically would improve oral health disparities by increasing access to care, locating dentists in areas where limited access to oral health care is present, and would reduce the costs of dental and medical care overall. Linking EHRs to EDRs could help to reduce patient wait-time in ED settings by providing emergency physicians information on a patient's oral health status, the last time they saw a dental provider, and enabling the physician quicker information for patient care assessment. Treatment outcomes for patients and improved communication barriers between medical and dental providers could potentially occur with systems integration, and dentistry could potentially be one step closer to being integrating into the systemic health care system. Linking EHRs to EDRs could also enable public health practice to expand dental insurance coverage and increase dental insurance benefits to those already served. Furthering the study of systemic health conditions and oral health conditions could also occur with systems integration, and public health practice measures could be put into place for viewing oral health as a necessary component to general health. Systems integration could also increase health literacy and education among patient populations for seeking care in a dental office instead of an ED in the first place.

Limitations

Due to private company proprietary information, it was not possible to gather all the requirements being sought, including costs of integration and data mapping, and examples of past integration projects with the EHR software company. Interviews with SMEs were conducted with EDR software organizations, but was not possible to verify with the EDR software companies if their software has been mapped with the EHR company. No EDR employee could verify those findings. The technical employee of the EHR company stated their company can interoperate with other organizations including other EDR companies, however, could not provide documentation due to private proprietary information not available to the public. No information could be obtained to determine if dentistry has the capability to integrate with FHIR® and SMART® on FHIR®, however, does not appear to affect the project outcome. Lastly, this project was a feasibility evaluation study for metro Atlanta, Georgia only and is not intended to be used for generalizable knowledge in private-practice dentistry or ED settings.

Recommendations and Next Steps

Although the analysis concludes integration is feasible from a technology standpoint, further investigation and public health policies would be required to further along this integration. Grady Hospital's ED currently has a very effective referral program in place that patients are either referred to their oral surgery clinic in which dental infections and extractions are performed for patients presenting to the ED for non-traumatic dental problems, and the remaining patients are referred to dental clinics that charge fees on a sliding scale. Grady reports only between three to five percent of

patients return to the ED for the same dental problem, therefore, linking the records electronically would not be cost-effective. Grady expressed interest in a program that would prevent patients from seeking care in the ED to begin with, however, that was beyond the scope of this thesis project. Other organizations and ED settings across the U.S. that do not currently have a dental referral program in place could potentially benefit from linking EHRs to EDRs. Any health care or dental care organization may utilize this methodology if it serves to benefit population health, or lower oral health disparities and close the medical-dental communication gap. This project is not meant to be representative of all ED settings and private-practice dentists, and serves only as a beginning in this needed integration. Many actors and stakeholders would need to be involved to thoroughly determine integrations long-term outcome.

It is not recommended that Grady's ED, or private-practice dentists in metro Atlanta, Georgia move forward with integration. It is currently not cost-effective or practical. Until further policies and mandates are put into place, it is unlikely linking EHRs to EDRs will become widespread adoption.

Conclusion

Although Meaningful Use (MU) has made significant improvements towards the adoption of EHRs and EDRs, it appears to only be an initial stepping-stone in the widespread adoption. Further financial incentives and other government mandates may be necessary for systems integration to occur. Although the Affordable Care Act (ACA) has also made significant progress in increasing access to health and dental care, there continues to be patient populations that are lacking adequate access to needed dental care.

Patients are continuing to seek dental care in an ED setting for non-traumatic dental problems instead of seeking care initially in a dental office. Expanding coverage of dental insurance and enabling dental providers to bill medical insurance plans for dental procedures referred by medical providers appears to be a needed solution for integration and increased access to care. Although the analysis shows integration is feasible from a technology standpoint, it does not appear to be feasible from a financial and policy standpoint. Further research would need to be done to fully capture the costs, benefits, risks, and return on investment (ROI) for stakeholders to be willing to adopt this systems integration. Further policy measures are also needed for linking EHRs to EDRs. It appears that all areas of health care and dental care will fully interoperate in the future, however, it is not known when that will occur.

Chapter V: PUBMED Summary

Introduction

Oral health is essential to population health. Research has shown that oral health and systemic health are related (Alsumait et al., 2015; Griffin et al., 2012; Patrick et al., 2006; Sanders et al., 2009). Patients of lower socioeconomic status have increased oral health and systemic health problems (Griffin et al., 2012; J. Y. Lee & Divaris, 2014; Malecki et al., 2015) and lack insurance and financial resources to pay for care. Many of these patients are seeking dental care in emergency department settings, creating a significant public health and expense burden (Davis et al., 2010; H. H. Lee et al., 2012; C. Lewis et al., 2003; Tomar et al., 2016). Grady Memorial Hospital's Emergency Department situation in Atlanta, Georgia is not unique. Their emergency department is facing overcrowding and increased expenses (Atallah & Lee, 2014). Adding to this burden, their emergency department sees 70 to 105 non-traumatic dental emergencies per week (Reznick, 2012). There is a lack of timely electronic exchange of data between medical and dental providers in emergency department settings that creates sub-optimal patient outcomes (Leonard A. Cohen, 2013; Pajewski & Okunseri, 2014; Trikhacheva et al., 2015). Electronic health records and electronic dental records data exists separately in the private sector and needs to harmonize for improved patient outcomes, and lowered health care costs (Din & Powell, 2008).

Purpose

The purpose of this research was to determine the feasibility of linking electronic health records in a hospital emergency department to electronic dental records at private

practice dentists. The knowledge gap of limited research of the feasibility of linking electronic health records to electronic dental records in the private sector was addressed through this thesis project for determining the practicality in today's world. Areas explored were determining if oral health disparities would be reduced, provider communication would improve, patient decisions and outcomes would improve, what incentives and technologies are required for the organizations to adopt systems integration, and if reduced health and dental care costs would occur. It was also explored if systems integration would achieve interoperability, and how that would be supported.

Methods

A systematic literature was conducted to gain information on barriers, policies, data standards and interoperability with electronic health records and electronic dental records, medical and dental care in emergency departments, and the electronic health care system in the United States. Research questions were formulated for the purposes of this project. Questionnaires were developed and interviews were conducted based on areas of expertise with subject matter experts representing areas of emergency health care, private-practice dentistry, and technology vendors with electronic health and dental record software organizations. This thesis project gathered requirements for linking the two systems, and questions were asked such as perceived value of systems integration, potential costs, benefits, and potential risks based upon interviews with subject matter experts. Answers to interview questions from subject matter experts were synthesized for conclusions drawn for the research questions.

Conclusions

Oral health disparities would be lowered, overall reduced costs for medical and dental care would occur, and increased access to dental care with improved communication and treatment outcomes would also occur. Providers would continue to require direct communication not available to be accessed in a patient's electronic record. From a technology standpoint, systems integration is feasible through linkage via a patient identifier, and interoperability is supported through a query-based and pushed-based approach. It is not, however, feasible from financial and policy considerations such as lack of funding and financial resources available. Other barriers and complexities involve dental insurance company policies placing constraints on receiving dental care and reimbursements. Further mandates and incentives extending beyond Meaningful Use that include increasing dental insurance benefits allowing dental providers to bill medical insurance for patients referred by medical providers, and tax breaks. Hospital emergency department referral programs referring dental emergency patients to low-cost dental clinics appears to be a cost-effective and practical solution currently for the emergency department, private-practice dentists, and the dental emergency patients instead of systems integration. Approximately only three to five percent of emergency dental patients are returning to the emergency department for the same dental problem. Lastly, until patients achieve increased health literacy, they will continue to seek dental care initially in emergency departments settings instead of seeking care at a dentist.

Recommendations

Due to the policy and financial barriers, it is not recommended to move forward with systems integration right now. It is not currently cost-effective and practical. Further research with numerous actors and participators would need to be done to fully capture the costs, benefits, and outcomes for systems integration, along with mandates and policies set forth prior to integration.

For More Information

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Appendix A

Subject Matter Expert Questions

Emergency department physician questions
This thesis project is a feasibility study to determine the viability of linking electronic health records in Grady Hospital's Emergency Department, to electronic dental records to local Atlanta dentists. I understand that many patients seek care in emergency departments for non-traumatic dental problems for conditions such as infections and pain, are prescribed antibiotics and opiates, but often return to the emergency department for the same dental problem. I am exploring if linking health records to dental records would reduce the burden on emergency department physicians, reduce overall costs to the emergency department, and improve overall patient outcomes. Your name and information will be kept strictly confidential. Do you give your verbal consent to proceed with the interview? Please answer these questions to the best of your ability.
1. What electronic health record software system does your hospital currently use? Is there another electronic health record software currently in use? If yes, which one? 2. If you had an electronic system that linked electronic health records to electronic dental records to Atlanta dentists to perform treatment, and have timely communication back and forth, would it be useful to you? How?

3. How would a system like this benefit you and your hospital?
4. Would you use this type of system? Why or why not?
5. Describe the current workflow of the emergency department regarding non-traumatic dental emergencies.
6. What improvements would you like to see to this current workflow?
7. What is the most pressing problem for the physicians and staff in the emergency department regarding dental emergencies?
8. How many non-traumatic dental emergency patients do you see per week?
9. Can you provide a percentage?
10. How many of these patients are repeat patients?
11. Do these patients slow down the workflow of the emergency department that needs attending to true emergencies? Why?
12. How much learning or training time would you be willing to commit to learning the new system?
13. Do you think linking electronic health records to electronic dental records would improve treatment outcomes?
14. Do you as a physician think this system would help reduce emergency department wait time and improve treatment overall?
15. What type of treatment information would need to be transmitted between physicians and dentists?
16. Do you think this type of system would make your work environment easier, or more difficult? Why or why not?

17. If this system was made available, how could this better inform treatment decisions?
18. Do you think direct, timely communication between physicians and dentists would be helpful? Why or why not?
19. If this system was made available, how could this better inform treatment decisions?
20. Do you think this type of technology would reduce communication problems between medical and dental providers?
21. Are there any risks or problems you see occurring?
22. Describe some of the types of data inside your electronic health record software.
23. Do you think this technology would lower oral health disparities?
24. What would need to take place for you to be willing to adopt this system?
25. You mentioned your emergency department refers patients to outside dental clinics. Why do you think patients are showing up to the emergency department instead of seeking care to a dental office first?
26. Do you think Grady would be willing to invest in this type of system financially?
27. What requirements do you think would be necessary for your emergency department to adopt this system?
28. What about open-sourced electronic health records?
29. Overall, what is your perceived value of linking electronic health records to electronic dental records?

30. What other barriers do you see that would prevent your hospital from adopting this integration system?
31. Is there anything else you would like to add to our interview, or ask me?

Atlanta dentists' questions
This thesis project is a feasibility study to determine the viability of linking electronic health records in Grady Hospital's Emergency Department, to electronic dental records to local Atlanta dentists. This is to explore if linking such records would be beneficial to all parties involved, and if when necessary, should proceed forward in the future. I understand that many patients seek care in emergency departments for non-traumatic dental problems for conditions such as infections and pain, are prescribed antibiotics and opiates, but often return to the emergency department for the same dental problem. I am exploring if linking health records to dental records would improve overall patient outcomes, and if dentists and Grady Hospital's Emergency Department would be willing to adopt and implement a system like this. Your name and information will be kept strictly confidential. Do you give your verbal consent to proceed with the interview? Please answer these questions to the best of your ability.
1. Describe your typical day in your practice such as how many patients you see and for what treatment and services.

2. Approximately what percentage of your patients are insurance?
3. What type of insurance?
4. Do you see any Medicaid or Medicare? Why not?
5. Do you see self-pay? How many?
6. Is your practice fully digitized?
7. What digital electronic dental record system does your practice use?
8. Are you Meaningful Use Certified?
9. How often do you see non-record emergency patients?
10. Do you treat emergency extractions and emergency root canals?
11. Please give me approximate cost for cash prices on extractions, root canals, and fillings per tooth.
12. Approximately how many patients return for antibiotics and opiates, but do not move forward with the extraction or root canal?
13. Would you be willing to adopt this system and be a participator with Grady Hospital's Emergency Department for linking electronic health records data to your electronic dental records data?
14. Do you think seeing patients referred from Grady would help increase your practice revenue or patient amount?
15. What would need to take place for you to adopt the system integration?
16. What are the out-pocket-costs you would be willing to spend on linking the systems?
17. If the answer is no: Would you be willing to adopt this system if there were any government or tax-break incentives?

18. How much of an incentive would be necessary for you?
19. If no, would you be willing to adopt this type of technology if it was open-sourced?
20. What types of concerns, issues, or risks do you foresee occurring?
21. What would the software need to do for you to be willing to use it?
22. How much learning/training would you be willing to commit to this new system?
23. What type of treatment information would you need to be transmitted back and forth between you and the physicians?
24. If this system was made available, how could this better inform treatment decisions?
25. Do you think this type of technology would reduce communication problems between physicians and dentists?
26. Do you think this system would lower oral health disparities?
27. Are there other health care fields you think would benefit linking to dentistry?
28. What is your perceived value of linking electronic health records data to electronic dental records data?
29. Describe some of the data types inside your electronic dental record software.
30. What would need to take place for you to be willing to adopt this system?
31. Is there anything else you would like to add or ask me?

Electronic health record technology employee questions
This thesis project is a feasibility study to determine the viability of linking electronic health records in an emergency room to electronic dental records. This is to explore if linking such records would be beneficial to all parties involved, and if when necessary, should proceed forward in the future. I have taken the time to review your product Dental Wisdom®, and I am interested in reviewing the feasibility of linking information to other electronic dental record software, and increasing the data transmission. Your name and information will be kept strictly confidential. Do you give your verbal consent to proceed with the interview? Please answer these questions to the best of your ability.
1. I am aware of your organization's electronic health record and electronic dental record software. Do these have the capability to talk to each other back and forth? 2. If no. What would be needed/required for that to happen? 3. If yes. Please provide a high-level overview of what information is transmitted and the requirements for it. 4. Do your software products have the capability to talk to other EDR software vendors such as Dentrix® or Eaglesoft®? 5. If yes. Please provide a high-level overview of how the information is transmitted and how it can talk to each other.

6. If no. What would be needed for that to happen?
7. I see Epic® is now engaging in FHIR®. Would Fast Healthcare Interoperability Resource® be an option for linking the systems?
8. What about SMART® on FHIR®?
9. Are there standard protocols that the electronic health record system supports for exchanging data with other systems?
10. What information does the electronic health record system need to send to the dental records system to obtain data?
11. Overall, what changes to hardware or software do you think would be needed to support electronic health to dental record system interfaces?
12. What type of data standards are currently being used in your system?
13. What about SNODENT?
14. What would be needed for data conversion and migration in a new system?
15. How is interoperability supported?
16. How many users can the systems support at one time?
17. What would be needed for pilot testing?
18. Are there any risks or problems you see occurring with linking both systems?
19. How much does it cost to implement this type of system linkage?
20. Can you tell me the total cost for an emergency department to implement this type of system?
21. Can you tell me the total cost for a private-practice dentist to implement this type of system?
22. Is the proposed technology practical?

23. Approximately how much time would it require to build this type of system?
24. How much labor would be required?
25. Do you know the costs and labor involved for FHIR® or SMART® on FHIR®?
26. Would there be additional training needed to build this system?
27. How would an organization be able to go about linking their electronic health data to electronic dental data if they currently had Epic®, and wanted to link to Dentrix® or Eaglesoft®?
28. What would be the process to move forward with it?
29. Is there anything else you would like to add or ask me?

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