

A PILOT QUALITY IMPROVEMENT PROJECT TO INTRODUCE  
UTILIZATION OF AN ELECTRONIC BONE HEALTH ORDER SET  
IN A POPULATION OF HOSPITALIZED PEDIATRIC PATIENTS  
IDENTIFIED AT RISK FOR FRACTURES

A Scholarly Project  
submitted to the Faculty of the  
Graduate School of Arts and Sciences  
of Georgetown University  
in partial fulfillment of the requirements for the  
degree of Doctor of Nursing Practice

By

Jean Nelson Farley, M.S.N.

Washington, DC  
November 18, 2016

A PILOT QUALITY IMPROVEMENT PROJECT TO INTRODUCE  
UTILIZATION OF AN ELECTRONIC BONE HEALTH ORDER SET  
IN A POPULATION OF HOSPITALIZED PEDIATRIC PATIENTS  
IDENTIFIED AT RISK FOR FRACTURES

Jean Nelson Farley, M.S.N.

Thesis Advisor: Julia Lange Kessler, D.N.P.

ABSTRACT

Heightened risk for secondary osteoporosis and subsequent vulnerability to low impact fractures is often observed in children with complex health needs (CCHNs). This susceptibility, and an increased incidence of low-impact fractures in a population at a pediatric practice site, prompted development of a practice change to support bone health and reduce fractures in these patients. The purpose of this pilot, quality improvement project (QIP) was to evaluate physician and nurse practitioner (MD/NP) utilization of a *clinical decision support rule*, i.e., an electronic bone health order set (e-BHOS), as a mechanism to promote bone health in a population of hospitalized CCHNs at risk for fracture. MD/NP attitudes and levels of satisfaction using an e-BHOS were also measured.

Synthesis of evidence revealed that best practices to support bone health in CCHNs plays a role in improving their quality of life and potential to prevent fractures. Such practices include baseline diagnostic testing, a regimen of nutritional support, musculo-skeletal stimulation and pharmaceutical therapies. No study or report was identified that investigated use of an e-BHOS as an intervention to promote consistent bone health prescribing practices by MDs/NPs caring for the target population. A pilot, quality improvement project was designed and implemented to determine if introduction of an evidence-based, e-BHOS embedded in the electronic health record at a practice site would influence MD/NP prescribing practices when admitting CCHNs at

risk for fracture. Descriptive statistical tests were used to describe MD/NP characteristics, effects of the e-BHOS on their bone health prescriptive practices and levels of satisfaction using this digital intervention. Post-intervention data analysis revealed a proportional increase in two of the six order set components, fracture risk precautions and bone health medication orders. The post-intervention increase noted in bone health medication orders was statistically significant.

A Likert survey was also administered to participant MDs/NPs at the conclusion of the post-intervention data collection period to evaluate their attitudes and levels of satisfaction with the e-BHOS. Factors assessed on the survey included the training provided on use of the order set, its ease and speed of use, degree of comprehensiveness and clinicians' desire to incorporate additional orders sets into the organization's EHR. The maximum score allocated to the agreement scale for each survey question was five. Analysis of MDs/NPs responses revealed a mean of 4.4, which was derived from aggregated scores on all five survey components.

Project planning, implementation and data analysis revealed a variety of facilitators and barriers posed by EHR platforms used for healthcare documentation and to improve patient care. Early and consistent participation of *end-users* in development and revision of EHRs plays a crucial role in reducing digital barriers to improved patient safety and outcomes.

## **ACKNOWLEDGEMENTS**

The research and writing of this thesis would not have been possible without the support of my husband, John. He kept our hearts and home together. I also could not have undertaken this journey without the help of my peer-cohort, NHS faculty and staff---a group of exceptional women and men whose advice and wise counsel literally kept me afloat and on course for the past two and a half years.

## TABLE OF CONTENTS

Chapter I. Description and Statement of the Problem.....	1
Chapter II. Synthesis of Evidence .....	18
Chapter III. Methods .....	42
Chapter IV. Evaluation and Results .....	52
Chapter V. Discussion and Conclusions .....	58
References. ....	68
Appendix A. Strategic Plan to Utilize MEBPC and Kotter’s Change Steps For a Bone Health Promotion Project .....	80
Appendix B. MD/NP Survey Tool .....	85
Appendix C. Bone Health Order Set .....	87

## LIST OF FIGURES

Figure 1. Comparison of Pre & Post-intervention Proportions of Bone Health Orders.....	53
Figure 2. Mean Scores on Items Included in Post-intervention Survey of MD/NP Attitudes and Levels of Satisfaction with e-BHOS Components.....	56

## LIST OF TABLES

Table 1. Application of MEBPC Process to Develop & Implement Electronic Bone Health Order Set.....	12
Table 2. Evidence Categories and Search Terms .....	19
Table 3. Rating System for the Hierarchy of Evidence.....	20
Table 4. Project Stakeholders and Roles .....	44
Table 5a. Data Analysis Plan for Pre & Post Intervention Bone Health Order Comparison .....	49
Table 5b. Data Analysis Plan for Participants' Survey Responses .....	49
Table 6. Demographic Characteristics of Participants.....	55

## Chapter I

### Description and Statement of the Problem

Children with complex health problems and disabilities represent a growing category of pediatric patients with extensive and challenging health care needs, leaving them vulnerable to functional impairments and medical fragility (Cohen, Kuo, Agrawal, Berry, Bhagat, Simon & Srivastava, 2011). This array of needs necessitates use of a broad spectrum of health resources, including complex medical technologies and the knowledge, skills and collaboration of multiple healthcare disciplines (Cohen et al., 2011). National studies reveal that “approximately 0.4—0.7 percent of all U.S. children (roughly 320,000—560,000 children), have medical complexity at the highest level” (Berry, Hall, Neff, Goodman, Cohen, Agrawal...& Feudtner, 2014, p. 2199). This group of children is also estimated to account for 15 to 33 percent of health care spending in the pediatric population, or about \$50 to \$110 billion annually (Berry et al., 2014). The growing prevalence and complexity of this population’s health needs clearly speaks to the demand to expand site-specific care that fosters their opportunity to grow and thrive. A potential obstacle to quality of life in this medically fragile population is their heightened risk for secondary osteoporosis and consequent chance to sustain low-impact fractures (Bianchi, 2013). Mergler, Evenhuis, DeMan, Bindeis, Huijbers & Penning (2009) addressed the scope of this vulnerability by conducting a systematic review of studies of the epidemiology of fractures and low bone mineral density (BMD) in children with severe motor disabilities. This review estimated that the incidence of fractures in this population approached four percent per year, and the prevalence of low, femoral BMD was 77 percent. The studies evaluated in this review took place at a wide variety of pediatric care facilities. However, this data clearly identified a need for clinicians who care for CCHNs to consistently address the promotion of bone health and fracture reduction, as

the impact of such an injury on a child can pose a significant threat to their physiologic and psycho-social well-being. The impact of such injuries became quite evident when a cluster of fractures occurred at the project leader's practice site, which primarily serves the CCHN population. Direct observation of the hazards posed to the health and well-being of this group of children, provided the impetus to develop and implement a practice change to promote bone health, with a long term goal of reducing their incidence of fractures.

### **Background and Significance of the Problem**

The practice site utilized to address a mechanism to promote bone health in the population of interest is a small, sub-acute pediatric transitional and rehabilitative care hospital ("the Center"). Lengths of stay (LOS) range from days to years, with an average LOS of 30 days. Approximately 70 percent of the average daily census consists of patients with complex health needs that compromise their quality of life and limit their life span. The most common diagnoses encountered in these patients include cerebral palsy, epilepsy, degenerative neurologic disorders, neurologic devastation, complications of prematurity, genetic disease, failure to thrive, central nervous system trauma, burns and remission-refractory cancers. Most of these patients have a multiple number of the health problems outlined above. As noted earlier, patients with these chronic, primary diagnoses are at risk for secondary osteoporosis, which then increases their bone fragility (Huh & Gordon, 2013). Such bone fragility may be associated with their basic disease process, or the medications and treatment modalities employed to treat the symptoms and complications associated with them. Diagnosis-related factors most frequently associated with this bone fragility include alterations in bone metabolism, malabsorption syndromes, Vitamin D deficiency, muscle disuse, lack of weight bearing and hormonal disturbances. Also, the presence of multiple, chronic diagnoses frequently necessitates use of

poly-pharmacy, including immune-suppressants, steroids, anticonvulsants and chemotherapeutic agents, many of which may contribute to development of secondary osteoporosis (Huh & Gordon, 2013; Bianchi, 2013; National Osteoporosis Foundation, 2014; Eghbali, 2014; Fong, Mallick, Burren & Patel, 2011; Saraf & Hogler, 2015).

Although it is not clear what all of the causative factors are, limited weight bearing and activity levels, especially diminished or absent ability to ambulate, are also associated with diminished bone mineral density (BMD), and seem to particularly place CCHNs at increased risk for low impact or fragility fractures (Plotkin & Sueiro, 2007; Szadek & Scharer, 2014). A retrospective review of the Center's records for a recent three month period further revealed that of 144 admissions, 88 (61 %) of those patients were at risk for fracture, as determined by an evidence-based screening tool currently embedded into the admission medical assessment. The latest review of occurrence screens by the Risk Manager at the practice site revealed that ten, low impact fractures have occurred over the past three and a half years (S. Rizzo, September 26, 2015, personal communication). These fractures were characterized as "low impact" or "fragility" fractures, i.e., they could not be explained by some identifiable, traumatic event or accident, such as a fall (Mughal, 2014; Boyce & Gaffni, 2011). Data regarding this recent cluster of low impact fractures at the Center also revealed that all of these patients had experienced prolonged or even life-long immobility due to the nature of their primary, complex, chronic health problems. Unfortunately, accurate fracture incidence data of the Center prior to the recent fracture cluster were not available for comparison.

Benchmarking against national fracture incidence data in children is also not possible, as Huh and Gordon (2013) note that "no data have been reported on the overall incidence of fractures in *hospitalized* children, but small, disease-specific, retrospective cohort studies found

a 12 to 23 percent prevalence rate of fractures in children with cerebral palsy” (p. 317). It is likewise difficult to directly compare this cohort data to the Center’s fracture data, because of the inability to match the variables between the studied patient populations, such as length of hospitalization, age, severity of diagnoses and treatment modalities received.

### **The Stakeholders**

Regardless of the cause or how the Center’s rate compares to its previous data or that of similar organizations, sustaining a fracture results in significant pain and suffering for the child with multiple health problems. There is also a wide ranging impact on a broader circle of stakeholders, especially when a definitive cause of the fracture cannot be identified. These primary stakeholders are discussed below.

**The child.** Sustaining a major long bone fracture, usually involving the distal end of the femur, causes pain and suffering for the child, and typically results in transfer to a tertiary facility for initial care. Once there, the child undergoes urgent orthopedic evaluation and treatment, including X-rays and closed or surgical bone realignment, followed by placement in a “spica” cast that encases the trunk, hips and legs for approximately six weeks. This process entails several days to weeks of post-operative hospitalization, pain management and therapeutic rehabilitation before being able to return to their usual therapeutic, educational and social activities. Body casting also increases risk of skin breakdown and hospital-acquired infection. Once transferred back to the Center for further recovery, multiple trips by ambulance to a tertiary hospital are required for post-operative, orthopedic follow up, X-rays and cast modifications. The complexity and time needed to recover and heal from a serious fracture in a CCHN also undermines their existing fragile health state and ability to derive enjoyment from the people and environment that support their well-being and quality of life.

**The parents and family.** Being informed that their child has sustained a fracture with no obvious cause is distressing for families, difficult for them to understand and reduces trust in the team to whom they have delegated their child's care. They are understandably sad, angry and worried that their child is in pain, needs to be hospitalized and may need major surgery. They also may be apprehensive or suspicious that their child has received sub-standard care, been neglected or physically abused. These understandable parental fears are a stronger possibility if the risks of fracture associated with their child's health problems have not been previously explained by a health care team.

**The clinical staff.** The occurrence of an unexplained fracture may trigger fear, guilt, sadness and remorse for staff members who care for the injured child. They may question whether they could have provided some additional or different care that would have prevented the injury. Per Center policy, once any fracture occurs, an occurrence report must be completed by assigned staff in an electronic, incident report database. Extra rehabilitative resources must now be allocated to the child to ensure healing and post-recovery care, including additional nursing care hours, unique handling precautions, physical therapy and use of special, adaptive equipment.

**The organization.** When any patient sustains a fracture, regardless of its cause, a cascade of investigations is activated to determine the circumstances under which the injury occurred and how it could be prevented. After a low impact fracture, the Center's Risk Manager initiates a Failure Mode and Effects Analysis (FMEA) and root cause analysis (RCA) to determine how the fracture occurred and what corrective action may need to be taken to prevent future incidences. Depending on the contributory factors identified, a plan is devised and implemented to remediate staff through training, make policy and procedural revisions and/or modify equipment related to safe patient handling and mobility. A disclosure meeting is then held with the family and key

members of the Center’s clinical and administrative staff, to share the results of the investigation of the child’s injury and plan of correction. The family may or may not choose to initiate a suit against the organization because of the pain and injury experienced by their child.

It is clear that when a CCHN sustains a fracture, a resource-intensive process is initiated that involves many stakeholders. Supporting these individuals requires the investment of significant time and money to defray the costs of human and supportive resources needed to care for the child and family, conduct a thorough investigation, implement follow up procedures and remediate staff. Most importantly, it further reduces the quality of life of a child who is already experiencing many other health problems, and a fracture may even permanently increase their level of disability. The background of the problem demonstrates a need for initiating an evidence-based practice change to enhance the bone health of such children. The aims of this change include reduction of future harm and suffering, maintenance of quality of life and strengthening the bond of trust between caregivers and families. A secondary aim for this quality improvement project (QIP) is to potentially add healthcare *value* through reduced expenditure for healthcare costs and decreasing risk to the organization. Finally, a decision was made to capitalize on the electronic order set functionality within the Center’s existing EHR to implement this practice change.

### **Organizational Needs Assessment**

The Center is a small, sub-acute pediatric hospital located in a metropolitan area that provides physical and medical rehabilitative care to children from birth to 22 years of age. It is one of five entities under a health care system “umbrella” which also encompasses a philanthropic foundation, case management service for children with special needs, a pediatric home care agency and an out-patient rehabilitation therapy department. The stated mission of the

organization is to “provide quality rehabilitative and transitional care for infants, children, adolescents and young adults with special health care needs in a supportive, culturally competent, respectful environment, and to participate in related local, regional, and national projects with government, private and philanthropic organizations” (The HSC Healthcare System, 2016, para 2). The hospital is currently licensed for 117 beds and patients are admitted via transfer from tertiary hospitals in a large metropolitan area, and sporadically from home, when a child comes for short term respite care. Assessment and treatment focuses on interdisciplinary care, including physical medicine and rehabilitation, pediatrics, nursing, physical, occupational, speech and respiratory therapies, psychology, chaplaincy services, nutrition, psychology, case management, child life and social work. There are seven primary healthcare providers, consisting of a mix of pediatric hospitalists and pediatric nurse practitioners. After admission, the primary focus of care is to formulate goals that stabilize their chronic health status and educate family and/or community caregivers about the child’s special health care needs, to promote safe transition to home or other community settings. Before discharge, both a primary and secondary care provider must become proficient in providing a variety of skilled support to their child, such as tracheostomy and ventilator care, management of enteral feedings, wound care and medication administration. A consultative pediatric palliative care team is also available to support the unit-based, interdisciplinary teams to provide relief of patients’ distressing symptoms that affect their quality of life and that of their family. The Center is licensed as an acute care specialty hospital by the local Department of Health, accredited by The Joint Commission (TJC), and maintains membership in The Commission on Accreditation of Rehabilitation Facilities (CARF) and the Children’s Hospital Association (CHA).

Capitalizing on the organizational culture of the Center was an important factor to

consider to successfully launch and sustain a practice change to support bone health. Schein's (2010) Levels of Culture identify aspects of the organization that could promote or create barriers to implementation of a practice change such as the one described. Basic assumptions and values at the Center include its informal motto, "it's for the kids," and the capacity of the organization's small size to promote respect and sense of community, where names and roles of each employee are well known throughout the hospital. Such cultural assumptions and values also encourage teamwork and team building throughout both clinical and auxiliary sectors of the organization. Initial responses to the proposed practice change with key stakeholders were very positive and supportive. Although Schein (2010) acknowledges the overarching macro-cultures of countries, ethnic groups and occupations that exist globally, he also maintains that within an organizational culture, such as a healthcare delivery system, the various disciplines can also be considered a subculture within that larger system. Such subcultures clearly exist at the Center, as there are numerous clinical disciplines required to meet the needs of the hospitalized child who has complex medical needs. Implementation of a practice change process will involve several of these clinical subcultures, such as physical therapy, nutrition, pediatrics, orthopedics and pharmacy.

Additionally, some health care organizations have even smaller, discrete subcultural groups considered microsystems (Schein, 2010). Such designations apply to the non-clinical entities that must be included at the project development table, including risk management, quality assurance and informatics. Non-clinical subcultures included in this project's development involved information technology (IT), risk management and quality assurance departments. Bridging the competing needs and values of the various organizational subcultures and microsystems to launch and ultimately sustain this project has been challenging. Each step of the QIP revealed

competing needs of patient care, stakeholder preferences, digital constraints and inadequacies that jeopardized the feasibility of delivering the final product. Moving forward demanded continued resilience, resourcefulness, patience and willingness to accept organizational impediments that simply could not be altered. The most anticipated organizational barriers to implementation encountered by the project leader were those posed by the Center's electronic health record's (EHR) technological capabilities. Initial discussions with the IT Director, who is not a clinician, revealed that the EHR platform had the capability to automatically trigger a complete order set for review. As the time drew near to launch the order set, the staff member instead reported that the EHR did *not* have the capability to provide this function, and that only a clinical "pop up" alert could be issued to the clinician. It is not clear whether the project leader failed to clearly communicate the functionality needed, or made erroneous assumptions about the Clinical IT's understanding of the utility being sought. This incident clarified that a "clinical" information technologist *manages* systems used to collect *clinical* health data. It does not denote that the individual necessarily has clinical background and knowledge. Thus, once this knowledge gap of the Clinical IT was identified, further interactions included detailed verbal and written explanations for each step. A steep learning curve was also encountered when trying to understand the exact capabilities of organization's EHR. Much of this was due to the project leader's lack of experience and competency with digital terminology and jargon when posing questions about its capabilities. The most illuminating moment was the realization that an EHR is truly an *input* system, and it is technologically quite difficult to build easily accessible, internal *output* capability to end-users, the cost of which must be assumed by the organization. When such challenging barriers were encountered, reexamining and reflecting upon the organization's cultural mores' and values proved helpful. More often than not, such consideration revealed a

viable, alternative solution to overcome the obstacle and move forward.

### **Research Question**

The description and background of the clinical practice problem also generated a need to identify a delivery method of best bone health practices that would reliably prompt admitting MDs/NPs at the Center to address this issue in patients identified at risk for fracture. Because the Center already used a commercial EHR platform, utilization of its digital capabilities seemed to be the most logical choice as that delivery system. Recent literature increasingly describes use of Clinical Provider Order Entry (CPOE) systems to create *electronic order sets*, which are “collections of clinically related orders grouped by purpose” (Wright, Feblowitz, Pang, Carpenter, Krall & Sittig, 2012, p. 733). Order sets serve to support CPOE systems that are more efficient, improve care quality and increase adherence to evidence-based guidelines (Wright et al., 2012). When the Center’s clinical IT director confirmed that its EHR had the capability for incorporating an order set, this mechanism was selected as the most logical method to standardize and systematize best care practices indicated for pediatric patients at risk for fracture. Finalizing this choice for intervention delivery generated the following PICO components:

Patient Population = Hospitalized pediatric patients at risk for fractures

Intervention = Use of an electronic bone health order set

Compared to = No use of an electronic bone health order set

Outcome = Increased implementation of comprehensive, evidence-based bone health orders?”

The PICO components above were then utilized to derive the following study question: “Does introduction of an electronic bone health order set in a population of hospitalized pediatric patients at risk for fracture, result in increased implementation of evidence based interventions aimed at maintaining or improving their bone health?”

In addition to the primary purpose of improving bone health in the target population, this QIP question generated several secondary aims:

- 1) To examine the attitudes and levels of satisfaction of an organization's MDs and NPs towards use of an electronic bone health order set (e-BHOS);
- 2) To contribute to the organization's responsibility to meet to federally mandated *meaningful use requirements* through incorporation of an e-BHOS) into the Center's EHR platform;
- 3) To determine if consistent, long term use of an e-BHOS is associated with a reduction in incidence of low-impact fractures in hospitalized, medically complex pediatric patients;
- 4) To reduce the bio-psycho-social and financial burden for all potential stakeholders, if consistent implementation of bone health orders ultimately leads to a lower incidence of fractures in the target population;
- 5) To explore utilization of digital technology as a practical and effective mechanism for systematically addressing *other* chronic health problems in the CCHN population at the Center.

### **Evidence-Based Practice Model**

The Model for Evidence-Based Practice Change (MEBPC) was selected as the framework guiding the QIP. Initially described by Rosswurm and Larrabee (1999), the model incorporates six steps for implementing a practice modification. This model was further refined by Larrabee (2009), and combines “principles of quality improvement, teamwork devices and evidence-based translation strategies to promote adoption of a new practice” (Melnyk & Fineout, 2011, p. 287). Larrabee's (2009) six stages for implementing an evidence-based practice change include: “(1) assessing the need for change in practice, (2) locating the best evidence, (3) critically analyzing the evidence, (4) designing the practice change, (5) implementing and evaluating the change and



**Table 1. (cont.)**

<b>Step Two: Locate Best Evidence</b>	<b>Action</b>
Identify types/resources of evidence Plan the search Conduct the search	~Identify key search terms ~Literature reviewed and synthesized to identify best practices to promote pediatric bone health and prevention of fractures. ~Literature reviewed for best practices regarding use of electronic order sets ~Interviewed and participated in clinical observations of expert clinicians at Bone Health Clinic at hospital
<b>Step Three: Critically Analyze the Evidence</b>	<b>Action</b>
Critically appraise the evidence Synthesize the best evidence Assess feasibility, benefits, risk of new practice  (continued)	~Compiled Table of Evidence from evidence synthesis and assessed levels of evidence ~Used evidence synthesis to determine best pediatric bone health practices to include as key elements for e-BHOS ~Collaborated with Clinical IT Director and Director of Practice & Education to determine facilitators and constraints of integrating bone health order set into EHR at practice site ~Utilized Pharmacy Director and Registered Dietician to determine availability of bone health medications and supplements in organization’s formulary

**Table 1. (cont.)**

<b>Step Four: Design Practice Change</b>	<b>Action</b>
<p>Define proposed change</p> <p>Identify resources</p> <p>Design pilot project</p> <p>Design implementation plan</p> <p>(continued)</p>	<p>~Derived research question from PICO components</p> <p>~Developed electronic bone health order set using ROL best practices, expert opinion and technical guidance</p> <p>~Developed, submitted and received approval for research proposal plan from IRB to ensure protection of study participants</p> <p>~Obtained approval from Research Committee at practice site to move forward with project plan</p> <p>~Identified core group of key stakeholders needed for implementation, including</p> <ul style="list-style-type: none"> <li>• Medical Director</li> <li>• Pediatric Bone Health content experts</li> <li>• Clinical IT Director</li> <li>• Registered Dietician</li> <li>• Direct of Rehabilitation Therapy</li> <li>• MD and NP staff</li> <li>• Pharmacist</li> </ul> <p>~Pilot required for project due to small, total numbers of MDs/NPs within organization who prescribe bone health orders on admission</p> <ul style="list-style-type: none"> <li>• Implementation plan:</li> </ul> <p>~Collected three months of baseline number of MD/NP bone health admission orders for patients screened at fracture risk prior to initiation of bone health order set</p> <p>~Met with prospective MD/NP participants: shared retrospective data re: fracture incidence, prescribing practices and why data stimulated project</p> <p>~Developed presentation re: project aims and how to use bone health order set for potential MD/NP QIP participants</p> <p>~Obtained informed consent from MDs/NPs who wish to participate</p> <ul style="list-style-type: none"> <li>• Collaborated with Clinical IT to embed electronic order set and clinical alert</li> </ul> <p>Allowed 3 month study period of use of e-BHOS</p>

**Table 1. (cont.)**

<p><b>Step Five: Implement and Evaluate Practice Change</b></p>	<p><b>Actions</b></p>
<p>Evaluate processes, outcomes and costs</p>	<p>~Collected post-implementation bone health order data of MDs/NPs frequency of entering bone health orders for three month study period.            ~At end of post implementation data collection period, administered demographic and satisfaction surveys to participating MDs/NPs.            ~Used appropriate statistical tests to analyze effect of electronic bone health order set on MD/NP bone health ordering practices            ~Used appropriate statistical tests to analyze level of satisfaction of MDs/NPs use of e-BHOS            ~Sought expert consultation from Chief Operating Officer (COO) and determined that QIP would not require additional budget expenditures.</p>
<p>Develop conclusions and recommendations (continued)</p>	<p>~Conclusions and recommendations derived from data analysis.</p>

**Table 1. (cont.)**

<p><b>Step Six: Integrate and Maintain Change in Practice</b></p>	<p><b>Action</b></p>
<p>Communicate recommended change to stakeholders</p> <p>Integrate into standards of practice</p> <p>Monitor process and outcomes</p> <p>Disseminate change</p>	<p>~Project implementation, outcomes, conclusions and recommendations for future practice to be disseminated to organizational stakeholders in January, 2017</p> <p>~Use project data to inform consensus regarding incorporation of practice change into organizational policies and guidelines which govern order prescribing by MDs/ NPs at practice site</p> <p>~Address feasibility and appropriateness of continuing use of electronic bone health order set in particular, and future use of order sets in general, to promote consistent use of best practices for other specific, clinical conditions prevalent in organization’s patient population</p> <p>~Plan for incorporating periodic data collection and analysis re: bone health ordering practices into organization’s annual QI data collection plan</p> <p>~Collect data on fracture incidence in 2—3 years post-project implementation and yearly thereafter to determine if there a decrease in incidence of low-impact fractures when patients <b>consistently</b> have best bone health practices reviewed, considered and ordered, when appropriate</p> <p>~Write and submit article for publication to peer-reviewed nursing or quality assurance publication re: project development, outcomes, conclusions &amp; recommendations</p> <p>~Publicize project description/data results:</p> <ul style="list-style-type: none"> <li>• At the Center’s quarterly Medical Executive Committee meeting</li> <li>• At the Center’s Board of Directors</li> <li>• In quarterly clinical team newsletter</li> <li>• Graph and post data results on inpatient clinical units, medical staff office and Quality Council bulletin board</li> </ul> <p>~Poster presentation accepted by Washington Regional Nursing Research Collaboration annual doctoral research conference</p>

Although the MEBPC serves as a robust tool for assisting a project leader to systematically develop, implement and disseminate a new practice intervention, it does not contain detailed strategies for anticipating and overcoming actual and potential barriers to the change components of such a process. Therefore, Kotter's (1995) *Eight Steps for Transforming an Organization* were selected to help launch, secure and sustain momentum for the change throughout the preparation and implementation of the pilot project. Appendix A summarizes how both the MEBPC steps and Kotter's steps were utilized in tandem to strategically implement the QIP. The items in **bold font** on the table reflect commonalities between the MEBPC and Kotter's Change Steps.

## **Chapter II**

### **Synthesis of Evidence**

It was challenging to accumulate a critical mass of evidence to support the PICO question for this project. An initial, broad search was instituted using the terms “secondary osteoporosis in children” and “childhood fractures.” Recognizing that the project would focus on secondary osteoporosis, fracture prevention and incidence in the population of interest, evidence was initially retrieved to ascertain the background of these two topics, including common etiologies and current, comprehensive standards of care. As the literature review progressed, five categories of interventions emerged in addition to the electronic, clinical decision support rule (CDSR) methodology for making a practice change. Once the main treatment categories emerged, search terms were identified to collect evidence needed for each category. Databases searched included CINAHL, PubMed Medline, Ovid Medline, Johanna Briggs Institute Database of Systematic Reviews and Implementation and Cochrane Database of Systematic Reviews. Categories and related search terms that emerged as appropriate evidence for inclusion in the synthesis of evidence are outlined in Table 2 below.

**Table 2. Evidence Categories and Search Terms.**

<b>Evidence Categories</b>	<b>Search terms</b>
Background Information	~Medically complex children; children with special needs ~Pediatric fracture risk ~Pediatric osteoporosis
Diagnostic & laboratory assessment of bone health in pediatric patients	~DEXA scan-pediatrics ~Laboratory diagnosis-pediatric osteoporosis
Nutritional interventions in pediatric osteoporosis	~Nutritional treatment-pediatric osteoporosis
Physical therapy interventions in pediatric osteoporosis and safe handling	~Exercise/physical activity-pediatric osteoporosis
Pharmacologic interventions in pediatric osteoporosis	~Bisphosphonates-pediatric osteoporosis
Clinical decision support rules use in EHRs	~Electronic order sets-effect on outcomes ~Clinical decision support rules

When appropriate, the Rating System for the Hierarchy of Evidence for Intervention and Treatment Questions developed by Melnyck and Fineout (2015) was used to indicate the level of evidence in the body of the review. This evidence classification system is outlined in Table 3 below.

**Table 3. Rating System for the Hierarchy of Evidence.**

<b>Level of Evidence</b>	<b>Criteria</b>
Level I	~Evidence from a systematic review or meta-analysis of all relevant randomized controlled studies (RCT)
Level II	~Evidence obtained from well-designed RCTs
Level III	~Evidence obtained from well-designed and controlled trials without randomization
Level IV	~Evidence from well-designed case-control and cohort studies
Level V	~Evidence from reviews of descriptive and qualitative studies
Level VI	~Evidence from a single descriptive or qualitative studies
Level VII	~Evidence from the opinion of authorities and/or reports of expert groups

**Evidence Category One: Background of the Clinical Problem**

The introduction of evidence-based health care practice (EBP) over the past two decades has been a significant step forward to bridging the gap between the multiple needs of CCHNs and the multiple therapies needed to meet them. Forssberg (2008) notes that the impetus toward EBP has spurred an increase in testing new treatments through randomized control trials (RCT) before being introduced into clinical practice, while “old, not well-documented treatments are evaluated and discontinued, if they do not fill the scientific criteria for implementation” (p. 803). Thus, this pilot project was an attempt to find, organize and summarize scientific evidence into a cohesive, comprehensive, interdisciplinary care plan to maintain or improve bone health in medically complex, hospitalized children at fracture risk because of the nature of their disability or chronic health problems. In the early stages of project development, integrating this care plan into the EHR would have pioneered a process for future development and use of evidence-based, electronic order sets at the practice site. However, since that initial project planning period,

electronic order sets for other diagnoses (e.g., asthma, chronic lung disease, childhood immunizations) were developed and implemented due to an imminent deadline for meeting the Center for Medicare and Medicaid Services' (CMS, 2016a) meaningful use requirements within the practice site's EHR. An added advantage of the intervention is that the bone health care plan will accompany patients when they transition back to community-based primary and specialty pediatric care after discharge, as part of the CMS (2016b) medication reconciliation requirement.

As noted in the project aims and purposes, medically complex pediatric patients require a broad and intensive range of care resources to meet their needs. As healthcare knowledge and technology advance, the life span of this population is increasing, and this expanding survival rate is paradoxically accompanied by a variety of long-term complications, including secondary osteoporosis (Saraff & Hogler, 2015). This type of osteoporosis is due to either the effects of the disease process external to the skeleton, or the interventions that are used to treat the primary disability or disorder. Expert consensus recommends that diagnosis of osteoporosis in children should be based on densitometric measures and a clinically significant fracture history of a long bone of the lower extremity, a vertebral compression fracture (not due to trauma) or two or more long bone fractures of the upper extremities (Houlihan & Stevenson, 2009; International Society of Clinical Densitometry, 2014). The International Society of Clinical Densitometry (2014) assigns a grade of Fair/Good to the evidence used to develop this definition of childhood osteoporosis. All of the items included in the Center's screening tool represent recognize etiologies that are frequently, but informally identified as fracture risk factors related to secondary osteoporosis that are unique to the CCHN population. A scan of medical records at the Center revealed that the etiology of fracture risk identified in screening is virtually always related to a diagnosis of secondary osteoporosis. A systematic review conducted by Mergler,

Evenhuis, DeMan, Bindeis, Huijbers & Penning (2009), identified the epidemiology of fractures and low bone mineral density (BMD) in children with severe cerebral palsy (CP), with emphasis on risk factors. CP is a diagnosis frequently found in the practice site's patient population. This review was well-constructed and included a total of 32 studies that addressed either fracture prevalence or determinants and etiologies of low BMD. This review found the methodological quality of most of the reviewed studies to be poor, while five were considered well-constructed and conducted, and had low risk of bias. Some of the reasons cited for poor study design and methodology included lack of power analyses or failure to report confidence intervals. Half of the studies reviewed did not use appropriate statistical tests to compare variables [Level I].

There were no studies or reviews identified related to the topics of low BMD, fractures and best practices for managing secondary osteoporosis in a broad range of childhood disorders and disabilities. Those identified were typically diagnosis-specific, and focused primarily on children with CP. This is most likely a reflection that larger groups of children with a diagnosis of CP are more available as convenience samples in schools, orthopedic and neurology clinics and pediatric rehabilitation facilities. This makes generalizing evidence to other types of pediatric diseases and disorders problematic, but it seems reasonable to apply it to other types of childhood musculo-skeletal and neuromuscular disorders. However, it makes it difficult to identify general, evidence-based bone health interventions for an order set that are applicable to hospitalized children with a broad range of diagnoses contributing to their secondary osteoporosis.

In summary, there is limited evidence related to best practices for prevention or moderation of secondary osteoporosis in the broad category of children with complex health needs. Currently, the majority of studies and clinical reports are narrowly applied to a specific type of

disability, e.g., cerebral palsy, muscular dystrophies or genetic disorders of bone. Thus, it necessitates utilizing evidence-based interventions supported for specific diagnostic entities to those which are similar in nature.

### **Evidence Category Two: Nutritional Interventions**

Poor nutritional status is known to contribute to the low BMD often noted in CCHNs, especially those who are non-ambulatory (Apkon & Kecskemethy, 2008). Children with neuromuscular disabilities frequently experience reflux and food intolerances, or must receive artificial enteral or parenteral nutrition because of dysphagia (Houlihan, 2014; Apkon & Kecskemethy, 2008). Such complications increase impediments to maintaining their exogenous intake of the primary nutrients associated with healthy bone metabolism, especially Vitamin D, calcium, phosphorus and magnesium (Houlihan, 2014). Exogenous sources of nutrients include certain foodstuffs, food fortification and Vitamin D<sub>3</sub>, calcium and phosphorus supplementation (Golden & Abrams, 2014). Hough, Boyd and Keating (2010) conducted a systematic review of nutritional interventions for low BMD in children with neuromuscular disabilities. This review concluded that Vitamin D is “essential for maintaining calcium and phosphorus levels in the blood, optimizing peak bone mass and preventing bone loss” (p. e676). [Level I].

The primary endogenous method by which all vertebrates obtain Vitamin D is conversion through the skin, when exposure to UVB radiation from natural sunlight triggers its synthesis in the liver (Wagner & Greer, 2008). Increasing cases of rickets in children are also being reported, as sun exposure continues to decrease, and is felt to be related to more consistent and vigilant use of sunscreens and restricted opportunities for children to play outdoors due to family lifestyle changes (Wagner & Greer, 2008). Such opportunities for natural sun

exposure are further limited for children with medical complexity, due to the sheer enormity of the logistics and special equipment that are often required to take a sick child outside for routine, daily activities and recreation.

When considering bone health promotion in CCHN, it is also important to recognize that approximately 15—20% of this population also has epilepsy (Zelleke, Cabacar & Gaillard, 2013). Another source of interference with metabolism of Vitamin D and calcium are certain classes of anti-epileptic drugs (AED), especially phenobarbital, carbamazepine, phenytoin and valproate (Fong et al., 2011). These researchers surveyed the caseloads of 95 community-based neurologists who followed children with epilepsy in the United Kingdom. The investigators determined that only three percent of these neurologists recommended supplementation with Vitamin D and calcium for their patients receiving these AEDs [Level V]. Apkon and Kecskemethy (2008) further note in their review of the literature, that these “decreased nutritional indices are independently associated with decreased BMD, poor linear growth, delayed skeletal maturation and fractures” in this population (p.117). [Level V].

A systematic review conducted by Mergler and colleagues (2009) recommends “optimization of calcium intake and determination of Vitamin D status” in children with severe CP (p.777) [Level V]. Because most of the studies and reviews available have been conducted on a specific diagnostic sub-group, it is difficult to discern at this time how to generalize the body of evidence regarding Vitamin D supplementation to a population that displays a broad range of disorders and body systems involvement.

Calcium is essential to bone development, and dietary intake of this mineral throughout childhood and adolescence will ultimately affect the total bone mass acquired for the life

span (Golden & Abrams, 2014). “Approximately 99 percent of total body calcium is contained in the skeleton and its absorption there is mediated by Vitamin D” (Golden and Abrams, 2014, p. e1230). Studies by Johnston, Miller, Slemenda, Reister, Hui...& Peacock (1992) [Level III] and Lloyd, Andon, Rollings, Martel, Landis...& Kulin, (1993) [Level III] identified a positive effect of calcium intake on bone accretion in healthy children.

Current evidence supports the practice of conducting a thorough nutritional assessment on *all* admitted patients regardless of their fracture risk status. The evidence described above supports inclusion of an option to request consultation for nutritional assessment by a Registered Dietician (RD) in the e-BHOS. Such consultation would help determine if dietary modifications to promote bone health was indicated in those patients admitted who were determined to be at fracture risk. However, per institutional policy, every admitted patient, regardless of their fracture risk status, receives a full nutritional assessment by an RD. This assessment routinely includes review of hematologic laboratory data, blood chemistries, Vitamin D level, dietary nutrient intake analysis and treatment regimens that may adversely affect bone health. The RD would then recommend any needed therapies not already ordered to the MD or NP. Therefore, an option for referral for nutritional assessment will not be included in the e-BHOS. Because Vitamin D, calcium, phosphorus and magnesium supplements are part of the Center’s drug formulary and dispensed by the Pharmacy Department, orders for these “nutriceuticals” must be designated in the Medication category of the e-BHOS in order to conform to EHR platform, Pharmacy and regulatory requirements.

### **Evidence Category Three: Diagnostic Evaluation of Pediatric Secondary Osteoporosis**

There is a significant amount of evidence in the literature that addresses best methodologies for diagnosing low BMD in children and linking it to fracture susceptibility. A systematic review of ten case-control studies and meta-analysis of eight studies that was conducted by Clark, Tobias and Ness (2006), analyzed comparable data exploring the association of BMD, as measured by dual energy x-ray absorptiometry (DEXA) scans to fractures in children. The authors determined that “strong evidence for an association between bone density and fractures in children is limited” (p. e291) [Level IV]. However, evidence from their meta-analysis of a sub-group of reviewed articles suggests that “there is an association between low bone density and fractures in children” (p. e291) [Level IV]. These authors include a caveat that case control studies are prone to bias, although they noted no evidence of heterogeneity or publication bias. It should also be noted that the studies reviewed were conducted on healthy children, and cannot be fully generalized to those with chronic diseases or disabling conditions. Clark et al., (2006) also noted a weak, inverse relationship between Z-scores and fractures in children [Level IV]. The Z-score was developed to calculate BMD in children from a DEXA scan, when compared to a set of reference data from children who are the same age, gender and pubertal stage (National Osteoporosis Foundation, 2014). Normal ranges for Z-scores in children are derived from findings on DEXA scans per standards endorsed by the International Society for Clinical Densitometry (ISCD, 2014) and are based on a multi-center, seven year prospective study done by Zemel and his colleagues (2011). Because CCHNs often have anthropometric measures and body mass indexes that fall below the normal growth curve range, calculating a Z-score derived from this study more accurately indicates a child’s true bone density. Unlike the adult population, there is no specific Z-score below which fractures are more likely to occur in

children, but there is growing evidence supporting this link (Golden & Abrams, 2014). A review by Estrada and colleagues (2014) of normative databases and consensus statements by expert panels concludes that at this time, use of DEXA scanning is “considered best practice for determining two dimensional, areal BMD in the pediatric population” (p. 341) [Level VII]. The ISCD (2014) concurs with this conclusion in its 2013 Pediatric Position Statement, and assigns a grade of “good” to the available evidence that supports this position.

Although the DEXA is the current gold standard for measuring BMD in children, it requires them to lie quietly in different positions during the exam, which lasts approximately 20 minutes. This may be difficult for many children, especially those with complex health problems and postural abnormalities, and may require administration of sedation to ensure that accurate measures are obtained. For this reason, the DEXA scan will not be specifically included in the order set at the Center, and the decision to obtain one would be the purview of the pediatric bone health specialist at the tertiary children’s hospital when such a referral is sought.

A variety of other, more complex mechanisms are used to measure bone density in children, but these vary in their ease of use, amount of radiation produced and cost. Because of these limitations, such diagnostic measures as quantitative ultrasound or tomography are reserved for research purposes, where a more exacting measure of BMD is required (Estrada et al., 2014). Another category of diagnostic and laboratory indicators generally accepted to assess bone health, include serum alkaline phosphatase, calcium, phosphorus, Vitamin D and magnesium (Golden & Abrams, 2014). Measurement of serum Vitamin D (25-OH-D) incorporates “endogenous synthesis by the liver and exogenous intake of this vitamin, and is considered the ideal modality for determining an individual’s Vitamin D status” (Golden & Abrams, 2014, p. e1232). However, there are no current recommendations from the U.S. Preventive

Services Task Force (USPSTF) regarding Vitamin D screening in the general childhood population. The USPSTF (2014) does acknowledge that clinical decisions involve more considerations than evidence alone, and while appreciating the lack of high quality evidence, health practitioners should still personalize decision making about Vitamin D screening to the specific patient or situation [Level VII]. Practice guidelines issued by the Endocrine Society recommend that children at risk should be routinely screened, including those with obesity, black and Hispanic children, as well as children with conditions make them vulnerable to fractures (Holick, Binkley, Gordon, Hanley, Heaney... & Weaver, 2011) [Level VII]. The Nutrition Committee of the American Academy of Pediatrics does not make specific recommendations regarding Vitamin D screening, but also suggests “such screening be undertaken in children and adolescents with conditions associated with reduced bone mass and/or recurrent low-impact fractures” (Golden & Abrams, 2014, p. e1234) [Level VII]. Thus, there is currently no firm consensus regarding routine Vitamin D screening in the general population of children. However, a well-designed cohort study conducted by Bowden and colleagues (2008) identified Vitamin D deficiency in 80 percent of children (N = 85) already diagnosed with osteoporosis [Level IV]. Although considered the lowest form of clinical evidence, current expert opinion cited above supports clinical judgment about Vitamin D screening, and this should include consideration of a child’s overall health state and treatments that are known to contribute to secondary osteoporosis.

Another factor that should be considered when making decisions about obtaining diagnostic bone health testing in the CCHN population concerns opportunities for exposure to sunlight. Interestingly, well designed research regarding this issue in the CCHN population was not specifically discovered during evidence search and synthesis. The factors that primarily

contribute to this lack of exposure include prolonged and/or frequent hospitalizations and difficulty in safely and efficiently transporting a child outside who uses complex medical equipment. When Vitamin D screening is ordered, current guidelines proposed by the Committee on Nutrition of the American Academy of Pediatrics recommends attainment of a serum 25-OH-D concentration of 30 ng/mL in childhood populations at increased risk for fracture, “given the potential benefits and unlikely risk of toxicity of doses required to reach this concentration” (Golden & Abrams, 2014, p. e1238) [Level VII].

Other, well-supported laboratory determinations of bone metabolism which can provide a more complete picture of bone health in at-risk patients include serum calcium, phosphorus and magnesium (Delmas, Eastell, Garnero, Seibel & Stepan, 2000; Houlihan, & Stevenson, 2009; Saraff & Hogler, 2015). Unfortunately, there is not a single blood chemistry panel offered through the Center’s clinical laboratory that incorporates all of these bone health tests, and each of these chemistries had to be listed separately on the bone health order set. Therefore, when any blood panels ordered which included serum calcium, magnesium or phosphorus determinations, those values were included in the data collection frequencies. Any higher complexity markers of bone turnover metabolism that reflect levels of osteoclastic and osteoblastic activity, such as parathyroid hormone, growth hormone, insulin growth factors, osteocalcin, procollagen and hydroxyproline, are generally reserved for research and were not included in the order set or data collection (Delmas et al., 2000; Houlihan, & Stevenson, 2009; Saraff & Hogler, 2015).

Evidence of Vitamin D deficiency in the CCHN population, expert opinions and known, limited exposure to sunlight in the Center’s patients, provides a reasonable rationale for including the vitamin D, calcium, phosphorus and magnesium screening as an option in the e-BHOS, that allows for clinical judgment.

#### **Evidence Category Four: Physical Therapy and Safe Handling Interventions**

Limited weight bearing and activity levels are associated with diminished bone mineral density, placing such patients at increased risk for spontaneous fractures or fractures due to low impact forces (Plotkin & Sueiro, 2007; Szadek & Scharer 2014; Bainbridge & Gleason, 2013). Therefore, another category of intervention considered as an option in the e-BHOS relates to physical therapy and safe handling of CCHNs at risk for fractures.

The positive effect of planned, purposeful activity, exercise and weight bearing on optimizing bone formation in the normal child has been well studied (Hind & Burrows, 2007; Farr, Laddu & Going, 2014; Burrows, 2007). The studies on effects of exercise and activity and weight bearing on bone formation in children with decreased mobility have been more difficult to design and implement. However, there is more evidence to support that planned activity and exercise for the child with fracture risk holds benefits, due to its “potential for stimulating anti-gravity muscle strength and endurance, preventing hip dislocation, decreasing spasticity and improving feeding, elimination, respiratory and circulation function” (Pin, 2007, p. 62). A pilot, randomized controlled trial (RCT) by Pin (2007) provides some preliminary evidence that low-level, mechanical stimuli represent a noninvasive, non-pharmacological treatment of low BMD in children with disabling conditions [Level II]. However, significant evidence of the impact that these interventions can have on bone health of CCHNs, especially those who experience long term or life-long immobility, is still not fully known or understood (Caulton, Ward, Alsop, Dunn, Adams & Mughal, 2004). Because of their prolonged immobility, the skeletons of these children do not experience the normal level of mechanical forces and loading known to increase bone formation (Caulton et al., 2004). Thus, studies have been undertaken to determine what *types*

of exercise or activity might improve both mechanical loading and weight bearing in non-ambulatory children. A well-designed randomized control trial (RCT) by Caulton and colleagues (2004) compared a treatment and control group of non-ambulatory children. The treatment group received 50 percent more time in a standing frame throughout a school year, while the control group received the usual time. Results revealed that the treatment group showed significant improvement in vertebral BMD as measured by quantitative computed tomography, but had no changes in long bones of their lower extremities [Level II]. Ward, Tricco, Phuong, Cranney, Barrowman... & Moher (2004) also conducted a well-designed RCT on a heterogeneous group of disabled children to determine the effect of a weight bearing activity on BMD. This time, the treatment group stood on vibrating standing platforms, while the control group stood on sham platforms that emitted the same tone as the treatment device. Comparison of pre- and post-testing BMD revealed a highly significant increase in the BMD of the lower extremities in the treatment group, but no increase in their vertebral skeletons [Level II]. Chad, Bailey, McKay, Zello and Snyder (1999) also directed a well-designed RCT with experimental and control groups of children with spasticity, who were matched demographically and clinically. The intervention emphasized weight bearing and putting extremities through normal range of motion by physical therapists, while the control group maintained their usual level of lifestyle activity. Post-intervention, the treatment group demonstrated significantly greater increase in BMD of their femoral neck and experienced significant, overall increase in BMD of total femoral mass. A limitation of the study was the low number (N) of participants, with nine in each group [Level II].

Pin (2007) conducted a systematic review of ten studies that examined the effectiveness of static (versus dynamic or vibratory) weight bearing exercises in children with cerebral palsy, as

measured by BMD, incidence of hip dysplasia, degree of passive range of motion, spasticity, elimination function, hand function, communication and/or feeding skills. The review included studies of any design that investigated static weight bearing and its effectiveness on a desired outcome. This researcher concluded that the evidence to support effectiveness of static weight bearing in the study population remains limited, with the exception of increased BMD and a temporary decrease in spasticity [Level II].

Outcomes from use of a bundled set of physical therapy interventions routinely used on 78 children with CP at outpatient centers in Germany and the United Kingdom were retrospectively reviewed by Stark, Nikopoulou, Stabrey, Semler and Shoenau (2010). The bundled therapies, referred to as the “On Your Feet” program, included whole body vibration, resistance training, body weight-supported treadmill training and physical therapy. This bundled intervention demonstrated a significant, positive effect on BMD, muscle mass, muscle strength and gross motor function after six months of consistent use in children with CP. A limitation to interpreting the results is the difficulty determining if outcomes would have occurred naturally as the participants aged and developed, especially those children under age ten [Level IV]. A meta-analysis led by Behringer, Gruetzner, McCourt and Mester (2014) evaluated studies on the effects of weight bearing activities on BMD in healthy children and adolescents. The investigators concluded that “weight-bearing activities, alongside high calcium intake, provide a practical, relevant method to significantly improve bone mineral content in pre-pubertal children, justifying the application of this form of exercise as an osteoporosis prophylaxis at this stage of maturity” (p. 467) [Level I]. However, because the participants included in the studies reviewed were all healthy, it is difficult to determine to what extent these findings can be generalized to the CCHN population.

The Director of Rehabilitation Services at the Center, a Doctor of Physical Therapy (DPT), was also interviewed regarding the role of weight bearing in osteoporosis and fracture prevention in children at risk for fracture. The Director has been active with a DPT research community that investigates the risks and benefits of static versus dynamic mechanical loading and weight bearing interventions to improve bone health in the non-ambulatory child. At this time, the consensus of this group's expert opinion is that such interventions have not shown harm and, until research data reveal evidence to the contrary, most likely serves to at least maintain BMD levels in this population (A. Ruecktenwald, personal communication, June 12, 2015) [Level VII].

The accumulated evidence regarding the effect of weight bearing and activity on improved bone health of CCNHs is promising. Currently, there is not sufficient volume to strongly recommend specific types or duration of physical therapy that will improve or maintain BMD levels, or prevent or limit fractures in this population. However, consideration also needs to be given that other benefits can be derived from this type of physical therapy intervention, including improved gastrointestinal, respiratory and circulatory function. Best evidence available supports inclusion of an e-BHOS option for the MD/NP to request a physical therapy evaluation to determine if patients at risk for fracture could derive physiologic and/or functional gains from such services.

Although using methods to ensure safe patient handling and movement (SPHM) are not associated with prevention of osteoporosis, they are known to protect both provider and patient from injury and potential fractures (Association of Rehabilitation Nurses, 2014). Most inpatient adult and pediatric units have engaged staff mobility experts, such as physical and occupational therapists, to develop policies or care plans to ensure use of SPHM. Such guidelines, as at the Center, are typically referred to as "Fracture Precautions." These precautions include:

- Posting fracture risk signage at bedside;
- Using a mechanical lift and an adequate number of assistants when patient weight limits are reached;
- Protecting extremities during transfers and dressing;
- Using adaptive equipment to overcome counter-forces;
- Employing special beds and positioning modifications to limit stress on joints;
- Substituting vibration vests for manual chest physical therapy (American Nurses Association, 2013).

Based on the above evidence, fracture precautions and referral to physical therapy to evaluate need for exercise and/or weight bearing will both be an option included in the e-BHOS. Although rehabilitative assessments are routinely performed on all admitted patients, the Director of Rehabilitation Services requested that specific referral be included in the e-BHOS, to emphasize with the evaluating therapist that osteoporosis is a concern and determine if special weight bearing activities would be indicated for a child at risk for fractures.

#### **Evidence Category Five: Pharmacologic Interventions**

Bisphosphonates are the primary class of drugs used to treat low BMD in childhood secondary osteoporosis, and act by inhibiting osteoclast-mediated bone resorption, increasing BMD and maintaining or improving structural and material constituents of bone (Houlihan & Stevenson, 2009; Papapoulos, 2011). Although use of bisphosphonates is well studied in the adult population, childhood studies are limited, due to the research precautions that are in place to protect this vulnerable group. One group of children for whom the benefits of bisphosphonates have been more thoroughly supported by research are those with primary

osteoporosis, most notably, osteogenesis imperfecta (OI), often referred to as “brittle bone disease” (Eghbali, 2014). Currently, bisphosphonates have only been approved by the Food and Drug Administration (FDA) for use in children with OI (Szalay, 2014). Thus, all non-research use of bisphosphonates in children for treatment of secondary osteoporosis is considered “off-label.” Pediatric clinical trials investigating the use bisphosphonates to maintain or improve BMD or prevent fractures in secondary osteoporosis have not yet provided strong evidence to support their use for this purpose. A Cochrane Systematic Review conducted by Ward and colleagues (2007), evaluated nine studies related to bisphosphonate use in children from birth to 18 years who had secondary osteoporosis associated with neuromuscular conditions or chronic illness. The review included six RCTs, two controlled clinical trials (CCT) and one prospective cohort study, for a total of 281 participants. The reviewers reported that a variety of bisphosphonate formulations were used and study quality varied. The reviewers concluded that data supports the need for additional studies of bisphosphonate efficacy in this category of children, and also strongly advocated for use of consistent criteria for defining BMD and bone health outcomes in such research [Level II]. Because of the regulatory limitations placed on use of bisphosphonates in children, a prescriptive option for this class of medication treatment was not included in the e-BHOS. Instead, referral to the Bone Health Clinic at the nearby tertiary pediatric hospital was included as a final option in the order set. If an MD/NP feels that such drug treatment might be warranted, the bone health specialist will have access to specialized diagnostic options to determine if an off-label trial of bisphosphonates is warranted. Other reasons for referral for which the tertiary Bone Health Clinic advises evaluation include:

- Two or more fractures in childhood;
- Genetic disorders affecting bone metabolism;

- Prolonged, non-weight bearing status;
- Nutritional depletion secondary to eating disorders, malabsorption, inflammatory bowel disease, dairy avoidance;
- Chronic use of stimulants, immune suppressants, chemotherapeutic agents, steroids or anti-convulsants (M. Monti, personal communication, March 1, 2016).

### **Evidence Category Six: Use of Clinical Decision Support Rules**

After evidence synthesis regarding best bone health practices was completed, an intervention methodology was needed to prompt consistent review and consideration of the e-BHOS in the Center's fracture risk population. Although one digital mechanism, the fracture risk screen, was already in place to identify patients with special needs, a gap was identified in the process for initiating comprehensive bone health orders using electronic functionality. The fracture screening tool simply triggered a clinical "pop up" alert for admitting clinicians to order fracture precautions. If they wished to review and consider recommendations for other types of bone health interventions, they had to exit the EHR and log into the Center's electronic policy and procedure manual to locate and examine the Fracture Risk Guidelines document. These guidelines consisted of an algorithm and narrative descriptions of the variety of bone health interventions related to special handling, diagnostic testing, supplementation, physical therapy and specialist consultation. Therefore, a choice was made to employ the Center's existing EHR capabilities through use of a comprehensive electronic bone health order set, which is considered a sub-type of a clinical decision support rule (CDSR). According to the CMS (2014), a CDSR is "a health information technology (HIT) function that builds upon the foundation of an EHR to provide persons involved in care processes with general and person-specific information, intelligently filtered and organized at appropriate times, to enhance health and health care" (para

3). CMS (2014) also states that a CDSR can encompass a broad range of mechanisms, including electronically triggered alerts and reminders, mandated clinical guidelines, patient-focused data sets, documentation templates, decision algorithms, laboratory reference values and *condition-specific order sets*. Other general advantages of a CDSR include its capacity to serve as a reimbursement aid, advance quality and safety and facilitate evidence-based patient care (deRuiter, et al., 2016). Incorporation of a CDSR also helped satisfy a federal regulatory mandate for electronic meaningful use requirements stipulated by the Health Information Technology for Economic and Clinical Health Act (HITECH) of 2009 (CMS, 2014a). The specific CDSR format selected to implement the targeted practice intervention was a standardized, electronic order set or “care bundle,” as this structure could easily configure and organize a group of comprehensive bone health options for the Center’s admitting MDs/NPs. Electronic order sets provide a “structured way of improving the processes of care...using small, straightforward sets of evidence-based practices that, when performed collectively and reliably, have been proven to improve patient outcomes” (Institute for Healthcare Improvement, 2016, para 1). Landa (2012) further describes an electronic order set as a “standardized grouping of interventions within an EHR based on research evidence that is aligned with a patient’s condition and provides clinical decision support to health care providers” (para 3). Kurtin and Stucky (2009) aptly refer to comprehensive development and implementation of an electronic order set as a method of “standardizing excellence” (p. 893).

The Institute for Safe Medication Practices (ISMP, 2010), an organization recognized in the field of patient safety, has published guidelines for developing standard order sets. These guidelines address formatting, content, organizational approval, maintenance and specific criteria for specialized drug and medication classes that have a known increased incidence of

administration errors. These ISMP recommendations were incorporated into the e-BHOS developed for this project to the extent possible within the electronic functionalities available in the Center's EHR.

Prior to development of the set, a full assessment of the capabilities and gaps within the Center's EHR platform was conducted through a personal EHR review and interviews with the Clinical IT Director and Director of Clinical Practice and Education. The literature was also reviewed to identify facilitators and barriers to use of order sets that should be considered during project development. Two RCTs found that electronic, trigger-based interventions were effective in decreasing time to ensure thorough diagnostic testing for cancer (Murphy, Laxmisan, Reis, Thomas, Esquivel...& Singh, 2014; Murphy, Wu, Thomas, Forjuoh, Meyer & Singh, 2015) [Level II]. Corley (2015) implemented a quality improvement project to introduce an electronic order set to help reduce and prevent catheter-associated urinary tract infections (CAUTI). The hospital's CAUTI infection rate was reduced from 4.26 percent to 0.81 percent over the span of one year [Level VI]. When a retrospective review of records revealed a 35 percent rate of postnatal growth restriction (PNGR) in a neonatal intensive care unit, a perinatal nursing group utilized an electronic enteral feeding set to help reduce the incidence of this complication (Graziano, Tauber, Cummings, Graffunder & Horgan, 2015). Use of this order set resulted in a significant decrease in the rate of PNGR in the unit over a three year period [Level VI]. A study by Munasinghe, Arsene, Abraham, Zidan and Siddique (2011) demonstrated that instituting a before-and-after time series of condition-specific order sets increased the utilization of such sets by clinicians [Level VI]. No literature references were discovered which specifically addressed the use of electronic bone health order sets in the pediatric population.

As EHRs become increasingly utilized for streamlining best practices and outcome data

collection, the phenomenon of “digital change fatigue” has emerged (Ead, 2015). This tends to be a more significant issue for EHR users referred to as *digital immigrants*, as “people who grew up without digital technology, and had to adopt it as it emerged, versus *digital natives*, “who grew up with digital technology and are much more adept and comfortable using it” (Prensky, 2001, p. 122). Older healthcare clinicians, who have not had formal education on basic informatics technologies or the time to become comfortable using it, are more susceptible to this digital change fatigue phenomenon. This could lead to counter-productive or even unsafe clinician behaviors when engaging in digital documentation (Goldschmidt, 2015). For example, Holberg (2016) reported that excessive use of clinical alerts and CDSRs may contribute to clinicians engaging in “note bloat,” and ignoring or overriding numerous clinical alerts, especially when a patient has several admitting diagnoses that trigger sets containing repetitive orders. The issues regarding electronic barriers and obstacles merit further scrutiny and solutions, as regulatory and reimbursement complexity continues to evolve in the health care delivery system.

Once best practices for inclusion in an order set are identified, careful formatting is also required to ensure compliance with standards and guidelines suggested by CMS (2014) and the Institute for Safe Medication Practice (ISMP, 2010). Through collaboration with Clinical IT, the project leader ensured that the digital intervention also met CMS’s (2014) five rights for CDSRs, including, “use of the right channel (EHR), right portal (order set), right people (admitting MDs/NPs), right information (best bone health practices), right format (approved template) and the right point in workflow (admission assessment)” (para 3). Mechanisms to meet these standards included synthesizing evidence for appropriate set elements, inserting an immediate electronic trigger for a positive fracture risk screen, gathering expert consensus and utilizing the

Center's digital template for order set design and construction. Quality and safety improvement for the organization were advanced through the project director's use of leadership skills, strategic planning, utilization of resources, interdisciplinary and stakeholder collaboration, troubleshooting obstacles, continual process evaluation, project dissemination and building sustainability (McGreevy, 2013).

When a decision is made to adopt any form of CDSR, it is important to remember that these mechanisms are not intended to replace clinical judgment, but are simply a tool "to assist care team members in making timely, informed, higher quality decisions" (CMS, 2015, para 2). Although the e-BHOS developed for this QIP contains several diagnostic and care categories, clinicians still have the ability to engage in their cognitive work and draw on their expertise to choose which orders are deemed appropriate for the patient, or simply choose not to use this mechanism.

The search for best practices for use of electronic order sets also revealed an unforeseen number of reports about barriers posed by the EHR to provider satisfaction and patient safety (Piscotty, Kalisch & Gracey-Thomas, 2015; Borycki, Sangster, Schreiber, Feddema, Griffith & Swamy, 2015; Anders, Turner, & Wallace, 2007; Duffy, 2015). This issue will be more fully addressed in Chapter Five, when implications for future research are discussed.

### **Summary of Evidence Synthesis**

There is a significant amount of valid evidence regarding best practices to prevent and minimize the effects of secondary osteoporosis and fractures in the CCHN population, especially with respect to nutritional support. More evidence is needed regarding the types, timing and intensity of musculo-skeletal therapies in preventing and treating secondary osteoporosis, especially those involving weight-bearing activities. There has not been a significant amount of

evidence accumulated to date regarding the long term safety and efficacy of bisphosphonates for pediatric secondary osteoporosis due to long term immobility (Eghbali, 2014). This is due primarily to the strict limitations and safeguards imposed on pediatric drug studies. As a drug class, bisphosphonates may hold promise for this population as more studies are conducted. Finally, as use of the EHR has evolved over the past decade, a range of facilitators and barriers to documentation, patient safety and outcomes has emerged. It remains to be seen to what extent increasing demands for electronic data to drive reimbursement and guide healthcare delivery will have on the *care of the caregiver* objective of the Quadruple Aims of Healthcare.

## **Chapter III**

### **Methods**

#### **Design**

The primary purposes of this pilot QIP are to determine the effect of an electronic bone health order set (intervention) on MD/NP bone health prescribing practices, and assess their level of satisfaction with its use. Polit and Beck (2012) note that the main objective of quantitative, descriptive study design is to “accurately portray individual’s characteristics or circumstances and/or the frequency with which certain phenomenon occur” (p. 725). Therefore, this design was used to generate data to determine the impact of a digital intervention on the prescribing behaviors of one group of MDs/NPs, and on their attitudes towards, and satisfaction with, use of the order set. Polit & Beck (2102) refer to the pilot study as a “small scale version, or trial run in preparation for a major study, and is sometimes referred to as a feasibility study” (p. 735). The project was necessarily a pilot inquiry, as there were only a small number of MDs/NPs available to participate. However, its primary value was its use as a possible model for initiating future electronic order sets for other common care needs of the Center’s patient population. The project plan necessitated the following data collection activities:

- Retrospective and prospective patient record reviews to quantify the number of bone health orders entered by participant MDs/NPs on patients at fracture risk, before and after implementation of the e-BHOS intervention;
- Administration of a survey instrument to participant MDs/NPs at the conclusion of the post-intervention data collection period. The survey consisted of two portions, one which gathered demographic data regarding the participants, and a Likert scale, which elicited their levels of satisfaction using the order set. Due to the small number of participants, demographic data questions had to be minimized to protect their anonymity, as collection

of this information could allow linkages to their attitudinal portion of the survey. Also, after collaboration with a nursing research consultant, correlational tests between the two survey components were not conducted, due to the very small participant sample size (K. Anderson, personal communication October 3, 2016).

### **Project Sponsors and Resources**

The QIP was strongly supported by the stakeholders at the Center, which has been the project leader's practice site as a pediatric nurse practitioner and nurse educator for the past 18 years. Key stakeholders and other resource personnel with whom the author met to present the project, secure support and collaboration during project implementation are summarized in Table 4 below:

**Table 4. Project Stakeholders and Roles.**

<b>Key Resources</b>	<b>Role</b>
Chief Operating Officer	~Reviewed and approved proposal; informed key departmental clinical staff; Reviewed IRB application and decision; authorized final approval to begin retrospective chart review and obtain data pre and post implementation of order set
Nurse Manager	~Reviewed and supported proposal
Quality Assurance Officer (QAO)	~Reviewed and supported proposal
Risk Manager	~Reviewed proposal; collaborated with QAO to provide data set re: organization's fracture incidence
Medical Director continued	~Reviewed and supported proposal; approved final e-BHOS; Reviewed IRB approvals; facilitated education/orientation of MD's/NP's to project's goals and participation requirements
Director of Rehabilitative Services	~Reviewed and supported project; reviewed and approved orders relating to therapy consultation to be included in e-BHOS
Registered Dietician	~Reviewed proposal components related to nutritional supplements; determined that nutritional consultation not required in order set as one is routinely conducted on every patient, regardless of fracture risk status
Director of Pharmacy Services	~Provided list of nutritional supplements available in pharmacy formulary that could be included in e-BHOS
Director of Clinical Information Technology	~Reviewed proposal; collaborated with project leader regarding technical support for coding and embedding clinical alert and e-BHOS set into HER; provided pre- and post-intervention data sets on number of admitted patients with fracture risk
Director of Clinical Practice & Education	~Provided guidance for developing order sets using format required by EHR vendor platform
Project Committee Members	~Periodically reviewed and critiqued project leader's progress; referred to resources as required
Specialists in Pediatric Bone Health: Orthopedist & DNP	~Served as content experts; Reviewed and critiqued project; Supervised clinical observation hours in Summer, 2016
Statistician	~Reviewed project design & collaborated on plan for statistical data analysis

### **Marketing Plan**

During the preliminary planning portion of the QIP, a brief power point presentation was

designed to acquaint key stakeholders with its background and purpose, the study question, proposed intervention, desired outcomes and budgetary considerations. The project leader received full support from all stakeholders during the development and implementation of the project. A formal presentation of findings, conclusions and recommendations is planned for key stakeholders at the completion of the project. Analysis of participants' levels of satisfaction with use of the e-BHOS has provided useful information about revisions needed for implementation of any future electronic order sets at the Center.

### **Business Plan**

No specific steps were taken to develop a complete cost analysis of project implementation phases. Time expended by each key stakeholder-consultant did not exceed a period of three hours over the entire, two year duration of the project. Thus, no additional staff salary or full time equivalent adjustments were needed in order to support development and implementation phases of the project. Preparatory work and programming of the order set into the EHR was front-loaded. Once the clinical alert and order set were embedded in the record, work effort of clinical IT staff was no longer impacted. However, it would be compelling to consider the potential for cost savings for human and fiscal resources if the bone health QIP resulted in decreased fracture incidence over time, but that was not feasible during the time frame of this project. Hospitalization alone for medical and /or surgical treatment of a long bone fracture has been estimated to average \$32,000--\$34,800 per incident (Nork & Hoffinger, 1998; Hedin, Borgquist & Larrson, 2004). This figure does not include other associated costs incurred after a fracture, such as post-operative follow up visits, ambulance transport, additional physical therapy and increased nursing care costs. If a family decided to pursue litigation with the organization because of their child's injury, costs could mount exorbitantly.

## **Human Subject Reviews**

Institutional Review Board (IRB) approval for this project was granted by Georgetown University on February 1, 2016. IRB approval from a nearby, tertiary pediatric hospital was also sought, as they serve as the IRB of record for the Center. Upon receipt of the Georgetown University IRB letter of approval, the tertiary hospital designated the University as IRB of record for the project at the Center.

## **Population of Participants**

Participants in the QIP will consist of full-time and part-time MDs and NPs who provide primary hospital care for children admitted to the Center. These staff members conduct comprehensive health assessments, including fracture risk screening, on all patients admitted to the Center. Off-hours MDs (“nocturnists”) who provide medical coverage of patients outside of usual business hours, were not asked to participate, as they do not routinely admit patients. A total of eight medical staff members were oriented to the QIP and all opted to participate through the informed consent process. Over the course of the pre and post-intervention study period, two part-time MD’s resigned from the Center and one full-time MD joined the Center. There were no changes in NP staff participants.

## **Procedures**

The order and steps of project implementation are as follows:

### **Project development procedures.**

- 1) Desired practice change identified at clinical practice site;
- 2) PICO components developed and study question formulated;
- 3) Project aims and components reviewed with Center’s key stakeholders;
- 4) Faculty mentor and committee member identified;

- 5) Synthesis and analysis of evidence conducted to identify key categories of best care practices for hospitalized, pediatric patients at risk for fracture, and included special handling precautions, diagnostic studies, rehabilitation therapies, nutritional and pharmaceutical support, expert consultation and use of electronic order sets

**Pre-intervention procedures.**

1. Project leader reviewed EHR for all patients admitted to the Center from July 1, 2015 to September 30, 2015, identified as a fracture risk, and documented the total number of special handling, diagnostic, nutritional, rehabilitative and consultative orders entered by the admitting MD/NP;
2. Pre-intervention data coded and tabulated in Microsoft Excel®;
3. e-BHOS finalized and submitted to Clinical IT for coding by vendor and embedding into EHR;
4. Project orientation developed and presented to eligible MD/NP participants; informed consent process followed for all MDs/NPs choosing to participate;
5. Post-implementation data collection period proceeded for three month period after “go-live” date of e-BHOS and encompassed June 15, 2016 through September 15, 2016.

**Post-intervention procedures.**

- 1) MD/NP demographic and satisfaction surveys distributed to MD/NP participants for completion;
- 2) EHRs reviewed for all patients admitted to the Center from June 15, 2016 to September 15, 2016 who screened positive for fracture risk, with tabulation of the total number of special precautions, diagnostic, nutritional, rehabilitative and consultative orders prescribed by the admitting MD/NP;

- 3) Post-intervention data coded and documented in Microsoft Xcel®;
- 4) Appropriate statistical tests used to analyze MD/NPs bone health ordering practices, demographic characteristics attitudes and levels of satisfaction with e-BHOS;
- 5) Project findings, conclusions and recommendations summarized, based on data analysis;
- 6) Plan developed for dissemination of project findings and recommendations to Center's stakeholders, professional colleagues and community of interest

### **Instrumentation**

No mechanism was needed to identify patients at risk for fracture, as a screening instrument already existed in the EHR at the time of QIP development. This screening instrument was embedded into the MD/NP admission health history form in early 2014. The instrument was developed by a pediatric hospitalist at the Center after a literature review on this topic, and was not validated before its integration into the EHR. No validated instrument or tool was identified in the literature for use as a fracture screen for the general pediatric population, or those with complex health problems.

### **Data Analysis Plan**

Selection of methods to evaluate and analyze data requires re-consideration of the type and purpose of study conducted (Polit & Beck, 2012). The purpose of the QIP was to evaluate whether a higher proportion of MDs/NPs would prescribe bone health interventions to patients at fracture risk after the implementation of the e-BHOS, as compared to those MDs/NPs who admitted this same type of population before the order set was initiated. Although patient demographic data was also gathered during pre and post-intervention record reviews, it was not ultimately analyzed and utilized for purposes of this QIP. It may be used at a future date to determine if there were any patient characteristics that correlated to MD/NP bone health

prescriptive practices. At the conclusion of the post-intervention data collection period, a survey of attitudes and levels of satisfaction with the e-BHOS was distributed to MD/NP participants.

Tables 5a and 5b below summarize the data analysis plans for bone health order comparison and participant survey results:

**Table 5a. Data Analysis Plan for Pre & Post Intervention Bone Health Order Comparison.**

Data Source	Data Points	Statistical Tests
Pre (N= 31) and post (N=34) e-BHOS intervention patient record reviews of MD/NP bone health orders on admission	~Fracture Precaution orders ~Bone health laboratory orders @ and after admission ~Nutritional supplement orders ~Physical therapy orders ~Bone Health Clinic Referral orders	~Measures of central tendency ~Tests for significance: <ul style="list-style-type: none"> <li>• McNemar test</li> <li>• Paired t-test</li> </ul>

**Table 5b. Data Analysis Plan for Participants' Survey Responses.**

Data Source	Data Points	Statistical Analysis Tests
Post-intervention survey of MD/NP participants	~Demographic data <ul style="list-style-type: none"> <li>• Gender</li> <li>• Age range</li> <li>• Employment status</li> <li>• Years of clinical experience</li> </ul> ~Level of satisfaction with e-BHOS: <ul style="list-style-type: none"> <li>• Training</li> <li>• Speed, ease of use,</li> <li>• Comprehensiveness</li> <li>• Readiness for additional order sets</li> </ul>	~Descriptive frequency data ~Measures of central tendency

Data points regarding pre and post-intervention bone health orders were then organized, coded and tabulated using the Microsoft Excel® application and exported to the Statistical Package for Social Statistics (SPSS). The SPSS application was used to determine proportional frequencies of measures of central tendency (for non-dichotomous data) and if statistical significance between pre and post-intervention data was reached. Participants' *survey responses* were hand-tallied and computed, as such a small number of surveys (N=5) was available for analysis. Although it was known that there would be a limited number of survey respondents, analysis of data from these sources allowed some degree of evaluation of participants' opinions regarding efficacy of the e-BHOS.

### **Analysis of Pre and Post-Intervention Bone Health Order Frequencies**

In review, specific data frequencies that were analyzed and compared to test the hypothesis included MDs/NPs prescription of fracture precautions, diagnostic bone health laboratory measures at and after admission, bone health nutritional supplement-medications, physical therapy evaluations and referrals to a pediatric bone health specialist. Descriptive statistics (frequency, means, proportions) were used to depict and summarize MD/NP bone health orders extracted from retrospective and prospective EHR reviews of patients at fracture risk. The McNemar's test, a type of Chi square analysis tool, was used to determine if any increases in dichotomous bone health orders were significant. This test is used "to determine if there are differences on a dichotomous dependent variable between two related groups, and can be conceptualized to be testing two different properties of a repeated measure dichotomous variable. Thus, the McNemar test is used to analyze pretest-posttest study designs, as well as being commonly employed in analyzing matched pairs and case-control studies" (Laird Statistics, 2013, para 1). A paired t-test was used to test for significance between numerical (non-

dichotomous) data which demonstrated increases from the pre to post-intervention data collection periods. This parametric statistical test is used to “compare two population means when there are before and after observations on the same subjects” (Statstutor, 2004, para 2).

## Chapter IV

### Evaluation and Results

#### Analysis of Data Points

**Fracture risk precaution order.** The comparative data analysis demonstrated that there was a 7.1 percent increase in the number of patients who received orders for “Fracture Risk Precautions” on admission, after initiation of the e-BHOS. However, application of the McNemar test did not show that this increase was statistically significant ( $p = 0.688$ ).

**Bone health laboratory admission orders.** This data reflected a 23.4 percent decrease in the number of admitted patients receiving admission orders for the bone health diagnostic measures of Vitamin D, calcium, phosphorus and magnesium levels after the e-BHOS intervention.

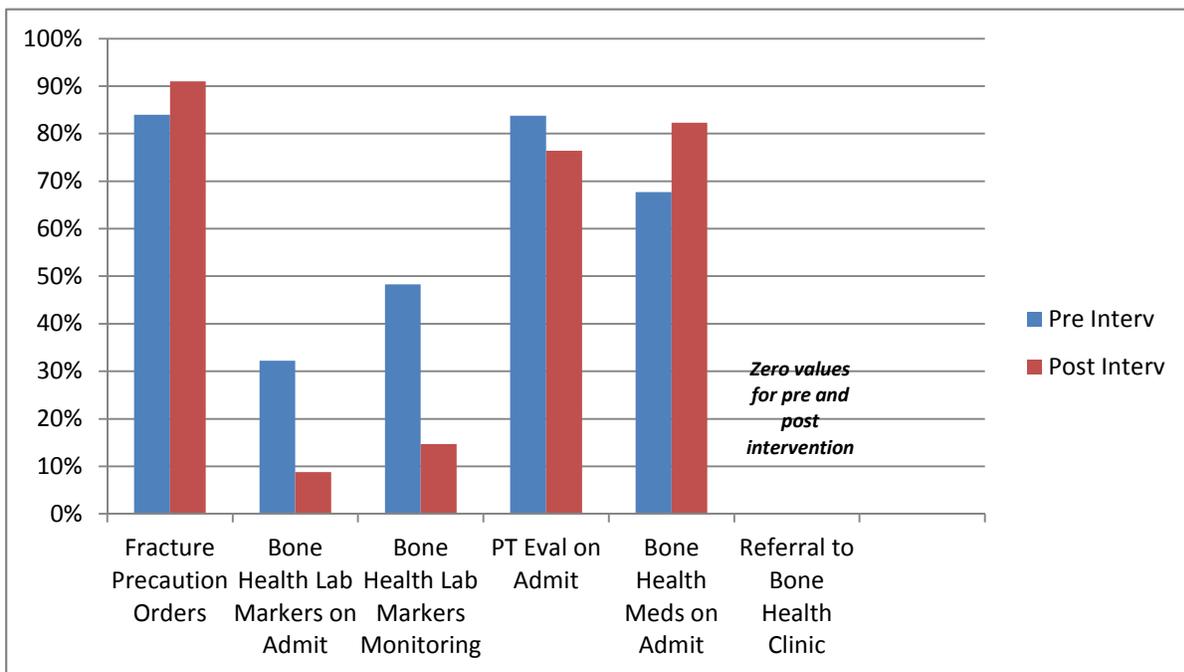
**Bone health laboratory monitoring orders.** Orders for monitoring of bone health diagnostic tests included those requested by the MD/NP any time after 72 hours from admission, and again included Vitamin D, calcium, phosphorus and magnesium levels. This data also revealed a 33.6 percent decrease in the number of post-intervention patients who received orders for bone health lab test monitoring in comparison with the pre-intervention monitoring patient data set.

**Physical therapy (PT) evaluation.** In this category, the total number of PT evaluation orders for the pre and post-intervention observation periods was tabulated. Data analysis revealed a 7.6 percent decrease in the number of PT evaluations requested by MDs/NPs for fracture risk patients after introduction of the e-BHOS.

**Bone health supplements ordered at admission.** In this category, the total number of bone health medication (supplementation) orders for the pre and post-intervention observation periods

was tabulated. Analysis revealed a 15.6 percent increase in this total number, and statistical testing revealed this increase to be *statistically significant* ( $p = 0.000$ ). During evaluation of this data category, it was observed that some patients received orders for multiple bone health supplement-medications. Discussion with a nursing research expert determined that comparing the total number of supplement- medications ordered was a more meaningful method to evaluate any change from the pre to post-intervention periods, rather than contrasting the total number of patients who received such orders (K. Anderson, personal communication, October 4, 2016).

**Referral to Bone Health Clinic.** No patient referrals were made to the Bone Health Clinic in either the pre or post-intervention group. A comparison of all pre and post-intervention data point proportions is summarized in Figure 1 below:



**Figure 1. Comparison of Pre & Post-intervention Proportions of Bone Health Orders.**

**Participant Post-Intervention Survey Results**

Post-intervention surveys were distributed to a total of seven MD/NP participants using a

commercial online survey service immediately following the end of the post-intervention data collection period. As noted earlier, two MDs from the original total of eight participants left the organization two weeks into the post-intervention data collection period. One MD joined the organization two weeks after the start of the post-intervention period, received orientation to the QIP and proceeded through the informed consent process to participate from that point. The survey consisted of demographic data section and a Likert survey to assess MD/NP attitudes and levels of satisfaction using the e-BHOS. Of the seven surveys distributed, five were completed and returned.

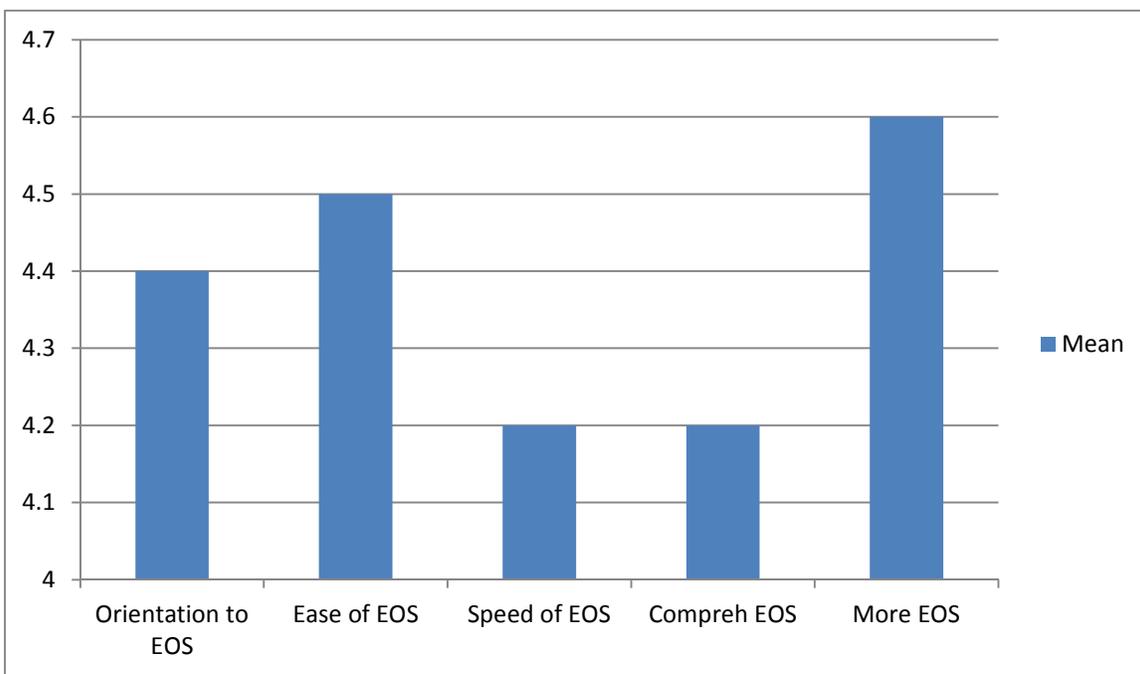
**Survey demographic data.** When gathering demographic data for the survey, practice credentials were not requested and ranges of response values were employed when possible to help maintain anonymity of MD/NP participants. This was necessary in view of the small N of participants, who were also well known to the project leader. Demographic categories queried included age range, gender, employment status, years of employment at the organization, practice experience and familiarity using an EHR. The complete survey is included in Appendix D. Of the five participants who completed the survey, two were males and three were females, ranging in age from 30—34 years to 55—59 years. Four of the five participants were employed full time (FTE) at the organization, and one respondent worked for less than a year, while the remaining four have worked a total of one to five years at the Center. Total years of practice as healthcare providers ranged from one to five years to greater than 15 years. These same ranges apply to their years of practice with the pediatric population. Finally, experience with use of an EHR spanned one to five years to greater than 15 years. Table 6 below summarizes the demographic profile of the five participants who responded to the survey.

**Table 6. Demographic Characteristics of Participants.**

<b>Subject</b>	<b>Age Range</b>	<b>Gender</b>	<b>FTE</b>	<b>Years @ Center</b>	<b>Total Years Practice</b>	<b>Total Years Pediatric Practice</b>	<b>Years EHR Experience</b>
1	30—34	Female	Fulltime	1—5	1—5	1—5	6—10
2	55—59	Male	Fulltime	1—5	> 15	> 15	11—15
3	50—54	Female	Fulltime	1—5	11—15	11—15	6—10
4	40—44	Female	Fulltime	1—5	11—15	11—15	6—10
5	30—34	Male	Fulltime	< 1	1—5	1—5	1—5

**Composite rating scale results.** The portion of the survey mechanism selected to assess MDs/NPs attitudes and levels of satisfaction with the e-BHOS was a five point Likert scale. Such composite rating scales are useful instruments for measuring varying attitudes, opinions or needs among individuals (Polit & Beck, 2012). The scale consisted of five declarative statements about their use of the e-BHOS during the admission process, including satisfaction with the order set orientation, its speed, comprehensiveness and ease of use and whether they would like future electronic order sets developed for other common patient health problems. Response descriptors included the terms with increasing positive value, including, strongly disagree, disagree, neutral, agree and strongly agree. Points allocated to these scale responses ranged in order from a minimum of one for “strongly disagree” to a maximum of five for “strongly agree.” There was one missing participant value assigned to “ease of use” of the e-BHOS. A decision was made to insert an *imputed mean* derived from the average of other respondents’ answers to this declarative statement and incorporate it into the data gap. Such substitutions are “believed to be good estimates of what the values would have been, had they not been missing” (Polit & Beck, 2012, p. 467).

Data analysis revealed a mean score of 4.1 for orientation and training to the e-BHOS, 4.5 for its ease of use, 4.2 for its speed of use, 4.2 for its comprehensiveness and 4.6 for interest in additional electronic order sets. The overall mean calculated for all five survey elements was 4.4. Figure 2 below depicts the means calculated for each element of the opinion section of the survey.



**Figure 2. Mean Scores on Items Included in Post-intervention Survey of MD/NP attitudes and Levels of Satisfaction with e-BHOS Components.**

### Summary of Findings

Analysis of pre and post-intervention MD/NP orders for admission and monitoring bone health laboratory tests, physical therapy evaluation and referral to the Bone Health Clinic revealed a decrease frequency between the pre and post-intervention e-BHOS data observation periods. Some possible explanations for these decreases include:

- The small N for both patient groups;

- The influx of respite care patients that only occurred during the post-intervention period;
- Differences in the primary diagnoses between the two groups of admitted patients;
- Practice and prescribing preferences of admitting MDs/NPs

There was proportional improvement in the frequency of prescriptions for fracture precautions and bone health supplement medications after the e-BHOS was instituted. The increase in the number of post-intervention fracture precautions was not significant, but the increase in bone health supplement orders entered by the MDs/NPs was statistically significant. Survey results measuring attitudes and satisfaction revealed ratings of “agree” or “strongly agree” on all component questions, with the exception of one “neutral” response.

## **Chapter V**

### **Discussion and Conclusions**

Development, implementation and evaluation of a quality improvement project involves careful planning, collaboration and thorough attention to detail. The challenge is to “interpret the findings and apply them in the context of the clinical question as outcomes” (Moran, Burson & Conrad, 2014, p. 343). Each step of the process may present obstacles to the integrity and completion of the project, and requires patience and perseverance to surmount them. This project was no exception, and many “lessons learned” emerged during its implementation. Although though the data did not significantly support the selected intervention in all the components evaluated, the most important of these lessons learned was that mastering the process trumped product, as it provided a lifelong template for facilitating change in professional practice. It is also important to disseminate results that do not support a study hypothesis to inform practice and the future investigators who plan to use similar approaches to test the same or similar intervention. This QIP also revealed several issues related to the roles of the EHR in documentation, reimbursement, patient safety and sharing of patient healthcare information among providers. For many clinicians, the advent of the EHR has been a source of frustration and disappointment as they have struggled to navigate its operational nuances and complexities to care for their patients. It remains to be seen how HIT will evolve, and how that evolution may or may not contribute to improved patient outcomes.

#### **Limitations**

A key step to address when analyzing quality improvement data and outcomes is to identify process limitations that could affect project findings and their interpretation. With this QIP, data analysis of e-BHOS utilization did not reveal a substantial improvement in the bone health

prescribing practices of the participating MDs/NPs. While there was a proportional increase in two of the six treatment variables studied, only one these two variables resulted in significant improvement. Ideally, identifying and managing limitations during the planning phase is preferred, but often they surface during a point in the project when modifications to the design or data collection cannot be made. Five sources of possible constraints were identified for this QIP:

**Organizational limitations.** A significantly reduced average daily patient census during the pre and post-intervention project phases, compared to the year prior to the QIP, resulted in an actual decrease in the number of MD/NP admission orders written. A higher number of patient admissions and consequent opportunities for the MDs/NPs to prescribe care could have lent more power to data analysis.

**Project design limitations.** The fact that the pre-existing admission fracture screening instrument was not a validated tool could have led to inaccurate identification of true fracture risk, i.e., patients may have been over or under identified. The MDs/NPs were aware that the screening instrument was not validated, and this may have influenced their prescribing patterns regarding bone health orders. However, this speculation is somewhat contradicted by the high mean scores on the post-intervention survey, which offer evidence that MDs/NPs found the e-BHOS to be a helpful type of CDSR. Also, the highest MD/NP survey mean score (4.6), was linked to the desire for additional electronic order sets to address common care needs in the CCHS population at the Center.

The original project plan established a six month period for both pre and post-intervention data collection, but this had to be shortened to a three month period due to unforeseen project delays. The primary factors that contributed to this process change were the substantial delays in

obtaining IRB approval and the time required by the Center's IT department to prepare and imbed the e-BHOS for launch. Time constraints imposed by the academic calendar did not permit waiting until the following year to match the same three calendar months of patient admissions for post- intervention data collection. Therefore, while the pre-intervention data collection period spanned April 1<sup>st</sup> through June 30<sup>th</sup> of 2015, the post-intervention data collection period occurred from June 15<sup>th</sup> through September 15<sup>th</sup> of 2016. Although the pre-intervention record review cohort (N = 31) closely approximated the post-intervention record review cohort (N = 34), seasonal fluctuations in the two different data collection periods may have influenced patient demographics, types of diagnoses and the orders eventually prescribed. Also, if the initial data collection periods had remained at six months, doubling the length of the pre and post-intervention phases could have contributed to intervention fidelity. This may potentially strengthened the integrity of the data and possibly altered outcomes. If time constraints had not arisen, it would have also been advisable to delay collection of post-intervention data for one month after "go-live" of the e-BHOS. This would have provided a period of time for the participants to acclimate to its availability and functions, and may have potentially altered their utilization of the e-BHOS, attitudes and levels of satisfaction with its use.

**Participant limitations.** Although all MDs/NPs employed at the Center consented to take part in the QIP, there was a very small pool from which to recruit participants. The small number of medical staff is related to the organization's size and census, and could not be increased through additional or different recruitment methods. Because there were alterations in the pre and post-intervention MD/NP cohort due to two resignations and one hiring, the participant cohorts did not fully resemble each other. However, the possibility of staffing changes was anticipated, and a pre-launch decision was made to move forward with data collection and

analysis as planned, should such variations occur. Finally, all participants were relatively naïve to the use of electronic order sets at the site, as the electronic clinical alert “pop up” function was first introduced at the Center in April, 2016, just two months prior to installing the order set’s clinical alert and the full e-BHOS itself.

**Patient limitations.** The possibility of short-term respite care admissions during both data collection phases was not taken into account during QIP planning. Respite care is planned, short-term care provided to caregivers of a child with special needs. These patients are admitted directly from home by families, and already have community-based, primary and specialist care providers. There were five respite care admissions during the post-intervention period, three of which were short-term admissions of the same patient, while there were no respite admissions during the pre-intervention period. Because these patients have an established medical home outside of the Center, admitting MDs/NPs do not generally alter their care plans, especially with respect to medication regimens, unless there is a change in their health status during the respite admission. This usual practice of carrying over admission medication reconciliation regimens when respite patients are admitted could have influenced the frequency of bone health orders written, especially during the post-intervention period.

**Technical limitations.** A technical factor discovered during project implementation was that the *full* e-BHOS could not be both automatically triggered and opened when an admitting MD/NP screened a patient as a fracture risk. The current EHR platform is only capable of activating an electronic “clinical alert,” and requires the clinician to activate two other functions before the entire order set will open for viewing and selection. This functional limitation may have affected whether the MD/NP decided to take the extra time and effort to open and review the e-BHOS. This barrier may have also impacted the participants’ post-intervention surveys,

especially those pertaining to ease and speed of use.

### **Implications for Practice, Research, Education and Policy**

**Introduction.** As medical discoveries and technological breakthroughs continue, there will be a simultaneous increase in the survivorship and life spans of very fragile, chronically ill infants and children who require increasingly complex care. This QIP explored a digital intervention to address bone health as a healthcare need that will continue to require vigilant attention, if CCHNs are to maintain an adequate quality of life and reach their developmental potential. Their care requirements, coupled with the increasing complexity and demands of electronic health documentation, poses challenging implications for future clinical practice.

**Implications for quality improvement project design.** At a micro level, several general principles of QIP planning and design emerged during this project and suggest implications for practice. First, there is a need to identify and engage a comprehensive group of administrative *and* end-user stakeholders when new or revised EHR functionalities are planned. An excessive amount of time was spent during the project negotiating and revising the e-BHOS with the clinical IT department, primarily due to barriers prompted by mandated, digital template designs, inflexible coding rules and IT staff who did not have clinical knowledge. It is also imperative to ensure that a “user-friendly” EHR has reasonable capacity for permitting clinical judgment and adaptation to special patient care circumstances. A pertinent example is the discovery that it was not technically possible to offer a complete “opt-out” alternative in the e-BHOS. Providing such adaptive capacity supports providers’ satisfaction when they perceive that their clinical judgment truly meets their patients’ needs.

**Implications for bone health promotion.** Facilitating bone health and preventing fractures in CCHNs is a multifaceted process, and requires an interdisciplinary approach to prevention and

treatment. An essential step of this approach is developing valid tools to screen and detect children at fracture risk, so that targeted interventions can be implemented as early as possible. The absence of a valid fracture risk screening tool for children, particularly CCHNs, is a significant barrier to early identification of secondary osteoporosis in this population. Studies that identify the range of primary, secondary and tertiary intervention strategies in children already identified would be another logical focus for future research endeavors. Another significant research gap in this field is identifying and evaluating drugs that can safely and effectively modify a broader range of etiologies for abnormal bone metabolism in children and reduce their risk for painful fractures.

Refining a comprehensive, electronic order set that addresses the digital limitations described earlier is one method for systematizing a comprehensive approach to bone health interventions. Project replication with a larger population and which addresses the limitations outlined above, with elimination of respite care patients, is recommended for this diagnostic category. Consideration should be given to form a collaborative study partnership with other similar, sub-acute pediatric hospitals, to create a larger pool of participants and patient orders eligible for review. Replication under these circumstances could provide a higher level of evidence needed to guide effective care decisions regarding use of digital mechanisms to promote pediatric bone health.

**Implications for nurse advocacy regarding digital documentation.** Electronic health records “will continue to evolve, as will the ways we use them” (Duffy, 2015, p. 61). During this evolution, nurses must act as strong advocates to ensure that digital technology is a facilitator, rather than barrier, to patient care. This requires that nurses “sit at the table,” to ensure that EHR development and revisions streamline and expedite care, minimize “alert fatigue,”

discourage unsafe “work-arounds” and expedite patient outcome data collection that can inform practice improvements. For example, embedding multiple electronic order sets will not be useful if they contain repetitive, overlapping orders, which clinicians then may proceed to ignore or override. Persistent activism supported by data is needed to ensure that future studies focus on determining what EHR functionalities best provide true healthcare value and improved patient outcomes. An advanced practice registered nurse must become fluent in the language of HIT, as well as the capabilities and pitfalls of digital documentation. Having such expertise holds significant potential for nurses to make a genuine contribution to the Quadruple Aim, when they can competently advocate for digital products that “enhance patient experience, improve population health, reduce costs and *improve the work life of health care providers* to optimize health system performance” (Bodenheimer & Sinsky, 2014, p. 573).

### **Recommendations for Nursing Practice and Further Study**

Planning and developing this QIP revealed two, primary recommendations for practice: the need for early identification and treatment of children at risk for fractures, and the need to determine how to best leverage the role of digital technology to meet the special needs of this population that are consistent with the Quadruple Aim of healthcare. Unlike seizures or spasticity, secondary osteoporosis often remains silent and undetected until the first fracture strikes. This prompts an avalanche of tests, consultations, surgeries and therapies that may result in a healed fracture, but will come too late to restore the bone deterioration that caused it. Currently, there is no validated fracture risk screening tool for children that can be conducted by clinical assessment alone, and which would not require specialized, costly diagnostic testing. A tool that relies only on health history and clinical assessment could also be administered by a broad range of healthcare providers who frequently encounter the CCHN population and expand

opportunities for early detection and treatment. Such a tool would offer a significant contribution to improving the health and well-being of these children.

All nurses in the field of pediatrics also work in a patient care environment where there is a very narrow margin for delivering safe and effective healthcare. A practice error that may not cause any significant threat to an adult could lead to permanent harm, or even death, in a young, vulnerable patient. The mandate for increasing reliance on an EHR to direct and document care holds potential for risks or benefits to all patients. The use of the CDSR described in this QIP, holds these same potential risks and benefits. This is particularly true now, as the federal government phases out meaningful use and transitions to the Advancing Care Information Program, under the Medicare Access and CHIP Reauthorization Act (MACRA) (Waldron & Solis, 2016). As phase-in proceeds, these new federal regulations will progressively tie reimbursement and bonuses to patient outcomes, instead of a fee for service model. This will place more pressure on healthcare administrators and HIT to build added complexity and functionality into digital documentation systems, or risk forfeiting the level of reimbursements needed to keep their organizations afloat.

In its review of digital technology and patient safety, the Institute of Medicine (IOM, 2010) reported stories of patient harm related to HIT misuse or malfunction, contrasted with other accounts of health providers being offered financial incentives to adopt the same systems that are implicated in patient injury. Doctorate prepared, advanced practice registered nurses are well positioned to become a stakeholder-advocate when their practice site is adopting a new EHR system or revising an existing one. Several strategies for nurses to become effective stakeholder-advocates and a competent end-user of HIT in clinical practice are recommended by the Technology Informatics Guiding Education Reform Initiative (TIGER, 2008). This collaboration

has developed guidelines to prepare the clinical workforce to use HIT to improve the delivery of safe, patient care. After conducting the synthesis of evidence for this QIP, the enormity of the role of HIT became much more tangible and clear. The following nursing practice changes incorporate the TIGER guidelines, and are proposed based on experience gained through the QIP process:

- Engaging end-user nurses in any process to adopt or revise an EHR system can identify documentation and data retrieval obstacles before “go-live,” and limit costly revisions later. It is also more likely that users involved in planning will use the technology correctly and safely (Goldschmidt, 2016);
- Expanding periodic competency evaluation of clinical psycho-motor skills should also include regular assessment of informatics proficiency and literacy, and offer a plan for remediation, if needed;
- Utilizing *interdisciplinary* HIT experts within the organization during EHR development or revision can help identify gaps and opportunities for digital collaboration;
- Using Prensky’s (2001) model of “digital natives” to mentor nurses who are “digital immigrants” without same level of HIT education, may help reduce individuals’ anxiety and increase their comfort level with technology;
- Involving nurses in quality improvement initiatives to monitor HIT safety on their own practice units confronts them with the reality of “near misses” and “never events” that could be a keystroke away from actually occurring;
- Sharing specific reports to individual providers that describes the EHR data that they created reveals missed care or incomplete documentation, may increase personal accountability for patient outcomes or reimbursement denials. Graphic portrayals of

consolidated unit data may also create a degree of healthy competition to improve documentation compliance

From a clinical practice standpoint, developing a longitudinal study of patients who do or do not receive focused bone health care facilitated by a CDSR would also be recommended to assess its impact on actual fracture frequency between the comparative populations.

## **Conclusion**

This pilot quality improvement project explored the use of a clinical decision support rule to organize best bone health care practices for medically complex children at risk for fracture. Data analysis revealed one significant increase in the six variables being examined, i.e., prescription of nutritional supplements that support healthy bone metabolism. Drawing conclusions from data analyses was limited by the low number of participants, patient records available for review and tabulation and technical and logistical barriers encountered during project planning and implementation. Sustainability of the e-BHOS is assured, as it has been established as a permanent functionality within the EHR of the practice site, and can be updated as new evidence regarding pediatric bone health emerges. Sustainability of the order set's use will require periodic data collection periods, to determine if it continues to be appropriately utilized in the patients who are at risk for fracture and employing remediation if needed. Conducting this pilot project provided a unique opportunity to advance to a higher level of competency needed to design, plan, execute and sustain a practice improvement project. The most significant insight gained as project leader was the recognition that mobilizing digitally competent, interdisciplinary stakeholders to minimize obstacles and maximize capabilities of HIT, holds significant potential for navigating the healthcare delivery challenges that surely lay ahead.

## References

- American Nurses Association. (2013). *Safe patient handling and mobility: Interprofessional national standards*. Retrieved from <http://nursingworld.org/DocumentVault/OccupationalEnvironment/SPHM-Standards-Resources/Sample-of-the-SPHM-book.pdf>
- Anders, M., Turner, L., & Wallace, L. (2007). Use of decision rules for osteoporosis prevention and treatment: Implications for nurse practitioners. (2007). *Journal of the American Academy of Nurse Practitioners*, 19, 299-305. doi: 10.1111/j.1745-7599.2007.0029.x
- Apkon, S., & Kecskemethy, H. (2008). Bone health in children with cerebral palsy. *Journal of Pediatric Rehabilitation Medicine*, 1(2), 115-121. Retrieved from: <https://gumc.hosts.atlas-sys.com/illiad.dll?Action=10&Form-75&Value=66728>
- Association of Rehabilitation Nurses. (2014). *Safe patient handling and mobility: A position statement*. Retrieved from [http://www.rehabnurse.org/uploads/Safe\\_Patient\\_Handling\\_and\\_Mobility\\_Position\\_Statement\\_Final.pdf](http://www.rehabnurse.org/uploads/Safe_Patient_Handling_and_Mobility_Position_Statement_Final.pdf)
- Bainbridge, D. & Gleason, J. (2013). Physical activity, exercise and sports. In Batshaw, M., Roizen, N., & Lotrecchiano, G.. *Children with Disabilities*. (7<sup>th</sup> Ed.). Baltimore, MD: Brooks Publishing Co.
- Behringer, J., Gruetzner, S., McCourt, M., & Mester, J. (2014). Effects of weight bearing activities on bone mineral content and density in children and adolescents: A meta-analysis. *Journal of Bone Metabolism Research*, 29(2), 467-478. doi: 10:1002.jbmr.2036

- Berry, J., Hall, M., Neff, J., Goodman, D., Cohen, E., Agrawal, R... & Feudtner, C. (2014). Children with medical complexity and Medicaid: Spending and cost savings. *Health Affairs*, 33(12), 2199-2206. doi: 10.1377/hlthaff.2014.0828
- Bianchi, M. (2013). Causes of secondary pediatric osteoporosis. *Pediatric Endocrinology Reviews*, 10(2), 424-436.
- Bodenheimer, T., & Sinsky, C. (2014). From triple to quadruple aim: Care of the patient requires care of the provider. *Annals of Family Medicine*, 12(6), 573-576.  
doi:10.1370/afm.1713
- Borycki, E., Sangster, E., Schreiber, R., Feddema, A., Griffith, J., & Swamy, M. (2015). Nurse practitioner perceptions of the impact of electronic medical records upon clinical practice. *Studies in Health Technology Informatics*, 218, 45-51. doi:10.3233/978-1-61499-574-6-45
- Bowden, S., Robinson, R., Carr, R., & Mahan, J. (2008). Prevalence of Vitamin D deficiency and insufficiency in children with osteopenia or osteoporosis referred to a pediatric metabolic bone clinic. *Pediatrics*, 121(6), e1585-e1590. doi:10.1542/peds.2007-2111
- Boyce, A., & Gaffni, R. (2011). Approach to the child with fractures. *Journal of Clinical Endocrine Metabolism*, 96(7), 1943-1952. doi: 10.1210/jc.2010-2546
- Burrows, M. (2007). Exercise and bone mineral accrual in children and adolescents. *Journal of Sports Science and Medicine*, 6(3), 305-312.
- Caulton, J., Ward, K., Alsop, W., Dunn, G., Adams, J., & Mughal, M. (2004). A randomized controlled trial of a standing programme on bone mineral density in non-ambulant children with cerebral palsy. *Archives of Diseases in Childhood*, 89(2), 131-135.  
doi: 10.1136/adc.2002.009316

- Centers for Medicare and Medicaid Services. (2014). *Clinical decision supports: More than just alerts*. Retrieved from [https://www.cms.gov/eHealth/downloads/ClinicalDecisionSupport\\_AlertsTipsheet.pdf](https://www.cms.gov/eHealth/downloads/ClinicalDecisionSupport_AlertsTipsheet.pdf)
- Centers for Medicare and Medicaid Services. (2014a). *Eligible professional meaningful use core measures*. Retrieved from <https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/downloads/ep-mu-toc.pdf>
- Centers for Medicare and Medicaid Services. (2015). *The Medicare Access and CHIP Reauthorization Act of 2015: Path to value*. Retrieved from <https://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/Value-Based-Programs/MACRA-MIPS-and-APMs/MACRA-LAN-PPT.pdf>
- Centers for Medicare and Medicaid Services. (2016a). *Electronic health records incentive programs*. Retrieved from <https://www.cms.gov/Regulations-and-guidance/Legislation/EHRIncentivePrograms/index.html?redirect=/ehrincentiveprograms>  
<https://www.cms.gov/Regulations-and-Centers>
- Centers for Medicare and Medicaid Services (2016b). *Medication reconciliation*. Retrieved from [https://www.cms.gov/Regulations-and-guidance/Legislation/EHRIncentivePrograms/downloads/7\\_Medication\\_Reconciliation.pdf](https://www.cms.gov/Regulations-and-guidance/Legislation/EHRIncentivePrograms/downloads/7_Medication_Reconciliation.pdf)
- Chad, K., Bailey, D., McKay, H., Zello, G., & Snyder, R. (1999). The effect of a weight bearing activity program on bone mineral content and estimated volumetric density in children with spastic cerebral palsy. *The Journal of Pediatrics*, 135(1), 115-117.
- Clark, E., Tobias, J., & Ness, A. (2006). Association between bone density and fractures in children: A systematic review and meta-analysis. *Pediatrics*, 117, e291-e297.  
doi: 10.1542/peds.2005-1404

- Cohen, E., Kuo, D., Agrawal, R., Berry, J., Bhagat, S., Simon, T., & Srivastava, R. (2011). Children with medical complexity: An emerging population for clinical and research initiatives. *Pediatrics*, *127*(3), 5290538. doi: 10.1542/peds.2010-0910
- Corley, L. (2015). CAUTI awakenings. *Nursing 2015*, *45*(1). 20-21.  
doi: 10.1097/01.NURSE.0000458937.65995.89
- Delmas, P., Eastell, R., Garnero, P., Seibel, J., & Stepan, J. for the Committee of Scientific Advisors of the International Osteoporosis Foundation (2000). The use of biochemical markers of bone turnover in osteoporosis. *Osteoporosis International*, (*Suppl 6*), s2-s17.
- deRuiter, H., Liaschenko, J., & Angus, J. (2016). Problems with the electronic health record. *Nursing Philosophy*, *17*, 49-58.
- Duffy, M. (2015). Nurses and the migration to electronic health records. *American Journal of Nursing*, *115*(12), 61-66. doi: 10.1097/01.NAJ.0000475294.12738.83
- Ead, H. (2015). Change fatigue in health care professionals: An issue of workload or human factors engineering? *Journal of Perianesthesia Nursing*, *30*(6), 504-515.
- Eghbali, G. (2014). Bisphosphonate therapy in pediatric patients. *Journal of Diabetes & Metabolic Disorders*, *13*(1), 109-126. doi: 10.1186/s40200-014-0109-y
- Estrada, A., Ramnitz, M., Gafni, R. (2014). Bone densitometry in children and adolescents. *Current Opinion in Obstetrics and Gynecology*, *26*(5), 339-346.  
doi: 10.1097/GCO.0000000000000100

- Farr, J., Laddu, D., Going, S. (2014). Exercise, hormones and skeletal adaptations during childhood and adolescence. *Pediatric Exercise Science*, 26(4), 384-391.  
doi: 10.1123/pes.2014.0077
- Fong, C., Mallick, A., Burren, C., Patel, J. (2011). Evaluation and management of bone health in children with epilepsy on long term antiepileptic drugs. *European Journal of Paediatric Neurology*, 15(5), 417-422. Retrieved from  
<http://www.sciencedirect.com/science/article/pii/S1090379811000675>
- Forsberg, H. (2008). Managing childhood disability: Progress in the past two decades. *Developmental Medicine & Child Neurology*, 50(11), 803.  
doi: 10.1111/j.1469-8749.2008.03164.x
- Golden, N., & Abrams, S. (2014). Optimizing bone health in children: Clinical report of the American Academy of Pediatrics. *Pediatrics*, 134, e1229-e1243.  
doi: 10.1542/peds.2014-2173
- Goldschmidt, K. (2015). Strategies to deliver safe, technology-enhanced care in pediatric settings. *Journal of Pediatric Nursing*, 31(2), 224-227. doi: 10.1016/j.pedn.2015.12.005
- Gordon, C., Leonard, M., & Zemel, B. (2014). 2013 pediatric position development conference: Executive summary and reflections. *Journal of Clinical Densitometry*, 17(2), 219-224.  
doi: 10.1016/j.jocd.2014.007
- Graziano, P., Tauber, K., Cummings, J., Graffunder, E., & Horgan, M. (2015). Prevention of postnatal growth restriction by the implementation of an evidence-based premature infant feeding bundle. *Journal of Perinatology*, 35(8), 642-649. doi:10.1038/jp.2015.35

- Hedin, H., Borgquist, L., & Larrson, S. (2004). A cost analysis of three methods of treating femoral shaft fractures in children. *Acta Orthopaedica Scandinavica*, 75(3), 241-248.
- Hind, K., & Burrows, M. (2007). Weight bearing exercise and bone mineral accrual in children and adolescents: A review of controlled trials. *Bone*, 40(1), 14-27.
- Holberg, J. (2016). Note bloat and the disruption of utility of electronic health records. *Proceedings of the Society of Hospital Medicine*, March 8, 2016.
- Holick, M., Binkley, N., Gordon, C., Hanley, D., Heaney, R., Murad, H., Weaver, C. (2011). Evaluation, treatment and prevention of Vitamin D deficiency: An endocrine society clinical practice guideline. *Journal of Clinical Endocrinology & Metabolism*, 96(7), 1911-1930.  
doi: 10.1210/jc.2011-0385
- Houlihan, C. (2014). Bone health in cerebral palsy: Who is at risk and what to do about it? *Journal of Pediatric Rehabilitation Medicine*, 7(2), 143-153. doi: 10.3233/PRM-140283
- Houlihan, C., & Stevenson, R. (2009). Bone density in cerebral palsy. *Physical Medicine & Rehabilitation Clinics of North America*, 20(3), doi: 10.1016/j.pmr.2009.04.004
- Hough, J., Boyd, R., & Keating, J. (2010). Systematic review of interventions for low bone mineral density in children with cerebral palsy. *Pediatrics*, 125(3), e670-e677.  
doi: 10: 1542/peds.2009-0292
- Huh, S. & Gordon, C. (2013). Fractures in hospitalized children. *Metabolism*, 62, 315-325.  
doi.org/10.1016/j.metabol.2012.07.018
- Institute of Medicine (2009). *One hundred initial priority topics for comparative effectiveness research*. Retrieved from <http://iom.nationalacademies.org/~media/Files/Report%20Files/2009.ComparativeEffectivenessResearchPriorities>

Institute for Safe Medication Practices. (2010). *ISMP's guidelines for standard order sets*.

Retrieved from <http://www.ismp.org/tools/guidelines/standardordersets.pdf>

International Society for Clinical Densitometry. (2014). The ISCD 2013 official pediatric positions: Fracture prediction and the definition of osteoporosis in children and adolescents: *Journal of Clinical Densitometry*, 17(2), 275-280.

Johnston, C., Miller, J., Slemenda, C., Reister, T., Hui, S., Christian, J., & Peacock, M. (1992). Calcium supplementation and increases in bone mineral density in children. *New England Journal of Medicine*, 327(2), 82-87.

Kotter, J. (1995). Leading change: Why transformation efforts fail. *Harvard Business Review* 73(2), 59-67. Retrieved from <https://hbr.org/2007/01/leading-change-why-transformation-efforts-fail>

Kurtin, P., & Stucky, E. (2009). Standardize to excellence: Improving the quality and safety of care with clinical pathways. *Pediatric Clinics of North America*, 56(4), 893-904.  
doi: 10.1016/j.pcl.2009.05.005

Laird Statistics. (2013). *The McNemar test using SPSS statistics*. Retrieved from <https://statistics.laerd.com/spss-tutorials/mcnemars-test-using-spss-statistics.php>

Landa, H. (2012, December). *Health Leader*. Order sets done well. Retrieved from <http://www.healthleadersmedia.com/technology/order-sets-done-well>

Larrabee, J. (2009). *Nurse to nurse evidence-based practice care*. New York, NY: McGraw Hill Medical.

- Lloyd, T., Andon, M., Rollings, N., Martel, J., Landis, R., Demers, L., Eggli, D...Kulin, H. (1993). Calcium supplementation and bone mineral density in adolescent girls. *Journal of the American Medical Association*, 270(7), 841-844.
- McGreevy, J. (2013). Order sets in electronic health records: Principles of good practice. *Chest*, 143(1), 228-235. doi: 10.1378/chest.12-0949
- Melnyk, B. & Fineout, E. (2015). *Evidence based practice in nursing & healthcare*. (3<sup>rd</sup> ed.). Philadelphia, PA: Wolters Kluwer.
- Mergler, S., Evenhuis, J., DeMan, S., Bindeis, K., Huijbers, W., & Penning, C. (2009). Epidemiology of low bone mineral density and fractures in children with severe cerebral palsy. *Developmental Medicine and Child Neurology*, 51(10), 773-738. doi: 10.1111/j.1469-8749.2009.03384.x
- Moran, K., Burson, R., & Conrad, D. (2014). *The doctor of nursing practice scholarly project: A framework for success*. Burlington, MA: Jones & Bartlett Publishing.
- Mughal, M. (2014). Fractures in children with cerebral palsy. *Current Osteoporosis Reports*, 12, 313-318. doi: 10.1007/s11914-014-0224-1
- Munasinghe, R., Arsene, C., Abraham, T., Zidan, M., and Siddique, M. (2011). Improving utilization of admission order sets in a computerized physician order entry system by integrating modular disease specific order subsets in a general admission order set. *Journal of the American Informatics Association*, 18, 322-326. doi: 10.1136/amiajnl-2010-000066
- Murphy, D., Laxmisan, A., Reis, B., Thomas, E., Esquivel, A., Forjuoh, S...Singh, H. (2014). Electronic health record-based triggers to detect potential delays in cancer diagnosis. *British Medical Journal of Quality and Safety*, 23(1), 8-16. doi: 10.1136/bmjqs-2013-001874

- Murphy, D., Wu, L., Thomas, E., Forjuoh, S., Meyer, A., & Singh, H. (2015). Electronic trigger based intervention to reduce delays in diagnostic evaluation for cancer: A cluster randomized controlled trial. *Journal of Clinical Oncology*, 23(31), 3560-3567.  
doi: 10.1200/JCO.2015.61.1301
- National Osteoporosis Foundation. (Fall, 2014). Clinical updates: Osteoporosis in children and adolescents. Retrieved from <https://www.cme.nof.org/Activity/4463324/Detail.aspx>
- Nork, S. & Hoffinger, S. (1998). Skeletal traction versus external fixation for pediatric femoral shaft fractures: A comparison of hospital costs and charges. *Journal of Orthopaedic Trauma*, 12(8), 563-568.
- Papapoulos, S. (2011). Bisphosphonate therapy in children with secondary osteoporosis. *Hormone Research in Pediatrics*, 76(suppl 1), 24-27. doi: 10.1159/000329151
- Pin, T., (2007). Effectiveness of static weight bearing exercises in children with cerebral palsy. *Pediatric Physical Therapy* 19(1), 62-73. doi: 10.1097/PEP.0b013e3180302111
- Piscotty, R., Kalisch, B., Gracey-Thomas, A. (2015). Impact of healthcare information technology on nursing practice. *Journal of Nursing Scholarship*, 47(4), 287-293.  
doi: 10.1111/jnu.12138
- Plotkin, H. Sueiro, R. (2007). Osteoporosis in children with neuromuscular diseases and inborn errors of metabolism. *Minerva Pediatrica*, 59(2), 129-135.
- Polit, D., & Beck, C. (2012). Nursing research: Generating and assessing evidence for nursing practice. (9<sup>th</sup> ed.). Philadelphia, PA: Wolters Kluwers.

Prensky, M. (2001). Digital natives, digital immigrants: On the horizon. Retrieved from

<http://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf>

Rosswurm, M., & Larrabee, J. (1999). A model for change to evidence-based practice.

*Journal of Nursing Scholarship*, 31(4), 317-322. Retrieved from

<http://onlinelibrary.wiley.com/doi/10.1111/j.1547-5069.1999.tb00510.x/epdf>

Saraff, V., & Hogler, W. (June, 2015). Osteoporosis in children: Diagnosis and management.

*European Journal of Endocrinology*, e-pub ahead of print. doi: 10.1530/EJE-14-0865

Schein, C. (2010). *Organizational culture and leadership*. (4<sup>th</sup> ed.). San Francisco, CA:

Josey Bass.

Stark, C., Nikopoulou, P., Stabrey, A., Semler, O., & Schoenau, E. (2010). Effect of a new

physiotherapy concept on bone mineral density, muscle force and gross motor function in

children with bilateral cerebral palsy. *Journal of Musculoskeletal and Neuronal Interaction*,

10(2), 151-158. Retrieved from <http://www.ismni.org/jmni/pdf/40/05STARK.pdf>

Statstutor. (2004). *Statistics: Paired t-tests*. Retrieved from

<http://www.statstutor.ac.uk/resources/uploaded/paired-t-test.pdf>

Szadek, L. & Scharer, L. (2014). Identification, prevention and treatment of children with

decreased bone mineral density. *Journal of Pediatric Nursing*, 29, e3-e14.

doi: 10.1016/j.pedn.2013.1.002

Szalay, E., (2014). Bisphosphonate use in children with osteoporosis and other bone conditions.

*Journal of Pediatric Rehabilitation Medicine*, 7, 125-132. doi: 10.3233/PRM-140281

The HSC Healthcare System. (2016). *Mission and history*. Retrieved from

<http://www.hshealth.org/about/history>

TIGER Initiative. (2008). *Information technologies and the transformation of nursing*

*education*. Retrieved from <http://docplayer.net/1884922-Overview-informatics-competencies-for-every-practicing-nurse-recommendations-from-the-tiger-collaborative.html>

United States Preventive Services Task Force. (November, 2014). *Final recommendation*

*summary: Vitamin D deficiency screening*. Retrieved from

<http://www.uspreventiveservicestaskforce.org/Page/Document/UpdateSummaryFinal/vitamin-d-deficiency-screening>

Wagner, C., & Greer, F. (2008). Prevention of rickets and Vitamin D deficiency in infants, children and adolescents. *Pediatrics*, 122(5), 1142-1152. doi: 10.1542/peds.2008-1862.

Waldren, S. & Solis, E. (2016). The evolution of meaningful use. *Family Practice Management*, 23(1), 17-23.

Ward, K., Alsop, C., Caulton, J., Rubin, C., Adams, J., & Mughal, Z. (2004). Low magnitude mechanical loading is osteogenic in children with disabling conditions. *Journal of Bone and Mineral Research*, 19(3), 360-369. doi: 10.1359/JBMR.040129

Ward, L., Tricco, A., Phuong, P., Cranney, A., Barrowman, N., Gaboury, I...Moher, D. (2007). Bisphosphonate therapy for children and adolescents with secondary osteoporosis. *Cochrane Database of Systematic Reviews*, 7, 1-42. Accession: 00075320-100000000-04191.

Wright, A. Feblowitz, J., Pang, J., Carpenter, J., Krall, M...Sittig, D. (2012). Use of order sets in inpatient computerized provider order entry systems: A comparative analysis of usage patterns at seven sites. *International Journal of Medical Informatics*, 81(11), 733-745.

Zelleke, T., Cabacar, D., & Gaillard, W. (2013). *Epilepsy*. In M. Batshaw, B Roizen & G. Latrechhiano (Eds.), *Children with disabilities*. (pp.487-506). Baltimore, MD: Paul H. Brookes Publishing.

Zemel, B., Kalkwarf, H., Gilsanz, V., Lappe, J., Oberfield, S., Shepherd, J... Winer, K. Revised reference curves for bone mineral content and areal bone mineral density according to age and sex for black and non-black children: Results of bone mineral density in childhood study. *Journal of Clinical Endocrinology & Metabolism*, 96(10), 3160-3190.

doi: [dx.doi.org/10.1210/jc.2011-111](https://doi.org/10.1210/jc.2011-111)

## Appendix A

### Strategic Plan to Utilize MEBPC and Kotter’s Change Steps

#### For a Bone Health Promotion Project

Model for Evidence Based Practice Change		Kotter’s Steps for Organizational Transformation	
Step	Implementation	Step	Implementation
1. Assess need for change	<ul style="list-style-type: none"> <li>~Data gathering re: <b>fracture (fx) rate &amp; number</b> of patients screened for fx on admission.</li> <li>~Staff frustration re: un-explained fxs PCPs <b>not</b> consistently <b>ordering</b> interventions to promote <b>bone health</b></li> <li>~<b>No trigger in EHR</b> to prompt appropriate orders on admission to promote bone health/prevent fractures</li> <li>~Minimal formal position statements or guidelines for EBP for bone health in medically fragile pediatric population.</li> <li>~Expert guidelines are available for use &amp; interpretation of DXA to diagnose (dx) osteoporosis in children</li> </ul>	1. Establish sense of urgency	<ul style="list-style-type: none"> <li>~Share organization’s <b>Incident Report data &amp; need to reduce harm</b> to patients &amp; risk to organization</li> <li>~Reminder to organization that use of e-BHOS will address federal mandate for <b>“meaningful use”</b> requirements in EHR, since site received Recovery Act-HITECH funds to subsidize EHR implementation</li> </ul>
2. Locate best evidence	<ul style="list-style-type: none"> <li>~Key search terms identified from PICO</li> <li>~ Modified, systematic review of literature (PubMed, CINAHL)</li> <li>~Search of national guideline sources (ARHQ)</li> <li>~Review of professional stakeholder organizations for policies/guidelines re: phenomenon of interest (American Academy of Pediatrics, Society of Pediatric Nurses, National Osteoporosis Foundation, American Academy of Nurse Practitioners).</li> </ul>	2. Form a powerful, guiding coalition	<ul style="list-style-type: none"> <li>~Identify &amp; engage key <b>stakeholders</b>, solicit opinions &amp; input</li> <li>~<b>Focus group</b> of key stakeholders</li> <li>~<b>Clinician education</b> re: intervention prior to implementation phase</li> <li>~ identify patient unit <b>“champions”</b> to support project leader during &amp; after implementation</li> </ul>
(continued)			

	~Selected articles for full review		
3. Critically analyze evidence	<p>~Critical appraisal of selected articles</p> <p>~Synthesize, summarize evidence</p> <p>~Identify best evidence for electronic order set that takes into account patient population, setting, risks &amp; benefits</p>	3. Create a vision	<p>~Develop and write proposal, to be shared with and reviewed by practice site's <b>stakeholders</b> to secure "buy in"</p> <p>~<b>Emphasize "wins"</b>, i.e., "it's for the kids" motto, fewer fxs, better QOL for patients</p> <p>~ Reduces nursing care hours</p> <p>~Orientation of medical &amp; nursing staff to order set and its utilization</p>
4. Design practice change  (continued)	<p>~Develop electronic bone health order set based on synthesis of evidence</p> <p>~Hold <b>focus group</b> with <b>stakeholders</b> to obtain expert input and opinion re: order set components</p> <p>~Reach consensus re: order set</p> <p>~Consult with Clinical IT to embed "trigger" for order set in EHR</p> <p>~Create spread sheet to summarize data:</p> <ul style="list-style-type: none"> <li>• Patient demographics</li> <li>• Outcome of fx risk screen @ admission</li> <li>• Bone health/fx prevention orders by MD/NP @ admission</li> </ul>	4. Communicate a vision	<p>~Share best evidence with stakeholders and users of order set</p> <p>~Write article about project program for <b>organizational newsletter</b></p>

	<p>~Conduct retrospective chart review of admission of all pts. screened as fx risk for identified 3 mo. period &amp; gather data per above</p>		
<p>5. Implement &amp; evaluate practice change</p>	<p>~Orient MDs/NPs/RNs re: order set use</p> <p>~Collaborate with Clinical IT to set “go live” date to activate trigger for order</p> <p>~Notification to <b>stakeholders</b> re: “go live” date</p> <p>~Allow 6 month period of order set implementation/use</p> <p>~Conduct chart audit of all admitted patients &amp; ID as fracture risk during 3 month post-implementation period:</p> <ul style="list-style-type: none"> <li>• Patient demographics</li> <li>• Outcome of fx screen @ admission</li> <li>• Did (+) fx screen trigger e-BHOS 100% of time?</li> <li>• ID of any bone health orders selected from bone health order set by MDs/NPs</li> <li>• Calculate proportion of use of e-BHOS elements by MDs/NPs</li> </ul> <p>~Collaborate with Clinical IT to determine number of IT requests received for technical assistance with use of bone health order set</p>	<p><b>5.</b> Empower others to act on the vision</p>	<p>~Obtain “buy in” from key stakeholders &amp; lower obstacles to change:</p> <ul style="list-style-type: none"> <li>• <b>Focus groups</b></li> <li>• <b>Orientation</b> sessions</li> <li>• Continuous collaboration with Clinical IT</li> <li>• Informal “check-ins” with MD/NP staff about use of order set</li> <li>• Informal focus group with stakeholders at mid-point to ID barriers/facilitators to pilot implementation</li> </ul>
(continued)			

<p>6. Integrate and maintain practice change</p>	<p>~Share pilot outcome data with <b>stakeholders</b></p> <p>~Pending results of outcome, collaborate with admin and medical staff to incorporate change into organizational <b>EHR policy</b></p> <p>~Conduct quarterly chart audit to gather data on rate of MD/NP compliance w/change for one year; share compliance @ quarterly <b>Medical Executive Committee</b></p> <p>~Evaluate need for continued chart audit @ that time w/ QI, Risk &amp; Medical Directors, based on compliance data</p> <p>~Include education re: bone health order set program in <b>orientation program</b> for new MD/NP hires</p> <p>~Display quarterly QA data in <b>graphic form</b> on patient units and Medical Staff office</p> <p>~Write article re: project outcomes for <b>organizational newsletter</b>; emphasize short term <b>“wins”</b> &amp; potential long term outcomes (reduced fx rate &amp; consequent <b>“wins”</b> for patients, families, rehab &amp; nursing staff and organization)</p> <p>~<b>Formal publication</b> about e-BHOS project and outcomes</p>	<p>6. Planning for short term wins</p>	<p>~<b>Medical Executive Committee</b> updates to share interim pilot outcomes &amp; compliance data</p> <p>~<b>Celebrate “wins”</b></p> <p>~<b>Graphic displays</b> of interim compliance data on patient care units &amp; in Medical Staff office (Note: unable to implement due to abbreviated post-intervention data collection period).</p> <p>~<b>Advertise/celebrate “go-live” date</b> for e-BHOS</p>
<p>(continued)</p>		<p>7. Consolidate improvements and produce more change</p>	<p>~Pending outcome data, collaborate with admin and medical staff to revise org policy to incorporate order set usage</p> <p>~Raise awareness with admin staff and Clinical IT re:</p>

			<p>potential for further use of order sets to implement best practices for other clinical quality problems</p> <p>~Reinforce use of order sets as a measure of <b>“meaningful use”</b> by federal payment agencies &amp; consequent <b>fiscal benefits</b> to organization</p>
		<p>8. Institutionalize new approaches</p>	<p>~Summarize pilot project outcomes at close of final data collection in <b>organizational newsletter</b></p> <p>~Emphasize benefits of compliance to patients families, staff and organization</p> <p>~Identify change <b>“champions”</b></p> <p>~Include quarterly QI data on order set compliance @ quarterly QI &amp; <b>Medical Executive Committee</b> meetings</p> <p>~<b>Formal publication</b> of pilot bone health project and outcomes</p>

## Appendix B

### MD/NP Survey Tool

**PART I:** Demographic Survey: Directions: Please **CIRCLE THE NUMBER** or **FILL IN THE BLANK** that represents your answer:

**1. My age range is:**

- |                |                 |
|----------------|-----------------|
| 1) 24-29 years | 6) 50-54 years  |
| 2) 30-34 years | 7) 55-59 years  |
| 3) 35-39 years | 8) 60-64 years  |
| 4) 40-44 years | 9) 65-69 years  |
| 5) 45-49 years | 10) 70-74 years |

**2. Gender:**

- 1) Male
- 2) Female

**3. I am employed, or contractually employed, at HSC:**

- 1) Full time ( $\geq .75$  FTE)
- 2) Part time ( $< .75$  FTE)

**4. How many years have you been **employed at HSC** as a physician **or** nurse practitioner?**

- 1)  $< 1$  year
- 2) 1—5 yrs
- 3) 6—10 yrs
- 4) 11—15 yrs
- 5)  $> 15$  yrs

**5. What is the *total number of years* you have practiced as a physician **or** nurse practitioner?**

\_\_\_\_\_ yrs

**6. How many years have you practiced as a physician or nurse practitioner with pediatric**

patients? \_\_\_\_\_ yrs

**7. How many years of experience would you *estimate* that you have entering medical treatment orders using an electronic health record (EHR) system? \_\_\_\_\_ yrs.**

(continued)

**PART II:** Study Procedure Satisfaction: Survey: **Circle the number of the word or phrase** which best describes your answer about the following statements:

8. The education session conducted by the student investigator enhanced my understanding about how to use the electronically-triggered bone health order set for patients at HSC identified at risk for fractures:

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

---

9. Using an electronically-triggered bone health order set for HSC patients identified at risk for fractures was an easy process.

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

---

10. Using an electronically-triggered bone health order set for HSC patients identified at risk for fractures was faster than entering these orders individually:

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

---

11. The options in the bone health order set (fracture precautions, diagnostic studies, supplementation, physical therapy assessment, referral to bone health clinic) comprehensively addressed the range of care needed by HSC pediatric patients identified at risk for fractures:

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

---

12. I would support using more electronically-triggered medical order sets for other identified chronic health problems frequently encountered in the HSC patient population:

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Optional Comments

## Appendix C

### Bone Health Order Set

#### **PRECAUTIONS, FRACTURE, Q SHIFT, ROUTINE**

##### **LABORATORY – Order “Now” if indicated**

- Alkaline Phosphatase, Once, Routine
- Calcium level Once, Routine
- Magnesium level Once, Routine
- Phosphorus level Once, Routine
- Vitamin D, 25-hydroxy level, Once, Routine

##### **MEDICATION:**

###### **Multivitamin Preparations for Infants Up to 2 years of age:**

- Poly-Vitamin Drops - 1 ml PO daily
- Poly-Vitamin with Iron Drops – 1 ml PO daily

###### **Multivitamin Preparations For Children Over 2 years of age:**

- Poly-Vitamin Chew - 1 tab PO daily
- Poly-Vitamin with Iron Chew - 1 tab PO daily
- Cerovite Jr. Tab – ½ tab PO daily for children 2→3 yrs
- Cerovite Jr. Tab – 1 tab PO daily for children > 4 yrs
- Phlexi-Vit Packet - 7 gram/ packet PO daily for children > 11 yrs

###### **Calcium Preparations for Children:**

- Calcium Carbonate Liquid - 100 mg/ml PO BID
- Calcium Carbonate Tab - 500 mg/tab PO BID

###### **Vitamin D3 Preparations for Children:**

- Cholecalciferol Liquid 400 I. U./ml PO daily
- Vitamin D3 Super Strength - 2000 I. U. /ml PO daily

###### **Phosphorus Preparation for Children:**

- Neutra-Phos Packet – 250 mg/packet, One packet PO daily

##### **PHYSICAL THERAPY: Specify in order:**

Physical therapy assessment to determine weight-bearing and muscle strengthening if appropriate, to promote bone health:

- MD - PT Evaluation and Treatment, Once, Routine

##### **○ REFFERAL TO BONE HEALTH CLINIC:**

Consider if patient exhibits:

- ≥ 2 fractures in infancy and childhood
- Prolonged, non-weight bearing status
- Nutritional depletion secondary to eating disorders, malabsorption, IBD, dairy avoidance, stimulant medications, chronic steroid use, anti-convulsants
- Immune suppressants or chemotherapeutic agents
- Genetic disorders affecting bone metabolism