Implementation of a Diabetes Risk Screening Instrument in the Preoperative Setting for Total Joint Orthopedic Patients

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Abstract

The national CDC (2017) statistics revealed 23 million cases of diabetes and 84.1 million cases of prediabetes, which is nearly 4x more prevalent than diabetes. Among United States (US) adults aged 18 years or older in 2015, 33% were diagnosed with prediabetes and only 10.6% reported awareness. Within the surgical realm of healthcare, an estimated 25% of patients with diabetes will require surgery at some point and 5 to 10% of patients who present for surgery are found to have previously undiagnosed diabetes (Setji et al., 2017). Identifying diabetic and prediabetic patients preoperatively supports targeted interventions to reduce the risks of complications. Yet, preoperative diabetic screening protocols are not consistently applied. The purpose of this paper is to present an evidence-based practice project examining the influence of implementing a preoperative diabetic screening process in an elective total joint orthopedic patient population. The American Diabetes Association (ADA) Diabetes Risk Screening Instrument was used to assess diabetes risk and guide further testing for adult patients undergoing elective total joint orthopedic surgeries. Throughout the 8-week screening period, a total of 121 total joint orthopedic patients were screened. Of the sample, 55 were undiagnosed and at-risk for diabetes according to the ADA screening instrument. Complete data were collected on this sample. Twelve (21.8%) patients who screened at-risk on the instrument also revealed elevated fasting blood glucose measurements. These patients were identified as potentially pre-diabetic. Eight of the 12 had no family history. Without preoperative screening, the diagnosis of prediabetes would have been missed. The findings of this project support adoption of the ADA screening instrument and further emphasize the feasibility of integration into the preoperative screening process, providing valuable information which contributes to comprehensive patient care.

Implementation of a Diabetes Risk Screening Instrument in the Preoperative Setting for Total Joint Orthopedic Patients

Diabetes is a global concern. From an international perspective, North America is leading globally with the highest number of people with diabetes at 13.03% of the total population and the next highest was the Middle East closely following at a comparative 9.56% (Cho, 2017). The Center for Disease Control (CDC) (2017) reported 23 million diagnosed cases of diabetes in 2015 within the United States. Even more alarming is the nearly quadrupled number of prediabetes cases at 84.1 million compared to diabetes. Among United States (US) adults aged 18 years or older in 2015, 33% were diagnosed with prediabetes and only 10.6% reported awareness. Indicating that over 36% of the population in Virginia are affected, the American Diabetes Association (ADA) (ADA, 2019) reported that 2,213,000 Virginians have prediabetes. Diabetes is partly a preventable disease, that when identified early as prediabetes, can potentially be avoided through evidenced-based screening and managed with lifestyle modifications.

Background and Significance

As the leading cause of diabetes, obesity remains a growing concern and one that deserves attention now and for future generations. Recent projections show the prevalence of overall obesity (identified by a body mass index BMI of greater than or equal to 30), will rise above 50% in 29 states by 2030 and will not be below 35% in any state (Ward et al., 2019). Obesity paired with physical inactivity and poor nutrition has triggered weight gain across the entire age spectrum causing the climbing percentage of our American population to suffer from diabetes and other chronic diseases that result from it: heart disease, impaired renal function, peripheral vascular disease, chronic vision complications, and delayed healing. The above statistics provide a clear realization that prediabetes and diabetes are still developing at excessive rates and even

more concerning is that many Americans are not aware of their metabolic instability, placing them at higher risk for comorbidities and declining health. As a leading risk factor for diabetes, obesity affects the odds ratio of developing both hip and knee osteoarthritis. As the class of obesity increases, so does the relative risk of requiring a joint replacement and therefore, the rate of revision of total hip and knee arthroplasties are projected to increase by 137% and 601% respectively by 2030 (Vasarhelyi & MacDonald, 2012). These climbing number present alarm as an estimated 25% of patients with diabetes will require surgery at some point and 5–10% of patients who present for surgery are found to have previously undiagnosed diabetes (Setji et al., 2017). This raises concern as patients unaware of their diabetes tend to have higher preoperative blood glucose levels and a higher risk of perioperative mortality compared to patients who do have awareness of their diabetes (American Diabetes Association, 2020).

The institutional diabetes education department, orthopedic service, and the accompanying inpatient units caring for the postoperative joint patients were facing challenges of this exact issue; postoperative hyperglycemia potentially contributing to renal insufficiency and increased length of stays as a result of undiagnosed prediabetes/diabetes. Therefore, institutional resources were being leveraged to address opportunities to improve glycemic management. A recent pilot project revealed that out of 47 orthopedic total joint patients screened for diabetes, 36 (75.6%) did not have a current prediabetes/diabetes diagnosis but were identified as at-risk (Smith, 2020). Renal insufficiency and increased length of stay, as well as acute renal failure and postoperative infections, are well-known surgical complications for patients with diabetes, making the above pilot project numbers even more alarming.

Early identification of patients with prediabetes and diabetes allows for earlier intervention and projects a reduction in complications. However, the lack of, or inconsistent use

of, standardized and validated screening instruments allows patients with undiagnosed diabetes to slip through the cracks, complete their scheduled surgery, and face potential challenges with their intra and postoperative recovery due to hyperglycemia. With the growing diabetes prevalence, standardized and valid screening along with appropriate management and timing of elective surgeries for at-risk diabetic patients is critical to improving patient outcomes, promoting a healthy lifestyle, and further reducing risk. Screening for and actively managing diabetes requires more robust discussion and attention. It is the role of researchers and healthcare professionals to aim their focus at increasing awareness in order to diminish disease progression and associated complications.

Both elective and emergent surgeries occur every day in healthcare facilities around the world. To the general population, surgery is viewed as a reproducible, streamlined process, when realistically, there is a myriad of meticulous step-wise components to ensure safe care and positive patient outcomes. A study conducted by Abdelmalak et al. (2010) revealed that a significant proportion (21%) of patients presenting for surgery do not carry a diabetes diagnosis yet are hyperglycemic, and about half of those (10%) have undiagnosed diabetes. Without a standardized screening process, a significant number of metabolically unstable patients, with or without a diagnosis, are being sent to the operating room and exposed to more risks and/or complications both intra and postoperatively as a result of their hyperglycemia. Diabetes alone is a costly disease, but even more costly when preventable complications occur. Complications related to elective surgeries could potentially be reduced if both care team and the patient are given time to make appropriate care adjustments and lifestyle modifications prior to surgery. This could be largely preventable with elective surgeries given the time available to make appropriate care adjustments and lifestyle modifications prior to surgery. Setji et al. (2017)

highlighted that the estimated health expenditures to prevent and treat diabetes and associated direct and indirect complications totaled $245 billion in 2012 with a trajectory to double by 2030. The simplicity of implementing systematic screening creates enormous potential for immense cost savings not only for the healthcare system but for the patient as well.

The cost of the potential complications noted above extend beyond the dollar amount alone and includes the increased demands on nursing resources and personnel. Setji et al. (2017) reported that the odds of patients with diabetes having surgical site infections are 1.5 times greater than those without diabetes. According to the American Diabetes Association (2020) Diabetes Care in the Hospital: Standards of Medical Care in Diabetes, the hospital readmission rate for patients with diabetes is between 14% and 20%, nearly twice that in patients without diabetes, or at best, controlled diabetes. Surgical site infections (SSI) are the leading cause of hospital readmissions following surgery and remain a leading cause of morbidity and mortality after surgery. They require more medical supplies for appropriate management and adequate nursing care and are among the most common preventable complication after surgery, occurring in 2% to 4% of all patients undergoing inpatient surgical procedures (U.S. Department of Health and Human Services, 2019). Labile blood glucose creates instability and increases patient acuity causing increased work effort for nurses and physicians as they attempt to diligently correct largely out-of-range blood glucose levels. Unnecessary and preventable readmissions tax nursing resources and time and require attention of the entire interprofessional team.

Purpose and Clinical Question

The purpose of this evidence-based practice project was to identify best practices for diabetes screening in orthopedic total joint patients and to identify individuals at-risk for diabetes in the preoperative setting. This project will serve as the beginning phase of glucose optimization

by conducting appropriate, evidence-based screening. Each essential component of this initiative was steered by the following clinical question: *In adult patients (19 years and older) receiving an elective orthopedic total joint surgery at an academic medical center (AMC), does the integration of a standardized diabetes screening instrument increase the identification of previously undiagnosed prediabetes or diabetes during the preoperative assessment?*

Definition of Terms

As the population focus was within the orthopedic department, total joint surgery was defined as a surgical procedure in which parts of an arthritic or damaged joint were removed and replaced with some form of prosthesis (OrthoInfo, 2014). In the designated facility, hip and knee surgeries specifically were categorized into the total joint population. Elective surgery referred to a surgery that was scheduled in advance and does not involve a medical emergency. Diabetes screening was defined by the use of an informal assessment of risk factors with a validated instrument, as recommended by the ADA (2020). In this setting, a standardized process was defined as a required part of the preoperative preparatory steps for surgery. The ADA (2020) separates diabetes into three categories based on glycated hemoglobin (HgbA1c) measurements, of which 5.6% and below is considered within normal range, 5.7-6.4% is classified as prediabetic and 6.5% and above designated a full diabetes diagnosis. Comparatively, FBG is similarly defined; <100 mg/dL reflects a normal measurement, 100-125 mg/dL indicates prediabetes, and >125 mg/dL is diagnosed as diabetes. Unstable or labile blood glucose referred to in this project was defined as consistent periods of hyperglycemia.

Conceptual Model for Evidence-Based Practice

The Iowa Model, which guides the implementation of evidence-based practice, structured the development and framework of this project (See Figure 1). The model was initially

developed by a team of nurses at the University of Iowa Hospitals and Clinics to promote quality patient care and assist clinicians in immersing evidence-based research into the care they provided (Iowa Model Collaborative, 2017). In applying this model, the first step is to identify triggering issues and/or opportunities, such as a specific clinical issue or efforts towards a specific organization, state, or national initiative. Determining whether the clinical question and purpose are a priority is a crucial next step, as buy-in from organizational leaders and stakeholders is critical in the development of the initiative. Once the topic is deemed a priority, the next step in the model is to form a team. Considerations should include personnel who are actively engaged in the employment of the specific process or care initiative, as well as comprehensive interprofessional participation from a variety of aspects within the organization. The role of the team is to assemble, appraise and synthesize the evidence through a systematic search of the literature to determine if there is sufficient evidence to support a practice change. The next step, designing and piloting the practice change, is the pinnacle of the model. From resource consideration and developing a protocol to promoting adoption and collecting post-pilot data, this step is the bulk of the model and finalized by determining whether change is appropriate for adoption into practice. In this model, alternative options are considered if change is needed, but otherwise, integration and sustaining the practice change is the next pivotal step in the Iowa model. This step is critical for sustaining change, ensuring that adoption of the change is successful by appropriately connecting and engaging key personnel. Ongoing assessment of the process can be supported by monitoring key measures of the designated change. Disseminating results within the organization as well as publishing findings is the final step in the model and provides an opportunity for results to be shared with collaborating departments and identify lessons learned as support for continued improvement.

Identifying Triggering Issues/Opportunities

Diabetes is a chronic and debilitating, but potentially preventable, disease when identified as prediabetes, that affects 34.2 million people in the United States (CDC, 2017). Diabetes also meets criteria for conditions where earlier detection and awareness is preferred, due to the long pre-symptomatic phase before an official diagnosis is made and individual health has already been impacted (ADA, 2020). Collaborative discussions with the Diabetes CNS and the lead RN at the preoperative clinic highlighted opportunities for patients to be screened prior to their scheduled procedures. A pilot project involving diabetes screening was conducted by the project leader student in March of 2020 targeting the total joint population. Of the orthopedic total joint patients without a current prediabetes/diabetes diagnosis, the results revealed that 76.7% were identified as at-risk for developing diabetes, as noted by an elevated score on the ADA screening instrument. These findings revealed an opportunity to explore a practice change.

Form a Team

The project took place at a single, nurse-run clinic within an academic medical center in central Virginia. The walk-in, preoperative clinic assesses patients before their scheduled surgical day, per the physician request. The visit includes time spent educating and preparing patients for surgery, collecting any required lab work, and conducting any other necessary tests and consultations. On average, the clinic receives 5 to 10 total joint patients per day with the majority of the patients being 60 years of age or older. The clinic staff consists of 10 registered nurses, four administrative personnel who support front desk operations as well as chart preparation for surgery, and three laboratory technicians. There are three orthopedic surgeons who service the total joint patient population within the health system.

The medical center as a whole is highly invested in quality improvement and evidence-based practice initiatives that yield positive patient outcomes and cost savings to the facility and patients. Collaboration amongst the facility's diabetes Clinical Nurse Specialist (CNS), data analyst, and the preoperative clinic lead RN evolved as part of a pilot project conducted within the preoperative clinic in previous months by the project lead. Additionally, there is strong departmental interest in enhancing glycemic management across the spectrum of the surgical setting and as part of the institutions Total Joint Certification, glucose control was and continues to be evaluated as part of the proposed improvement plans, although not a requirement for the certification itself. Discussions of a multifaceted glycemic management project in the operative setting supported this collaboration between stakeholders within the Orthopedic and Diabetes/Endocrine Department.

Assemble, Appraise, and Synthesize Body of Evidence

Assemble the Relevant Literature

An evidence review was conducted to assess the scientific findings surrounding preoperative diabetes screening and its impact on identifying patients who screen at increased risk for prediabetes or diabetes. To identify the literature, a search was executed using PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Web of Science, and Cochrane Library. There were no limits placed on publication type in any of the databases. Additionally, similar search terms and limiters for each database review were used, as feasible. Figure 2 presents the comprehensive search in a PRISMA format.

PubMed was searched using the advanced search options. "Diabetes" was added to the query box first. "Screening" and "preoperative" were added to the query box with the dropdown selection of "Add with AND". Before filters were added, this search yielded 192 results. The

following filters were added: publication in the last 10 years, English language, and ages “Adult 19+”. This search retrieved 82 results.

CINAHL was searched using the advanced search tool. Within search modes and expanders, “Find all my search terms” and the expander option “apply equivalent subjects” were checked along with the box “Suggest Subject Terms”. The initial search consisted of three independent keyword searches. The term diabetes was searched. When the CINAHL Subject Headings page was prompted, Diabetes Mellitus, Type 2 was selected as well as diabetes (search as keyword). No additional subheadings were selected. Under combine selections with, the word OR was checked. Of note, the selections being combined (with “OR”) were Diabetes Mellitus, Type 2, and diabetes. This search “(MH "Diabetes Mellitus, Type 2") OR "diabetes" yielded 191,353. The advanced search was next used in searching the keyword screen*. As noted with the screen keyword search, a wildcard was used for this term only in order to retrieve word variations and yielded 185,463 results. Lastly, preoperative was searched as a keyword and yielded 55,960 results. Of note, when utilizing a hyphen for the term preoperative, minimal results were yielded. For comparison, when searching without the hyphen, the results yielded were significantly higher, hence the decision to utilize no hyphen within the CINAHL search. For the final search, all three individual searches were checked and “search with AND” was selected. The following filters were applied: English language, All Adult, and published within the last ten years (2010-2020). This final search yielded 29 results.

The Cochrane Library’s advanced search was used combining the terms diabetes AND screening AND preoperative with a filter that limited articles published in the last 10 years (2010-2020). Title Abstract Keyword dropdown was selected as part of the search criteria. Word

variations were searched as part of the search criteria. This search retrieved 23 articles that were solely trials.

Web of Science basic search tool was used for a keyword search of *diabetes, screening, preoperative*. More results were yielded when utilizing a hyphen for the term preoperative compared to searching without the hyphen. The 'add row' option was selected between each of the above keywords, combining them with AND prior to conducting the search. The 'years of publication' filter was set to limit records published within the last 10 years (2010-2010). 'English' was the only language option available for selection, which was the preferred language and did not change the number of results retrieved. This search yielded 20 results.

The total number of articles between the four databases yielded 154 results. Four articles were duplicated between the designated database reviews. The total pool of articles collected in the review was 150 after the removal of duplicates. Titles were reviewed based on inclusion criteria of preoperative, screening or diabetes as well as relevance. A total of 132 records were excluded, leaving six records retained within CINAHL, three within Cochran Library, five within Web of Science and four within PubMed. The large title exclusion was explained by 79 sources solely focused on postoperative cardiac surgery complications with no focus on diabetes screening or recognition; 30 sources were directed at screening for diseases other than diabetes and 23 sources addressed diabetes complications. These exclusions left 18 records for abstract review.

The abstract review resulted in the retention of nine articles for full text review: four sources within CINAHL, two from Web of Science, and three from PubMed. No sources were retained from Cochrane Library. The nine records excluded did not meet relevance to the PICOT question: two articles were largely focused on overall surgical optimization; four were targeted

towards the management of diabetes, rather than screening; two records screened for other disease processes and not diabetes; and one record was a clinical trial that had not yet concluded.

Appraisal and Synthesis

Summary of Literature Search

A full-text review of nine records was completed and resulted in two records being excluded. Exclusion was due to the following reasons: optimization of a preoperative protocol by evaluating 19 separate risk factors with minimal focus on diabetes; impact of preoperative glycemic status on one-year postoperative functional recovery with a larger focus on functional rehabilitation and recovery and less about early recognition and health promotion. These exclusions resulted in seven remaining records for analysis. Of those, two were from CINAHL, three within PubMed, and two from Web of Science. Additionally, an ancestry search was conducted incorporating the reference lists from the final seven articles to acquire relevant sources. This resulted in the addition of one record. An additional two records were added as input from expert consultation in the diabetes practice realm. Items added from the ancestry search met the above inclusion criteria. There was a total of 10 records retained for analysis.

Method of Literature Analysis

The analysis of the 10 remaining articles was conducted in a systematic approach utilizing the John Hopkins Nursing Evidence-based Practice Model (See Figure 6). Each article was critiqued with the appropriate appraisal tool based on the study and type of research being conducted. The level and quality grading were assigned after extensive critique. Records that received a quality "C" rating were removed from the evidence-based review pool, reducing the pool to nine records (See Table 1: Literature Table). The lowest level of evidence was a level four, quality A with the highest at a level two, quality A. The records consisted of primarily case-

control and cohort studies, a single systematic review, one quasi-experimental study, and clinical practice guidelines. A thematic approach was taken in analyzing the evidence. The following five themes were identified to evaluate the implications of preoperative diabetes screening: preoperative HgbA1c level and diabetes prevalence, FBG and diabetes prevalence, diabetes risk factors and screening, postoperative complications, and cost.

Identified Themes

Preoperative HgbA1c

Preoperative HgbA1c level was a common method used in assessing diabetes prevalence amongst a variety of surgical populations. Out of the nine records analyzed, seven of them measured HgbA1c levels when evaluating the glycemic status and diabetes prevalence within a surgical population. Capozzi et al. (2017) found that out of 663 patients presenting for elective total joint arthroplasty (TJA), 223 (33.64%) were found to have previously undiagnosed dysglycemia, which was defined as having a HgbA1c of 5.7-6.4 (pre-diabetic) or >6.5 (diabetic) and followed ADA diagnostic criteria. Of those, 206 fell into the pre-diabetic range and 17 within the diabetic range. When comparing mean HgbA1c levels between patients with a known history of dysglycemia (6.52%), newly diagnosed pre-diabetics (5.91%) and newly diagnosed diabetics (7.05%), there was statistical significance in HgbA1c levels between known dysglycemic patients and previously undiagnosed dysglycemic groups ($p<.0001$).

Although not specifically focused on the surgical population, the American Diabetes Association (ADA) Standards of Care (2020) stated that fasting plasma glucose, 2-h plasma glucose during a 75-g oral glucose tolerance test, and HgbA1c are equally appropriate in diagnosing prediabetes and/or diabetes. The literature also pointed out that when using HgbA1c to diagnose diabetes, it is important to recognize that HgbA1c is an indirect measure of average

blood glucose levels and other factors need to be considered that may impact the measurement independently of glycemia, such as hemodialysis, pregnancy, HIV treatment, age, race / ethnicity, pregnancy status, genetic background, and anemia/hemoglobinopathies (ADA, 2020). Additionally, the ADA (2020) highlighted that HgbA1c has several advantages compared with FBG and OGTT such as greater convenience (fasting not required) and less day-to-day influences during stress, diet, or illness. From a diagnostic perspective without respect to surgery, the ADA Standards of Care for Classification and Diagnosis of Diabetes (2020) clarified that unless there is a clear clinical diagnosis, a confirmed diagnosis requires two abnormal test results from the same sample or in two separate test samples. If using two separate test samples (HgbA1c or FBG), it is recommended that the second test, which may either be a repeat of the initial test or a different test, be performed without any delay. For example, if the HgbA1c is 7.2% and a repeat result is 6.9%, the diagnosis of diabetes is confirmed. If two different tests (such as HgbA1c and FBG) are both above the diagnostic cut point when analyzed from the same sample or in two different test samples, this confirms a diabetes diagnosis. On the contrary, if a patient has conflicting results from two different tests, then the test result that is above the diagnostic cut point should be repeated. If a patient meets the diabetes criteria of the HgbA1c (two results of 6.5% but not FBG (>126), that person would be diagnosed with diabetes.

In a study completed by Hopkins et al. (2017), a glycemic control initiative was implemented among gynecologic oncology patients with an effort to reduce surgical site infections (SSI). HgbA1c measurement was the primary outcome of the intervention and a secondary outcome measure was identifying newly diagnosed diabetics. Of the 297 patients evaluated in the initiative implementation, 104 patients (35%) had a recorded HgbA1c of >6.0%, with 47 (45%) of those being newly identified as pre-diabetic (HgbA1c 6.0-6.4%) and 11 (11%)

being newly diagnosed (HgbA1c >6.5). It's important to highlight that the pre-diabetic HgbA1c range was not congruent with the ADA criteria of 5.7-6.4%, which could have excluded some patients whose HgbA1c was 5.7-5.9%. Although not focused on postoperative infections, Koupman, VanDenKerkhof, and Vylmen (2014) conducted a similar study to assess HgbA1c screening for elective surgical patients without a history of diabetes. Of the 332 patients without a history of diabetes, 77 (23.2%) were considered very high risk for diabetes (HgbA1c 6.0-6.4%) and 13 (3.9%) had a provisional diagnosis of diabetes (HgbA1c > 6.5%) when utilizing HgbA1c to assess glycemic status prior to surgery. Of the 70 known diabetics, 39 (56%) had suboptimal glycemic control, defined at HgbA1c greater than or equal to 7.0%. Twenty (51.3%) of those 39 patients falsely assumed their blood sugar was reasonably controlled. Another study utilizing HgbA1c to evaluate the prevalence of dysglycemia evaluated coronary bypass surgery patients and discovered that out of 1045 patients, 415 (40%) patients had a known history of diabetes and of more concern, 630 (60%) had no known history of diabetes. Of those without known diabetes, 356 (56.5%) had an HgbA1c in the "increased risk for diabetes" range and 67 (10.6%) patients had an HgbA1c in the diabetes range, both based on the ADA diagnosis criteria as discussed previously (McGinn et al., 2011). Overall, this same study revealed that out of all 1045 pre-surgical cardiac patients, the frequency of dysglycemia was high in that 838 (80%) of them had either a history of known diabetes or an elevated HgbA1c (>5.7%) at the time of surgery. A study by Shohat et al. (2018) took a similar approach in assessing the role of diabetic screening in patients undergoing TJA in order to determine the rate of undiagnosed prediabetes/diabetes. Diabetes was prevalent in 301 patients, which was nearly 20% of the entire sample population (1461). Of the 301 diabetes cases, 123 (40.9%) of them were undiagnosed and 178 (59.1%) had diagnosed diabetes. In evaluating prediabetes cases, 559/1461 patients were classified as pre-

diabetic based on ADA diagnostic HgbA1c criteria. There was a statistically significant difference between patients with diagnosed and undiagnosed diabetes when using HgbA1c (p=.001) as a diagnostic tool compared to FBG (p=.91).

There were notable strengths and limitations identified from the above evidence. Two of the studies had a narrowed pre-diabetic cut point (6.0-6.4%) which did not mimic the ADA diagnosis criteria regarding HgbA1c range of 5.7-6.4%, indicating that even more patients could have been categorized as high-risk or given a diagnosis of prediabetes. Additionally, some of the studies discussed targeted specific patient populations whereas others were widely broad, making generalizability of results a consideration when deciding to reproduce similar studies or implement researcher recommendations. On that same note, a grouping of studies either focused on TJA patients or cardiac patients and one evaluated the gynecological population. Although several other studies simply excluded cardiac patients only, the remaining participants consisted of a potentially diverse population but remained to show a large prevalence of undiagnosed prediabetes/diabetes by way of HgbA1c values. The use of HgbA1c as an assessment of preoperative glycemic status identified large numbers of patients with prediabetes and diabetes who were unaware of their metabolic function. Bringing a preventable diagnosis to the attention of any patient allows for modifiable risk factors to be altered by the individual. As a commonly asymptomatic chronic disease, the studies pointed out that the use of HgbA1c to identify dysglycemia allows for a longer-term view of glycemic stability/instability.

Fasting Blood Glucose (FBG)

As a common comparison in measuring glycemic status, FBG was often used in conjunction with HgbA1c to assess glycemic status in the operative setting but was also utilized alone in some studies. Five of the nine records utilized FBG either alone or in conjunction with

HgbA1c. Abdelmalak et al. (2010) conducted a study in order to estimate the prevalence of undiagnosed diabetes among non-cardiac surgery patients and to determine mean glucose concentration. Of the 39,434 patients analyzed, 5,511 were (14%) were previously diagnosed as having diabetes while 3,426 (10%, 95% CI 9.8-10.4%) of the remaining 33,923 nondiabetics (previously undiagnosed diabetics) had FBG >126. Another 3,549 (10.5%, 95% CI 10.1-10.8%) had FBG >110. In total, 6,975 (21%, 95% CI 20.1-21.0%) patients in the non-diabetic group presented with abnormally high glucose, a FBG of at least 110 or greater. There was a statistically significant difference ($p<.001$) when comparing preoperative FBG levels of previously undiagnosed diabetics with known diabetics (161 vs 146 respectively). The ADA Standards of Care for Classification and Diagnosis of Diabetes (2020) recommends that in conditions associated with an altered relationship between HgbA1c and glycemia, such as sickle cell disease, pregnancy, glucose-6-phosphate dehydrogenase deficiency (G6PD), Human immunodeficiency virus (HIV), hemodialysis, recent blood loss or transfusion, or erythropoietin therapy, only plasma blood glucose criteria should be used to diagnose diabetes. As stated previously, the American Diabetes Association (ADA) Standards of Care (2020) clarifies that fasting plasma glucose, 2-h plasma glucose during a 75-g oral glucose tolerance test, and HgbA1c are equally appropriate in diagnosing prediabetes and/or diabetes, but are dependent on an appreciation of underlying conditions that may confound the results.

Koupman, VanDenKerkhof, and Vylmen (2014) utilized HgbA1C, random blood sugar (RBS), and FBG in their study to determine the adequacy of recent glycemic control among diabetic patients and the validity of random blood sugar (RBS) and fasting blood glucose (FBG) testing (using HgbA1c as the gold standard) to identify patients with suboptimal glycemic control in patients with no history of diabetes. RBS and FBG were collected during the

preoperative assessment and day of surgery, respectively. Of the previously undiagnosed diabetic patients (labeled as non-diabetic) with a HgbA1c >6.5, 8/12 (66.7%) of those patients had an elevated FBG (>126) on the day of surgery. When evaluating the previously diagnosed diabetic patients, 31/36 (86.1%) diabetics with suboptimal glycemic control (HgbA1c >7.0) had an elevated FBG (>126) on the day of surgery, both indicating similar diagnostic trends with HgbA1c measurements taken during the preoperative assessment. Sheehy et al. (2012) found that 67/275 elective orthopedic (TJA or lumbar decompression and/or fusion) patients (24%) were recognized as newly diagnosed diabetic or pre-diabetic and 50/275 (18%) had known prediabetes/diabetes based on two fasting blood glucose values obtained on the day of surgery and then again at a postoperative follow-up appointment (six to eight weeks apart). Of the newly diagnosed prediabetes/diabetes patients, 8/67 (12%) were diabetic and alarmingly, 59/67 (88%) were pre-diabetic. The second preoperative (day of surgery) FBG of >100 predicted visit three (postoperative follow up) FBG >100 64% of the time. Seventy-two percent of the time, the second preoperative (day of surgery) FBG >100 and HgbA1c >5.7% predicted a postoperative visit FBG >100, showing parallel patterns with both tests. Shohat's et al. (2018) study fell short of statistical significance (p =.91) when comparing preoperative FBG between diagnosed and undiagnosed diabetic patients, 141.2 and 141.7 respectively. Conflicting statistical significance (p=.005) was then revealed between the same groups respectively with postoperative day one FBG results, 147.3 and 133.1.

The use of FBG in identifying patients at-risk for diabetes revealed some strengths and limitations within the studies taking this approach. Many of the studies above did not use FBG alone as a solo diagnostic method; HgbA1c was often used as a comparison or a dual approach in identifying dysglycemia, which reveals a gap in the literature of FBG alone being a strong

diagnostic tool. Additionally, there was inconsistency regarding statistical significance when comparing FBG results between known and unknown diabetics rising concern for the lack of consistency and predictability of the diagnostic test. From the dual approach, when using HgbA1c as a comparison, FBG measurements matched ADA diagnostic criteria in the presence of elevated HgbA1c scores.

Risk Factors for Diabetes Screening

Several authors conducted risk factor screening in some manner as an essential segment of the surgical screening process in all the records analyzed. According to the ADA Standards of Care for Classification and Diagnosis of Diabetes (2020), screening for prediabetes and diabetes risk through an informal assessment of risk factors or with an assessment tool, such as the ADA risk test is recommended to guide providers on whether performing a diagnostic test is deemed appropriate. Screening for prediabetes/diabetes with an informal assessment of risk factors or validated tools should be considered in asymptomatic adults. Additionally, testing for prediabetes/diabetes in asymptomatic people should be considered in adults of any age who are overweight or obese and who have one or more additional risk factors for diabetes. When evaluating risk factors within the study population, Abdelmalak et al. (2010) adjusted for the following risk factors: Body Mass Index (BMI), age, sex, and American Society of Anesthesiologists (ASA) physical status, revealing that the higher preoperative blood glucose values of undiagnosed diabetics (160.9) compared to known diabetics (145.8) was statistically significant ($p < .001$). Additionally, a higher FBG in undiagnosed diabetics was associated with older age and patients with FBG <110 had a significantly lower BMI compared with the higher FBG ($p < .001$). The author made note that patients with FBG <110 were more commonly female and mean ASA physical status increased as the FBG increased. The pairwise comparisons

between FBG <110, FBG between 110-126 and FBG >126 differed significantly relative to age, BMI, female sex, and ASA physical status ($p < .001$). Abdelmalak's et al. (2010) study highlighted that as a whole, BMI, age, sex, and ASA physical status were significant predictors of FBG >126 for undiagnosed patients as evidenced by the odds ratio (OR) (95% CI) of 1.17 with an increase of 10 years in age ($p < 0.001$), 1.12 with a BMI increase of five ($p < 0.001$), 0.73 for females compared to males ($p < 0.001$), and 1.81 with an increase of one in ASA category ($p < 0.001$). Although an official tool was not utilized, Capozzi et at. (2017) evaluated comorbidities as part of the retrospective review of the 663 electronic health record, which revealed that 404 (60.93%) patients had hypertension, 133 (20.06%) had hyperlipidemia, 67 (10.11%) had hypercholesterolemia and 91 (13.72%) had cardiovascular disease, all of which are highlighted as criteria for further diagnostic testing in asymptomatic adults, according to the ADA Standards of Care for Classification and Diagnosis of Diabetes (2020). Hopkins' et al. (2017) quasi-experimental study included consideration of BMI, age, and smoking history part of data collection in their glycemic control initiative and impact on SSI. In undiagnosed diabetes, when comparing the BMI of those who did and did not experience postoperative wound infections, the BMI was higher in patients who experienced infections (39.0 vs. 30.8, $p < .001$). With the same comparison, known diabetics showed a trend towards experiencing a wound infection but lacked statistical significance ($p = .111$).

Koupman, VanDenKerkhof, and Vylmen (2014) utilized an informal questionnaire to collect demographics and assess diabetes risk factors and comorbidities of each study participant. Other data collected from a preoperative assessment were age, sex, BMI, blood pressure, and surgery type. Utilizing this information, a modified form of the Canadian Diabetes Risk Assessment Questionnaire (CANRISK) was used to categorize participants into diabetes risk

categories. This questionnaire evaluated the 10-year risk of developing diabetes based on how participants were categorized according to their HgbA1c results. The tool ranged from 0-16, with upper and lower limits of: score <6 defined as 1/100 patients will develop diabetes and a score of >16 meaning one out of every two individuals will develop diabetes, with three additional risk categories in between. In an evaluation of non-diabetics at very high risk (score >16) for developing diabetes (HgbA1c 6.0-6.4%), 37/76 (48.7%) fell into the ‘‘slightly elevated’’ risk group (1/25 chance of developing diabetes), and 25/76 (32.9%) fell into the ‘‘moderate’’ risk group (1/6 chance of developing diabetes). Among non-diabetics with a provisional diagnosis of diabetes (HgbA1c >6.5%), 7/13 (53.8%) were labeled in the moderate risk category, while only 3/13 (23.1%) were in the ‘‘high’’ (1/3 chance of developing diabetes) or ‘‘very high’’ risk groups, which was identified as the highest category and defined by a 50% chance of developing diabetes. McGinn’s et al. (2011) study included an informal assessment utilizing the 2010 ADA guidelines for HgbA1c to identify cardiac surgical patients with potential dysglycemia. Review of these characteristics showed that the average BMI increased significantly with increasing HgbA1c measurement ($p = 0.031$). Although not an official characteristic of the referenced ADA characteristics, the number of vessels requiring revascularization was evaluated and determined that those whose HgbA1c indicated a diabetes diagnosis had more vessels vascularized (mean 3.6) than the participants who were prediabetic or had normal HgbA1c levels (mean 3.1, $p = 0.009$). Along with basic demographics, Sheehy et al. (2012) included an ADA risk factor-focused questionnaire which also consisted of clarifying questions regarding previous history of prediabetes/diabetes. Comparisons were made between normoglycemia and new prediabetes/diabetes which revealed that patients with new prediabetes/diabetes were somewhat older than normoglycemia patients (62.37 vs. 58.08, $p = 0.0054$), which met the ADA diabetes

screening age of 45 significantly more frequently than normoglycemia patients (100% vs 84%, $p < 0.001$). Another study utilized an unidentified but standardized questionnaire to assess age, sex, race, comorbidities, and confirmation of a previous or current prediabetes/diabetes diagnosis. BMI was also calculated as part of preoperative screening. Out of all diabetic patients (known or undiagnosed diabetes), diabetes prevalence was higher in patients older than 65 years of age (27%), the non-white population (26.7% blacks and 25.7% other race), and patients who received a total knee arthroplasty (25.9%) rather than a total hip arthroplasty (Shohat et al., 2018).

In regard to risk factor identification, the collective view of the studies identified minor limitations and obvious strengths. Abdelmalak's et al. (2010) study made clear that there were missing values when calculating BMI (up to 20% of data missing in at least one category) and age (up to 11% of data missing in at least one category) which could have impacted the significance of the results (this limitation was only identified in one study). Although the majority of the studies did not provide the actual screening questionnaires utilized to gather risk factor and demographic data, United States-based studies made mention to the fact that risk factor data collection was based on ADA guidelines for screening, which provides a central point of reference for overall diabetes screening conducted within these studies and consistency throughout.

Postoperative Outcomes/Complications

Postoperative outcomes and/or complications linked with metabolic status and glycemic management were common associations evaluated in the records analyzed. As secondary outcomes, Capozzi et al. (2017) evaluated the effect of glycemic status on 90-day readmissions, which showed that 55/663 patients had 61 total readmissions within 90 days from their surgery

date, but lacked statistical significance (p = .612). Postoperative length of stay was also assessed, which was statistically significant when comparing the dysglycemic group (average LOS 3.89 days) with the previously unknown dysglycemic group (average LOS 3.32 days, p = 0.028) and when compared to the non-diabetic group (average LOS 3.31, p = 0.014). Hopkins et al. (2017) took a similar approach when evaluating the effect of a glycemic control initiative and its impact on SSI. The group enrolled in the glycemic control initiative had significantly lower SSI than the control group (5.7% vs. 14.6%, p = 0.001, adjRR: 0.45, 95% CI (0.25-0.81)). Potential confounders (age, obesity, open surgery, bowel resection, and prior diabetes) were controlled for and revealed a 55% relative risk reduction of SSI overall. BMI >30 was also a significant risk factor for the occurrence of SSI (p < 0.001). Karimian's et al. (2018) systematic review concluded that four out of the six studies included in the analysis showed consistency among the association between higher HgbA1c measurements (> 6.0%) and increased rates of postoperative complications. Of the four studies within their review that included postoperative infection as an outcome measure, three of them showed no association between infection rates in the postoperative period and elevated HgbA1c in the preoperative assessment; only one study revealed statistical significance (Karimian et al., 2018). The study conducted by Shohat et al. (2018) took a similar focus in evaluating periprosthetic joint infection (PJI) and wound complications in regards to HgbA1c measurement and found that 14 out of the entire cohort of patients (1461) had PJI (1.0%) and 69 of the 1461 experienced some type of wound complications (4.7%), neither reaching statistical significance. When breaking down the cohort between diagnosed and undiagnosed patients, the rates for both trended in a similar fashion; rates (p = 1.0) for PJI and wound complications for diagnosed diabetics (1.7% and 5.1%, respectively) and undiagnosed diabetics (1.6% and 4.9, respectively) were not significant.

The studies reviewed made valid considerations when evaluating postoperative complications and association with glycemic control. Because of the variety and number of incidents that can be included when discussing postoperative complications (ex: infection, wound dehiscence, etc.), consideration should be made to the evidence found in this review in this regard. Although valid, several factors must be considered when replicating such studies, such as population, type of surgery, length of surgery, individual risk factors (other than HgbA1c alone), demographics, etc. The study by Hopkins et al. (2017) was the solo quasi-experimental study that carried strength in that the initiative was not only focused on HgbA1c measurement but glycemic control that managed blood glucose with various pharmacological interventions and monitoring from the preoperative thru operative setting and throughout the postoperative timeframe. Additionally, confounding factors were controlled for prior to reporting the true SSI rates. Although statistically significant associations were found with glycemic status in some aspects of the remaining studies, results should be perceived with caution in that many factors have the potential to be a contributing factor to a postoperative complication whether that be a SSI, sepsis, wound dehiscence, readmission, or a number of other complications. It must be considered that HgbA1c may only be a fraction of the cause and that another physiological aspect could be contributing.

Cost

Cost along with return on investment are key points of implementing a change in practice and require close assessment and consideration in process improvement within patient care. With that, the cost of screening was not addressed as a primary or secondary outcome in any of the studies. In support of the studies utilizing HgbA1c as part of the diabetes screening method, the cost of the test itself in comparison to alternative implications of not testing was discussed. The

cost-effectiveness of screening all patients using HgbA1c is a valid question. After determining that the number needed to screen in order to identify a person with undiagnosed diabetes was only two, Shohat et al. (2018) calculated that the cost for a single HgbA1c test at their designated facility was $13.30. Given that explanation, at a total cost of $26.60, they would be able to diagnose a person as either pre-diabetic or diabetic. Shohat et al. (2018) made the cost comparison of screening the entire cohort at $17,063 versus the direct cost of treating a single periprosthetic joint infection at a range of $68,053 to $107,264 and the future indirect cost ranging from $389,307 to $474,004. Capozzi et al. (2017) pointed out that the average cost of a HgbA1c test without insurance coverage ranges from $22-$65, which is more costly than FBG. When comparing that cost to the cost required to manage the issues of undiagnosed diabetes and prediabetes, which are $4030 and $510 per case, respectively, the $22-$65 seems minimal. As cost is always a high priority within clinical practice, this cost comparison is only one of many financial equations that suggest that screening is financially beneficial to both the patient and healthcare facility when the cost of immediate and long-term care due to complications is matched against it.

Publication Bias Evaluation

In order to address the concern of publication bias, a grey literature search was conducted within Google Scholar section “Find articles with all the words” by searching the following terms: Diabetes preoperative screening. After a review of the first 10 results, there was no evidence of publication bias based within the gray literature. The findings in the gray literature were consistent with the findings revealed from the systematic review. The common themes identified within the grey literature consisted of: opportunities for diabetes screening in the

preoperative period, effects of preoperative glycemic control on postoperative outcomes, and the importance of screening in undiagnosed populations.

Limitations

There were limitations to this evidence review. Within all four databases utilized, all searches were limited to English language only. Additionally, “all adult” was selected and the search of records was restricted to a publication date from within the last 10 years. Placement of these filters within the database searches could have eliminated records that would have yielded additional supportive evidence. Diabetes is a leading chronic disease within the United States and has been studied heavily and frequently within the public health arena. Because of that, a limited publication date range was deemed appropriate and intended to yield the most up-to-date evidence. As the term adult typically identifies persons 18 years of age or older, this was a limitation within the database searches as the adult population filter was defined as 19 years and older. This limitation could have excluded studies that included patients aged 18 years old. This was not deemed as a significant limitation as the studies included in the evidence review mostly targeted middle-aged patients.

Discussion

As the question driving this review targets the total joint population, it’s important to recall that over 1,053,000 TJA surgeries are completed in the United States each year. Opportunistic screening of this population could identify 252,720 patients with prediabetes or diabetes who could otherwise remain undiagnosed and develop more chronic illness as a result of diabetes (Sheehy et al., 2012). The majority of the studies discussed the use of questionnaires focused on ADA-identified risk factors along with other demographic data in identifying patients who were at risk if they did not already have a diagnosis of diabetes. This consistent approach

identified in the review of literature provides clarity that screening evaluations/questionnaires are essential components of the evaluative process to appropriately identify what patients should receive further diagnostic testing to confirm or refute a diagnosis. Additionally, conclusions drawn from the literature made it clear that FBG and HgbA1c are both effective as diagnostic tests, but each have preferred and non-preferred uses depending on timeline and setting. To elaborate, FBG can be impacted by stress and/or recent food intake, which could impact the day of surgery testing as many patients can be anxious or stressed in this setting, providing a false or inaccurate measurement. FBG can provide an accurate picture of glycemic status if fasting protocol is followed and the setting in which the patient is being tested can accurately capture a true FBG. FBG is convenient and there is limited concern in regards to coverage from insurance coverage, while many companies do not routinely cover HgbA1c expenses as compared to FBG. Although not affected by stress, HgbA1c can be altered by blood loss, transfusions, and other factors that can be seen during surgery and hospitalization, but are also not typical concerns in the preoperative setting. As HgbA1c provides a better picture of glycemic control and is not impacted by fasting status, it is a more convenient test to be incorporated into the primary care setting as other preoperative labs are simultaneously being drawn in the weeks prior to surgery. Confirmation could be made with a repeat HgbA1c test on the day of surgery or during a postoperative follow-up appointment. HgbA1c testing also allows for progressive tracking. Because the surgeries are elective in nature, there is often lag time between the preoperative screening and the surgery date. This dwell time prior to surgery could allow for the optimization of glucose control via medication management and lifestyle and diet modifications. Depending on HgbA1c measurement, it could potentially indicate the need for postponement of surgery until the blood glucose levels have been deemed controlled and safe for surgery.

In following the guidelines for diabetes-based care provided from the ADA (2020) Diabetes Care in the Hospital: Standards of Medical Care in Diabetes, regardless of how screening is implemented, a diagnosis of diabetes is confirmed if both HgbA1c and FBG are elevated beyond the diagnostic cutoff when analyzed from the same sample or in two different test samples. For example, if the HgbA1c is 7.0% and a repeat result is 6.8%, the diagnosis of diabetes is confirmed. If two different tests (such as HgbA1c and FBG) are both above the diagnostic threshold when analyzed from the same sample or in two different test samples, this also confirms the diagnosis. The consistent guidance across all records in the literature review highlighted the importance of assessing glycemic status in preoperative screening using an approved strategy. Because the review was directed towards best practices for identifying patients at risk for diabetes preoperatively, the literature led to either HgbA1c or FBG (or a combination of both) as valid options for screening as long as repeat testing is completed as described above for diagnosis confirmation. Overall, the best approach is determined by evidence-based practice as it can be supported by the setting and clinicians in the context of the patient population.

Literature Review Conclusion

The purpose of this systematic review was to address the evidence-based practice question of: In adult patients (19 years and older) receiving an elective orthopedic total joint surgery at an academic medical center (AMC), does the integration of a standardized diabetes screening instrument increase the identification of previously undiagnosed prediabetes or diabetes during the preoperative assessment? In summary of the thematic analysis, the identified themes are all very impressionable in the effort to recognize undiagnosed diabetes: reducing postoperative complications, reducing cost to the healthcare facility and the patient, and utilizing

guideline-driven diagnostic testing after simplistic demographic and risk factor screening. The prevalence of undiagnosed diabetes continues to climb given the asymptomatic nature of the beginning stages of diabetes. To systematically address diabetes as a growing public health concern, the preoperative assessment is an opportune time to screen for diabetes. The ADA (2020) clearly states that diabetes can be diagnosed by more than one type of test, but considerations must be made in particular clinical situations and individual circumstances. The literature in this review largely consisted of cohort and case-control studies assessing the prevalence of diabetes which provided clear guidance in answering the research question. Recommendations for additional research are largely focused on the impact of glycemic control on postoperative outcomes. In that regard, more experimental research would lend insight to the effectiveness of implementing a structured glycemic control protocol for the entire surgical process, from preoperative through postoperative follow-up, as Hopkins et al. (2017) did in their study when evaluating the impact of glycemic control on SSI. Regardless of HgbA1c or FBG measurement as a test choice, undiagnosed diabetes was evident in a variety of surgical populations and identified as a modifiable risk factor to improve surgical outcomes and overall health, bringing awareness to this potentially preventable chronic disease. This review emphasized the magnitude of undiagnosed diabetes, the risk that accompanies it, and most importantly, the appropriate nature of testing for earlier diagnosis and promptly implementing risk factor reduction.

Design and Pilot the Practice Change

Based on the literature review findings identified above, an EBP project was designed. Prior to project commencement, submission of the project specifications to the institutional review board approval was completed and the board determined that it was evidence-based

practice (EBP). Additionally, support was garnered from the preoperative clinic and surgical suite staff as well as the team of orthopedic total joint surgeons and clinical support staff. Continuous collaboration with the Diabetes Clinical Nurse Specialist (CNS), Quality Improvement team lead, and the ordering Orthopedic Physician Assistant was active in all phases of the project development and implementation.

Setting and Sample

The EBP project was implemented among a cohort of elective total joint orthopedic patients within a preoperative clinic, located in an academic medical center in the southeastern part of the United States. The medical center consists of 600+ inpatient beds and averages 100 surgical cases per day. A remarkable portion of surgical cases are orthopedic in nature and under the umbrella of the orthopedic department, numerous orthopedic clinics are situated across the medical center campus. One orthopedic clinic that focuses on the management of patients with hip and knee conditions served as the entry point for patients undergoing elective total joint replacement surgery. Once patients were seen and evaluated here, they then were referred to the preoperative clinic, which serves as a funnel for most surgical patients, in order to conduct a comprehensive preoperative screening prior to the scheduled surgical procedure. The clinic consists of seven patient screening rooms and three laboratory stations. The clinic operates Monday through Friday. On average, the clinic services between 5-10, total joint orthopedic patients per day and more an than 75% are over the age of 65. All adults aged 19 years and older receiving an elective total joint (knee or hip) surgery were screened as part of their preoperative assessment appointment. Patients were not seen the day immediately prior to surgery and most visit the clinic to undergo screening no later than 3-5 days prior to surgery. Patients receiving preoperative screening at any location other than the preoperative clinic were excluded. Patients

who had a pre-existing prediabetes or diabetes diagnosis were noted in data collection but separated from the targeted at-risk population.

Measures

Verifying validity of the ADA Risk Screening Instrument, Bang et al. (2009) conducted a study that evaluated its validity and compared it with other available screening instruments. Defined characteristics were evaluated and all found to be statistically significant in their association with identifying undiagnosed diabetes. Those characteristics included age, sex, family history of diabetes, history of hypertension, obesity and physical activity, all of which are included as items on the ADA Risk Assessment Instrument. As part of the study, separate analyses were completed to assess the impact of the individual risk factors when determining diabetes risk. In particular, one analysis assessed patients 45 years and older (as is the age threshold recommended by the ADA for universal screening) and found a sensitivity of 88% and specificity of 40% for detecting diabetes. In the pilot study conducted by the project lead, 35 of the 36 patients (97.23%) that screened at-risk were 45 years or older supporting the ADA guidelines for universal screening based on age (Smith, 2020). Additionally, Bang's et al. (2009) study utilized FBG to define diabetes which reflected a sensitivity of 88% and specificity of 40% for participants aged 45 years or older. The study also evaluated the use of HgbA1c in detecting diabetes in a separate analysis, which revealed 80% sensitivity and 63% specificity. Sensitivity and specificity were evaluated regarding patients 45 years and older specifically if the cut point were to be at a score of four rather than five which yielded a higher sensitivity (97%) but a significantly lower specificity (20%). This reduced cut point was also evaluated when utilizing HgbA1c and revealed a higher sensitivity (91%) but a slightly lower specificity (47%). In future research or studies, the consideration could be made to adjust the at-risk score to four in an

attempt to increase identification of prediabetes in certain populations, as a lower threshold score could be used.

The ADA Diabetes Risk Screening Instrument is used to evaluate diabetes risk. The self-administered screening instrument consisted of seven items that addressed age, gender, history of gestational diabetes (as applicable), family history of diabetes, history of or current diagnosis of hypertension, physical activity, and weight, in accordance with the ADA. Based on applicable patient responses, points were provided for each item and totaled at the bottom of the instrument. A score of five or greater denoted that the individual was at increased risk for having or developing Type II Diabetes Mellitus and correlated with a need for further evaluation and/or testing. Of the patients who received a score of five or greater, a FBG in the form of a point of care (POC) test was to be drawn on arrival to the preoperative suite on the day of surgery. Of note, the measurement was ordered/scheduled to be taken prior to receiving steroids (Dexamethasone) to avoid falsely elevated blood glucose measurements. A score of four or lower on the ADA screening instrument indicated a lower risk for diabetes and additional testing was not conducted.

In this EBP project, FBG was the primary test utilized when screening at-risk patients for prediabetes/diabetes, HgbA1c measurements were also utilized to asses undiagnosed at-risk patients who had received a HgbA1c test within the last 90 days. HgbA1c is a venous blood sample that can be drawn at any point in the day and does not require a patient to be fasting. Hemoglobin is the oxygen-carrying pigment that gives blood its red color and is the predominant protein in red blood cells. About 92% of hemoglobin is labeled hemoglobin A and the remaining 8% of hemoglobin A is made up of minor components, one of which is HgbA1c (E-medicine Health, 2020). Hemoglobin A1c (HgbA1c) is the component of hemoglobin of which glucose is

bound. ADA criteria were used to measure FBG results and categorized as appropriate. For clarity, fasting is not having anything to eat or drink for at least eight hours before the test, with the exception of water. A FBG was considered normal if measured less than 100 mg/dL. Prediabetes was used to describe individuals whose FBG measures between 100-125 mg/dL. Any FBG measurement of 126 mg/dL or greater was considered diabetes (ADA, 2020).

Procedures

The Iowa EBPO Model was used to anchor this project. Prior to implementation, a face-to-face education session was provided to the preoperative clinic staff to ensure a clear understanding of the project intent and importance as well as their roles throughout implementation. Additional education sessions were not required. The printed screening forms were provided and kept at the patient check-in desk and maintained by the administrative staff responsible for providing the screening and additional paperwork to the patients. The implementation and data collection occurred from 10 September through 30 October 2020.

Before the first week of the pilot, the project lead was provided a list of total joint orthopedic patients expected to be seen during the upcoming week by the Orthopedic PA involved in the project. Each week the project lead was sent a new list for each upcoming week. The list was then provided to the preoperative clinic staff as a projection of how many total joint patients would be coming for their preoperative assessment each week. It's important to note that not all patients who were seen in the orthopedic clinic by the PA actually came to the preoperative clinic, as discussed above. Each day, clinic staff greeted orthopedic total joint patients upon arrival to the preoperative clinic for their appointment. The patients were provided with the routine preoperative screening instruments and health assessment forms as well as the diabetes risk screening instrument (See Figure 3) and asked to complete it while in the clinic

waiting room. The first page of the screening (See Figure 4) included the determination of whether the patient had a current prediabetes or diabetes diagnosis as well as an item selection for race and ethnicity, which was also available for capture in the electronic health record (EHR). Report of a previous diagnosis of prediabetes/diabetes prompted the individual to *not* continue with the risk questionnaire as the intent was to identify only individuals at risk and currently undiagnosed. With that, patients with a pre-existing prediabetes/diabetes diagnosis were noted in data collection but did not receive further testing. Patients who reported no previous prediabetes/diabetes diagnosis were prompted to continue with the diabetes risk questionnaire and complete the screening. Once the completed screening instruments were returned to the clinic staff, the staff confirmed the screening had been completed correctly. If the staff determined that the screening instruments were not fully completed, appropriate instructions were provided or clarification obtained from the patient.

All screening forms were marked with numeric identifiers prior to dissemination to patients. In order to match the screening instruments with the FBG (via point of care) measurements, a linking document was created. The linking document was kept at the check-in desk of the preoperative clinic, in a confidential and secured file. The linking document contained two columns: one with the numeric identifier and the other left open for patient stickers to be placed as the screening instruments were completed and returned to the front desk. This ensured de-identification of any patient data on the screening instrument.

Screening instruments revealing no previous prediabetes/diabetes diagnosis, with a score of five or greater, indicated that the patient screened at-risk and needed a point of care test on the day of surgery to capture a fasting blood glucose measurement. The patient identification stickers of all total joint patients were placed on the linking document, but only those who screened at-

risk were marked with a colored sticker which indicated further testing was needed as part of their day of surgery preoperative requirements. Each day, the project lead would inform the orthopedic PA which patients required an additional one-time order for a point of care test to be completed in the Surgical Admission Suite (SAS) on their day of surgery. This order was placed by the PA and was visible in the patients' electronic record until performed. Fasting blood glucose measurements were then collected from the EHR and recorded for further analysis in conjunction with the screening instrument and the individual items.

Data Collection and Analysis

EBP project implementation and data collection occurred over an eight week period. The project lead was regularly present in the clinic to provide oversight of the process with continuous collaboration and oversight from project leader, practice mentor and DNP advisor. Additionally, the contact information of the project lead and the institutional diabetes CNS were made available to all preoperative clinic and surgical suite staff as an immediate resource for patient or staff concerns/questions arose regarding calculated ADA risk scores or process inquiries.

In-patient chart audits were conducted throughout the entirety of the pilot to ensure at-risk patients were not overlooked and therefore lacking necessary diagnostic testing, if indicated. Confirmation of risk score calculation and verification of patient data was also consistently monitored. Screening forms and linking documents were collected and recorded daily and stored in a secure locked drawer within the institution. As mentioned, data was de-identified with use of the linking document and results were collected and analyzed within a secured electronic database.

The Iowa Model reflects key decision points that allow reflection on processes to determine if change or adjustment is needed. As with any new process, a transition period occurred during the first two weeks of implementation, allowing for process evaluation and real-time adjustments and feedback from staff. The process itself contained several steps, all of which were critical to appropriately screening and further testing the intended population (See figure 7). To allow for this transition period and increased collection of data, screening period was increased from five to eight weeks. At the completion of the pilot, descriptive and inferential statistics were computed using raw numbers and percentages to display results and identify relationships between the measured variables and the data collected. Consultations with statisticians provided guidance regarding further statistical analysis, if needed.

Results

Characteristics of Sample. During the 8 week implementation period, 121 total joint patients were screened in the preoperative clinic. ADA screening instrument scores were calculated and analyzed in comparison with demographic data as well as the results of the day of surgery FBG measurements and HgbA1c measurements that were documented within the previous 90 days and recorded in the electronic health record. Of the 121 patients, 27 (22.31%) had a self-reported or confirmed diagnosis of prediabetes or diabetes; 17 (14.05%) screened at low risk, which is designated by a score of less than 5 on the ADA risk screening instrument. For the focus of the project, 77/121 (63.64%) previously undiagnosed patients screened at-risk (designated by a score of 5 or higher).

Screening Evaluation. After further analysis of the 77 at-risk patients, 23 had a documented HgbA1c in the EHR within the previous 90 days. Twenty of those were within normal limits and three were elevated. In addition, among patients who received a FBG on their

scheduled day of surgery, nine were found to be elevated and 23 were normal. It's important to note here that an additional 22 patients did not receive their ordered FBG or received it after Dexamethasone was administered, leading to a reduction in the analyzable sample size from 77 to 55 patients. Of those 55 undiagnosed, at-risk patients, 12 (21.8%) were identified as being prediabetic.

In a detailed analysis of the 12 at-risk patients who were found to have elevated fasting blood glucose or HgbA1c within the past 90 days, the vast majority were 'White, Non-Hispanic/Latino'. Two patients self-identified as 'Black, Non-Hispanic/Latino'. The mean BMI was 28.95 with a maximum of 34.45 and a minimum of 24.25. indicating that the majority had an elevated BMI. Fifty-eight percent of the patients were male and 75% were 60 years or older and had a history of hypertension. Eight of the 12 patients reported no family history of diabetes. Ten of the twelve patients self-reported being physically active. All but one of the patients had some level of risk based on weight; only one patient reflected a normal weight category. One of the 12 patients failed to complete the screening but with close tracking by clinic staff and a chart evaluation with audit, patient data was able to be extracted from the EHR to answer four out of the seven questionnaire items, which alone provided a score of five. Family history and physical activity were not able to be accounted for but did not prohibit the project lead from being able to determine risk level and the need for further diagnostic testing.

Discussion

Regardless of clinical setting, implementation of standard work allows for processes to be followed and supports a step-wise process to avoid gaps in care, reduce errors, and strive for positive patient outcomes. Although many frameworks are available, the Iowa Model supported this EBP initiative in the effort to adopt diabetes screening as part of the preoperative process for

total joint orthopedic patients. The primary objective was to screen and identify all patients at-risk for diabetes and conduct further diagnostic testing for confirmation. As a two-part process, the diabetes risk screening instrument was effective in assessing all total joint patients processing through the preoperative clinic, but challenges were presented when conducting further diagnostic testing in the surgical suite. Based on standard work in place prior to implementation, patients who had a documented diagnosis of prediabetes/diabetes in their EHR automatically receive a point of care test immediately prior to surgery. It was not the surgical suite's standard work to conduct point of care testing on patients without a confirmed diagnosis and as a result 22 patients did not receive the intended point of care test to confirm or refute their risk score of five or greater. This accounted for 40% of the sample being undetermined in regards to their glycemic status after determining they were at-risk. If captured, these patients could have revealed a vast difference in fasting blood glucose measurements that were potentially elevated. Continuous chart audits provided awareness of missed point of care tests and allowed the project lead to conduct additional education sessions to the SAS staff, ensuring clarity of their role and need for the point of care tests. Although several face-to-face education sessions were conducted with the surgical suite staff along with shared electronic tracking of which patients needed a point of care, there remained constant challenges with obtaining the ordered lab. This highlighted the many barriers often faced with implementing a practice change and garnering support from key stakeholders to fully support the practice change and adoption into practice. The first of three 'decision points' imbedded within the Iowa Model asks: 'Is this topic a priority?' More involvement and collaboration with the surgical suite staff when 'forming a team' may have revealed that including diabetes screening with a point of care as part of their standard work

wasn't as high as a priority as expected, or viewed as feasible in their already established work flow.

This challenge and feasibility of adopting this new practice change leads to the discussion of alternative methods of diagnostic testing for diabetes. Although HgbA1c would have been the preferred biomarker for evaluating glycemic status in this project, lack of insurance coverage for the test required FBG to be utilized for further diagnostic testing of at-risk patients. According to Medicare coverage guidelines, Part B covers lab test screenings if the patient is determined to be at-risk for developing diabetes. Furthermore, lab screenings are covered if a patient has any of the following risk factors: hypertension, dyslipidemia, obesity, or a history of high blood sugar. More specifically, if two or more of the following apply to the patient, the screenings are covered: age 65 years or older, overweight, a family history of diabetes or gestational diabetes (Medicare coverage 2020). Despite Medicare coverage information, HgbA1c coverage still remained a challenge when evaluating its use in the pilot. According to the ADA (2020), HgbA1c testing has several advantages compared with FBG and OGTT such as greater convenience (fasting not required) and less day-to-day influences during stress, diet, or illness, all of which can influence FBG accuracy. Shohat et al. (2018) revealed this very point in their study conducting diabetes screening in patients undergoing total joint arthroplasty surgery when a statistically significant difference between patients with diagnosed and undiagnosed diabetes was found when using HgbA1c ($p=.001$) as a diagnostic tool compared to FBG ($p=.91$). With the understanding of HgbA1c and less variability associated with it compared to FBG, it's not unreasonable to suggest that a healthcare policy change should be considered in regards to insurance coverage of HgbA1c for screening purposes in all diabetes screening and not just the preoperative setting alone.

Although it is clear that there are advantages and disadvantages with using both FBG and HgbA1c for diabetes screening and diagnosis, there are also challenges in imbedding them both in the preoperative screening process. Specific to the practice site and supporting institution, there are multiple pathways of preoperative screening and the variety of that creates challenges of its own. Out of the 187 total joint patients that were seen by the PA at the orthopedic clinic, the preoperative clinic captured and screened 121 of them, leaving 66 patients who may or may not have been appropriately screened for diabetes prior to surgery. This gap proves the importance of implementing universal diabetes screening across the institution regardless of the pathway taken for preoperative patient assessment and screening. The challenge remains with where in the preoperative process is best to implement screening to ensure diabetes risk (and follow on testing if indicated) is evaluated prior to surgery. A clear challenge in the pilot was capturing point of care tests in the SAS immediately prior to surgery. Based on the identified gaps in the pilot, it's reasonable to suggest that moving screening and testing to earlier in the preoperative process allows for complete assessment and testing, adjustment of care prior to surgery as indicated , and decreased potential for missed screenings. The adoption of a diabetes screening consisting of a risk factor assessment and further diagnostic testing if indicated could be added to the institution's preoperative assessment, ensuring all patients are screened regardless of their preoperative pathway and choice of clinic.

In regards to specific diabetes risk factors, it's appropriate to discuss the ADA Diabetes Risk Screening Instrument and its individual items. First and foremost, the tool was self-administered which alone is subject to variance in regards to accuracy. Three of the seven instrument items have the potential to be subject to more personal bias than the others. Gestational diabetes is one item that could have presented some discrepancy simply because it's

assumed that most people actually understand what ‘gestational’ is referring to, which may not have been the case. Pilot data reflected that not one patient selected yes to having a history of gestational diabetes. If it’s assumed that gestational was understood across the sample, this item would not have been one for concern in regards to accuracy of risk score. The second item that could present a discrepancy with scoring is identifying if the patient has an immediate family member with diabetes. Many patients struggle to remain fully informed and in-tune with their own health so expecting that they know the health history of family members could be a stretch. This understanding makes it fair to believe that this item could be reported inaccurately. Out of the seven items, the most subjective topic addresses whether the patient is physically active. The definition of physically active can vary dramatically depending on many characteristics, but age alone is a primary example of the variance that could be present when answering this question. For example, physical activity of a 30 year old is very different than a 60 year old. Even more, the physical health of two 60 year old patient could reflect two very different activity abilities. Although many patients in the sample answered ‘yes’ to being physically active, it’s important to consider the extreme variance and personal bias present in this question. In order to counter the potential self-bias from the instrument, incorporating the screening items into the EHR to be asked by healthcare personnel could significantly reduce the discrepancy and variance that comes with the instrument being self-administered. Administration via healthcare staff would also allow for clarifications and explanations to be made and provided as needed when answering each item.

Strengths and Limitations

The implementation of the current clinical practice recommendations was the most impactful strength of this project. Additionally, the change in practice did not require a drastic

adjustment in the current standard work or administrative flow. The addition of the screening instrument did not delay patient care or increase the need for clinical or personnel resources, but stands to strengthen the preoperative clinical assessment for awareness of the interdisciplinary care team and promotes early recognition of chronic disease prevention. The validated instrument is utilized by the American Diabetes Association as a tool to screen and promote awareness of diabetes risk factors as well as a means to support further diagnostic testing. As previously mentioned, the project itself required minimal change to current practice, but revealed incredible potential to improve individual health and wellness as well as increase positive patient outcomes such as length of stay and reduction of hyperglycemic episodes in the postoperative period. Because diabetes prevalence is so high and continues to increase despite comprehensive efforts, early recognition and intervention could impact a significant number of patients by simply increasing awareness, as people are unable to address change if they unaware of a threat or issue. A final strength of this study was that a smaller scale pilot was previously conducted that yielded more than 75% of patients screening at-risk for diabetes, providing valid reasoning to conduct further diagnostic testing.

Limitations of this project begin with the fact that understanding that the target population was the total joint population within the orthopedic department. Because of this, the results may not be generalizable to other surgical populations. Additionally, the sample from the earlier pilot consisted of patients mostly 60 years or older, revealing that there was minimal variance in the age of the cohort. This doesn't completely stand as a limitation as majority of total joint arthroplasties are in the older population, similar to this pilot where nearly 80% of the at-risk patients were 60 years of age or older. Lack of age variance may be more applicable in different surgical categories and less of a concern in the total joint population as discussed. One

clearly notable limitation that was briefly pointed out previously is that not all patients who receive an elective surgery at this facility complete preoperative assessments at the preoperative clinic, but instead do so at various outlying clinics. This was a recognized limitation due to the possibility of not capturing *all* elective total joint patients receiving surgery and high likelihood of diabetes screenings not being conducted at all.

Integrate and Sustain Practice Change

Because of the high prevalence of diabetes and the significant impact screening can have on this large population of patients, the feasibility of implementing diabetes screening is appropriate to adopt into practice with certain adjustments considered.

Implications for Practice

Diabetes is a chronic illness that often remains asymptomatic for most patients until the organs involved have already been negatively impacted. Because of this, screening for the disease is imperative to provide early recognition and intervene as appropriate. Increasing screening opportunities increases awareness of potential diabetes and associated risk factors. While the implementation of this screening opens yet another avenue for diabetes health promotion, it also serves as an opportunity to streamline intra and postoperative glucose management, decrease postoperative complications, and increase cost savings. In addition to routine costs associated with diabetes management, treatment of surgical complications as a result of glycemic instability generate increased costs to the healthcare facility and the patient. The burden of undiagnosed diabetes and prediabetes, which are $4030 and $510 per case, respectively, is significant when comparing the cost of a single HgbA1c blood test that typically ranges between $22-$65 when not covered by the patient's insurance (Capozzi et al., 2017). Capozzi et al. (2017) also pointed out that patients with diabetes have a significantly higher risk

of requiring revision of their arthroplasty surgery at the one and five year mark and prediabetic patients exhibit a similar risk, even if they do not progress to a full diabetes diagnosis. In addition, the same study discussed the presence of increased wound complications with postoperative glucose levels greater than 200 mg/dL and that postoperative hyperglycemia was associated with wound infection rate, even in patients without a prior diagnosis of diabetes. From a behavioral perspective, increased awareness of diabetes risk may serve as a motivating force for patients to take personal responsibility of their health choices and improving their health therefore preventing or minimizing disease progression. Adoption of this screening as part of the preoperative assessment could serve as a baseline for intra and postoperative glucose management reducing fluctuations and instability of blood glucose throughout the operative process. As a result, a potential reduction in postoperative complications would yield a cost savings not only for the patient but also for the facility.

Sustainability Plan

Continued use of the validated screening instrument requires minimal effort for the level of impact it can have on health promotion, disease prevention, and patient outcomes in the operative environment. The addition of the screening instrument requires no change to staffing resources or responsibility, does not impact the current established patient flow processes, and serves as a means to guide intra and postoperative care. The correction of the challenges discussed above would be crucial in completely capturing glucose measurements to confirm or refute a diabetes diagnosis and support clinically appropriate measures to improve patient health. Specifically, imbedding screening into the electronic health record for expedited and more accurate screening is a modification that should be considered in the future to avoid personal bias as well as making diabetes screening (and testing if indicated) a requirement prior to surgery

would be critical steps to the sustainment of this project. This requirement would ensure minimal gaps in diabetes screening across not only the total joint population other surgical departments as well.

Disseminate Results

The project findings, data, and recommendations for future practice were presented to the practice site, relevant hospital leadership, and support staff involved in the development and implementation of this project by way of a formal presentation to reveal the impact of the project and justification for adoption of the diabetes risk screening instrument along with added adjustments as deemed appropriate A full manuscript will be submitted to the institution's School of Nursing at the completion of the Doctor of Nursing Practice program as well as the University's scholarly institutional repository, Libra. A manuscript will be submitted to the Journal of the American Academy of Orthopedic Surgeons (AAOS) for publication based on journal guidelines for submission. Additionally, the project will be presented at the institutions 2021 Evidence Based Practice Conference and the Military Health System Research Symposium in the fall of 2021.

Conclusion

Diabetes is a growing, and preventable, chronic illness particularly when identified as prediabetes. It has significant impact from a global perspective, effecting individuals of all ages. Undiagnosed diabetes rates continue to climb and lack of awareness creates a harsh domino effect for individual health. Diabetes alone leads to other chronic illness and health concerns, but when combined with surgery, postoperative complications increase the risk for negative patient outcomes. Regardless of the simplicity of screening and the alarming statistics that surround diabetes, screening remains inconsistent and variant across the clinical setting. The ease

demonstrated in this project reveals the practicality and impact of implementing a validated screening instrument within the preoperative setting. Although barriers and challenges are ever-present, the importance of diabetes screening remains evident and it is the role of health care providers to advocate for preventive and proactive measures to improve patient outcomes by way of screening for, diagnosing and managing diabetes.

References

Abdelmalak, B., Abdelmalak, J. B., Knittel, J., Christiansen, E., Mascha, E., Zimmerman, R., Argalious, M., & Foss, J. (2010). The prevalence of undiagnosed diabetes in non-cardiac surgery patients, an observational study. Canadian Journal of Anesthesia/Journal Canadien d'anesthésie, 57(12), 1058–1064. https://doi.org/10.1007/s12630-010-9391-4.

American Diabetes Association. (2019). Statistics by State. Retrieved from http://www.diabetes.org/diabetes-basics/statistics/state.html.

American Diabetes Association (2020). 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes—2020. Diabetes Care, 43(Supplement 1), S14–S31. https://doi.org/10.2337/dc20-S002.

Bang, H. (2009). Development and Validation of a Patient Self-assessment Score for Diabetes Risk. Annals of Internal Medicine, 151(11), 775. https://doi.org/10.7326/0003-4819-151-11-200912010-00005

Buckwalter, K. C., Cullen, L., Hanrahan, K., Kleiber, C., McCarthy, A. M., Rakel, B., Steelman, V., Tripp-Reimer, T., Tucker, S. (2017). Iowa Model of Evidence-Based Practice: Revisions and Validation: Iowa Model-Revised. Worldviews on Evidence-Based Nursing, 14(3), 175–182. https://doi.org/10.1111/wvn.12223.

Capozzi, J. D., Lepkowsky, E. R., Callari, M. M., Jordan, E. T., Koenig, J. A., & Sirounian, G. H. (2017). The Prevalence of Diabetes Mellitus and Routine Hemoglobin A1c Screening in Elective Total Joint Arthroplasty Patients. The Journal of Arthroplasty, 32(1), 304–308. https://doi.org/10.1016/j.arth.2016.06.025.

Centers for Disease Control and Prevention. (2017). U.S. Dept of Health and Human Services: National Diabetes Statistics Report, 2017. Retrieved from https://www.cdc.gov/diabetes/pdfs/data/statistics/national-diabetes-statistics-report.pdf.

Cho, N. H., International Diabetes Atlas. (2017). (S. Karuranga, J. da R. Fernandes, Y. Huang, & B. Malanda, Eds.) (8th ed.). International Diabetes Federation. Retrieved from https://www.idf.org/e-library/epidemiology-research/diabetes-atlas/134-idf-diabetes-atlas-8th-edition.html.

Dang, D., & Dearholt, S. (2017). Johns Hopkins nursing evidence-based practice: model and guidelines. 3rd ed. Indianapolis, IN: Sigma Theta Tau International

E-Medicine Health. (2020. Hemoglobin A1c Test, Chart, Results, Normal, High & Low Levels. from https://www.emedicinehealth.com/hemoglobin_a1c_hba1c/article_em.htm

Hickey, J.V. & Brosnan, C.A. (2017). Evaluation of Health Care Quality for DNPs. 2nd ed. New York: Springer.

Hopkins, L., Brown-Broderick, J., Hearn, J., Malcolm, J., Chan, J., Hicks-Boucher, W., De Sousa, F., Walker, M. C., & Gagne, S. (2017). Implementation of a referral to discharge glycemic control initiative for reduction of surgical site infections in gynecologic oncology patients. GYNECOLOGIC ONCOLOGY, 146(2), 228–233. https://doi.org/10.1016/j.ygyno.2017.05.021.

Karimian, N., Niculiseanu, P., Amar-Zifkin, A., Carli, F., & Feldman, L. S. (2018). Association of Elevated Pre-operative Hemoglobin A1c and Post-operative Complications in Non-diabetic Patients: A Systematic Review. WORLD JOURNAL OF SURGERY, 42(1), 61–72. https://doi.org/10.1007/s00268-017-4106-4.

Koumpan, Y., VanDenKerkhof, E., & van Vlymen, J. (2014). An observational cohort study to assess glycosylated hemoglobin screening for elective surgical patients. Canadian Journal of Anesthesia/Journal Canadien d'anesthésie, 61(5), 407–416. https://doi.org/10.1007/s12630-014-0124-y.

McGinn, J. T., Shariff, M. A., Bhat, T. M., Azab, B., Molloy, W. J., Quattrocchi, E., Farid, M., Eichorn, A. M., Dlugacz, Y. D., & Silverman, R. A. (2011). Prevalence of dysglycemia among coronary artery bypass surgery patients with no previous diabetic history. Journal of Cardiothoracic Surgery, 6, 104. https://doi.org/10.1186/1749-8090-6-104.

Medicare Coverage (2020). *Diabetes Screening Coverage.* https://www.medicare.gov/coverage/diabetes-screenings.

Office of the National Coordinator for Health Information Technology. (2013). Continuous Quality Improvement (CQI) Strategies to Optimize your Practice. https://www.healthit.gov/sites/default/files/tools/nlccontinuousqualityimprovementprimer.pdf

Ortho Info—American Academy of Orthopedic Surgeons. (2014). Total Joint Replacement. https://www.orthoinfo.org/en/treatment/total-joint-replacement/

Setji, T., Hopkins, T. J., Jimenez, M., Manning, E., Shaughnessy, M., Schroeder, R., Mendoza-Lattes, S., Spratt, S., Westover, J., & Aronson, S. (2017). Rationalization, Development, and Implementation of a Preoperative Diabetes Optimization Program Designed to Improve Perioperative Outcomes and Reduce Cost. Diabetes Spectrum, 30(3), 217–223. https://doi.org/10.2337/ds16-0066

Sheehy, A. M., Benca, J., Glinberg, S. L., Li, Z., Nautiyal, A., Anderson, P. A., Squire, M. W., & Coursin, D. B. (2012). Preoperative “NPO” as an opportunity for diabetes screening. Journal of Hospital Medicine, 7(8), 611–616. https://doi.org/10.1002/jhm.1958.

Shohat, N., Goswami, K., Tarabichi, M., Sterbis, E., Tan, T. L., & Parvizi, J. (2018). All Patients Should Be Screened for Diabetes Before Total Joint Arthroplasty. The Journal of Arthroplasty, 33(7), 2057–2061. https://doi.org/10.1016/j.arth.2018.02.047.

Smith, A. (2020). *Pre-operative Diabetes Screening: Glucose Optimization in the Total Joint Population* [Unpublished manuscript]. University of Virginia.

U.S. Department of Health and Human Services. (2019). Agency for Healthcare Research and Quality: Surgical Site Infections; Patient Safety Network. Retrieved from http://psnet.ahrq.gov/primer/surgical-site-infections

US News and World Report. (2018). How Healthy Is Albemarle County, Virginia: Healthiest Communities. Retrieved from https://www.usnews.com/news/healthiest-communities/virginia/albemarle-county.

Vasarhelyi, E. M., & MacDonald, S. J. (2012). The influence of obesity on total joint arthroplasty. *The Journal of Bone and Joint Surgery. British Volume*, *94-B*(11_Supple_A), 100–102. https://doi.org/10.1302/0301-620X.94B11.30619.

Ward, Z. J., Bleich, S. N., Cradock, A. L., Barrett, J. L., Giles, C. M., Flax, C., Long, M. W., & Gortmaker, S. L. (2019). Projected U.S. State-Level Prevalence of Adult Obesity and Severe Obesity. New England Journal of Medicine, 381(25), 2440–2450. https://doi.org/10.1056/NEJMsa1909301.

Tables

Table 1

Literature Review Table

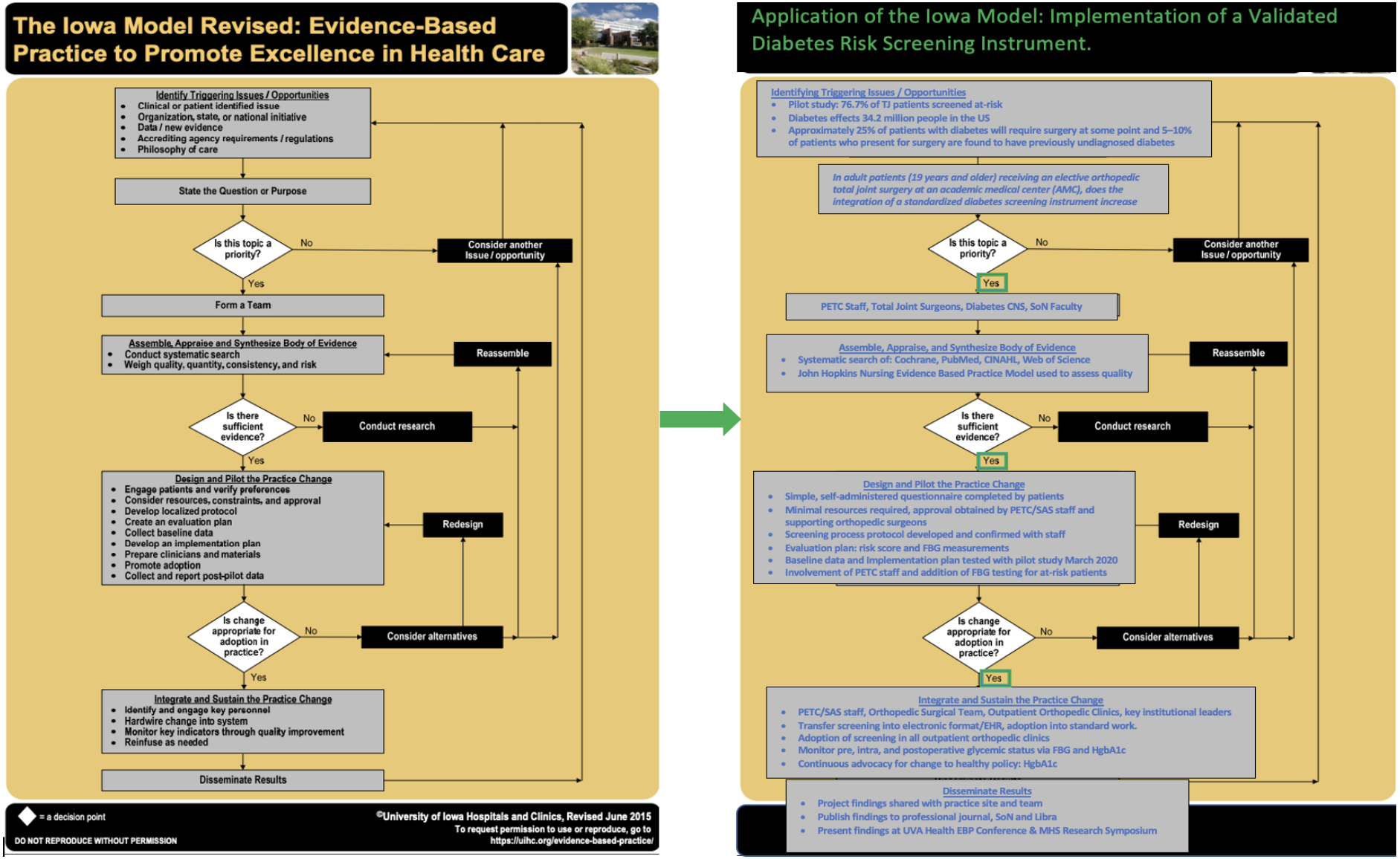
Citation	Study Sample & Size / Study Setting	Findings	Theme
Abdelmalak et al. (2010)	39,434 charts: 5,511 known diabetics; 33,923 known non-diabetics / Anesthesia Institute at Cleveland Clinic; surgical/preoperative setting; United States	Of the 33,923 non-diabetics, 3,426 (10%) were undiagnosed diabetics and another 3,549 (11%) had impaired fasting glucose. In total, 6,975 (21%) patients in the non-diabetic group presented with abnormally high glucose. Previously undiagnosed diabetics had higher preoperative glucose levels compared with known diabetics (161 vs 146 respectively), which remained significant after adjusting for age, sex, BMI, and ASA physical status. Among non-diabetic patients, the following factors independently predicted hyperglycemia: older age, obesity, male sex, and higher ASA status.	*2, 3
Capozzi et al. (2017)	Patients scheduled for elective total hip and total knee arthroplasties; 392 females, 271 males (272 hip; 391 knee); mean age: 67.59; mean BMI: 29.92; mean LOS 3.42 days; mean HgbA1c 5.73663 total records reviewed / preoperative and postoperative assessment in a hospital setting	Based on HgbA1c categorization, 33.6% (223) were previously undiagnosed dysglycemic patients: 31% (206) were pre-diabetic and 2.6% (17) were diabetic; 48% were nondiabetic. Mean HgbA1c: known diabetics-6.52%, Nondiabetics-5.28%, Newly diagnosed pre-diabetics-5.91%, newly diagnosed diabetics-7.05%. There was a statistically significant difference in HgbA1c levels between the known dysglycemic and previously unknown patient groups ($p < .0001$); and between previously unknown dysglycemic and non-diabetic patient groups ($p < .0001$); Re-admission rates were not statistically significant between any of the three study groups nor significantly affected by age, gender, first post-op BG or comorbidities. There was a statistically significant difference when comparing LOS of known dysglycemic group (3.89 days) to previously unknown dysglycemic group (3.32 days) ($p < .028$) and when compared to the nondiabetic group (3.31 days) ($p < .014$).	*1, 3, 4, 5
Classification and Diagnosis of Diabetes: Standards of	Addresses diabetes across the age spectrum in regards to screening.	Screening for prediabetes and type 2 diabetes risk through an informal assessment of risk factors or with	*1, 2, 3

Medical Care in Diabetes (2020)		an assessment tool, such as the ADA risk test is recommended to guide providers on whether performing a diagnostic test is appropriate. Prediabetes and type 2 diabetes meet criteria for conditions in which early detection is appropriate. Both conditions are common and impose significant clinical and public health burdens.	
Hopkins et al. (2017)	Patients undergoing major pelvic surgery for gynecologic malignancy; Total sample: 462 [Group II 297 (Intervention), Group I 165 (Control) / preoperative setting, Canada	The control group had an infection rate of 14.6%; Intervention group had an infection rate of 5.7%, which showed statistical significance; 56/297 patients (19%) of from group II (intervention group) were newly diagnosed with either prediabetes or diabetes.	*1, 3, 4
Kariman et al. (2018)	Patients >18 year old with prediabetes or no known history of confirmed diabetes who have undergone any type of surgical procedure and have a documented preoperative HgbA1c level; 14,363 non-diabetic patients; 4,898 (34%) of these had sub-optimal HgbA1c prior to surgery (HgbA1c > 6%); 6 studies included / Pre and postoperative setting	4/6 studies reported a significant association between preoperative HgbA1c levels and postoperative complications in non-diabetic patients. 2/6 revealed increased postoperative infection rates and 2/6 reported no difference. LOS: 3/4 studies reported no association with HgbA1c level compared to 1 who reported a significant impact. Only 1 study found higher mortality rates in patients with suboptimal HgbA1c. High preoperative HgbA1c (>6%) was associated with higher risk of overall postoperative complications after colorectal, bariatric, vascular and cardiac surgery.	*1, 3, 4
Koupman et al. (2014)	Elective surgical patients >18 years of age. Scheduled for an onsite preoperative assessment; 402; 332 with no diagnosis of diabetes and 70 with diagnosis of diabetes / preoperative clinic (ambulatory care hospital that prepare preoperative patients) / Canada	Out of 332 patients without a history of diabetes, 77 were considered very high risk for diabetes (HgbA1c between 6.0-6.4) and 13 had a Provisional diagnosis of diabetes (HgbA1c > or equal to 6.5%). Of the 70 known diabetics, 39 of them had sub-optimal glycemic control, defined at HgbA1c greater than or equal to 7.0%. 20 of those 39 patients assumed their blood sugar was reasonably controlled.	*1, 2, 3
McGinn et al. (2011)	Patients undergoing CABG surgery with no known history of diabetes; 1045 total sample; Patients having a CABG surgery with no known history of diabetes / Community tertiary hospital; United States	630/1045 patients had no known history of diabetes. A total of 207/630 (32.9%) patients were found to have a HgbA1c in the normal range, 356/630 (56.5%) had an HgbA1c in the "increased risk for diabetes" range and 67 (10.6%) patients had an HgbA1c in the diabetes range.	*1, 3
Sheehy et al. (2012)	All patients aged 18 years or older scheduled for elective total knee or hip arthroplasty, elective lumbar decompression and/or fusion. 275 elective orthopedic patients, 100% insured and who most had seen their	24% of patients had unrecognized IFG or DM on the basis of 2 fasting blood glucose values; No patients with new DM or IFG had POC glucose checks ordered or had dysglycemia mentioned on discharge summary.	*1, 2, 3

	primary care provider within 12 months; 18 years or older / United States; Large midwestern academic medical center		
Shohat et al. (2018)	Patients undergoing elective total joint (hip or knee) arthroplasty; 611 males, 850 females; mean age 63.4 years (range of 21-92); Mean BMI 29.7 (range 17-47). Mean HgbA1c 5.7% (range 2-10); Mean FBG 103.1 (range 45-370); 1461 total joint patients (782 hip, 679 knee) / Conducted a single medical institution in limited geographical area.	In regards to diagnosed diabetes cases, 301/1461 patients had diabetes, 123 of them being undiagnosed. In evaluating prediabetes case, 559/1461 patients were classified as pre-diabetic based on HgbA1c levels. No significant differences in periprosthetic joint infection and wound complications were observed when comparing diagnosed versus undiagnosed diabetes.	*1, 2, 3, 4, 5

Figure 1.

Comparison and Application of the Iowa Model Revised.



Note. Left image: Iowa Model Revised; Right image: Application of Iowa Model Revised for Implementation of Diabetes Screening.

Figure 2.

Prisma Flow Diagram

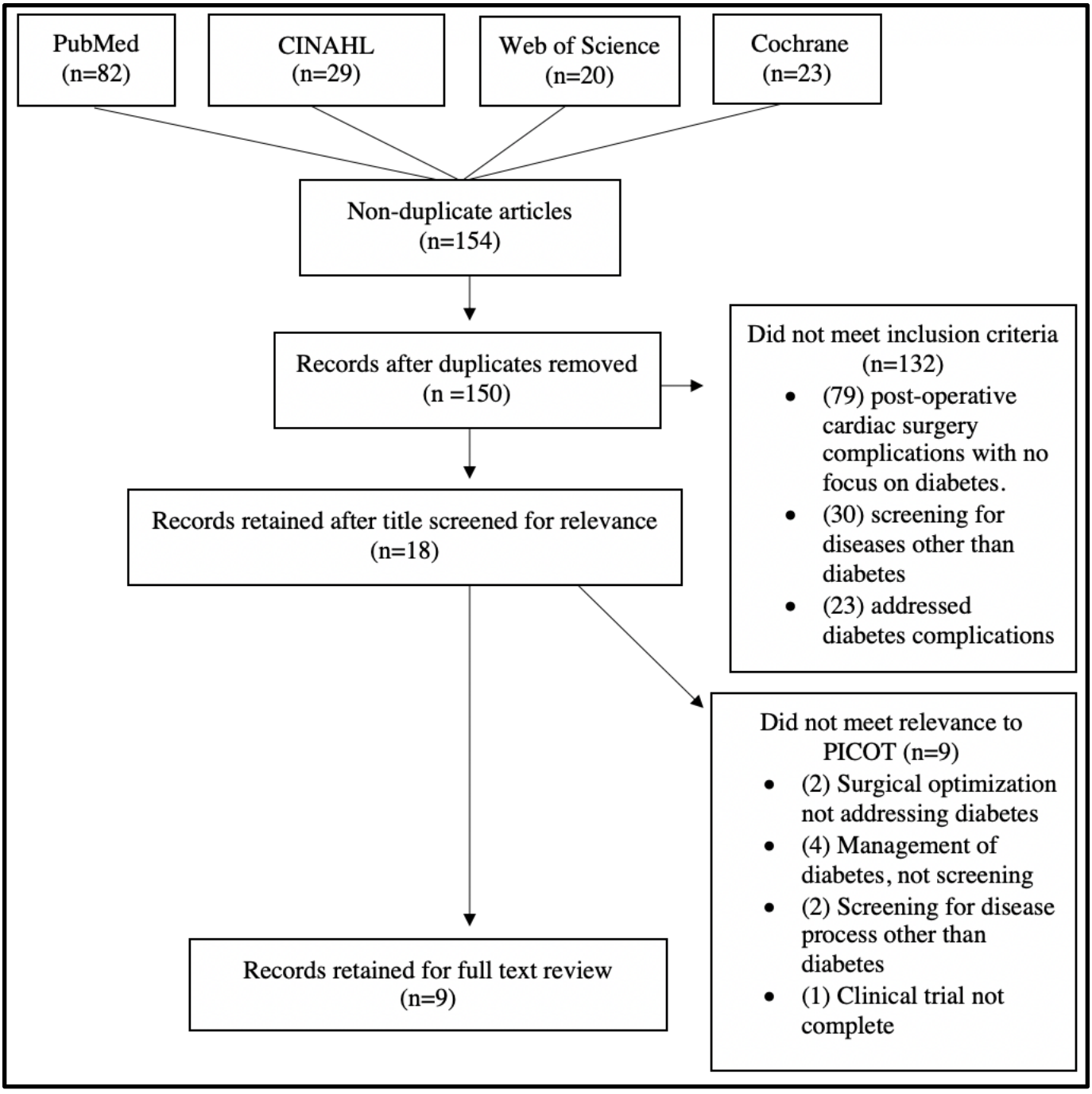
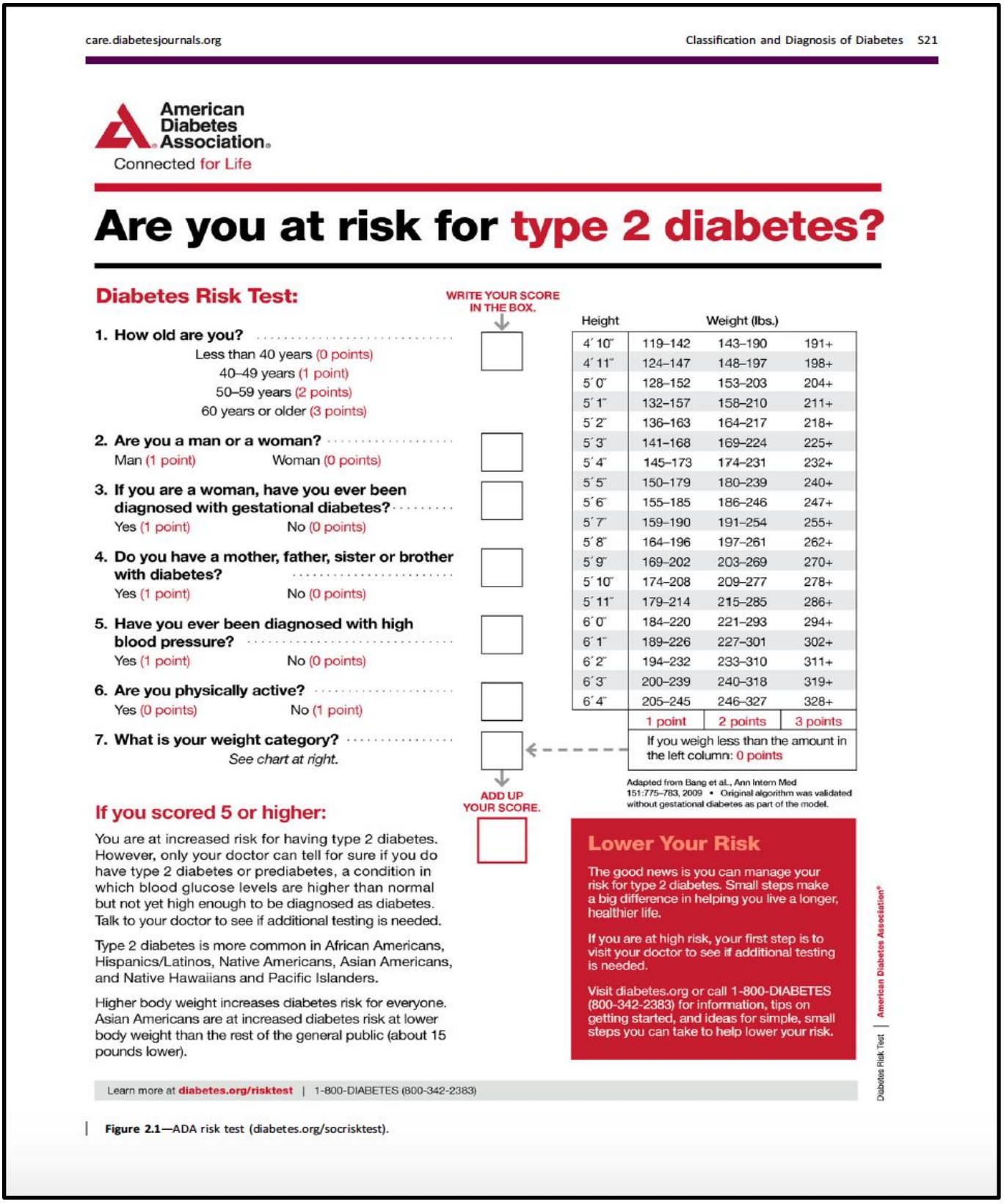


Figure 3.

American Diabetes Association Risk Screening Instrument



care.diabetesjournals.org Classification and Diagnosis of Diabetes S21

American Diabetes Association.
Connected for Life

Are you at risk for type 2 diabetes?

Diabetes Risk Test:

WRITE YOUR SCORE IN THE BOX.

1. How old are you?
Less than 40 years (0 points)
40–49 years (1 point)
50–59 years (2 points)
60 years or older (3 points)

2. Are you a man or a woman?
Man (1 point) Woman (0 points)

3. If you are a woman, have you ever been diagnosed with gestational diabetes?
Yes (1 point) No (0 points)

4. Do you have a mother, father, sister or brother with diabetes?
Yes (1 point) No (0 points)

5. Have you ever been diagnosed with high blood pressure?
Yes (1 point) No (0 points)

6. Are you physically active?
Yes (0 points) No (1 point)

7. What is your weight category?
See chart at right.

Height	Weight (lbs.)		
4′ 10″	119–142	143–190	191+
4′ 11″	124–147	148–197	198+
5′ 0″	128–152	153–203	204+
5′ 1″	132–157	158–210	211+
5′ 2″	136–163	164–217	218+
5′ 3″	141–168	169–224	225+
5′ 4″	145–173	174–231	232+
5′ 5″	150–179	180–239	240+
5′ 6″	155–185	186–246	247+
5′ 7″	159–190	191–254	255+
5′ 8″	164–196	197–261	262+
5′ 9″	169–202	203–269	270+
5′ 10″	174–208	209–277	278+
5′ 11″	179–214	215–285	286+
6′ 0″	184–220	221–293	294+
6′ 1″	189–226	227–301	302+
6′ 2″	194–232	233–310	311+
6′ 3″	200–239	240–318	319+
6′ 4″	205–245	246–327	328+
	1 point	2 points	3 points

If you weigh less than the amount in the left column: 0 points

Adapted from Bang et al., Ann Intern Med 151:775–783, 2009 • Original algorithm was validated without gestational diabetes as part of the model.

ADD UP YOUR SCORE.

If you scored 5 or higher:

You are at increased risk for having type 2 diabetes. However, only your doctor can tell for sure if you do have type 2 diabetes or prediabetes, a condition in which blood glucose levels are higher than normal but not yet high enough to be diagnosed as diabetes. Talk to your doctor to see if additional testing is needed.

Type 2 diabetes is more common in African Americans, Hispanics/Latinos, Native Americans, Asian Americans, and Native Hawaiians and Pacific Islanders.

Higher body weight increases diabetes risk for everyone. Asian Americans are at increased diabetes risk at lower body weight than the rest of the general public (about 15 pounds lower).

Lower Your Risk

The good news is you can manage your risk for type 2 diabetes. Small steps make a big difference in helping you live a longer, healthier life.

If you are at high risk, your first step is to visit your doctor to see if additional testing is needed.

Visit diabetes.org or call 1-800-DIABETES (800-342-2383) for information, tips on getting started, and ideas for simple, small steps you can take to help lower your risk.

Learn more at diabetes.org/risktest | 1-800-DIABETES (800-342-2383)

Diabetes Risk Test | American Diabetes Association®

Figure 2.1—ADA risk test (diabetes.org/socrisktest).

Note. Self-administered ADA Risk Screening questionnaire to assess diabetes risk factors.

Figure 4.

Determination for Diabetes Screening Questionnaire

Do you have a current prediabetes or diabetes diagnosis or ever been told so by your physician? Check the appropriate box below.

***Diabetes is also known as: ‘sugar’, ‘high blood sugar’, ‘high blood glucose’

☐ YES ☐ NO

*If you answered NO to the above question, please continue with the questionnaire on the following page, and return this sheet and the completed questionnaire to the front desk staff. Please clarify any questions regarding the items on questionnaire with the front desk clinic staff to ensure accurate scoring.

*If you answered YES to the above question, please disregard the questionnaire on the following page and return this paperwork to the front desk clinic staff.

Race: Select the appropriate box

☐ American Indian or Alaska Native

☐ Asian

☐ Black or African American

☐ Native Hawaiian or Pacific Islander

☐ White

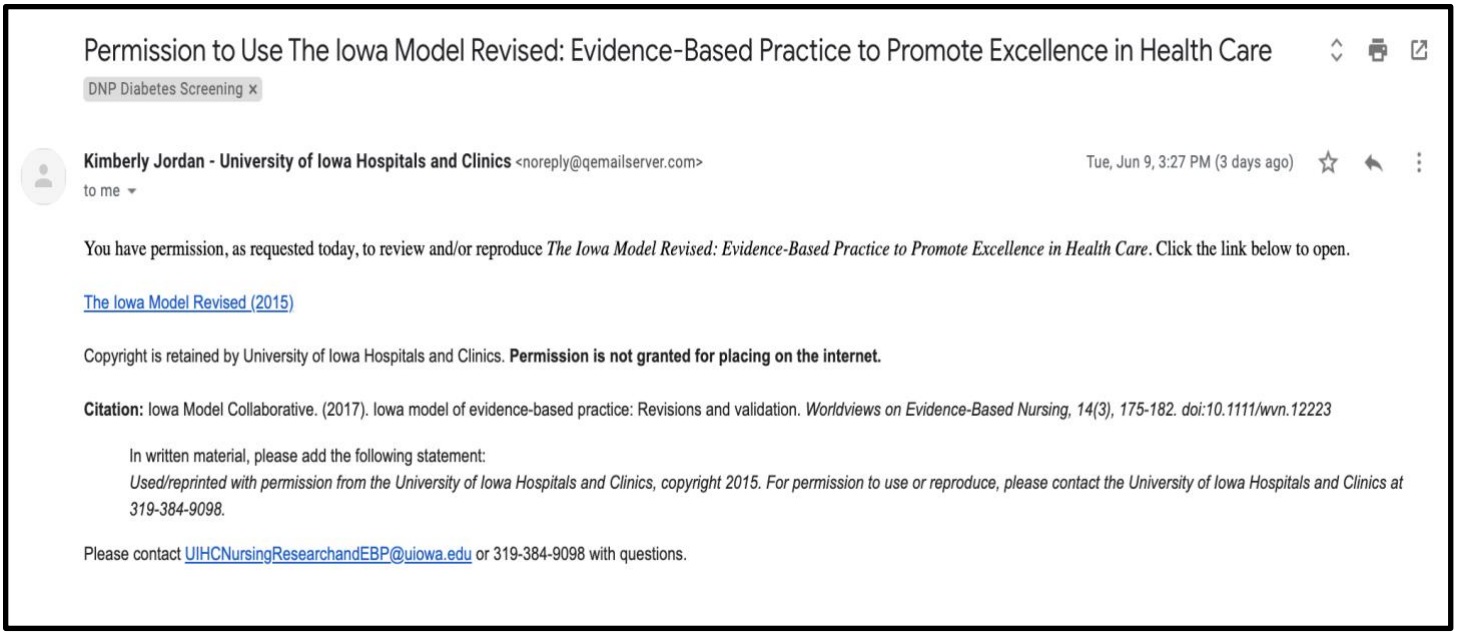
Ethnicity: Select the appropriate box

☐ Hispanic or Latino

☐ Not Hispanic or Latino

Figure 5.

Permission for use of Iowa Model Revised



Permission to Use The Iowa Model Revised: Evidence-Based Practice to Promote Excellence in Health Care

DNP Diabetes Screening ×

Kimberly Jordan - University of Iowa Hospitals and Clinics <noreply@qemailserver.com> Tue, Jun 9, 3:27 PM (3 days ago)

to me

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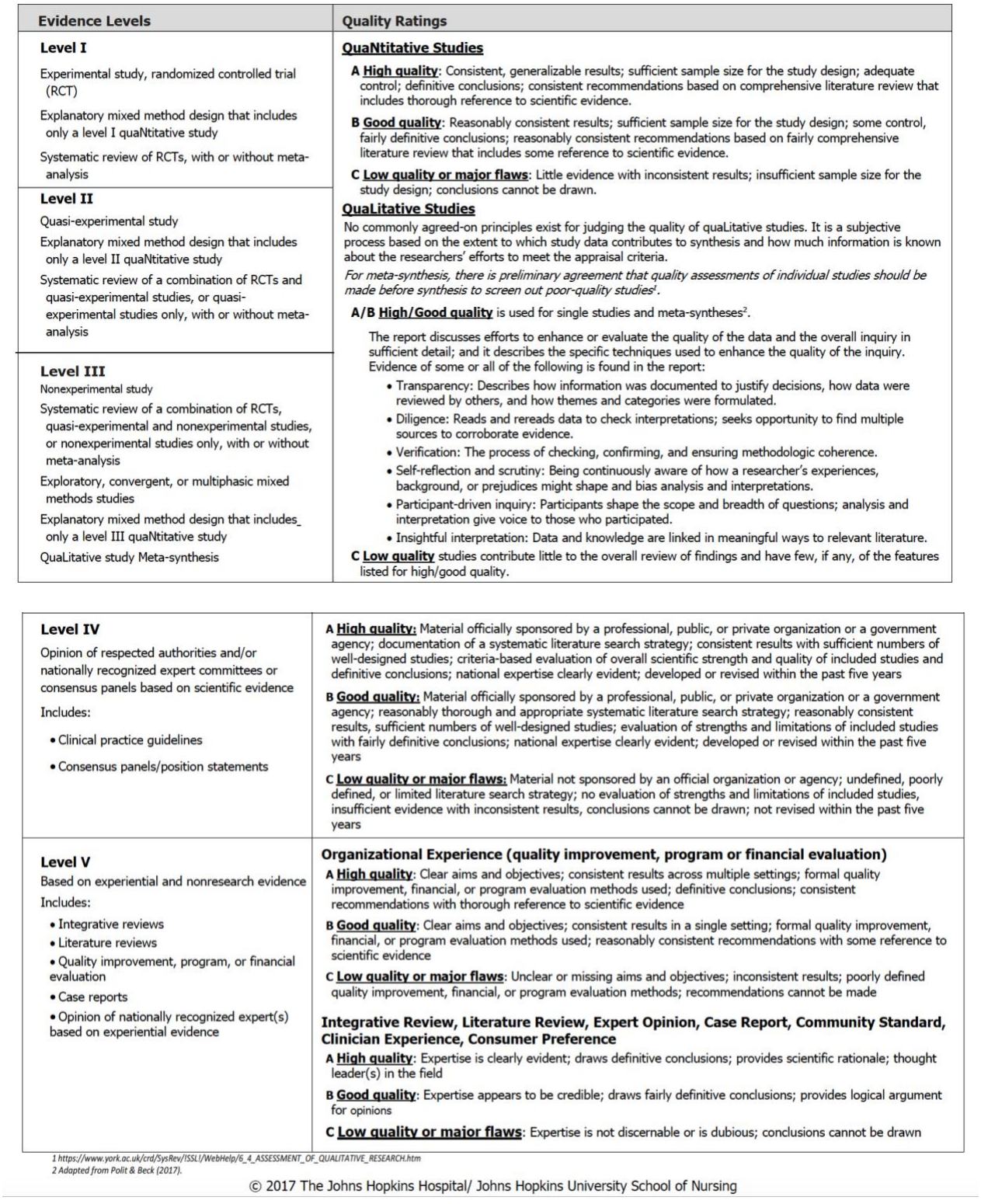
Note. Email correspondence confirming permission to use Iowa Model Revised.

Figure 6.

Johns Hopkins Nursing EBP Evidence Level and Quality Guide



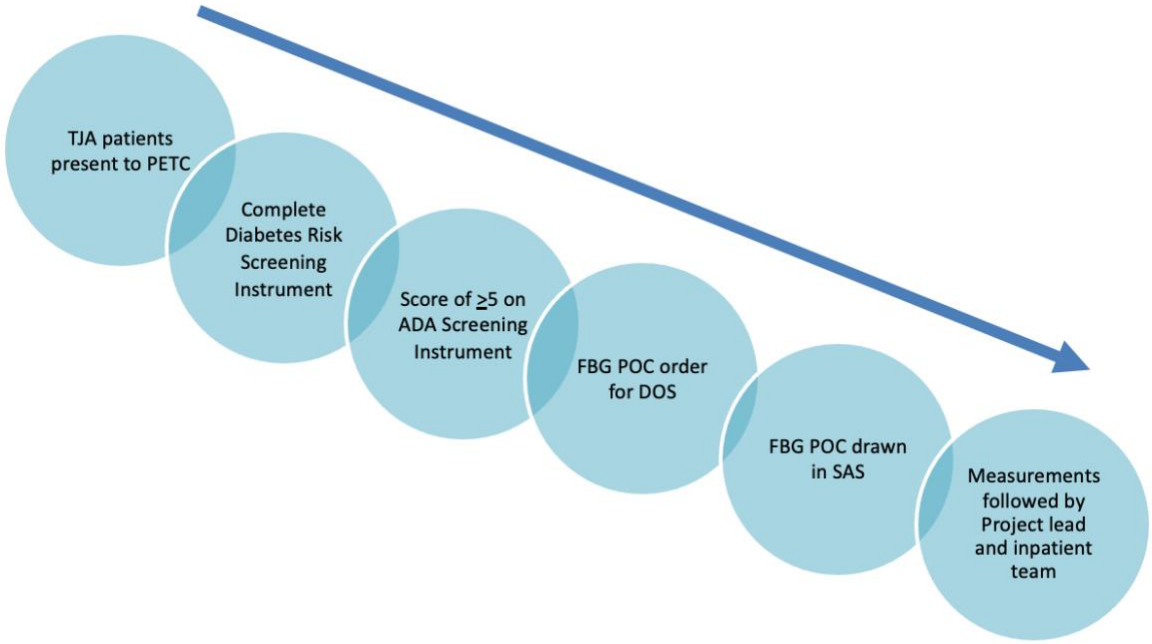
Evidence Levels	Quality Ratings
Level I Experimental study, randomized controlled trial (RCT) Explanatory mixed method design that includes only a level I quaNtitative study Systematic review of RCTs, with or without meta-analysis	**QuaNtitative Studies** **A High quality**: Consistent, generalizable results; sufficient sample size for the study design; adequate control; definitive conclusions; consistent recommendations based on comprehensive literature review that includes thorough reference to scientific evidence. **B Good quality**: Reasonably consistent results; sufficient sample size for the study design; some control, fairly definitive conclusions; reasonably consistent recommendations based on fairly comprehensive literature review that includes some reference to scientific evidence. **C Low quality or major flaws**: Little evidence with inconsistent results; insufficient sample size for the study design; conclusions cannot be drawn.
Level II Quasi-experimental study Explanatory mixed method design that includes only a level II quaNtitative study Systematic review of a combination of RCTs and quasi-experimental studies, or quasi-experimental studies only, with or without meta-analysis	**QuaLitative Studies** No commonly agreed-on principles exist for judging the quality of quaLitative studies. It is a subjective process based on the extent to which study data contributes to synthesis and how much information is known about the researchers' efforts to meet the appraisal criteria. *For meta-synthesis, there is preliminary agreement that quality assessments of individual studies should be made before synthesis to screen out poor-quality studies[1].* **A/B High/Good quality** is used for single studies and meta-syntheses[2]. The report discusses efforts to enhance or evaluate the quality of the data and the overall inquiry in sufficient detail; and it describes the specific techniques used to enhance the quality of the inquiry. Evidence of some or all of the following is found in the report: • Transparency: Describes how information was documented to justify decisions, how data were reviewed by others, and how themes and categories were formulated. • Diligence: Reads and rereads data to check interpretations; seeks opportunity to find multiple sources to corroborate evidence. • Verification: The process of checking, confirming, and ensuring methodologic coherence. • Self-reflection and scrutiny: Being continuously aware of how a researcher's experiences, background, or prejudices might shape and bias analysis and interpretations. • Participant-driven inquiry: Participants shape the scope and breadth of questions; analysis and interpretation give voice to those who participated. • Insightful interpretation: Data and knowledge are linked in meaningful ways to relevant literature.
Level III Nonexperimental study Systematic review of a combination of RCTs, quasi-experimental and nonexperimental studies, or nonexperimental studies only, with or without meta-analysis Exploratory, convergent, or multiphasic mixed methods studies Explanatory mixed method design that includes only a level III quaNtitative study QuaLitative study Meta-synthesis	**C Low quality** studies contribute little to the overall review of findings and have few, if any, of the features listed for high/good quality.
Level IV Opinion of respected authorities and/or nationally recognized expert committees or consensus panels based on scientific evidence Includes: • Clinical practice guidelines • Consensus panels/position statements	**A High quality:** Material officially sponsored by a professional, public, or private organization or a government agency; documentation of a systematic literature search strategy; consistent results with sufficient numbers of well-designed studies; criteria-based evaluation of overall scientific strength and quality of included studies and definitive conclusions; national expertise clearly evident; developed or revised within the past five years **B Good quality:** Material officially sponsored by a professional, public, or private organization or a government agency; reasonably thorough and appropriate systematic literature search strategy; reasonably consistent results, sufficient numbers of well-designed studies; evaluation of strengths and limitations of included studies with fairly definitive conclusions; national expertise clearly evident; developed or revised within the past five years **C Low quality or major flaws:** Material not sponsored by an official organization or agency; undefined, poorly defined, or limited literature search strategy; no evaluation of strengths and limitations of included studies, insufficient evidence with inconsistent results, conclusions cannot be drawn; not revised within the past five years
Level V Based on experiential and nonresearch evidence Includes: • Integrative reviews • Literature reviews • Quality improvement, program, or financial evaluation • Case reports • Opinion of nationally recognized expert(s) based on experiential evidence	**Organizational Experience (quality improvement, program or financial evaluation)** **A High quality**: Clear aims and objectives; consistent results across multiple settings; formal quality improvement, financial, or program evaluation methods used; definitive conclusions; consistent recommendations with thorough reference to scientific evidence **B Good quality**: Clear aims and objectives; consistent results in a single setting; formal quality improvement, financial, or program evaluation methods used; reasonably consistent recommendations with some reference to scientific evidence **C Low quality or major flaws**: Unclear or missing aims and objectives; inconsistent results; poorly defined quality improvement, financial, or program evaluation methods; recommendations cannot be made **Integrative Review, Literature Review, Expert Opinion, Case Report, Community Standard, Clinician Experience, Consumer Preference** **A High quality**: Expertise is clearly evident; draws definitive conclusions; provides scientific rationale; thought leader(s) in the field **B Good quality**: Expertise appears to be credible; draws fairly definitive conclusions; provides logical argument for opinions **C Low quality or major flaws**: Expertise is not discernable or is dubious; conclusions cannot be drawn

1 https://www.york.ac.uk/crd/SysRev/ISSLI/WebHelp/6_4_ASSESSMENT_OF_QUALITATIVE_RESEARCH.htm
2 Adapted from Polit & Beck (2017).

Note. Dang, D., & Dearholt, S. (2017). Johns Hopkins nursing evidence-based practice: model and guidelines. 3rd ed. Indianapolis, IN: Sigma Theta Tau International

Figure 7.

Diabetes Screening Process



TJA: Total Joint Arthroplasty
PETC: Pre-anesthesia Evaluation Testing Center
ADA: American Diabetes Association
FBG: Fasting Blood Glucose
POC: Point of Care
DOS: Day of Surgery
SAS: Surgical Admission Suite

Note. This image represents the process developed from the time patients entered the preoperative clinic to the time the patient received a FBG test on their scheduled day of surgery if indicated. The end of this process was intended to result in the facilitation of increased screening of an at-risk population as well as improve pre, intra- and postoperative blood glucose management, with the goal of increasing positive patient outcomes.