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Method Article

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Development and Implementation of an Automated Electronic Health Record (EHR)-Integrated Clinical Decision Support Tool for Preoperative Triage

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Abstract

Background:

Effective preoperative triage ensures surgical patients receive an appropriate level of evaluation based on medical complexity and procedural risk. Traditional approaches rely on manually completed risk assessments or individual clinician judgment, contributing to variability in referral practices, administrative burden, and workflow inefficiencies. We sought to develop, implement, and internally validate an automated electronic health record (EHR)-integrated tool to standardize preoperative risk stratification and guide evaluation pathways and surgical venue selection.

Methods/Design:

A multidisciplinary quality improvement initiative was conducted at a large academic medical center. Appropriate medical risk variables were identified through literature review, expert consensus, and retrospective review of fifty outpatient preoperative clinic referrals using Pareto methodology. Variables were weighted according to their anticipated impact on perioperative management. Procedural risk was established through surgical collaboration and literature-informed classification of approximately 6,000 institutional Current Procedural Terminology codes. Medical and procedural risk components were combined to generate a composite Presurgical Risk Score. Clinical variables were translated into EHR logic using diagnosis groupers comprising related ICD-10 codes and structured clinical data. The algorithm was embedded within existing surgical workflows to generate automated scores and guide preoperative evaluation pathways. Technical validation included manual score validation over a six month period with comparisons to automated scores, and structured review of discordant cases to inform iterative refinement

Discussion:

The automated approach eliminated the need for a previously inconsistent manual risk evaluation process and enabled a standardized workflow for patients requiring higher-acuity preoperative evaluation. The automated tool was successfully integrated into existing EHR workflows and generated real-time scores without requiring manual data entry. This platform provides a scalable approach to standardized patient routing and perioperative risk stratification. Further dedicated technical validation of the risk score is underway along with future integration of surgical risk prediction models, and readmission risk scores to further enhance surgical venue selection.

Keywords: Preoperative Risk Score, Clinical Decision Support, Electronic Health Records, Perioperative Triage, Perioperative Workflow

BACKGROUND:

Perioperative medicine is an increasingly important multidisciplinary subspecialty, driven by the growing complexity of surgical patient populations and the need for coordinated care across anesthesiology, surgery, and medicine. Perioperative evaluations are essential for patients with comorbidities, polypharmacy, frailty, and cognitive impairment and have consistently been shown to improve surgical and postoperative outcomes. Pre-operative assessments reduce delays, cancellations, and associated costs, and improve scheduling and resource utilization. However, ensuring that the right patients are selected for this evaluation is often difficult. Low-risk patients undergoing surgery at ambulatory pavilions getting an in-person perioperative evaluation can create a bottleneck and affect throughput. At The Ohio State University Wexner Medical Center (OSUWMC), there was no consistent pattern of referral from the surgical teams leading to overutilization of the perioperative evaluation services. As a result, the development of multiple pathways of evaluations and optimal triage of patients, based on medical comorbidities and surgical risk, was necessary for our institution. First, we pioneered two pathways for patients needing preoperative optimization: a virtual telehealth pathway for low-risk ambulatory surgery and an in-person pathway at our perioperative clinics for high-risk patients undergoing surgery. This has been a model that has been adopted at multiple academic centers across the nation.

An efficient scoring tool that allows for accurate triage minimizes delays in optimization, allows for appropriate venue selection, and more importantly creates a standardized workflow that does not rely on clinical judgement alone. To standardize the criteria that delineate between a telehealth and in-person visit, our institution developed and implemented a predictive scoring tool that uses both patient medical history and surgical risk. Multiple triage approaches have been described in the past that include manual patient questionnaires which we implemented as the first phase in our process. [2]. A challenge with manual or staff administered questionnaires was the sustainability and scalability of the process across surgical specialties. Leveraging the electronic medical records and partnering with our EPIC Integrated Healthcare Information System (IHIS) team, we were able to develop an algorithm that allows for successful differentiation between low-risk patients needing telehealth evaluations and high-risk patients needing in-person evaluations.

In this paper, we will describe the development and validation methodologies used for the IHIS-integrated triage risk scoring tool called the Pre-surgical Risk Score. This tool leverages predictive modeling and large language model capabilities to generate a score that guides triaging decision making. A few institutions have been able to leverage AI including Chi Mei University in China that developed a machine learning algorithm with patient comorbidities that could predict post operative risks and the development of the POSPOM (PreOperative Score to predict PostOperative Mortality). [3,4] These are global scoring tools that allow for better detection of post-operative risks. One institution was able to develop a CAST (Comorbidity Assessment for Surgical Triage) score that incorporates both patient comorbidities and surgical case characteristics to predict 30-day morbidity and serve as a triaging tool for the type of preanesthetic evaluation the patient would receive. This paper will include the multiphase framework and process to develop, integrate, and validate an electronic health record (EHR)–embedded preoperative triage risk scoring tool to guide patients to the appropriate preoperative evaluation venue. We will discuss tool development with EHR integration followed by retrospective validation and future directions.

METHODS:

Study Design and Setting

This quality improvement project was conducted at a large academic medical center using an enterprise IHIS. The project used a multiphase approach to develop, implement, and validate an automated EHR-integrated clinical decision support tool for preoperative risk stratification and patient triage.

Preoperative evaluations at our institution are coordinated through a standardized preprocedural preparation process. Low-risk ambulatory patients are generally evaluated through a nurse-led telehealth pathway, whereas patients with greater medical complexity are referred to the outpatient preoperative assessment clinic (OPAC) for an in-person evaluation by a medical provider with internal medicine and anesthesiology oversight. Surgical procedures are performed across multiple venues with differing capabilities and patient-selection requirements.

Existing Triage Process and Rationale for Automation

Prior to development of the automated tool, patients were triaged using a manually completed risk-scoring instrument. Ancillary staff within surgical clinics reviewed predefined clinical criteria and calculated a cumulative score (Table 1).

Patients with a score ≥3 were referred to OPAC for an in-person provider evaluation, whereas patients with a score <3 were generally directed to a nurse-led telehealth evaluation.

Although the manual instrument provided a standardized framework for triage and for identifying patients requiring higher-level preoperative evaluation, implementation across the enterprise proved challenging. Completion rate for the manual risk score was around 24%. To improve adherence, a Best Practice Alert (BPA) was introduced within the electronic health record to prompt completion of the manual assessment. However, frequent BPA activation created additional workflow burden and clinician dissatisfaction, highlighting the limitations of relying on manual data entry for enterprise-wide implementation.

These challenges prompted development of an automated, EHR-integrated approach that could reproduce the same risk output without requiring additional clinician documentation. Importantly, approximately one year of manual scoring data showing low compliance with the tool, inaccurate data capture, and inaccurate scoring prior to implementation of the automated system, providing an opportunity to compare automated scores with the existing manual process and support technical validation of the new model.

Transitioning to an automated model allowed risk stratification to occur within the existing workflow without requiring additional manual documentation. Because the original manual and automated scoring systems were designed to generate the same risk outputs, historical manual data also provided a unique opportunity for technical validation. Manually reconstructed scores were compared with EHR-generated scores using percent agreement, and discordant cases underwent structured review to identify data-capture or algorithm-logic limitations and inform iterative grouper refinement

Design Principles and Multidisciplinary Development

The automated tool was developed in collaboration with anesthesiologists, internal medicine physicians, nursing leadership, and clinical informaticists, with structured input from surgical stakeholders regarding procedural risk stratification. Design requirements included:

1. Fully automated score generation without manual data entry
2. Use of structured EHR data to ensure scalability and reproducibility

3. Ability to identify both medically complex patients and higher-risk surgical procedures
4. Seamless integration into IHIS to augment surgeon clinic workflows

A multidisciplinary development committee was convened to oversee variable selection, weighting, and iterative refinement of the tool.

Variable Selection and Scoring Development

Medical comorbidity variables were identified using a combination of literature-informed thresholds, expert consensus, and retrospective analysis of prior referral patterns for in-person visits. Conditions associated with increased postoperative morbidity and perioperative resource utilization, including severe cardiopulmonary disease, uncontrolled diabetes mellitus, anemia, polypharmacy, frailty, and recent hospitalization or skilled nursing facility placement were prioritized based on published perioperative risk literature. Additional conditions considered likely to alter perioperative planning at our institution included implantable devices requiring perioperative management, recent stroke or acute cardiac events, major aneurysmal disease, and moderate-to-severe valvular heart disease

To ensure that the model also reflected local clinical practice, the development team retrospectively reviewed 50 referrals to preoperative clinic. Referral indications documented by surgical teams were confirmed through chart review, categorized, and evaluated using Pareto methodology to identify the most frequent drivers of referral for in-person preoperative evaluation. A relatively limited number of clinical conditions accounted for most of the referrals. The purpose of this developmental sample was to identify dominant referral drivers and establish content and workflow relevance rather than to perform statistical derivation or predictive validation of the model.

Findings from the literature review, retrospective referral analysis, and expert consensus were combined to create the initial set of medical risk variables (Table 1).

A weighted point system was developed by multidisciplinary expert consensus according to the anticipated likelihood that an identified condition would alter preoperative optimization, require additional evaluation, or influence perioperative management. Individual medical risk variables were assigned values of 0.5, 1.0, or 2.0 points, with increasing values representing greater anticipated impact on perioperative planning. The complete medical risk scoring schema and subsequent modifications are presented in Tables 1 and 2.

The scoring framework underwent iterative review over a six month time frame to improve sensitivity for clinically meaningful conditions and to align the algorithm with institutional preoperative practices.

Development of Procedure-Specific Risk

A procedural risk component was developed to complement the medical comorbidity score. Published guidance and consensus recommendations regarding low-, moderate-, and high-bleeding-risk procedures were reviewed to establish the initial classification framework. Institutional informatics personnel extracted Current Procedural Terminology (CPT) codes for approximately 6,000 procedures performed within the health system.

Procedures were reviewed and categorized according to procedural bleeding risk. Procedural risk categories were assigned weighted values ranging from 1 point for low-risk procedures to 3 points for high-risk procedures. Procedures for which classification was uncertain were reviewed with surgeons from the relevant specialties, and surgical feedback was incorporated into the final classification.

The medical comorbidity component and procedure-specific risk component were subsequently combined to generate the composite Presurgical Risk Score (Table 3). The resulting score was designed to stratify patients into predefined risk categories linked to recommended preoperative evaluation pathways and to provide additional information to support surgical venue selection.

Translation of Clinical Variables Into IHIS Diagnosis Groupers

Following development of the clinical scoring framework, the multidisciplinary team partnered with institutional clinical informatics specialists to translate the clinical variables into executable IHIS logic.

For conditions represented by diagnostic information, electronic diagnosis groupers were created. Each grouper consisted of a collection of related diagnostic codes representing a clinically defined risk condition. Standardized ICD-10 diagnoses from structured EHR fields, including problem-list diagnoses, encounter diagnoses, and available historical diagnoses, were mapped to the corresponding clinical risk domains.

This approach allowed multiple individual diagnostic codes to be translated into a single clinically meaningful risk variable. When IHIS identified a qualifying diagnosis within a predefined grouper, the corresponding risk condition was

considered present, and its assigned weight contributed to the medical risk score. Structured information from laboratory results, medications, and other available EHR fields were incorporated for variables not adequately represented by diagnosis codes alone.

The grouper methodology therefore provided a bridge between granular EHR data and the higher-order clinical conditions used in the risk-scoring framework.

Automated Score Generation and IHIS Workflow Integration

The scoring logic was embedded directly within IHIS to eliminate the need for manual calculation in real time as follows: IHIS queries available structured patient data, then applies the predefined diagnosis grouper and rule logic, assigns the corresponding medical risk weights, and finally generates an automated risk score.

The architecture was designed to permit risk information to become available early in the surgical planning process. At the time of surgical case request, procedure-specific information is incorporated into the algorithm and combined with the medical risk component to generate the final Presurgical Risk Score.

The resulting score is displayed within the surgical scheduling and referral workflow and is linked to predefined preoperative evaluation pathways. This design allows surgical teams to use information generated from existing EHR data without completing a separate risk assessment instrument. The composite score also provides decision support for surgical venue selection.

Clinical and Technical Validation of Automated Scoring

Technical validation was performed to evaluate the accuracy with which the clinical scoring framework had been translated into executable IHIS logic. Adult patients referred for preoperative evaluation between July 2025 and December 2025 were eligible for the validation cohort.

Using the prespecified scoring criteria, reviewers examined available diagnoses, problem-list information, laboratory results, medications, and procedure-related information and independently reconstructed the expected risk score. Manually constructed scores were compared with EHR-generated scores using percent agreement, and discordant cases underwent structured review to identify data-capture or algorithm-logic limitations and inform iterative grouper

refinement. The frequency and direction of score discrepancies were recorded as qualitative data to help refine the grouper logic. Where applicable, agreement at the individual risk-variable level was also evaluated to determine whether specific components of the algorithm contributed disproportionately to discordance.

Iterative Refinements

Cases in which the manually calculated and IHIS-generated scores differed underwent structured review by members of the development team and clinical informatics team. Sources of discordance were categorized according to the underlying cause.

Common categories included incomplete or outdated problem lists, clinically relevant conditions documented outside structured EHR fields, missing discrete data elements, incomplete medical information for patients receiving care outside the health system, and limitations in diagnosis grouper definitions or scoring logic.

Importantly, discrepancies related to unavailable or incomplete source data were distinguished from discrepancies caused by incorrect execution of the electronic algorithm. This distinction allowed the team to differentiate limitations of EHR data captured from errors within the scoring implementation itself.

Identified grouper or rule-logic discrepancies were reviewed and used to iteratively refine diagnosis definitions and scoring rules. Revised logic was subsequently retested against patient charts prior to broader implementation. This iterative process, spanning over 6 months, was intended to optimize the fidelity of the automated implementation while preserving the original clinical intent of the scoring framework

Analysis

We plan to evaluate the implementation, technical accuracy, and clinical pathway concordance of the automated preoperative risk stratification tool. Implementation will be assessed by comparing the proportion of eligible surgical patients with completed risk scores using the previously established manual scoring process (baseline implementation rate of 24%) versus the automated EHR-based tool.

Technical validation will assess exact percent agreement between manually calculated and automated risk scores, as well as concordance across predefined risk categories. We will further evaluate whether the automated score appropriately

directs patients to the intended preoperative evaluation pathway based on medical complexity and procedural risk, using a research study protocol.

Cases of discordance will undergo targeted chart review to identify the source and clinical significance of disagreement. This will include assessing whether discrepancies result from limitations in diagnosis grouper or scoring logic, incomplete or outdated structured clinical data, or appropriate physician-directed decisions outside the recommended pathway. We will also determine the proportion of scoring discrepancies that result in a change in recommended triage pathway and distinguish clinically justified overrides from potential under or over triage.

This analysis will help strengthen the reliability and applicability of the automated tool, identify opportunities for algorithm refinement, and support standardized preoperative pathway selection while preserving physician clinical judgment.

Limitation

The automated risk stratification tool has several limitations. First, its performance depends on the availability and accuracy of structured clinical information within IHIS. Incomplete or outdated problem lists, diagnoses documented only in free-text notes, and medical information from outside health systems may limit the tool's ability to identify relevant risk factors accurately.

Second, the algorithm applies standardized risk criteria and does not account for individual physician practice preferences, specialty-specific considerations, or all patient-specific clinical circumstances that may influence preoperative evaluation decisions. Consequently, deviations from the recommended pathway may reflect appropriate clinical judgment rather than limitations of the algorithm.

Finally, agreement between manual and automated scoring establishes technical concordance but does not independently establish the clinical validity of the underlying scoring framework or its impact on postoperative outcomes. Further evaluation is necessary to determine the tool's effectiveness in improving patient routing, surgical venue selection, and perioperative outcomes.

DISCUSSION:

The development and implementation of an automated, EHR-integrated Presurgical Risk Score represents an approach to standardizing preoperative risk assessment and patient routing within a complex surgical health system. By translating clinical risk criteria into automated decision support, the tool facilitates identification of patients who may require higher-acuity preoperative evaluation and provides guidance for surgical venue selection. Importantly, this work demonstrates the feasibility of incorporating standardized perioperative risk assessment directly into existing clinical workflows without requiring additional manual data entry.

Our experience highlights an important distinction between successful pilot implementation and sustainable enterprise-wide adoption. Although the original manual scoring tool provided a standardized approach to preoperative triage, its scalability was limited by the need for surgical clinic staff to complete additional documentation and calculate risk scores. Subsequent efforts to improve adherence through EHR-based Best Practice Alerts (BPAs) generated frequent notifications and clinician dissatisfaction. This experience reinforced that clinical decision-support interventions must consider not only the validity of the underlying clinical criteria but also their impact on workflow efficiency and clinician burden. By automating the scoring process within IHIS, we sought to shift risk assessment from an additional administrative task to an embedded component of routine surgical planning.

A central innovation of this work is the translation of clinically derived perioperative risk criteria into executable EHR logic using diagnosis groupers and structured clinical information. Similar to computable phenotype methodologies, diagnosis groupers aggregate multiple diagnostic codes into clinically meaningful risk domains, allowing heterogeneous patient information to be interpreted consistently within an automated scoring framework.[9] Unlike standalone risk calculators that require clinicians to manually enter patient information, the Presurgical Risk Score generates risk scores within the existing surgical workflow.

Beyond automation, the clinical significance of this tool lies in its ability to support a more coordinated and standardized preoperative evaluation process. Building on prior work demonstrating the value of EHR-integrated clinical decision support in perioperative care,[10] our approach extends beyond individual testing decisions by incorporating medical complexity and procedural risk into a unified triage framework. Embedding this assessment within surgical workflows may facilitate earlier identification of patients requiring higher-acuity evaluation, optimize the use of limited preoperative resources, and support more consistent surgical venue selection. These potential benefits are particularly relevant as health

systems manage increasing surgical volumes and expand ambulatory surgical services, although their impact on clinical outcomes and resource utilization requires further evaluation.

Future development will focus on expanding the clinical and operational capabilities of the platform. Incorporation of validated surgical risk prediction and hospital readmission models may improve identification of patients likely to require higher-acuity surgical settings or postoperative resources. Advances in artificial intelligence, including natural language processing and large language models, may also enable extraction of clinically relevant information from unstructured notes and external clinical documentation, potentially expanding the information available for automated risk assessment. Such applications require independent evaluation of extraction accuracy and clinical safety before integration into scoring logic.

Overall, this work illustrates how multidisciplinary clinical expertise and informatics infrastructure can be combined to translate a manually administered preoperative scoring framework into an automated, EHR-integrated clinical decision-support system. Continued evaluation of technical performance, clinical pathway concordance, and operational outcomes will be essential to determine whether this approach improves the efficiency, consistency, and appropriateness of perioperative care.

List of Abbreviations:

OSUWMC: The Ohio State University Wexner Medical Center

POSPOM: PreOperative Score to predict PostOperative Mortality

IHIS: EPIC Integrated Healthcare Information System

CAST: Comorbidity Assessment for Surgical Triage

EHR: Electronic health record

OPAC: Outpatient preoperative assessment clinic

BPA: Best Practice Alert

Declarations:

Ethics approval and consent to participate: Not applicable

Consent for publication: Not applicable

Availability of data and materials: The datasets generated and/or analyzed during the current study are not publicly available due to patient privacy reasons but de-identified data are available from the corresponding author on reasonable request

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Authors' contributions: PH, BR, JH, RS, IC analyzed and interpreted patient data, developed scoring criteria and validated results and wrote the manuscript. WF, GR were IHIS project leads and contributed to the technical IHIS based information in the manuscript. All authors equally edited, read and approved the final manuscript."

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Table 1: First Iteration of Medical Comorbid Conditions used for the Presurgical Risk Score
Medical Comorbid Diagnosis
Age > 85
Home O2 and COPD
Cirrhosis or Liver Failure
Orthopnea or Shortness of breath
Implant Devices
Insulin Pump
Stroke History
Heart Attack/Stent
Blood Clot or Bleeding Problems
Aneurysm of a blood vessel
A1C > 8
Thrombocytopenia
Anemia
VTI > 2
Skilled Nursing Facility
This represents an initial list of medical conditions that were elected to serve as screening criteria for the Presugical Risk Score

Table 2: Scoring Schema and Inputted Criteria for the Presurgical Risk Score		
Medical Comorbid Diagnosis	**Score**	**Criteria inputted**
Age >85	2 points	Documented patient age
Home oxygen use with COPD	1 point	Previously documented home oxygen in Flowsheets or documented medical history of Problem List
Liver disease	2 points	Documented medical history

Orthopnea or Shortness of Breath	2 points	Documental medical history or Problem List
Insulin Pump Use	0.5 points	Document infusion pump and active infusion pump medications
History of stroke or heart attack/stent	2 points each	Documental medical/surgical history or Problem List within the last six months
Bleeding or Clotting Disorders	1 point	Documented medical history, Problem list or bleeding problems documented in the chart
Elevated A1c>8	1 point	Lab results (HbA1c)
Thrombocytopenia and anemia	1 point each	Lab results: Platelets (<50,000 for three consecutive results), hemoglobin (<8) for three consecutive results
Low ejection fraction below 35%	2 points	Documented Echocardiogram or TEE (LVBPEF <35%)
Severe aortic or mitral valve area reduction	2 points	Documented Echocardiogram or TEE; Aortic: (AVACONVMAX<1), Mitral (MVAP <1.2)
Right ventricular systolic pressure above 45	2 points	Documented Echocardiogram or TEE; (ESTRVSP>45)
Recent skilled nursing facility admission	0.5 points	Documented ADT Point of Origin, or skilled nursing in Patient Registration/Demographics

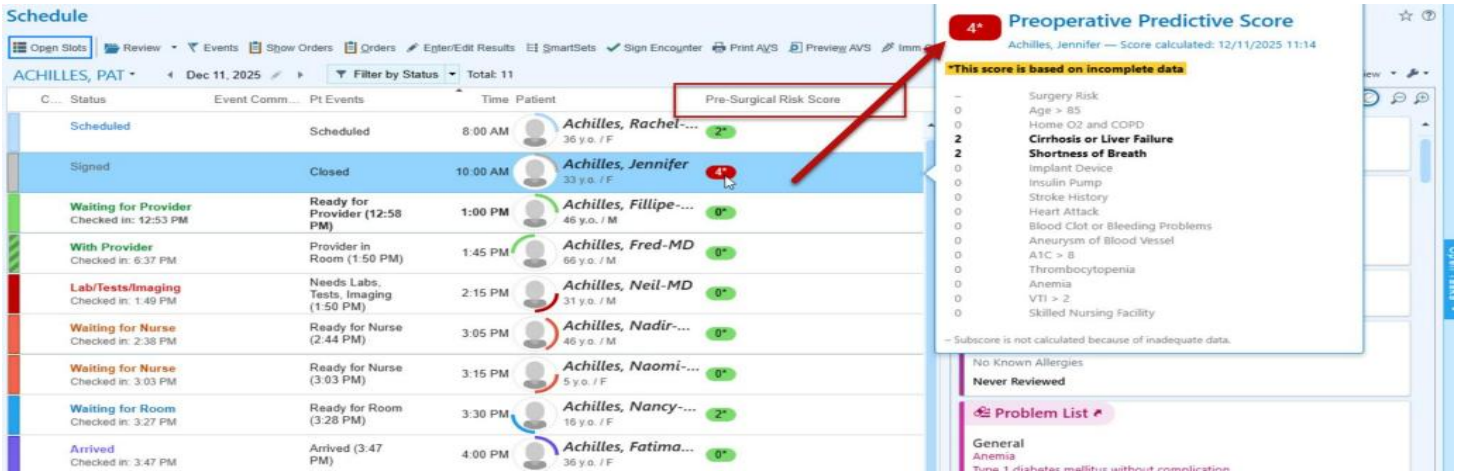
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Table 3: Inputs for the Presurgical Risk Score and Triaging Algorithm used	
Surgical Bleeding Risk of the Procedure/Surgery	Points
Medical Comorbidities	Points
	TOTAL SCORE
TOTAL SCORE < 3	**TOTAL SCORE ≥ 3**

= Telehealth Visit with a nurse	= In person visit with a provider
The presurgical risk score represents the composite score that includes both medical comorbidities and surgical bleeding risk of specific surgeries.	

Figure 1: **Presurgical Risk Score Integration into IHIS and Daily Schedules**



This figure represents the integration of the presurgical risk score into IHIS and furthermore into the daily schedules in the ambulatory setting so that triaging decision can be made at the point of contact with the surgeon