**Online Appendix 1**

Intraoperative Hypotension Measure Specifications

*Note: Beginning in 2020, anesthesia providers can choose to report this measure in the Center for Medicare and Medicaid Services’ Merit-based Incentive Payment System (MIPS) program (measure ID EPREOP31).*

**Measure title:** Intraoperative Hypotension among Non-Emergent Noncardiac Surgical Cases

**Description:** Percentage of general anesthesia cases in which mean arterial pressure (MAP) fell below 65 mmHg for cumulative total of 15 minutes or more

**Rationale:** MAP below 60–70 mmHg among adults having non-cardiac surgeryis associated with increased risk of acute kidney injury (AKI), myocardial injury, and mortality, and the risk is a function of both hypotension severity and duration (Sessler et al. 2019). Noncardiac surgery patients are at increased risk of AKI when their cumulative time below a MAP of 65 mmHg reaches or exceeds 13 minutes. When patients fall even further below this threshold (for example, MAP below 55 mmHg), even shorter durations are associated with increased risk of AKI (Salmasi et al. 2017). Among adult noncardiac surgery patients, 31.3 percent have experienced MAP below 65 mmHg for 10 minutes or longer (Bijker et al. 2007). Different approaches for managing patients’ blood pressure during surgery are significantly associated with higher or lower risks of postoperative organ dysfunction, including renal dysfunction (Futier et al.2017).

**Improvement notation:** A lower score indicates better quality. Note that providers are not expected to receive a score of zero on the measure, because some patients could have a MAP that falls below 65 for reasons outside a provider’s control.

**Guidance:** This measure evaluates the proportion of cases in which the patient’s MAP is below 65 mmHg for 15 minutes or more, cumulatively over the course of the surgery. The numerator condition is met when MAP is below 65 mmHg for one continuous period lasting 15 minutes or more, or if the patient has several discrete periods with a MAP below 65 mmHg that collectively sum to 15 minutes or more. Note that this measure is not intended to substitute for the clinician’s judgement about managing IOH for any given patient, and for some patients the clinician may manage blood pressure using a higher or lower target MAP (e.g., a higher MAP target for patients with chronic hypertension).

To report the measure, the reporting clinician must submit data on the patient’s MAP over the course of the surgery as monitored by an anesthesia information management system (AIMS). The reporting clinician must submit intraoperative patient vitals extracted directly from an interface with the monitor. Reporting clinicians who track blood pressure manually are not eligible to report the measure. If the record for a given case includes both vitals pulled from the monitor and manually recorded vitals, only those from the monitor will be used to score the measure.

The first blood pressure reading is defined as the anesthesia start time. The measure end time is defined as the anesthesia end time. A given blood pressure reading will be attributed to the period that runs from the time the reading was recorded to the time of either the next reading or the measure end time. If the period between a given reading and either the next reading or the measure end time lasts for longer than five minutes, the reading will only be attributed for five minutes. If the reporting clinician monitors a patient using more than one method (i.e., using invasive and non-invasive methods) and there are two MAPs available at the same point in time, the measure uses the invasive value for scoring the measure. The measure attributes the full case to all reporting clinicians who provide care during any portion of the case from the beginning to the end of the measurement period.

The measure excludes patients with a baseline MAP below 65 mmHg. To determine the patient’s baseline MAP, the measure relies on the most recent reading taken from the preoperative holding area. If no such reading is available, the measure uses the most recent MAP taken in the operating room before induction of anesthesia.

If a clinician does not have MAP values available to report either for the baseline MAP or for measurements across the measurement period, the clinician may submit pairs of systolic and diastolic blood pressures (SBPs and DBPs) as a replacement for the MAP. The registry collecting the data will use these systolic and diastolic pressure values to calculate MAP values. Specifically, the registry will calculate MAP using the following formula: MAP = 1/3 (SBP) + 2/3 (DBP) (Sesso et al. 2000).

Non-emergency surgeries include both elective and urgent surgeries.

Because longitudinal blood pressure data can contain artifactual values (for example, inaccurate readings caused by the surgeon’s leaning on the blood pressure cuff), the measure will drop MAP, SBP, and DBP readings that are likely to be artifacts. Specifically, the measure will drop individual MAP readings that meet any of the following criteria:

* Documented as an artifact by the clinician
* SBP ≥ 300 mmHg or ≤20 mmHg
* DBP ≤5 mmHg or DBP ≥ 225 mmHg
* SBP and DBP within 5 mmHg
* MAP ≤30 mmHg or ≥ 250 mmHg

**Measurement period:** Measurement period is 12 months.

**Initial population:** All cases in which adults (ages 18 and older) with noncardiac, non-emergency surgery require general anesthesia or monitored anesthesia care

* **Data elements and definitions**
	+ Age: The length of time that the patient has lived. Note: Age in years at the Anesthesia Start Time (see definition below under Numerator). Age will be calculated from the date of birth if available (Anesthesia Quality Institute 2018).
	+ Non-emergency: Refers to both elective and urgent surgeries.
		- Elective: A surgical, therapeutic, or diagnostic procedure that can be performed at any time or date with an agreement between the surgeon and the patient (Anesthesia Quality Institute 2018)
		- Urgent: A surgical, therapeutic, or diagnostic procedure that must be performed to prevent death or permanent impairment but that can be delayed. Note: The procedure may be delayed to allow for medical optimization of the patient or to permit better availability of resources (ex., personnel or equipment) (Anesthesia Quality Institute 2018).
	+ General anesthesia: A drug-induced loss of consciousness during which patients are not arousable, even by painful stimulation. General anesthesia often impairs the patient's cardiovascular function and/or the ability to independently maintain spontaneous ventilation. Under general anesthesia, patient may require assistance in maintaining a patent airway and positive pressure ventilation may be required because of depressed spontaneous ventilation or drug induced depression of neuromuscular function (Anesthesia Quality Institute 2018).
	+ Monitored anesthesia care: A specific type of anesthesia service in which a qualified anesthesia provider has been requested to participate in the care of a patient undergoing a diagnostic or therapeutic procedure. *Note*: Indications for Monitored Anesthesia Care depend on the nature of the procedure, the patient's clinical condition, and/or the potential need to convert to a general or regional anesthetic. This is a specific type of anesthesia service that excludes general anesthesia, peripheral nerve block, and neuraxial anesthesia (spinal and epidural anesthesia). Deep sedation/analgesia is also included in MAC (Anesthesia Quality Institute 2018).

**Denominator:** Equals initial population

**Denominator exclusions**

* American Society of Anesthesiologists (ASA) Physical Status Classification of 5 and 6
* Baseline MAP below 65 mmHg
* Obstetric non-operative procedures
* Obstetric non-operative procedure rooms
* Obstetric non-operative procedures with labor epidural
* Liver transplant
* Lung transplant
* Cataract surgery
* **Definitions**
	+ ASA Physical Status Classification of 5 and 6: Cases in which the patient’s American Society of Anesthesiology Physical Status classification, as captured in the anesthesia record for the case, is either 5 or 6.
		- ASA 5: American Society of Anesthesiologists (ASA) Physical Status indicating the patient is considered to be moribund and is not expected to survive without the operation (Anesthesia Quality Institute 2018).
		- ASA 6: American Society of Anesthesiologists (ASA) Physical Status indicating the patient is declared brain-dead and whose organs are being removed for donor purposes (Anesthesia Quality Institute 2018).
	+ Baseline MAP < 65 mmHg: Cases in which the baseline MAP is below 65 mmHg. If one or more MAP values are available from the pre-operative holding area, the most recent value determines whether the patient meets the exclusion criteria. If no pre-operative holding area values are available, then the most recent pre-induction value from the operating room determines whether the patient meets the exclusion criteria. If a MAP reading is not available, then a calculated MAP value based on SBP and DBP readings is acceptable.
	+ Cardiac surgery: Refers to cases involving anesthesia provided during cardiac surgeries, defined by the following Current Procedural Terminology (CPT®) codes present during this encounter:
		- 00560: Anesthesia for procedures on heart, pericardial sac, and great vessels of chest; without pump oxygenator
		- 00562: Anesthesia for procedures on heart, pericardial sac, and vessels of chest; with pump oxygenator, age 1 year or older, for all noncoronary bypass procedures (e.g., valve procedures) or for re-operation for coronary bypass more than 1 month after original operation.
		- 00563: Anesthesia for procedures on heart, pericardial sac, and vessels of chest; with pump oxygenator with hypothermic circulatory arrest
		- 00566: Anesthesia for direct coronary artery bypass grafting; without pump oxygenator
		- 00567: Anesthesia for procedures on heart, pericardial sac, and vessels of chest; with pump oxygenator
		- 00580: Anesthesia for heart transplant or heart/lung transplant
	+ Obstetric non-operative procedures: Refers to cases involving delivery procedures defined by the following CPT codes present during this encounter:
		- 01958: Anesthesia for external cephalic version procedure
		- 01960: Anesthesia for vaginal delivery only
		- 01967: Neuraxial labor analgesia/anesthesia for planned vaginal delivery (this includes any repeat subarachnoid needle placement and drug injection and/or any necessary replacement of an epidural catheter during labor)
	+ Liver transplant: Refers to cases involving liver transplant surgery procedures or anesthesia provided during liver transplant surgery, defined by the following CPT codes present during this encounter:
		- 00796: Anesthesia for intraperitoneal procedures in upper abdomen including laparoscopy; liver transplant (recipient)
		- 47135: Liver allotransplantation, orthotopic, partial or whole, from cadaver or living donor, any age
	+ Lung transplant: Refers to cases involving lung transplant surgery procedures defined by any of the following CPT codes present during this encounter:
		- 32851: Lung transplant, single; without cardiopulmonary bypass
		- 32852: Lung transplant, single; with cardiopulmonary bypass
		- 32853: Lung transplant, double (bilateral sequential or en bloc); without cardiopulmonary bypass
		- 32854: Lung transplant, double (bilateral sequential or en bloc); without cardiopulmonary bypass
		- 32855: Backbench standard preparation of cadaver donor lung allograft prior to transplantation, including dissection of allograft surrounding soft tissues to prepare pulmonary venous/atrial cuff, pulmonary artery, and bronchus; unilateral
	+ Cataract surgery: Refers to cases involving cataract surgery, defined by any of the following CPT codes present during this encounter:
		- 66820: Discission of secondary membranous cataract (opacified posterior lens capsule and/or anterior hyaloid); stab incision technique (Ziegler or Wheeler knife)
		- 66821: Discission of secondary membranous cataract (opacified posterior lens capsule and/or anterior hyaloid); laser surgery (e.g., YAG laser), (1 or more stages)
		- 66830: Removal of secondary membranous cataract (opacified posterior lens capsule and/or anterior hyaloid) with corneo-scleral section, with or without iridectomy (iridocapsulotomy, iridocapsulectomy)
		- 66982: Extracapsular cataract removal with insertion of intraocular lens prosthesis (1-stage procedure), manual or mechanical technique (e.g., irrigation and aspiration or phacoemulsification), complex, requiring devices or techniques not generally used in routine cataract surgery (e.g., iris expansion device, suture support for intraocular lens, or primary posterior capsulorrhexis) or performed on patients in the amblyogenic developmental stage
		- 66983: Intracapsular cataract extraction with insertion of intraocular lens prosthesis (1 stage procedure)
		- 66984: Extracapsular cataract removal with insertion of intraocular lens prosthesis (1 stage procedure), manual or mechanical technique (e.g., irrigation and aspiration or phacoemulsification)

**Numerator:** Cases in whichpatients have a MAP below 65 mmHg that exceeds the cumulative length of 15 minutes.

* **Data elements and definitions**
	+ MAP < 65 mmHg: Refers to periods of time (minutes) in which the AIMS records a MAP reading that falls below 65 mmHg at any point between the anesthesia start time and anesthesia end time. The reading can be taken using either invasive or non-invasive means. If two readings are taken at the same time using a combination of invasive and non-invasive means, the invasive reading is used in calculating the measure. The measure defines the duration of the period below 65 mmHg as the total number of minutes starting from the time of a reading below 65 mmHg and either (1) the time of the next reading that meets or exceeds 65 mmHg or (2) the anesthesia end time. If the period between a given reading and either the next reading or the measure end time lasts for longer than five minutes, the reading will only be attributed for five minutes.
	+ Anesthesia start time: Time when the anesthesia team assumes continuous care of the patient and begins preparing the patient for an anesthetic for anesthesia services in the operating room or an equivalent area (Anesthesia Quality Institute 2018).
	+ Anesthesia end time: Time at which qualified anesthesia provider turns over care of the patient to a post anesthesia care team (either PACU or ICU). This time ends when the anesthesia team is no longer furnishing anesthesia services to the patient, that is when the patient may be placed safely under postoperative care and when the anesthesia team has completed transfer of patient care (Anesthesia Quality Institute 2018).
	+ Cumulative length of 15 minutes with MAP < 65 mmHg: Refers to cases in which the sum of minutes between the anesthesia start time and anesthesia end time during which the patient’s MAP was below 65 mmHg equals or exceeds 15 minutes. This sum may include multiple, nonconsecutive periods during the measurement period when the patient’s MAP is below 65 mmHg.

**Risk adjustment:** Variables incorporated into the risk adjustment model include the following:

* Age
* ASA physical status classification
* Body mass index
* Duration of surgery
* Gender

**Steps for Calculating Unadjusted and Risk-Adjusted Measure Scores:**

The measure is risk-adjusted to account for patient-level and case-level risk factors that affect the probability of IOH that are outside of an anesthesia provider’s control. The risk adjustment model calculates the likelihood that a given case would result in IOH based on patient factors; the risk-adjusted measure then scores a clinician by comparing observed instances of IOH to the expected number of IOH cases for that clinician, given the characteristics of their patient population. Clinicians with more observed cases of IOH than expected would receive a higher (worse) score than those with fewer observed cases of IOH than expected.

Use the following steps to calculate clinician-level unadjusted and risk-adjusted measure scores. Note that this measure is specified at the individual clinician-level, but those wishing to report this measure at the group level can follow the calculation steps below but perform those calculations at the group rather than clinician-level (e.g., identifying measure denominator cases associated with the provider group).

1. First, *clean the data* to be used in calculating the measure scores. Check for missing or implausible values for key variables, and drop artefactual blood pressure readings from the longitudinal blood pressure data.
2. Apply the measure logic to all cases occurring during the measurement period to identify all cases meeting *the denominator criteria*, all cases *excluded from the denominator*, and all cases meeting *the numerator criteria* (i.e., cases with IOH).
3. Calculate a *clinician-level unadjusted measure score*. This score is a percentage, with the numerator defined as all numerator cases associated with the clinician, and the denominator defined as all denominator cases (minus excluded cases) associated with the clinician.
4. Apply the risk adjustment model to calculate *the predicted probability that a given case would meet the numerator criteria* (i.e., result in IOH). The model use logistic regression to calculate the log-odds that a given case will result in IOH based on patient- and case-level factors. Apply the model to all cases that meet the denominator criteria and that are not excluded from the denominator. Transform the case-level log-odds into case-level predicted probabilities. To do so, exponentiate the log-odds to first transform it to odds. Then transform the odds to probability by taking the odds divided by 1 plus the odds.
5. Calculate a *clinician-level expected number of IOH cases*. For a given clinician, take the sum of the predicted probabilities for all denominator cases associated with the clinician (minus exclusions). This sum represents the total number of cases for the clinician that are expected to result in IOH, given the risk level of his or her patients.
6. Calculate a *risk-adjusted score* for each clinician. The score is the ratio of the clinician’s total count of cases meeting the numerator criteria to the expected number of IOH cases, among cases that meet denominator criteria for that clinician.
7. (Optional) Transform the risk-adjusted score for each clinician *into a percentage*. Note that performing this transformation is not necessary to calculate the measure, but individual sites may find that representing the scores as a percentage may be helpful for communicating with providers about their measure score. To do so, multiply each clinician’s risk adjusted score from Step 6 (the observed to expected ratio) by the average unadjusted IOH measure score for the larger unit within which clinicians are being compared, for example, a group practice, hospital department, or national reporting program. This transformation may make the risk-adjusted score more easily interpretable, although it is not a true percentage generated from the ratio of numerator and denominator, and it can result in “percentages” greater than 100%.

The remainder of this document describes each of these steps in detail.

*Step 1: Clean the data to be used in measure score calculation*

This section described the recommended steps for cleaning the data to be included in the measure score calculation. It identifies checks to run on the data, but in most cases it does not proscribe a specific approach for cleaning the data, leaving that determination to each individual site.

1. Check for missing values of any of the risk adjustment variables (age, gender, ASA status, BMI, surgery length); the risk adjustment model requires that all covariates are non-missing for each case. Determine how best to address missing values (e.g., impute them, or drop the case if there are few cases with missing values).
2. Check for implausible values for the risk adjustment variables. Determine how best to address them (e.g., correct them if possible, or drop the case if there are few implausible values).
3. Check for implausible values for the timestamp variables. For example, anesthesia start time and induction time should always occur before anesthesia end time. Determine how best to address implausible timelines (e.g., correct them if possible, or drop the case if there are few implausible timelines).
4. Drop artefactual blood pressure readings from longitudinal blood pressure data. See Guidelines section above for details.

*Step 2: Apply measure logic to identify denominator cases, denominator exclusions, and numerator cases*

This section describes the steps used to apply the measure logic to each case included in the measure’s initial population. See specifications above for more detailed guidance on applying measure logic, including definitions of all key parameters.

1. Run the measure on all anesthesia cases during the measurement period, representing a full calendar year.
2. Apply the initial population criteria to each case (see Initial Population section above for definitions for key parameters), and remove cases from the population if any of the below scenarios applies:
	1. Patient is under 18 years of age
	2. Case is an emergency surgery
	3. Case does not include general anesthesia or monitored anesthesia care
3. Use the cases in the initial population as *the denominator cases*.
4. *Apply denominator exclusion criteria* to the denominator cases (see Denominator Exclusions section above for definitions of key parameters), and exclude cases if any of the below scenarios applies:
	1. Case has ASA Physical Status Classification of 5 or 6
	2. Patient has baseline MAP below 65 mmHg
	3. Case is a cardiac surgery
	4. Case is an obstetric non-operative procedure
	5. Case is a liver or lung transplant
	6. Case is a cataract surgery
5. For each denominator case not excluded from the measure, apply the numerator criteria. Calculate the cumulative duration in which the patient’s MAP was below 65 mmHg from anesthesia start time to anesthesia end. If this duration reaches or exceeds 15 minutes, assign the case to *the numerator population*. Otherwise, do not assign the case to the numerator population.

*Step 3: Calculate the clinician-level unadjusted measure score*

This section describes the steps for calculating each clinician’s unadjusted score on the IOH measure.

1. For a given clinician, identify all cases the clinician is associated with that are included in the measure denominator.
2. Calculate the clinician’s unadjusted score on the measures using the following equation:

$$IOH\_{Unadjusted}=\frac{(Sum of numerator cases)}{\left(Sum of denominator cases\right)-(Sum of denominator exclusion cases)}$$

*Step 4: Apply risk adjustment model to calculate predicted probability of IOH*

After calculating the unadjusted score, the next step is to apply the risk adjustment logistic regression model to each denominator case to determine the case’s predicted probability of inclusion in the numerator population (i.e., of IOH occurring) given the case mix. The model includes five risk adjustment variables that may have an association with risk of IOH based on the clinical literature, input from experts during development of the measure, results from measure testing, or a combination of these factors. The risk adjustment variables include the patient’s age, the ASA Physical Status Classification for the case, the patient’s body mass index (BMI), the duration of the surgery, and the patient’s gender. These variables were selected because they are associated with IOH but are outside the control of the clinician. In the model, these categorical variables with k categories are transformed into (k-1) variables with two levels.

1. Apply the risk adjustment model to each case that is part of the denominator population and that has not been excluded.
2. The risk adjustment model is a logistic regression model with the following form:

$$logit(IOH)=β\_{0}+β\_{1}\*Age+β\_{2}\*ASA\\_1+β\_{3}\*ASA\\_2+β\_{4}\*ASA\\_4+β\_{5}\*BMI+β\_{6}\*Surg\\_Length\\_Cat\\_60–119+β\_{7}\*Surg\\_Length\\_Cat\\_120–179+β\_{8}\*Surg\\_Length\\_Cat\\_180–239+β\_{9}\*Surg\\_Length\\_Cat\\_240–299+β\_{10}\*Surg\\_Length\\_Cat\\_300–+β\_{11}\*Female\\_1$$

Where:

β0 = the intercept term of the logistic regression

β1 = the coefficient for age

*Age* = the age in years of the patient at the time of surgery (in years)

β2 = the coefficient for ASA physical status classification being 1.

*ASA\_1* = a binary variable indicating whether the ASA physical status classification of the case is 1, with ASA\_1=1 for cases in which the ASA physical status classification is 1, and ASA\_1=0 for cases in which it is not 1.[[1]](#footnote-1)

β3 = the coefficient for ASA physical status classification being 2.

*ASA\_2* = a binary variable indicating whether the ASA physical status classification of the case is 2, with ASA\_2=1 for cases in which the ASA physical status classification is 2, and ASA\_2=0 for cases in which it is not 2.

β4 = the coefficient for ASA physical status classification being 4.

*ASA\_4* = a binary variable indicating whether the ASA physical status classification of the case is 4, with ASA\_4=1 for cases in which the ASA physical status classification is 4, and ASA\_4=0 for cases in which it is not 4.

β5 = the coefficient for body mass index (BMI)

*BMI* = the BMI of the patient at the time of surgery

β6 = the coefficient for the duration of surgery being between 60 and 119 minutes

*Surg\_Length\_Cat\_60–119* = a binary variable indicating whether the duration of surgery from anesthesia start time to anesthesia end time was between 60 and 119 minutes, with Surg\_Length\_Cat\_60–119 = 1 for surgeries that met this criteria and Surg\_Length\_Cat\_60–119 = 0 for surgeries that did not meet this criteria.

β7 = the coefficient for the duration of surgery being between 120 and 179 minutes

*Surg\_Length\_Cat\_120–179* = a binary variable indicating whether the duration of surgery from anesthesia start time to anesthesia end time was between 120 and 179 minutes, with Surg\_Length\_Cat\_120–179 = 1 for surgeries that met this criteria and Surg\_Length\_Cat\_120–179 = 0 for surgeries that did not meet this criteria.

β8 = the coefficient for the duration of surgery being between 180 and 239 minutes

*Surg\_Length\_Cat\_180–239* = a binary variable indicating whether the duration of surgery from anesthesia start time to anesthesia end time was between 180 and 239 minutes, with Surg\_Length\_Cat\_180–239 = 1 for surgeries that met this criteria and Surg\_Length\_Cat\_180–239 = 0 for surgeries that did not meet this criteria.

β9 = the coefficient for the duration of surgery being between 240 and 299 minutes

Surg\_Length\_Cat\_240–299 = a binary variable indicating whether the duration of surgery from anesthesia start time to anesthesia end time was between 240 and 299 minutes, with Surg\_Length\_Cat\_240–299 = 1 for surgeries that met this criteria and Surg\_Length\_Cat\_240–299 = 0 for surgeries that did not meet this criteria.

β10 = the coefficient for the duration of surgery being 300 minutes or longer

*Surg\_Length\_Cat\_300–* = a binary variable indicating whether the duration of surgery from anesthesia start time to anesthesia end time was 300 minutes or longer, with Surg\_Length\_Cat\_300– = 1 for surgeries that met this criteria and Surg\_Length\_Cat\_300– = 0 for surgeries that did not meet this criteria.

β11 = the coefficient for the gender of the patient

*Female\_1* = a binary variable indicating the gender of the patient, with Female\_1 =1 for female and 0 for male.

See *Table 1* for the values of the constant and the regression coefficients.

*Table 1: Parameters for risk adjustment model for the intraoperative hypotension quality measure*

| **Parameter** | **Value** |
| --- | --- |
| β0: Constant/Intercept | -1.482 |
| β1:Coefficient 1: Age | -0.008 |
| β2: Coefficient 2: ASA\_1 | 0.400 |
| β3: Coefficient 3: ASA\_2 | 0.164 |
| β4: Coefficient 4: ASA\_4 | 0.532 |
| β5: Coefficient 5: BMI | -0.018 |
| β6: Coefficient 6: Surg\_Length\_Cat\_60–119 | 1.231 |
| β7: Coefficient 7: Surg\_Length\_Cat\_120–179 | 1.664 |
| β8: Coefficient 8: Surg\_Length\_Cat\_180–239 | 1.871 |
| β9: Coefficient 9: Surg\_Length\_Cat\_240–299 | 2.128 |
| β10: Coefficient 10: Surg\_Length\_Cat\_300– | 2.810 |
| β11: Coefficient 11: Female1 | 0.171 |

1. The model calculates the log-odds of each case developing IOH, given the risk factors for the given patient and case. Next, transform the case-level log-odds into case-level predicted probabilities. To do so, exponentiate the log-odds to first transform it to odds. Then transform the odds to probability by taking the odds divided by 1 plus the odds. Predicted probabilities can range from 0.00 to 1.00. Values closer to 1.00 represent a higher likelihood that the case would result in IOH. The predicted probability (denoted as $IOH\_{expected}$) can be presented as:

$IOH\_{expected}=\frac{e^{ logit(IOH)}}{1+ e^{ logit(IOH)}}$

Where *logit(IOH)* is defined in Step 4.2.

*Step 5: Calculate the clinician-level expected number of IOH cases*

Next, determine each clinician’s expected number of IOH cases based on the risk-adjustment model by summing the case-level predicted probabilities.

1. For a given clinician, identify all cases the clinician is associated with that are included in the measure denominator and that have not been excluded.
2. Calculate the clinician’s expected number of IOH cases by summing all of the predicted probabilities of IOH for all of the denominator cases.

*Step 6: Calculate the clinician-level risk-adjusted measure score*

After computing an observed and expected number of IOH cases for each clinician, the measure uses those two values as inputs for the risk-adjusted score.

1. For a given clinician, use the observed and expected number of IOH cases to calculate the risk-adjusted score. The observed number of cases is the numerator from the equation in Step 3, and the expected number of cases is the sum calculated in Step 5. Calculate the risk-adjusted score as follows:

$$IOH\_{Adjusted}=\frac{(Sum of numerator cases) \_{}}{(Sum of expected IOH cases)\_{}}$$

The resulting score will be a ratio. A score of 1 indicates the clinician had the number of IOH cases we would expect, based on their case mix. Scores less than 1 indicate the clinician had fewer IOH cases than predicted, meaning they are performing better than expected for their case mix. Scores greater than 1 indicate the clinician had more cases of IOH than predicted, meaning they are performing worse than expected given their case mix.

*Step 7 (optional): Transform risk-adjusted measure score into a percentage*

To make the risk-adjusted scores more easily interpretable, the clinician-level ratios calculated in Step 6 can be multiplied by the overall unadjusted performance rate on the measure to transform them into percentages. Note that performing this transformation is not necessary to calculate the measure, but individual sites may find that representing the scores as a percentage may be helpful for communicating with providers about their measure score. To do so, multiply each clinician’s risk adjusted score from Step 6 (the observed to expected ratio) by the average unadjusted IOH measure score for the larger unit within which clinicians are being compared, for example, a group practice, hospital department, or national reporting program. This transformation may make the risk-adjusted score more easily interpretable, although it is not a true percentage generated from the ratio of numerator and denominator, and it can result in “percentages” greater than 100%.

$$IOH\_{Adjusted}=\frac{(Sum of numerator cases) \_{}}{(Sum of expected IOH cases)\_{}}\*Overall\\_rate$$

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1. We used ASA physical status classification of 3 as the reference group for the ASA status variables. [↑](#footnote-ref-1)