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Introduction to the NHSN Adjusted Ranking Metric (ARM), and HAI Composite Measure

Kevin Kennedy, Statistics Team

Darielle Oliver, MPH, Acute Care Analytics Team

Presented on behalf of the NHSN Team, DHQP, NCEZID, CDC

What you need to know before we begin

- This webinar is designed to deepen your understanding of the ARM and Composite rankings, helping you effectively interpret and apply these concepts in your healthcare facility.
- **Prerequisites:**
 - A working understanding of the Standard Infection Ratio (SIR), including its purpose and calculation
- **Resource to review:**
 - [ARM | Analysis Resources | NHSN | CDC](#)

Disclaimers and Disclosures

- **This presentation does not include Patient Health or Identifiable Information (PHI/PII) data.**
 - Images of fictitious data and facility information are for illustrative purposes only and do not represent actual NHSN data.
- **The ARM dashboard is only available to acute care hospitals (ACHs) in NHSN at this time.**
 - Not available for NHSN Groups
- **The ARM rankings use the same 2022 baseline as the updated SIRs.**

Objectives

At the end of this presentation, participants will be able to:

- **Define what is the Adjusted-Ranking Metric (ARM), and how it compares to the Standard Infection Ratio (SIR).**
- **Understand the HAI-Composite measure.**
- **Locate and interpret rankings in the new ARM dashboard:**
 - Navigate to the ARM dashboard in the NHSN application and identify parts of the dashboard.
 - Interpret ARM percentile rankings with examples.
 - Understand why a facility may have “Numerator Only” or “No Data” instead of an ARM ranking.

Plan for Today

1. Kevin will present the **adjusted ranking metric model**, discuss **statistical methods** for developing the ARM score and rankings, and will provide a **comparison with the SIR**. Additionally, Kevin will present the Composite measure.
2. Darielle will then show how the **ARM and Composite rankings** will be presented in the dashboard in the NHSN application, how to **interpret your rankings**, and what **special scenarios** might exist.
3. **Q&A** will be open at the end for both presenters, although participants are encouraged to submit questions to the Q&A box throughout the presentation.

ARM: Definition and relationship to SIR

Standardized Infection Ratio (SIR)

$$\text{SIR} = \frac{\# \text{ Observed HAIs}}{\# \text{ Predicted HAIs}}$$

← HAIs reported to NHSN

← Calculated by CDC

- When # of observed HAIs is greater than the # predicted, the SIR will be greater than 1.

$$\frac{5 \text{ observed HAIs}}{3.2 \text{ predicted HAIs}} = \text{SIR of } 1.6$$

- If # observed HAIs is less than # predicted, the SIR will be less than 1.
- P-values and 95% confidence intervals (CI) provide information about statistical significance.
- Review the 2022 Baseline SIR Guide and the Statistics Calculator for more information.
 - NHSN's Statistics Calculator:
 - <https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/statscalc.pdf>
 - NHSN's Guide to the 2022 Baseline SIRs:
 - <https://www.cdc.gov/nhsn/2022rebaseline/analysis-resources.html>

Adjusted Ranking Metric (ARM)

$$\text{ARM} = \frac{\# \text{ Reliability Adjusted HAIs}}{\# \text{ Predicted HAIs}}$$

Calculated by CDC



Calculated by CDC



- Similar interpretation of the ratio:
 - **ARM < 1** means **Fewer** outcomes than predicted
 - **ARM > 1** means **More** outcomes than predicted
- The Numerator is now derived from a special model instead of a “count”, this allows for fractional (decimal) values in the numerator and will never be **ZERO**.
- This special model builds on the SIR model and is used to calculate an adjusted number of HAIs accounting for the reliability of each hospital’s data.

What is “Reliability” and why adjust for it?

- Reliability is synonymous with “precision,” which directly relates to exposure volume or opportunity for HAIs (i.e., device days, patient days or procedures depending on the HAI).
- Some hospitals have larger volumes others have smaller volumes depending on the type of HAI used for surveillance.
- In terms of the SIR, the larger the exposure volume, the larger the number of predicted events.
- Larger numbers in the SIR denominator yield a greater precision, and this is accounted for in the ARM to adjust for reliability when measuring HAI incidence.

Example of Exposure Volume and Reliability

- In the below example, the 2nd hospital has 5 times the volume of the 1st. Hence, the 2nd hospital has a more “reliable” measure of HAI incidence.

Hospital ID	Number of Procedures	Observed Number of SSI	Predicted Number of SSI
*****	82	0	1.007
*****	553	0	5.548

** Magnitude real, but numbers fictitious*

- The ARM accounts for this difference in exposure volume.
- The resulting ARM value can be best interpreted by percentile rankings.

Does anyone else use Reliability adjusted measures?

- Yes!
- CMS started reporting ARM-type measures in 2012 for their Hospital Readmission Reduction Program (HRRP).
- Recommended by the Committee of Presidents of Statistical Societies (COPSS)
- Other large hospital data registries also report ARM type measures.

Prospective Payment Systems
Home Health Agency (HHA) Center
HIPPS Codes
Provider Specific Data for Public Use in Text Format
Provider Specific Data for Public Use in SAS Format
Historical Provider Specific Data for Public Use File in CSV Format

Hospital Readmissions Reduction Program (HRRP)

The Hospital Readmissions Reduction Program (HRRP) is a Medicare value-based purchasing program that, for example, encourages hospitals to improve communication and care coordination to better engage patients and caregivers in discharge plans and, in turn, reduce avoidable readmissions. The program supports the national goal of improving health care for Americans by linking payment to the quality of hospital care.

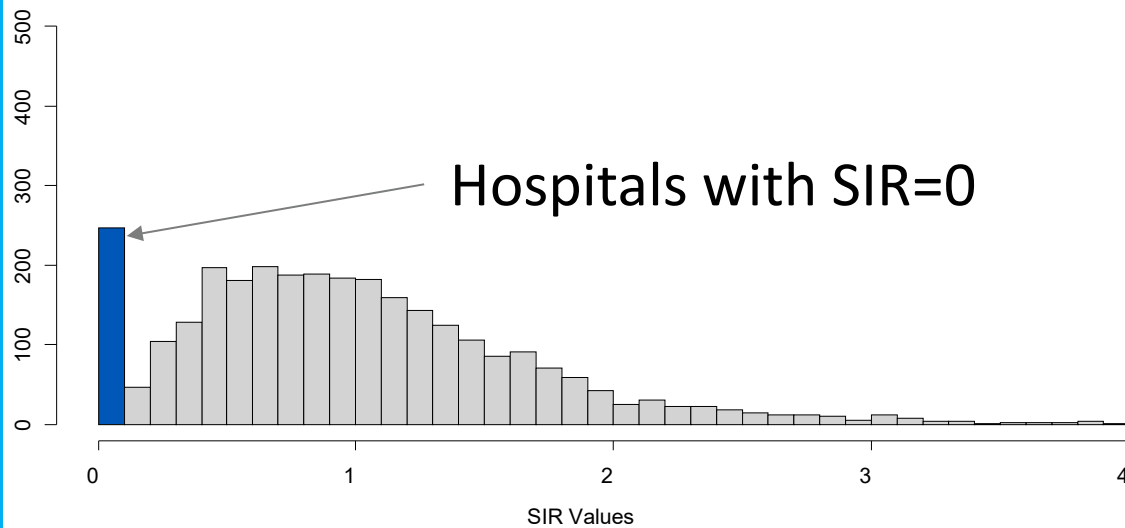
Section 1886(q) of the Social Security Act sets forth the statutory requirements for HRRP, which required the Secretary of the U.S. Department of Health and Human Services to reduce payments to subsection (d) hospitals for excess readmissions beginning October 1, 2012 (that is, fiscal year [FY] 2013). In addition, the 21st Century Cures Act directs CMS to assess a hospital's performance relative to other hospitals with a similar proportion of beneficiaries who are dually eligible for Medicare and full Medicaid benefits beginning in FY 2019. The legislation requires estimated payments under the peer grouping methodology (that is, FY 2019 and onward) equal payments estimated under the non-peer grouping methodology (that is, FY 2013 to FY 2018) to maintain budget neutrality.

SIR and ARM: How do they Compare?

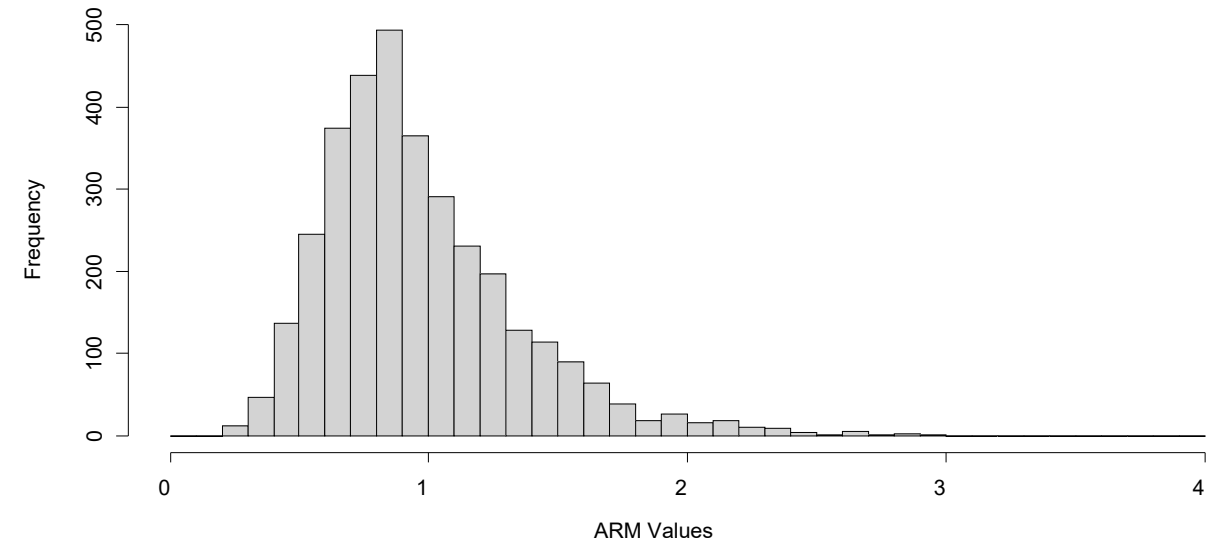
Major Difference #1: Central Shift with No ZERO's

- The numerator in the SIR is a “count.” Meaning ZERO is a plausible value. An observed count of zero will give a $SIR=0$ every time.
- The numerator in the ARM is “derived.” Zero *CANNOT* be a value for Reliability-Adjusted outcomes; hence the ARM will never be ZERO.

Histogram of SIR (CDI 2022)



Histogram of ARM (CDI 2022)



What happens to the many Zero SIR's?

- Many of the hospitals with zero HAIs (SIR=0) are low exposure hospitals.
- The more **exposure** a hospital has, the less it gets shifted or “shrunk” with the ARM (Low Exposure=High Shrinkage, High Exposure=Low Shrinkage).

Hospital ID	Number of Patient Days (CDI)	Observed Number of CDI	Predicted Number	SIR	ARM
*****	7829	0	1.06	0	0.82
*****	69499	0	26.3	0	0.20

- The 2nd hospital has 20x the exposure as the first, but they both have ZERO CDI events, and therefore both have a ZERO SIR.
- The ARM “shrinks” the 1st substantially toward the center (i.e., middle) but shrinks the 2nd more modestly.

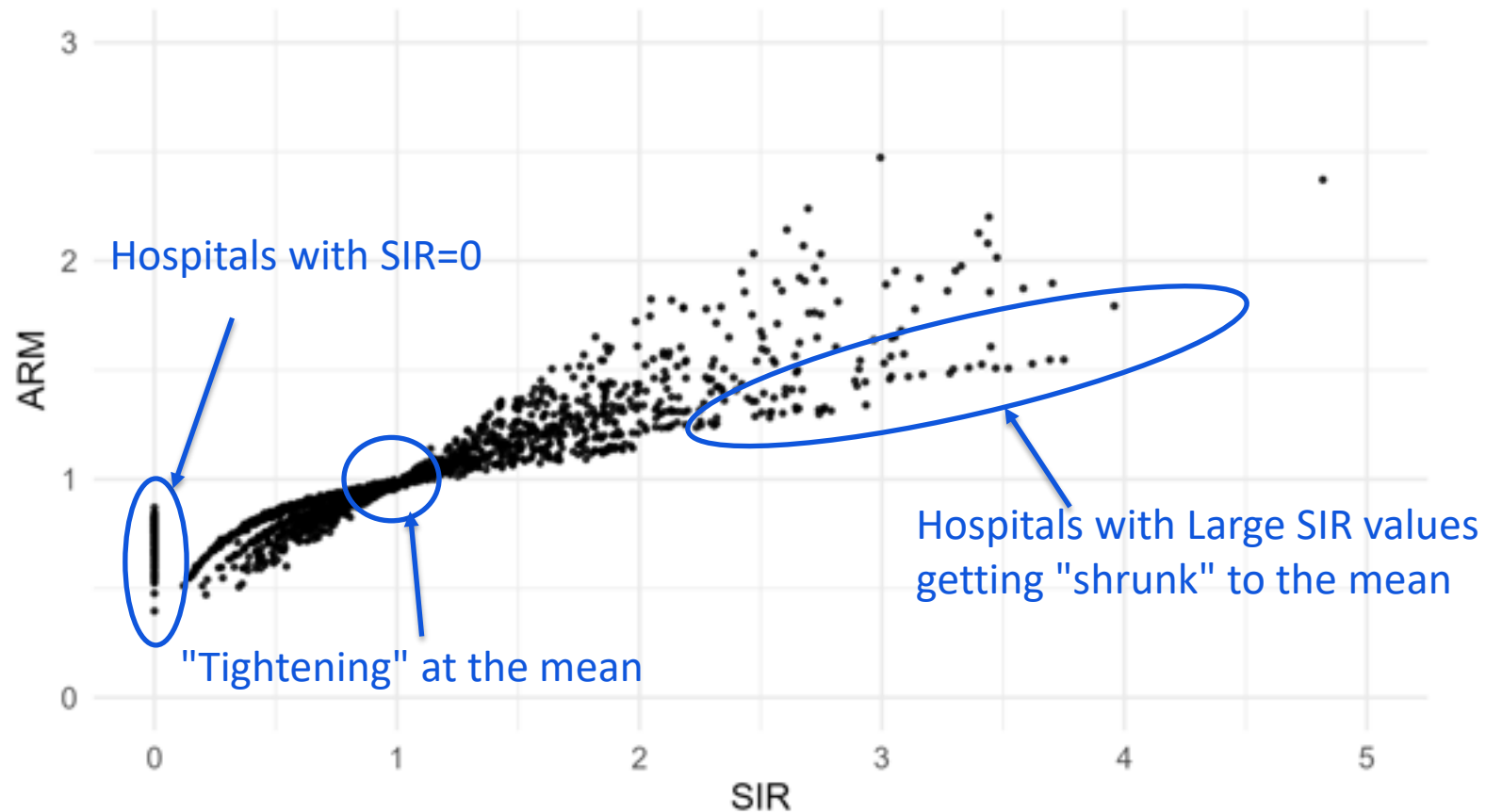
Major Difference #2: No Extreme Outliers

- The ARM has no extreme outliers unlike the SIR.
- Lower exposure hospitals get shifted or “shrunk” to the middle regardless of whether the SIR is low or high (it works both ways!).

Hospital ID	Number of Patient Days (CDI)	Observed Number of CDI	Predicted Number	SIR	ARM
*****	8711	4	1.12	3.58	1.66
*****	14741	19	4.8	3.99	2.92

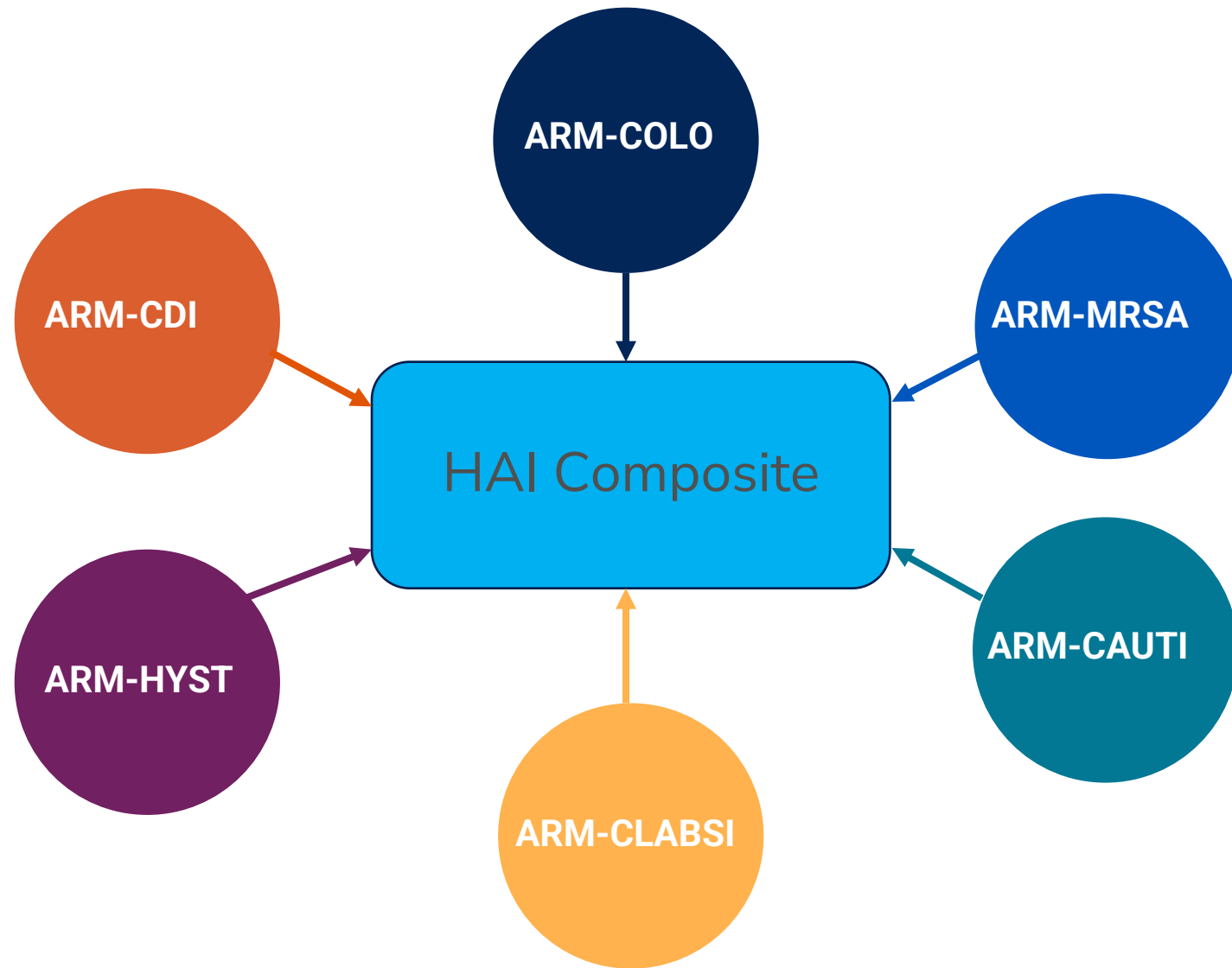
Putting it all together

- Below shows a scatter plot of ARM (y-axis) vs SIR (x-axis), it shows both the effect of the ZEROs and Large outliers.



HAI Composite

HAI Composite: Conceptual Framework



HAI Composite

- Goal: Combine all 6 ARMs into a single score “composite”
- Problem: How do we do it?
- Strategies investigated
 - Numerator Weighting
 - Denominator Weighting
 - Aggregate Numerator/Denominator
 - Weighted Aggregate Numerator/Denominator
 - Arithmetic Mean
 - Geometric Mean

HAI Composite: Arithmetic vs Geometric Mean

Arithmetic Mean

- Simple average learned in Grade school
- Can be computed on any set of numbers (zero, negative, positive...)
- Will be larger than Geometric Mean (Arithmetic will “chase” large values)

$$\bullet \text{ ArithMean} = \frac{x_1 + x_2 + x_3 + \dots + x_n}{n} = \frac{\sum_{i=1}^n x_i}{n}$$

Geometric Mean

- “nth” root of the product of “n” numbers
- Can only be computed on POSITIVE (NON-ZERO) NUMBERS
- Preferable for multiplicative measures (like stock market gains (%))

$$\bullet \text{ GeoMean} = \sqrt[n]{x_1 * x_2 * x_3 * \dots * x_n}$$

HAI Composite: Arithmetic vs Geometric Mean

Remember...

- The ARM is a RATIO (Smoothed version of the SIR)
- An ARM=2 means there were TWICE as many outcomes as predicted

Consider an example hospital that has 2 ARM measures

- $ARM_1=5$ (Hospital has 5x more events than predicted)
- $ARM_2=0.2$ {or $1/5$ } (Hospital has 5x fewer events than predicted)
- ARM_2 is EQUALLY “Good” as ARM_1 is “Poor”

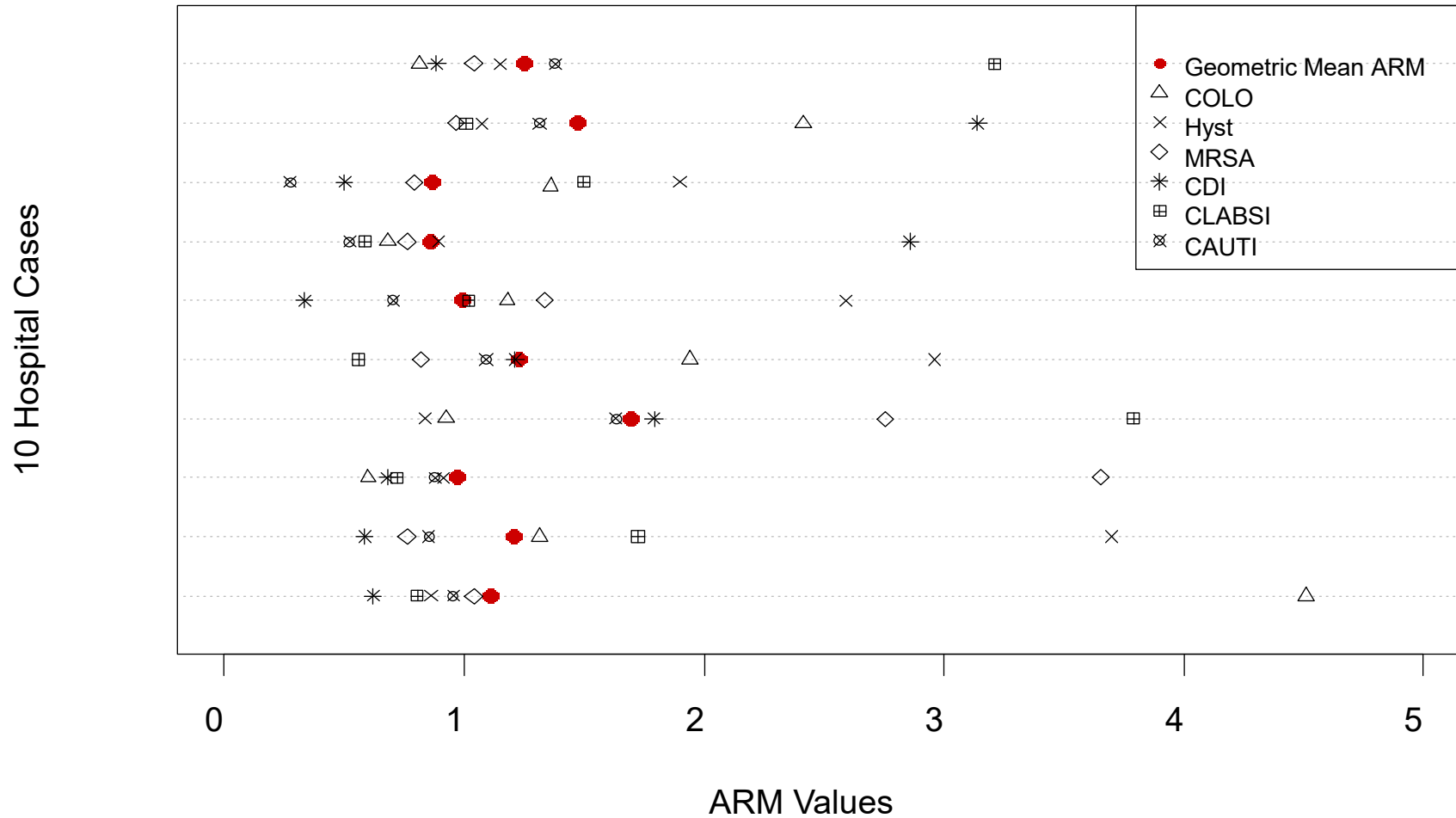
Aggregate 2.6x more events

$$ArithMean = \frac{0.2 + 5}{2} = 2.6$$

Aggregate 1.0x more events

$$GeoMean = \sqrt[2]{0.2 * 5} = 1.00$$

HAI Composite: Case Examples



ARM and Composite: Common Follow-up Questions

Follow-up Questions

- **Do we need both measures: ARM and SIR?**
 - Yes! The SIR and ARM can and should co-exist in a complementary way.
 - The SIR will still be the preferred metric for tracking HAIs over time. Also, the SIR supports the use of the Cumulative Attributable Difference (CAD) metric useful for prevention prioritization.
 - The ARM excels for ranking performance among facilities by adjusting for reliability (i.e., related to exposure volume).
- **Can a facility calculate their own ARM?**
 - No. Unlike the SIR (which can be calculated in the NHSN application or by using excel/calculator), there is no way for facility staff to calculate their ARM directly. This is why NHSN plans to continually publish these data in the ARM Dashboard within the web application as the full complement of all facility data required for any given year at the time ARM values are to be produced.

Follow-up Questions (cont'd, page 2)

- **What is the “ranking”?**
 - NHSN will be reporting the ranks based on facility-specific ARM values instead of the values themselves. The ranks will be from 1 (best rank) to 100 (worst rank).
- **Why am I getting an ARM ranking but not an SIR?**
 - The SIR and ARM have different criteria for being calculated and reported. The SIR requires at least 1 predicted event called the minimum precision criteria, whereas the ARM utilizes a minimum exposure threshold of 1 predicted event for every five years or 0.2. So, it is possible for NHSN to report an ARM ranking for a facility with no SIR reported.

Follow-up Questions (cont'd, page 3)

- **What are some alternate terms for reliability adjustment?**
 - Reliability adjustment may be referred to as "shrinkage," "stabilized," or "smoothed" estimation.
- **Are there other names for the ARM metric?**
 - The ARM metric was originally called the reliability adjusted SIR.
 - It may be called a "Predicted to Expected" or "P/E" ratio.
- **Will NHSN report an ARM rank or value by Sub-Unit within my facility?**
 - The quick answer is no. NHSN will report a single ARM rank for each HAI and year for each facility given the exposure threshold is met. The primary use for the ARM is to rank overall facility performance in a risk- and reliability-adjusted manner. Also, this will help avoid computational complexity and allow the SIR to remain the primary metric for sub-unit and intra-facility comparisons.

Follow-up Questions (cont'd, page 4)

- **My Hospital doesn't have data for all 6 ARMs. Will we get a composite?**
 - Yes. If your hospital qualifies for at least 1 ARM you will get a composite. The composite is simply the geometric mean of your available ARMs.
- **My Composite was marked as an outlier (worst 10%) but none of my ARMs were in the worst 10% individually. How can this happen?**
 - It can happen, although it is uncommon. The Composite reflects the combined performance across all available measures. A hospital can be consistently worse than average across several measures without being in the bottom 10 percent for any single measure. When those measures are combined into one Composite score, the overall result can fall into the worst 10 percent.

Knowledge Check-in

Knowledge Check 1

The ARM can be ZERO

- A) TRUE
- B) FALSE

False: This is one of the BIG difference between the ARM and SIR. The SIR can be ZERO, but because the numerator of the ARM is model derived, it can NEVER be ZERO.



Knowledge Check 1

The ARM can be ZERO

A) TRUE

B) FALSE

False: This is one of the BIG difference between the ARM and SIR. The SIR can be ZERO, but because the numerator of the ARM is model derived, it can NEVER be ZERO.



Knowledge Check 2

The Composite is made from what calculation of available ARMs?

- A) Arithmetic Mean
- B) Geometric Mean
- C) Aggregating Numerators and Denominator
- D) A dartboard with random numbers



B: The composite is made by taking the Geometric mean of available ARMs. This can be done even if a hospital does not have all measures.

Knowledge Check 2

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- A) Arithmetic Mean
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B: The composite is made by taking the Geometric mean of available ARMs. This can be done even if a hospital does not have all measures.

Darielle Oliver, MPH

Acute Care Analytics Team, NHSN

ARM Rankings and Composite Scores Help Facilities Understand and Compare Their Performance Nationally

- Provide a standardized way to compare performance nationally
- Show performance for each HAI measure
- Highlight areas of stronger and weaker performance
- Serve as actionable feedback

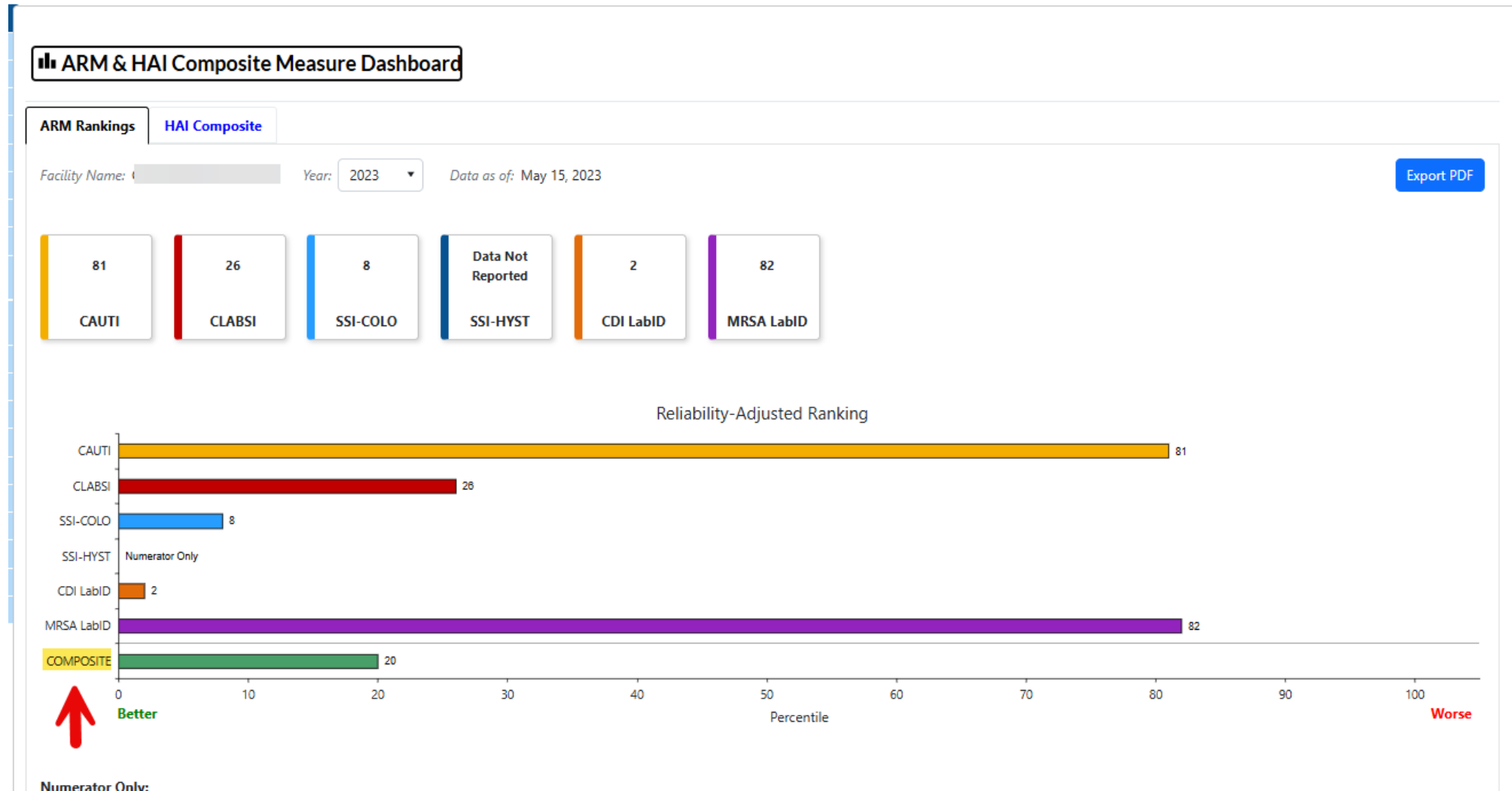
Navigating the ARM and HAI Composite Measure Dashboard in NHSN

Accessing the ARM & HAI Composite Measure Dashboard in NHSN

- Select Dashboard.
- Select ARM & HAI Composite Measure Dashboard.

The screenshot displays the NHSN Patient Safety Component Home Page. On the left, a vertical navigation menu lists various options: NHSN Home, Alerts, Dashboard, Reporting Plan, Patient, Event, Procedure, Summary Data, Hospital Respiratory Data, Infectious Diseases of Public Health Concern, Import/Export, and Surveys. A red arrow points to the 'Dashboard' option. A dropdown menu is open from 'Dashboard', listing: TAP Strategy, ARM & HAI Composite Measure Dashboard (highlighted with a red box and a red arrow), TAS Dashboard, HAI Pathogen Dashboard, and Survey Data Quality Dashboard. The main content area shows the title 'NHSN Patient Safety Component Home Page' and an 'Action Items' section with the heading 'COMPLETE THESE ITEMS'. Below this heading are four items: 'Survey Required 2024', 'Mini-IRF Survey Required', 'Confer Rights', and 'Facility Geolocation Confirm'.

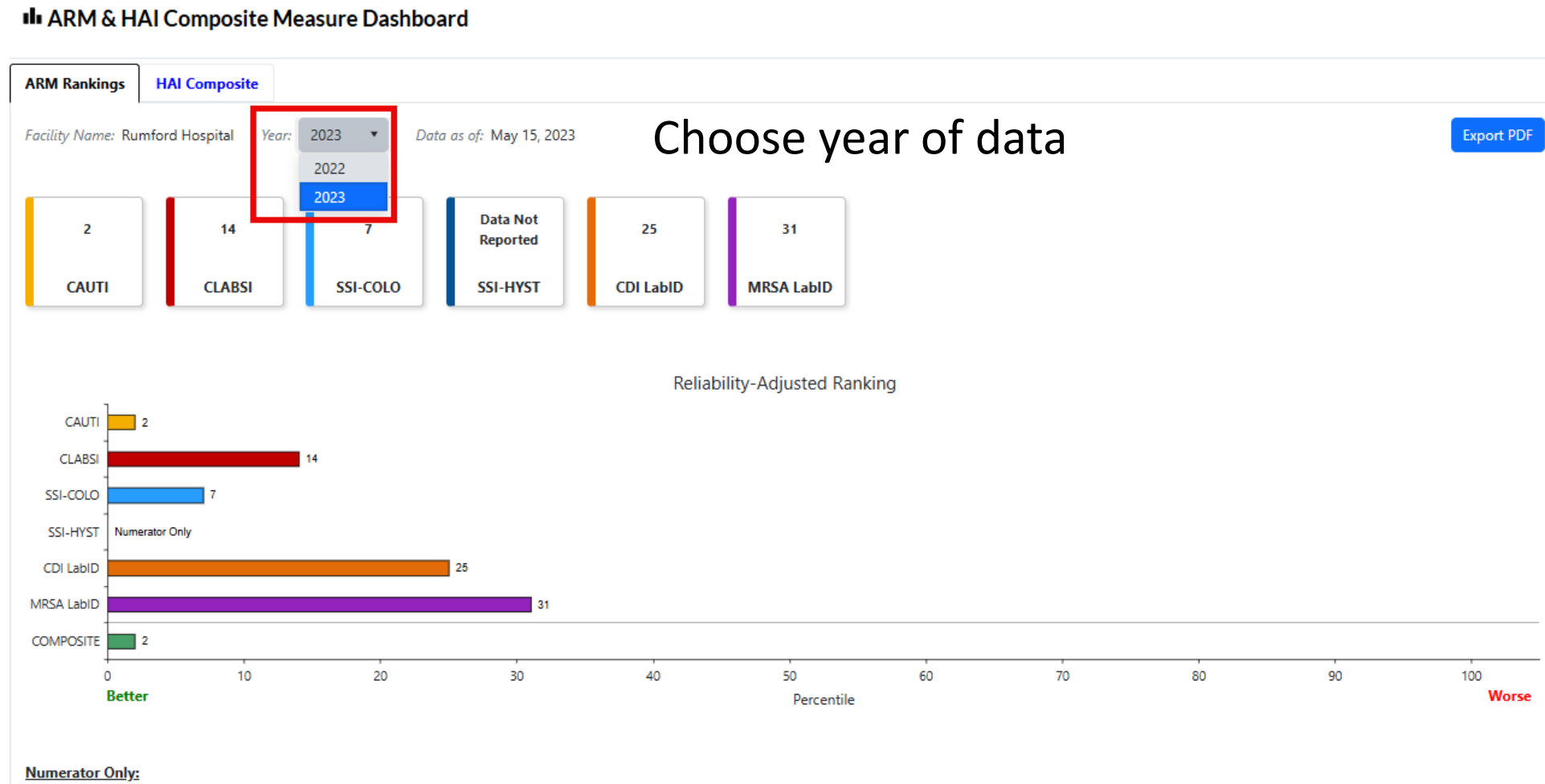
The Dashboard Now includes ARM Rankings for Six HAI Types and a Composite Score



Disclaimer: fictitious data for illustrative purposes only

Select the Year of Data to View ARM and Composite Dashboard Results

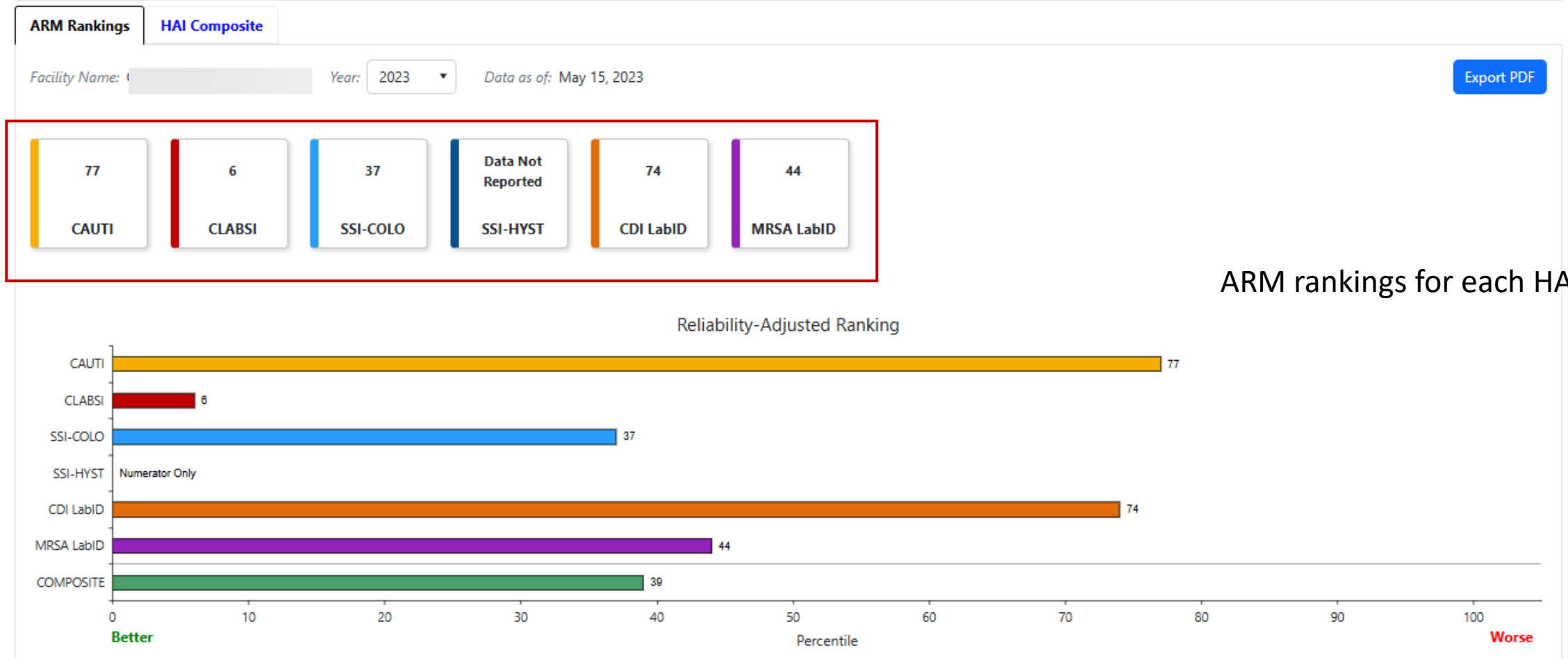
- Use the year filter to view ARM dashboard results
- 2022 and 2023 data



Disclaimer: fictitious data for illustrative purposes only

Hero Box Show the ARM Ranking for Each HAI Measure

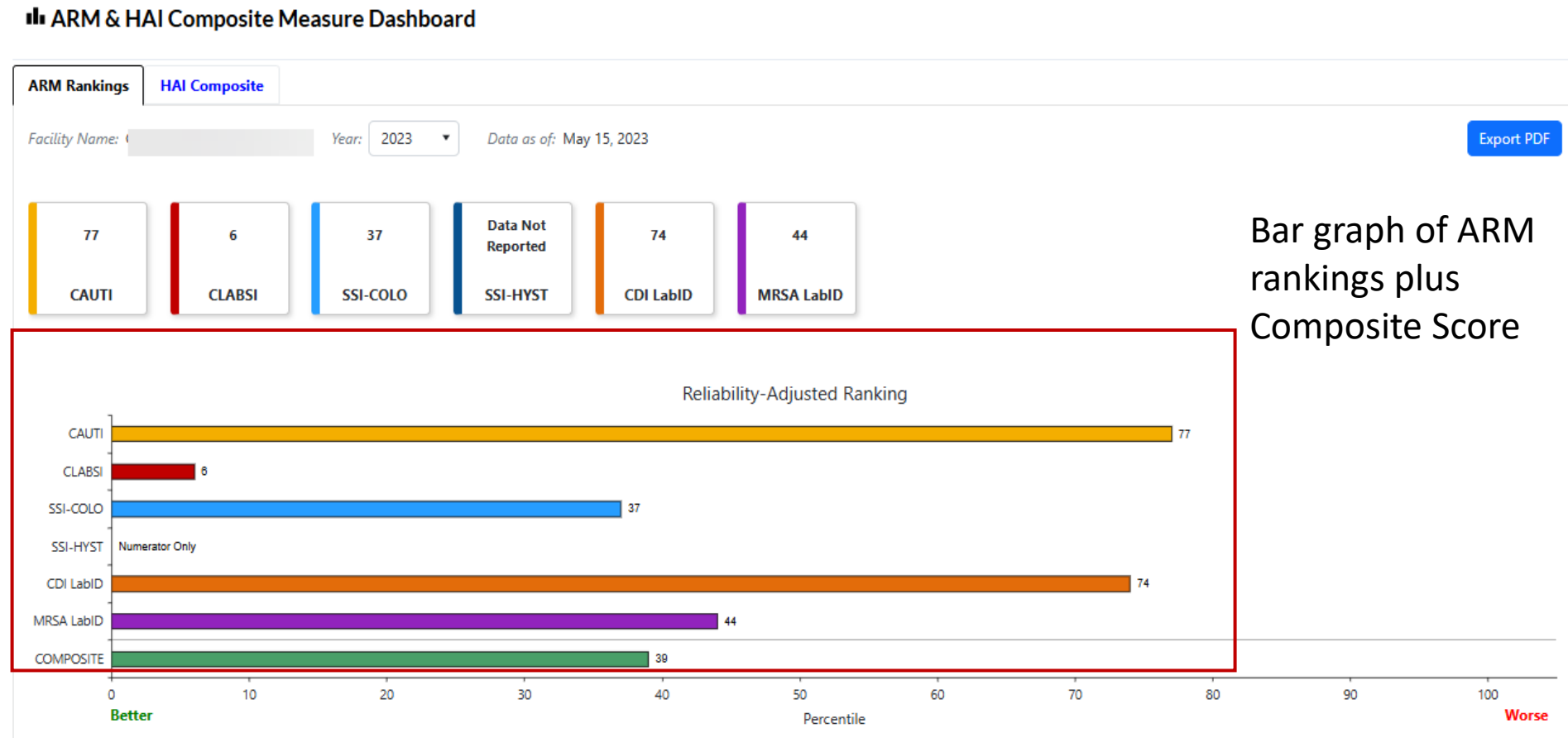
ARM & HAI Composite Measure Dashboard



Disclaimer: fictitious data for illustrative purposes only

Bar Graph Displays ARM Rankings and a Composite Score on a Percentile Ranking Scale

- The bar graph plots the ARM score
- Scores are displayed on a percentile ranking
- Includes the composite score



Bar graph of ARM rankings plus Composite Score

Knowledge Check 3

What information is displayed in the hero boxes at the top of the ARM dashboard?

- A. The predicted number of HAIs
- B. The facility's ARM ranking for each HAI type
- C. Only the composite score
- D. The number of procedures reported



Knowledge Check 3

What information is displayed in the hero boxes at the top of the ARM dashboard?

- A. The predicted number of HAIs
- B. The facility's ARM ranking for each HAI type**
- C. Only the composite score
- D. The number of procedures reported

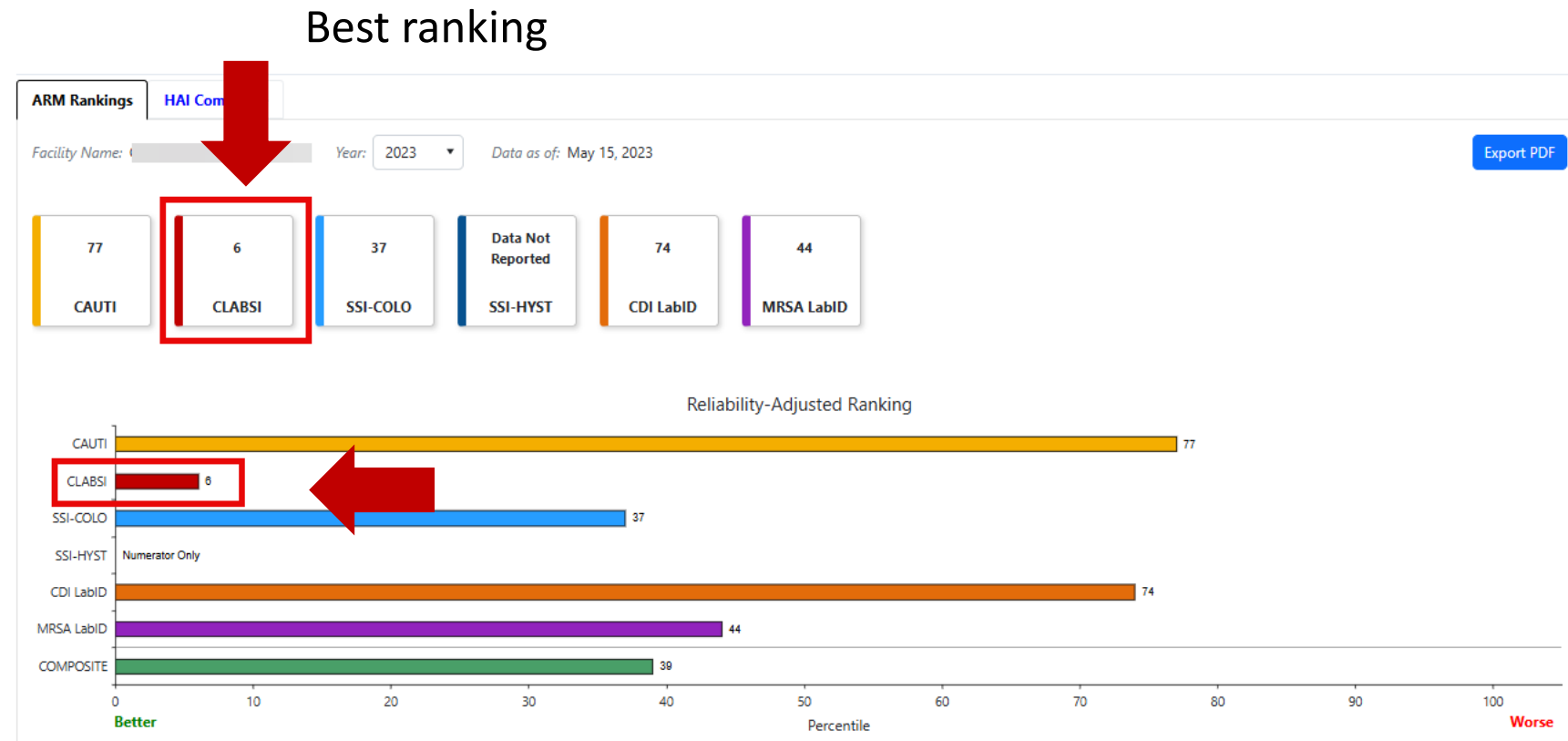


Rationale: The hero boxes show the facility's ARM ranking for each HAI type, giving a quick snapshot of how the facility compare nationally

Interpreting your ARM rankings

Lower ARM Percentile Rankings Indicate Better Performance

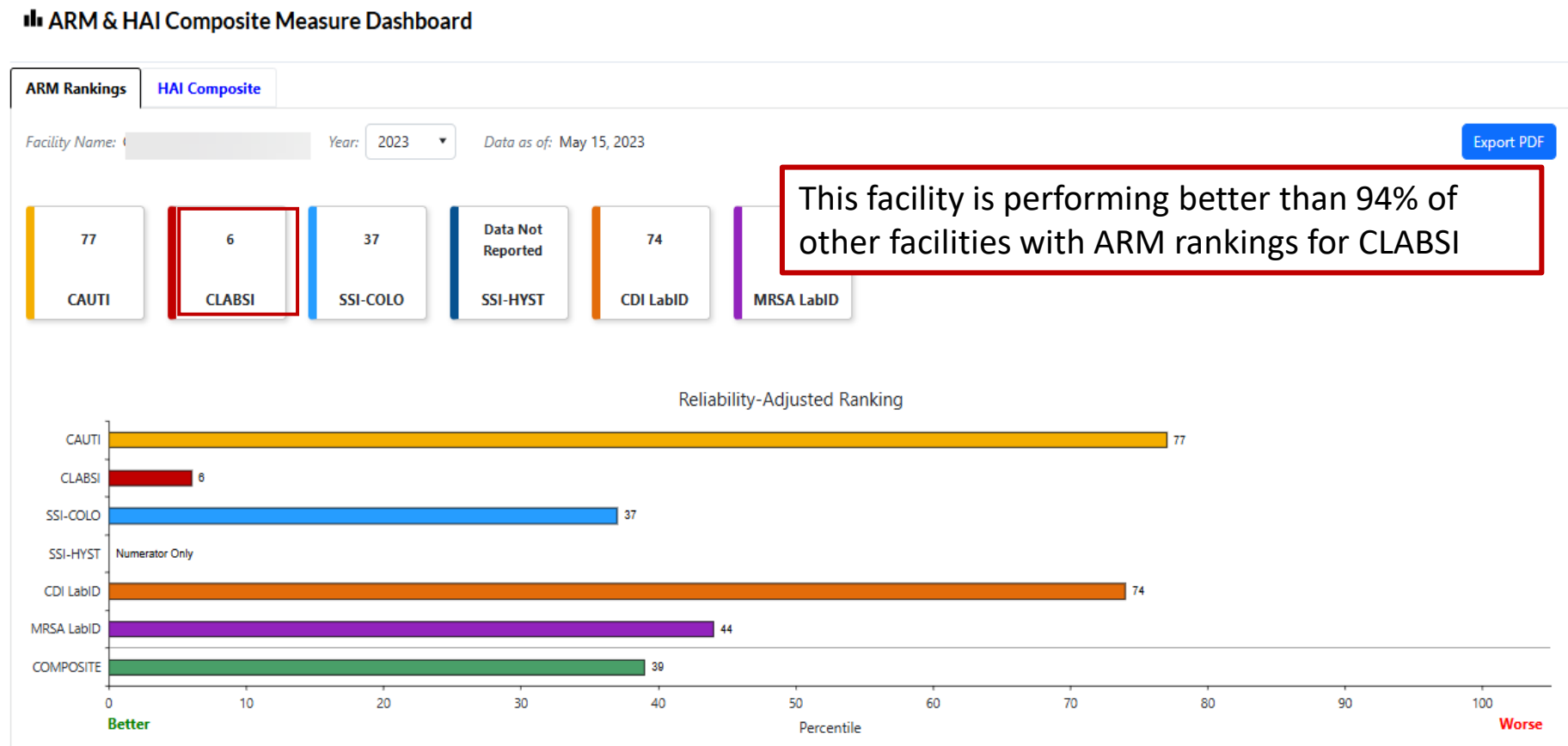
- ARM rankings are displayed as percentiles comparing facilities to peers
- Lower percentile rankings indicate better performance
- An ARM ranking of 6 is the best ranking, in this example



Disclaimer: fictitious data for illustrative purposes only

An ARM Ranking of 6 Indicates the Facility is Performing Better Than Most Peers

- ARM rankings are reported as percentiles comparing facilities to peers
- In the example, this facility is performing better than 94% of peers

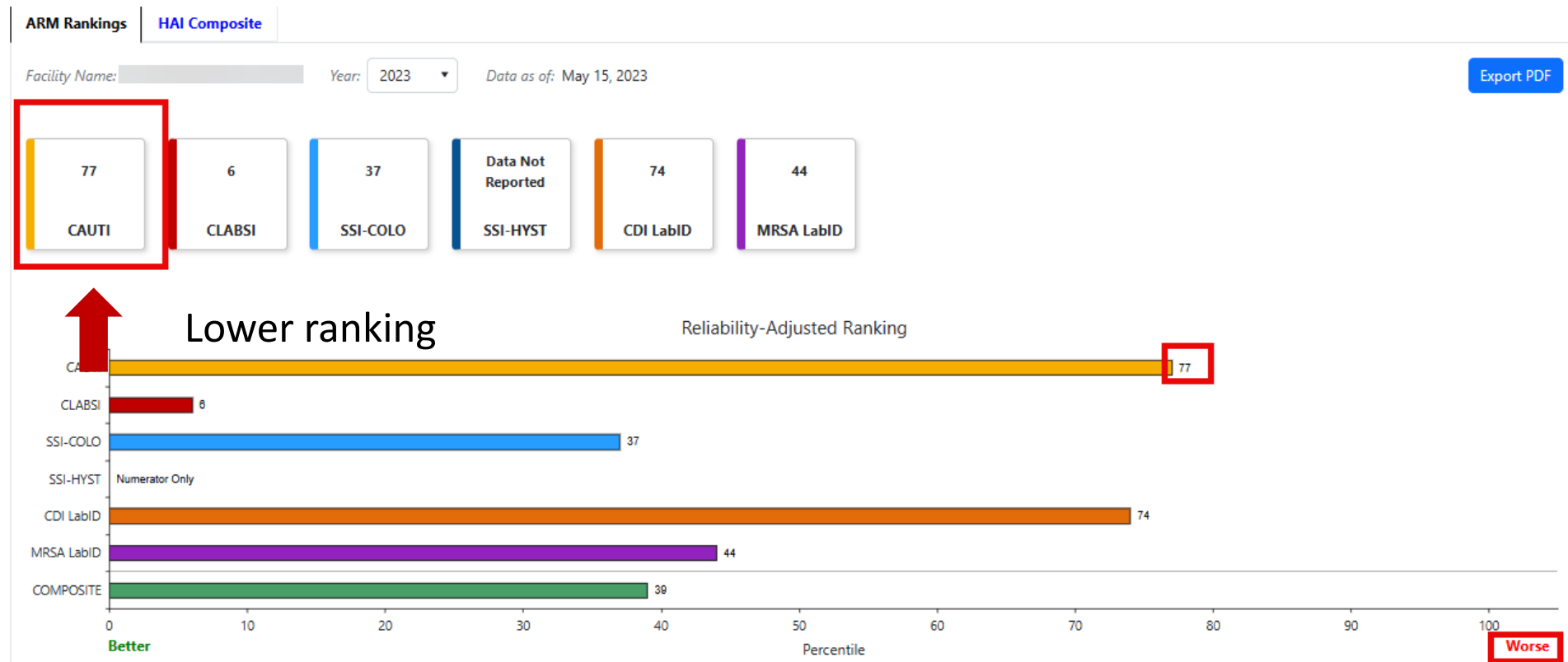


This facility is performing better than 94% of other facilities with ARM rankings for CLABSI

Disclaimer: fictitious data for illustrative purposes only

Higher ARM Percentile Rankings Indicate Lower Performance Relative to Peers

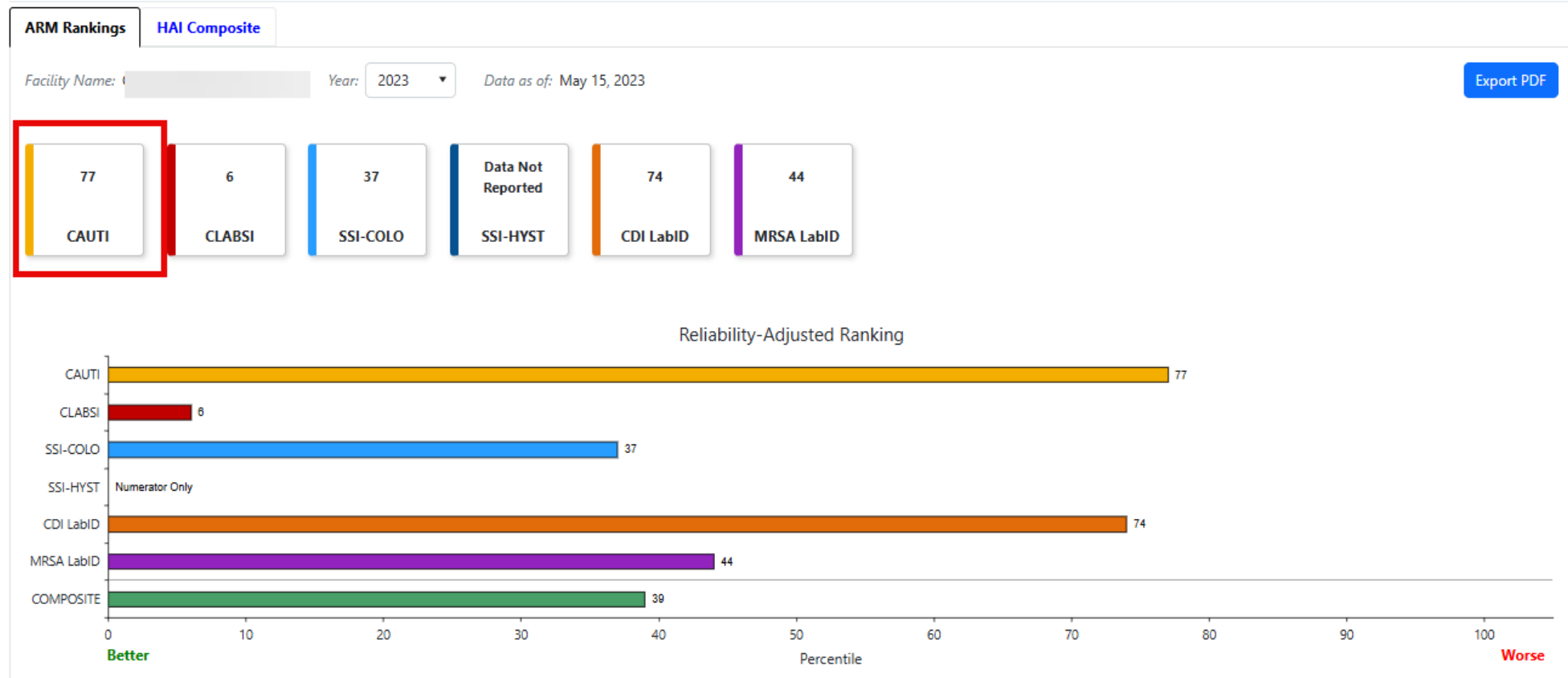
- Higher percentile rankings indicate lower performance.
- An ARM ranking of 77 represents lower performance.



An ARM Ranking of 77 Indicates Worse Performance Relative to Peers

- This facility is performing better than only 23% of peer facilities.

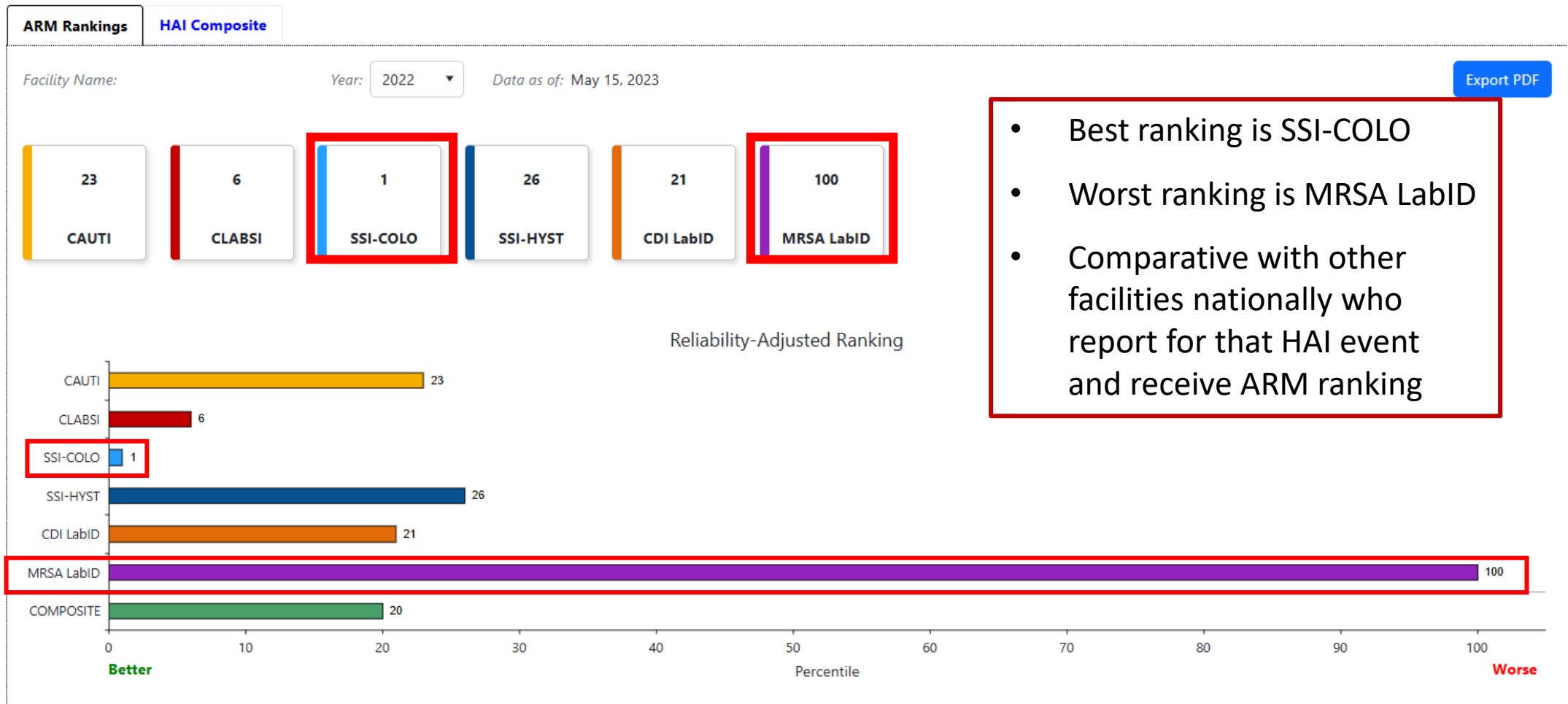
ARM & HAI Composite Measure Dashboard



Disclaimer: fictitious data for illustrative purposes only

ARM Rankings Range from 1 (Best) to 100 (Worst) and Compare Facilities Nationally

ARM & HAI Composite Measure Dashboard



Disclaimer: fictitious data for illustrative purposes only

Knowledge Check 4

ARM rankings are presented on a percentile scale where lower rankings indicate better performance relative to peer facilities.

- A. True
- B. False



Knowledge Check 4

ARM rankings are presented on a percentile scale where lower rankings indicate better performance relative to peer facilities.

A. True

B. False



Rationale: ARM rankings are displayed on a percentile scale from 1 to 100, where lower rankings indicate better performance and higher rankings indicate worse performance relative to peer facilities reporting the same HAI measure.

Special Scenarios in the ARM dashboard

Facilities with Too Few Predicted Events Will Display Only the Reported Event Count

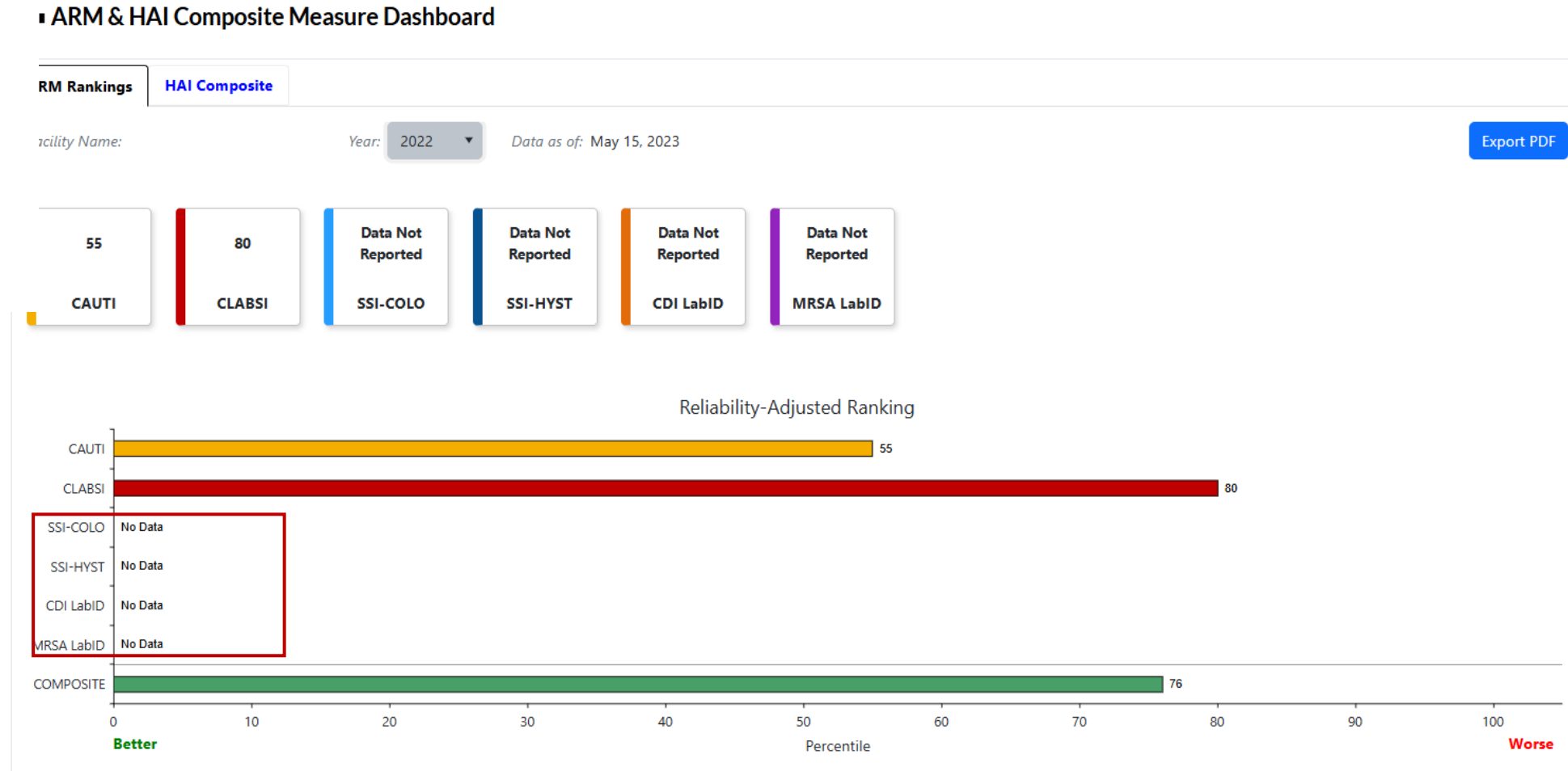
- Facilities that do not receive SIR for an event type
- **At least 1 predicted event in 5 years**
- Only the total reported number of events will be provided



Disclaimer: fictitious data for illustrative purposes only

Facilities That Do Not Report Data for an HAI Will Display “No Data”

- Facilities who did not report any HAI data will see “No Data.”
- They will not receive an ARM ranking or number of events.



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How to use the ARM rankings

Which Measure to Use?

SIR

- Scalable summary measure
- Comparison vs. baseline
- Facility/state/nation **performance over time**

Progress

CAD

- Uses SIR denominator
- Measures # of excess infections as part of TAP strategy
- Useful for prioritizing prevention efforts

Prevention

ARM

- Similar to SIR but accounts for differences in exposure between facilities
- Some facilities without SIRs can receive ARMs
- **Preferable for ranking**

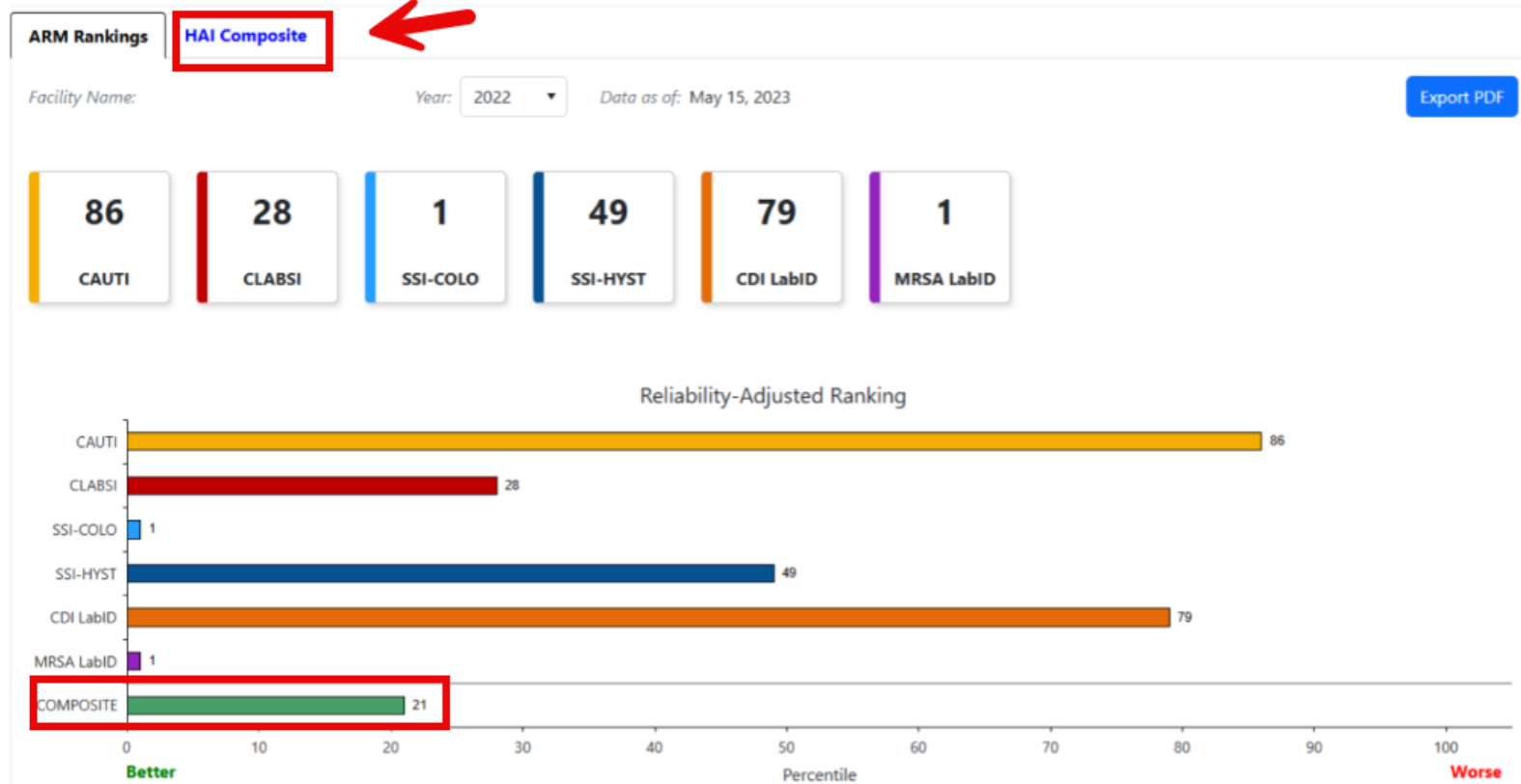
Ranking

Navigating the ARM Composite Measure

Navigate to the HAI Composite Tab to View the Composite Score

- Select the **HAI Composite** tab to view the composite score.
- The composite score is displayed in the bar graph.
- The composite summarizes overall performance.

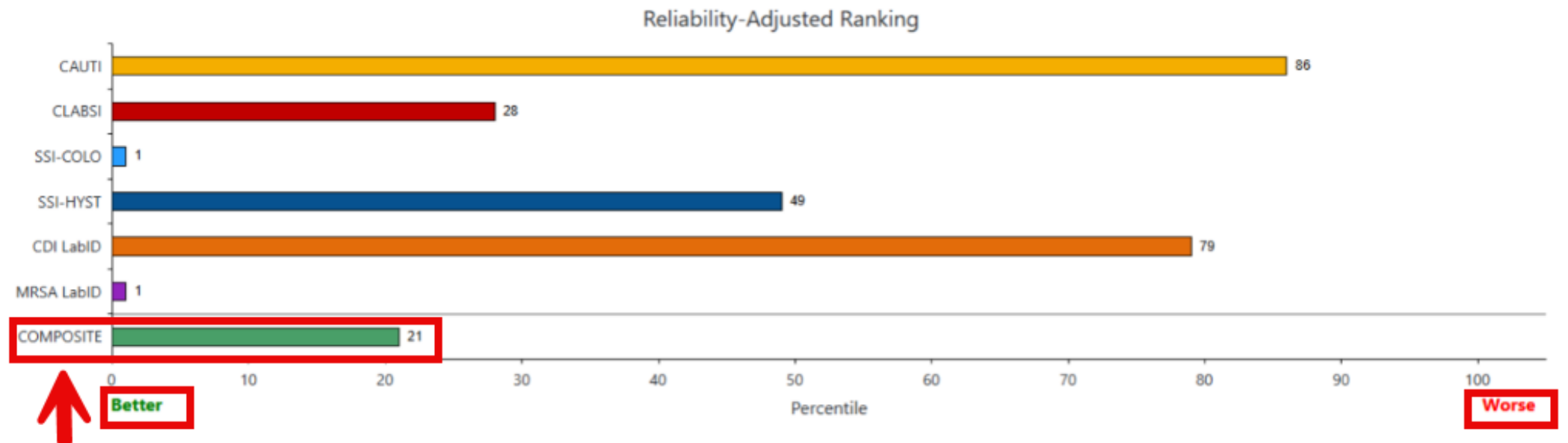
ARM & HAI Composite Measure Dashboard



Disclaimer: fictitious data for illustrative purposes only

The Composite Score Uses the Same Percentile Scale: Lower is Better, Higher is Worse

- The composite score is displayed on the same scale as ARM rankings.
- Lower composite scores indicate better overall performance.
- Higher composite scores indicate worse performance.

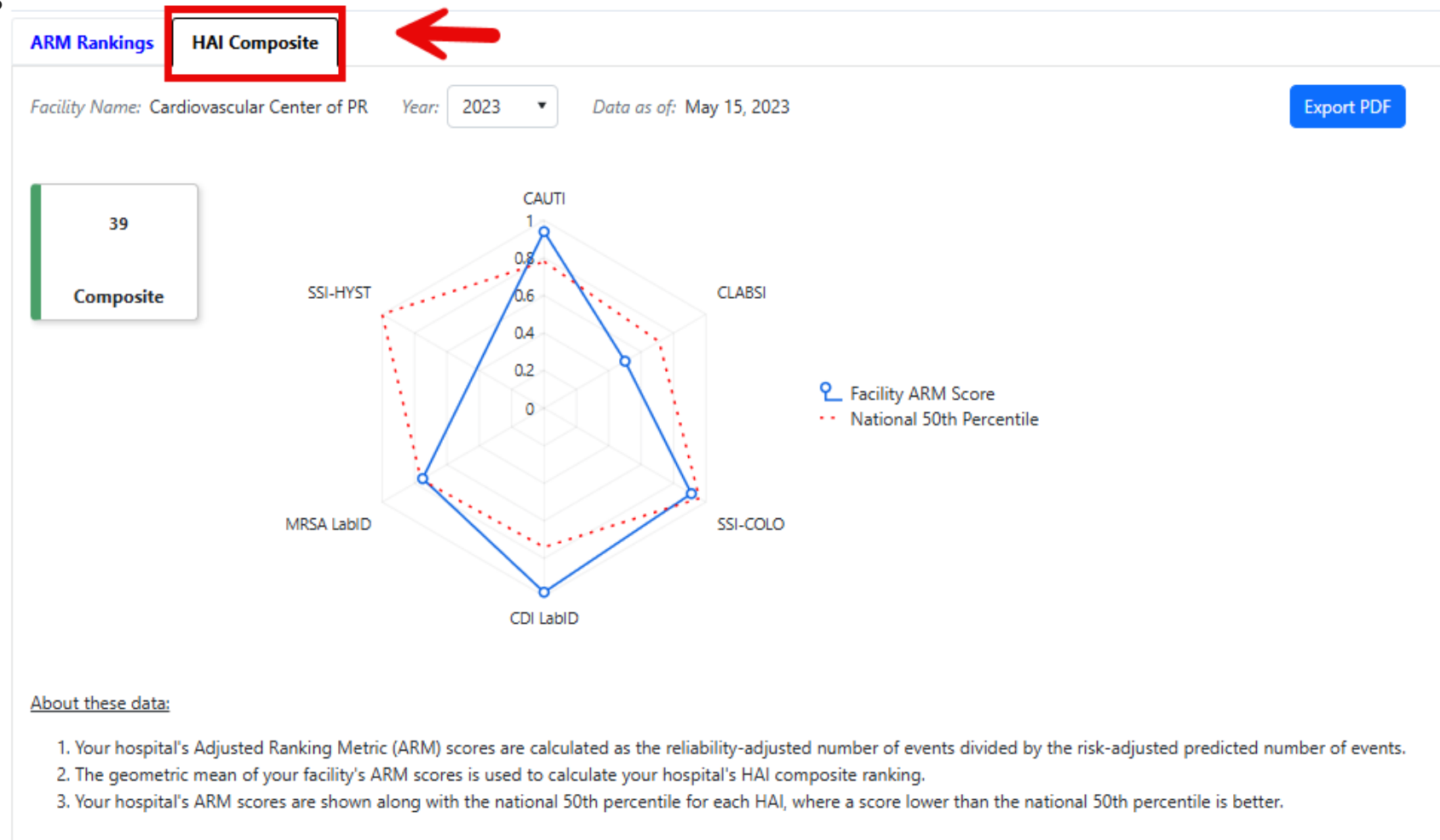


Disclaimer: fictitious data for illustrative purposes only

The Composite View Displays the Overall Composite Score and a Spider Plot of ARM Performance

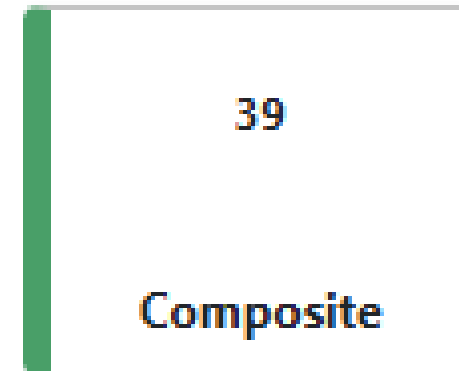
- The HAI Composite tab displays the facility's composite score.
- The spider plot visualizes ARM scores.
- Compare performance to the national 50th percentile benchmark.

ARM & HAI Composite Measure Dashboard



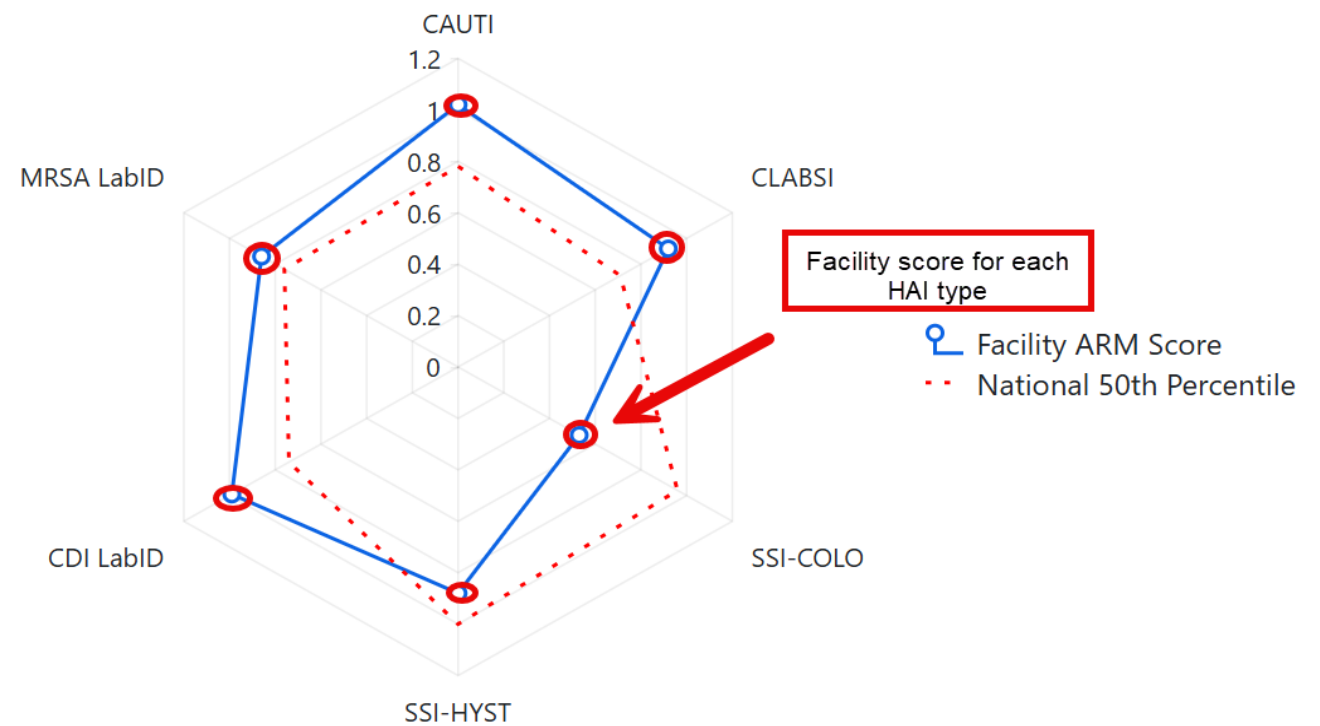
The Composite Hero Box Displays the Facility's Composite Percentile Ranking

- The composite is calculated from the facility's ARM scores.
- The composite is ranked against peer facilities.
- A composite score of 39 indicates better performance than 61% of peer facilities.



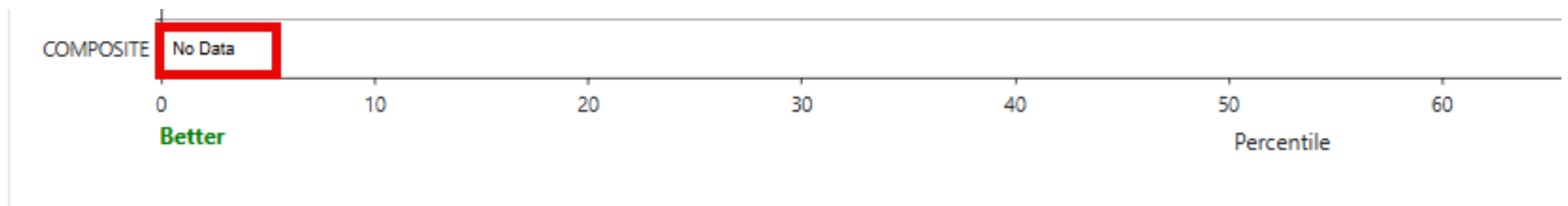
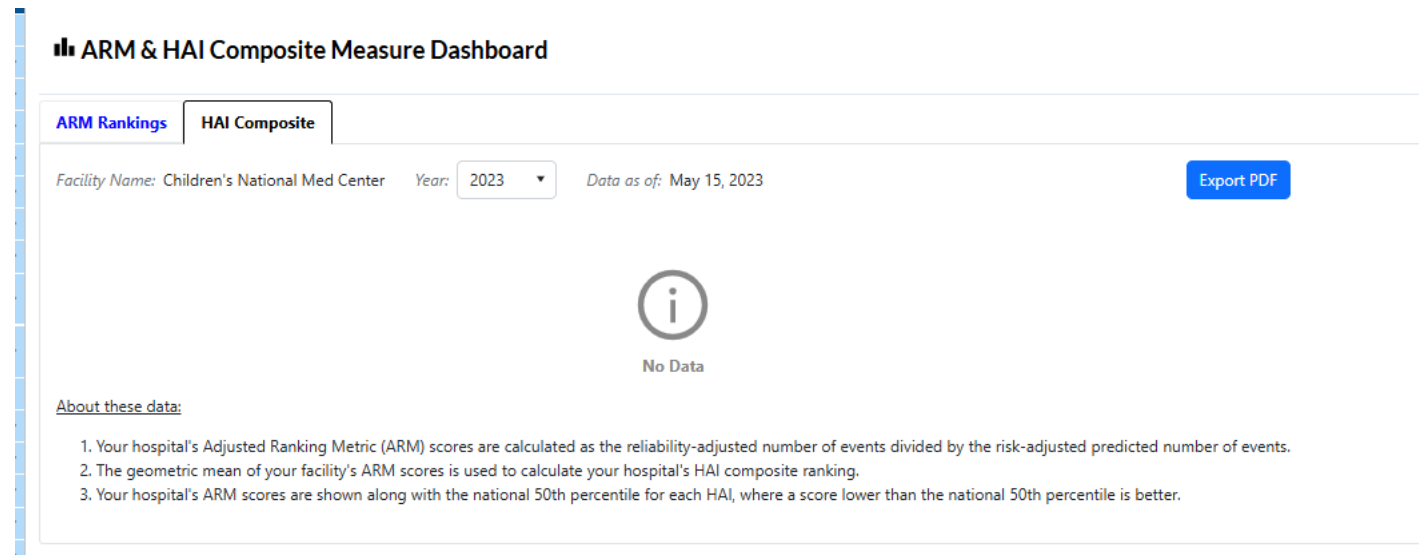
The Spider Plot Displays ARM Scores for Each HAI Compared to the National Median

- Each point on the spider plot represents the facility's ARM score for the specific HAI.
- The dashed lined represents the national 50th percentile.
- Points closer to the center indicate better performance.
- Points farther away indicate worse performance.



A Composite Score Will Not Be Generated When There is No/Insufficient Data

- The composite score is calculated only when sufficient ARM data is available.
- The dashboard will display 'No Data.'



Knowledge Check 5

In the ARM Dashboard, what does a lower score indicate?

- A. Worse performance compared to other facilities
- B. Better performance compared to other facilities
- C. No difference in performance



Knowledge Check 5

In the ARM Dashboard, what does a lower score indicate?

- A. Worse performance compared to other facilities
- B. Better performance compared to other facilities**
- C. No difference in performance



Rationale: ARM and Composite scores are shown on a percentile scale from 1 (best) to 100 (worst). A lower score means the facility is performing better compared to peer facilities.

ARM and Composite Scores Help Facilities Benchmark, Interpret, and improve Performance

Key Takeaways:

- ARM rankings and Composite scores support national benchmarking.
- ARM rankings are percentile-based comparisons with peer facilities.
- Lower scores indicate better performance.
- The composite score summarizes overall performance across eligible HAI measures.
- If there is no/insufficient data, an ARM ranking or composite score may not be generated.

Future Enhancement Will Expand Data Availability and Dashboard Access

- Introduction of 2024/2025 data to provide more current performance insights
- Exploration of group-level access to support facility networks and shared reporting

Resources Are Available Through the NHSN Help Desk, ServiceNow Portal, and the ARM webpage

- NHSN Help Desk: nhsn@cdc.gov
- ServiceNow portal: [NHSN-ServiceNow portal](#)
- ARM webpage: [ARM | Analysis Resources | NHSN | CDC](#)
- Please reference **handouts** for detailed information on resources

Thank you.

For any questions or concerns, contact the NHSN Helpdesk

- **NHSN-ServiceNow** to submit questions to the NHSN Help Desk.
- Access new portal at <https://servicedesk.cdc.gov/nhsncsp>.
- If you do not have a SAMS login, or are unable to access ServiceNow, you can still email the NHSN Help Desk at nhsn@cdc.gov.

For more information, contact CDC

1-800-CDC-INFO (232-4636)

TTY: 1-888-232-6348 <https://www.cdc.gov/>

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