

INTRODUCTION

PJI occurs in **0.2–3%** of arthroplasties and is linked to a **fivefold increase** in long-term mortality. Risk assessment has traditionally examined patient and surgical factors **in isolation**, overlooking the interaction between host vulnerability and procedural burden.

AIM

Does combining **how demanding the operation was** with **how frail the patient was** predict PJI better than either one alone — and does it hold in both primary and revision surgery?

METHODS

- Source.** TriNetX federated network of de-identified electronic health records from US academic medical centers; primary and revision hip and knee arthroplasty identified by CPT and ICD-10-PCS codes.
- Outcome.** Periprosthetic joint infection, by ICD-10-CM **T84.5** diagnosis codes.
- Analysis.** χ^2 tests compared PJI rates across the four groups; relative risks with 95% confidence intervals were calculated against the lowest-risk group using Fisher's exact test, then repeated separately in primary and revision patients. Level of evidence 3.

RESULTS

675,115 PATIENTS STUDIED	24,086 DEVELOPED PJI (3.57% OVERALL)	2.56 _x HIGHER PJI RISK IN THE HIGHEST- VS. LOWEST-RISK GROUP	3.07 EXTRA PJI CASES PER 100 PATIENTS IN THE HIGHEST-RISK GROUP	33 PATIENTS IN THE HIGHEST-RISK GROUP PER ONE EXTRA PJI CASE
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STEP 1 Score the surgical stress

Seven markers of how demanding the operation was were combined into a **single surgical stress score** using principal component analysis. The **weight** below is how strongly each marker pushes that score up — anesthesia and operative time dominate, so a long, complex case scores high.

SURGICAL STRESS MARKER	WEIGHT IN SCORE
Anesthesia time Recorded anesthesia duration	0.631
Operative time Recorded procedure duration	0.626
Increased procedural complexity Multiple major procedures per encounter	0.278
Joint deformity diagnosis ICD-10-CM M21–M24	0.255
Navigation use CPT 20985	0.190
Transfusion requirement ICD-10-PCS transfusion codes	0.141
Estimated blood loss volume Recorded EBL	0.111

STEP 2 Score the patient's frailty

Each patient was checked for **30 health deficits** in the year before surgery. The frailty score is the **share of those items the patient had**, from 0 (none) to 1 (all). Cohort average **0.092**. Most common deficits: recent opioid use **77.1%**, recent hospitalization **36.8%**, abnormal blood pressure **30.3%**.

Comorbidity 13 items

Immunodeficiency · heart failure · COPD or asthma · chronic kidney disease · diabetes mellitus · coronary disease or prior MI · atrial fibrillation · stroke or TIA · peripheral vascular disease · cirrhosis · dementia · depression or anxiety · malignancy

Physiologic & laboratory 9 items

Hypoalbuminemia · anemia · abnormal sodium · lymphopenia · poor glycemic control · abnormal BMI · abnormal heart rate · abnormal blood pressure · hypoxemia

Utilization & function 5 items

Hospitalizations · emergency department visits · documented falls · mobility aids or durable medical equipment · nursing facility residence

Medications 2 items

Benzodiazepine or antipsychotic exposure · chronic opioid therapy

Nutrition 1 item

Unintentional weight loss or malnutrition

STEP 3 Sort into four risk groups

Both scores were split at the **cohort midpoint** into low and high, giving four groups. **PJI rate** is the share of patients in a group who developed an infection. **Relative risk** is how many times that group's rate exceeds the lowest-risk group's.

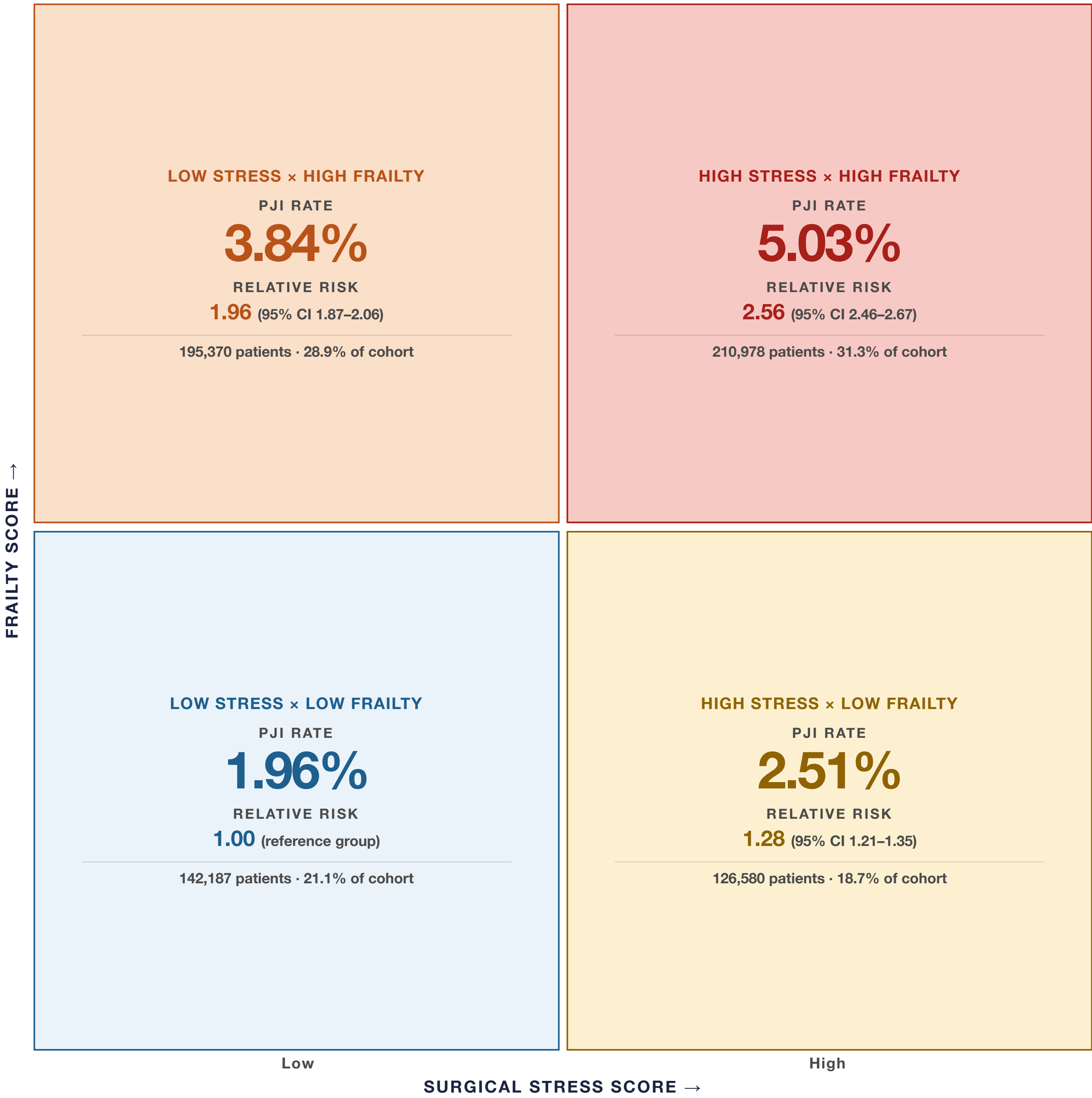


Figure 1. PJI rate rose stepwise across the four groups, from **1.96%** to **5.03%** ($\chi^2 = 1,797.8$; all relative risks $p<0.001$).

FIGURE 2 · BUILDING THE SURGICAL STRESS SCORE

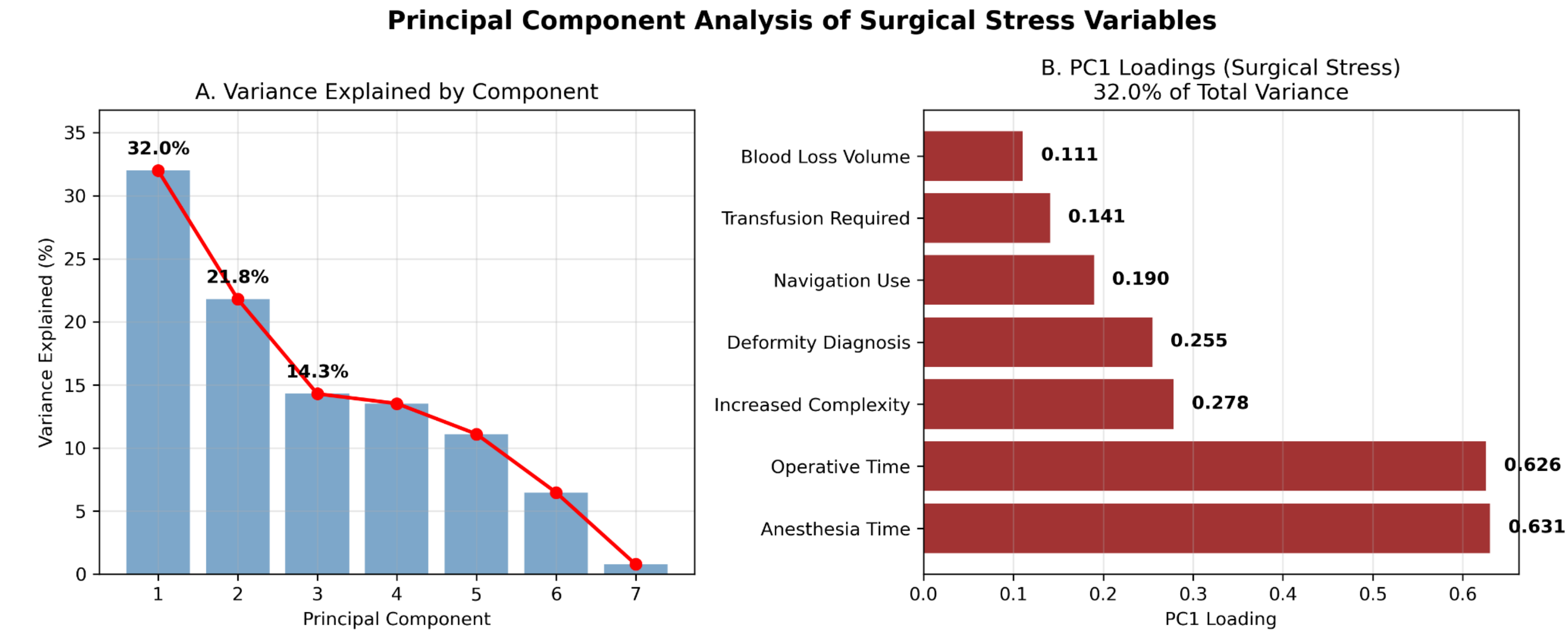


Figure 2. Principal component analysis of the seven surgical stress markers. (A) How much of the variation between operations each combined component explains — the first (PC1, used as the stress score) captured **32.0%**, the first two **53.8%**. (B) The weight each marker carries in that score; anesthesia time (**0.631**) and operative time (**0.626**) dominate.

TABLE 1 · PJI RATE IN EACH GROUP, PRIMARY VS. REVISION

RISK GROUP	PRIMARY n = 652,467	REVISION n = 20,598
Low stress × Low frailty	1.80%	12.72%
High stress × Low frailty	2.09%	15.10%
Low stress × High frailty	3.43%	22.61%
High stress × High frailty	3.96%	24.73%
Relative risk, highest vs. lowest	2.20	1.94

The same stepwise gradient appeared in both populations (primary $\chi^2 = 1,797.8$; revision $\chi^2 = 261.2$; both $p<0.001$) — but revision patients started from a baseline roughly **seven times higher**.

Cohort: **97.0%** primary, **3.0%** revision; knee **54.9%**, hip **45.1%**. Complexity markers present: navigation **2.2%**, transfusion **8.7%**, increased complexity **15.3%**, deformity **12.1%**.

CONCLUSION

- Scoring **how demanding the operation was** alongside **how frail the patient was** separates PJI risk better than either factor alone.
- Patients high on both faced **more than twice** the infection risk of patients low on both (5.03% vs. 1.96%; one extra infection for every 33 such patients) — a gradient that held in primary and revision surgery alike, and one that can be calculated before the operation to target prevention.

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