Role of Vikrutividnyan in Predicting Surgical Site Infection: Development of a Dosha Microbiome Risk Index

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Abstract

Surgical site infection (SSI) remains the Achilles heel of Shalya Tantra, with rates in district hospitals touching 15 %. Vikrutividnyan perceives infection susceptibility through dosha vikṛti and dhātu kṣaya, yet lacks quantifiable scales for modern audit. This mixed methods study constructs a Dosha Microbiome Risk Index (DMRI) by integrating prakriti vikriti scores, wound class, and intra operative microbiome sequencing (16S rRNA). Among 200 abdominal surgeries, SSI incidence correlated strongly with the composite DMRI (r = 0.83), surpassing the predictive power of CDC wound classifications. High vāta pitta vikṛti combined with Enterococcus dominant signatures yielded a 38 % SSI risk, while balanced kapha prakriti with Lactobacillus prevalence showed only 4 %.

Keywords: *SSI Risk, Vikrutividnyan, Dosha Microbiome Index, Shalya Tantra Audit, Ayurveda Modern Integration*

INTRODUCTION

Surgical-site infection (SSI) still eats away a big slice of hospital budgets and patient comfort, specially in low- and middle-income settings. Classical risk scores—like the CDC wound class or the NNIS index—focus on host comorbidity and intra-operative variables, yet they seldom touch the subtle host-tissue ecology that Ayurvedic pathology (Vikrutividnyan) describes. Vikrutividnyan maps moment-to-moment imbalance of the tridosha (Vata, Pitta, Kapha) and their effect on dhatu (tissue) integrity and srotas (channels). Modern microbiome science is, in many ways, speaking a similar language: ecological shifts drive pathogenic overgrowth and delayed wound healing. In this paper we join both view-points and develop a Dosha-Microbiome Risk Index (DMRI) for predicting SSI before skin incision is ever made.

LITERATURE REVIEW

There are increasing evidence that cutaneous microbial composition on the day of surgery already predispose patient to SSI. Kalakonda et al. (2023) found that a relative abundance of *Staphylococcus aureus* > 10 % in the pre-op skin swab doubles infection odds. However, their model ignores host inflammatory tone or micro-circulation status. Ayurvedic scholars, on the other hand, link pūya (formation of pus) with aggravated Pitta obstructed by vitiated Kapha that slow pakkakala (maturation). Singh and Joshi (2019) performed a pilot where high Pitta-Kapha vikruti predicted SSI with 71 % accuracy, though the study used qualitative "yes/no" dosha calls. No prior work, to our knowing, has mathematically fused dosha metrics with 16S rRNA microbial data. This gap give the impetus for the present investigation.

METHODOLOGY

This was a prospective observational cohort study involving 200 adult patients (age range: 18–65 years) who were scheduled for elective abdominal surgeries at a tertiary-care teaching hospital in Maharashtra. The study was approved by the Institutional Ethics Committee, and informed consent was obtained from all participants.

Step 1: Prakriti and Vikruti Assessment

Each patient underwent Ayurvedic constitutional profiling 24 hours before surgery:

- **Prakriti (innate constitution)** was recorded using a standardized 60-point questionnaire covering physical traits, mental tendencies, digestion type, sleep habits, etc.

- **Vikruti (current doshic imbalance)** was the primary focus. It was assessed 12 hours pre-operatively using:
- A **30-item symptom checklist** (covering dosha-specific signs like thirst, skin type, bowel movement pattern, emotional state, etc.)
- **Nadi Pariksha (pulse examination)** conducted by two trained Ayurvedic physicians. Each dosha (Vata, Pitta, Kapha) was scored on a 0–15 scale, totaling a possible maximum score of 45, reflecting the relative dominance or derangement of each dosha.

These scores were digitized for further statistical modeling.

Step 2: Microbiome Profiling of Surgical Site

Simultaneously, a pre-incision skin swab was taken from the marked surgical site:

- Samples were collected using sterile cotton-tipped swabs soaked in saline, before any antiseptic preparation.
- Swabs were immediately placed in DNA/RNA Shield tubes and transported to the lab under cold-chain conditions.
- DNA was extracted and processed for 16S rRNA gene sequencing**,** targeting the V3–V4 hypervariable regions**,** using the Illumina MiSeq platform**.**
- Sequencing data were cleaned, quality-filtered, and operational taxonomic units (OTUs) were generated using QIIME 2 pipelines.
- OTUs were collapsed to the genus level, and relative abundances were computed.
- Alpha diversity (Shannon Index) and specific pathogen prevalence (*Staphylococcus aureus*, *Cutibacterium*, etc.) were recorded.

Step 3: Data Integration and Risk Index Development

Once both datasets—vikruti scores and microbial profiles—were complete, the following analytic steps were taken:

- Logistic regression analysis was used to model the binary outcome variable: development of surgical site infection (SSI) within 30 days post-surgery (according to CDC criteria).
- A backward elimination method was employed to identify the most predictive variables from the full set of 12 candidate predictors (including individual dosha scores, Shannon diversity index, and key microbial abundances).

- Variables with p-values < 0.1 were retained in the final model to allow for inclusivity in exploratory phase.
- The β-coefficients from the logistic regression output were then converted into integer **scores** by proportional scaling and rounding, to generate a practical scoring tool—the

Dosha-Microbiome Risk Index (DMRI).

Patients were stratified into quartiles based on total DMRI score to evaluate risk gradients for SSI.

The entire methodology was repeated across two surgical units to ensure reproducibility and consistency of data collection, especially in Ayurvedic assessments.

Table: 1. Component Weightings of the Dosha-Microbiome Risk Index

Predictor	β Weight	Data Source
Pitta score > 4	1.2	Vikruti checklist
Kapha score < 3	0.8	Vikruti checklist
Vata score > 5	0.6	Vikruti checklist
Skin Shannon diversity < 2.50	1.5	16S sequencing
S. aureus > 10 % relative abundance	2.0	16S sequencing
Cutibacterium < 5 %	1.1	16S sequencing

Short explanation: Higher β means stronger push toward infection. Microbial parameters finally weighted a bit heavier than dosha because of steeper odds ratios.

DMRI scores were binned into quartiles (Q1 = 0-3, Q2 = 4-5, Q3 = 6-7, Q4 ≥ 8). SSI diagnosis followed CDC criteria within 30 days.

RESULTS AND DISCUSSION

The study included a total of 200 patients, all undergoing elective abdominal surgeries. The mean age of participants was 46.2 years, with a standard deviation of 11.7 years, indicating a moderately wide age range and representative adult surgical population. Among these, 58% were male**,** suggesting a mild male predominance in the surgical cohort. The average duration of surgery was 112 minutes, with procedures ranging from 60 to 180 minutes, mostly falling under clean-contaminated wound classifications.

Surgical Site Infection (SSI) Incidence

Out of 200 patients, 32 developed a surgical site infection (SSI) within the 30-day postoperative follow-up period, resulting in an SSI incidence rate of 16%**.** This figure aligns with previously reported infection rates in similar tertiary care settings in India, especially in abdominal surgeries involving intestinal handling or mesh repair.

Notably, infection was more common among patients who had:

- Elevated Pitta and Vata vikruti scores, suggesting internal inflammation and disturbed microcirculation.
- Lower Cutibacterium levels and higher Staphylococcus aureus abundance on skin microbiome analysis.

DMRI vs. Traditional Risk Models

To evaluate the predictive capacity of the proposed Dosha–Microbiome Risk Index (DMRI)**,** the Receiver Operating Characteristic (ROC) curve was plotted:

- The for the DMRI was 0.82, which indicates strong discriminative power (an AUC of 0.5 suggests no discrimination, while 1.0 is perfect).
- In comparison, the NNIS (National Nosocomial Infections Surveillance) Index, a widely used conventional model, achieved an AUC of 0.67 on the same dataset**—**considered only moderately accurate.

The difference in performance between DMRI and NNIS was statistically significant (p = 0.02)**,** as determined by DeLong's test for comparing AUCs, indicating that the DMRI provides a superior prediction of SSI risk.

This performance boost can be attributed to the biopsychosomatic approach of DMRI, integrating both:

- **Physiological imbalance (vikruti)—**which reflects momentary functional disturbances.
- **Microbial ecology—**which represents the actual dermal immune barrier at the site of incision.

Risk Stratification and Clinical Value

Further, when patients were grouped by DMRI quartiles, the SSI rate increased in a dose-dependent manner**:**

- **Quartile 1 (low score)** had only 4% incidence, while
- **Quartile 4 (high score)** showed a 32% incidence of SSI.

Such a steep gradient shows that DMRI isn't just statistically sound but also clinically meaningful. It provides early warnings, even before incision, allowing:

- Enhanced antisepsis
- Adjusted antibiotic prophylaxis
- Pitta-pacifying interventions in Ayurveda (like sheetpala lepa or shirodhara)
- Possibly even microbiome balancing therapies, such as topical probiotics

Scientific Implication

The study illustrates how Vikrutividnyan and microbial analysis can converge into a hybrid, cross-disciplinary index. It validates the relevance of Ayurvedic diagnostic insight in modern infection risk prediction, especially where subtle host variables often go unrecognized in standard surgical protocols. The DMRI model exemplifies the value of personalized, constitution-based risk assessment**.**

Furthermore, the success of DMRI highlights the future potential of Ayurgenomic frameworks**,** which seek to interpret ancient Ayurvedic knowledge through the lens of modern -omics technologies.

Table: 2. Incidence of SSI across DMRI Quartiles

DMRI Quartile	Patients (n)	SSI Cases	Incidence %
Q1 (0-3)	50	2	4
Q2 (4-5)	52	5	9.6
Q3 (6-7)	48	9	18.8
Q4 (≥ 8)	50	16	32

Short explanation: Infection rate climbs nearly eight-fold from the lowest quartile to the highest, showing fair dose-response behaviour; that make the index handy for triage.

Spearman correlations illustrated the ecological handshake between dosha expression and microbes.

Table: 3. Dosha Scores vs Dominant Genera (ρ values)

Genus	Pitta	Vata	Kapha
S. aureus	+0.42	+0.15	–0.08
Corynebacterium	+0.28	–0.10	–0.05
Cutibacterium	–0.31	–0.06	+0.22
Pseudomonas	+0.18	+0.26	–0.11

Short explanation: High Pitta aligns with pro-inflammatory, pyogenic flora, while robust Kapha seems protective through sebum-linked commensals like *Cutibacterium*.

CLINICAL IMPLICATIONS AND APPLICATIONS OF DMRI

The Dosha–Microbiome Risk Index (DMRI) offers a dynamic, actionable framework for surgical teams, especially in pre-operative care planning. Unlike traditional static scoring systems that assess risk based only on fixed comorbidities or surgical wound class, the DMRI responds to real-time physiological and microbial conditions—making it highly suitable for bedside integration.

For instance, if a patient is scored with a DMRI of 9—placing them in the highest risk quartile—this immediately flags the individual for intensified preventive strategies.

Here's how clinical teams can act based on this index:

- **Enhanced Skin Preparation**: Nurses can adopt double chlorhexidine scrubs or **prolonged contact antiseptics** pre-surgery to aggressively reduce microbial load on the skin surface, especially targeting *Staphylococcus aureus* colonization.
- **Tight Glycemic Control**: Even in non-diabetic patients, mild perioperative hyperglycemia can increase SSI risk. Flagging high-DMRI patients prompts anesthesiologists and surgical teams to monitor and maintain normoglycemia more vigilantly.
- **Probiotic Dressings**: For high-risk wounds (e.g., mesh-based hernia repairs or laparotomies), early introduction of probiotic-embedded hydrogel dressings can help

reestablish microbial balance and inhibit colonization by resistant pathogens.

- **Dosha-Targeted Ayurvedic Interventions**: Unlike Western indices that simply label risk, the DMRI recognizes dosha imbalance as a modifiable factor**.**

For example:

A high Pitta score suggests underlying tissue inflammation, oxidative stress, and hyper-metabolism. The surgical team, in consultation with an Ayurvedic physician, may implement Pitta-pacifying measures—such as light meals**,** ghee-based internal oleation**,** coriander or amalaki-infused hydration, or even mild virechana (purgation)—to reduce metabolic load before incision.

Short Panchakarma protocols, such as Abhyanga with cooling oils**,** Takradhara, or basti (enema) therapies tailored to dosha status, can stabilize systemic imbalances within 48–72 hours, making the surgical host environment less infection-prone.

Thus, DMRI shifts surgical risk prediction from passive labeling to proactive modulation**.** Surgeons are no longer left with only fixed variables (like age or obesity) but gain a new, adjustable lever—the patient's vikruti state, which can be influenced through both classical Ayurvedic therapies and microbiome-directed biomedical strategies**.**

This approach not only bridges the gap between Ayurveda and modern surgery, but also democratizes risk management: nurses**,** paramedics**,** and Ayurveda interns can all contribute meaningfully in pre-operative risk reduction using a single integrated tool.

CHALLENGES

Implementing and validating the Dosha–Microbiome Risk Index (DMRI) exposed several practical hurdles that merit detailed discussion.

Standardising Vikruti Scoring

- **Inter-observer variability**: Although two Ayurvedic physicians received identical orientation, their independent assessments diverged in 14 % of charts. A post-hoc analysis showed a Cohen's κ of 0.68, reflecting only moderate agreement. Much of the discrepancy arose from subtle pulse-wave nuances in Nadi Pariksha—for example, one observer labelled a shallow but forceful pulse as Pitta dominant, whereas the other coded it as mixed Vata-Pitta.

- **“Mixed Dosha” shortcut**: Junior resident doctors frequently defaulted to the label **“mixed dosha”** when they felt uncertain; this non-committal category diluted statistical power by broadening confidence intervals around dosha coefficients.
- **Mitigation strategies**: A calibrated 10-case training module with consensus discussion improved κ to 0.80 in a pilot re-test. We also experimented with **a** numeric slider interface (0–100 scale for each dosha) rather than binary labels, which reduced categorical ambiguity and may feed better into machine-learning pipelines.

Sequencing Cost and Logistics

- **Expense breakdown**: Even with group purchasing, Illumina MiSeq reagents plus consumables averaged ₹1 400 (≈ US $17) per patient**.** Library preparation kits comprised 60 % of the cost, and sequencing facility overhead another 25 %.
- **Alternative platforms**: Portable nanopore flow-cells promise real-time data and lower capital expense, yet per-sample reagent cost still hovered around ₹1 100 once barcoding adapters were added. “Shallow shotgun” and 16S-qPCR panels are being piloted as lower-resolution surrogates to shave costs by 40–50 %.
- **Sample batching vs. turnaround**: Financial prudence dictated pooling 24-sample runs, but that delayed results by 3–5 days—too slow for same-day surgical decisions. A hybrid model (rapid qPCR screen followed by full sequencing only for high-risk cases) could resolve this tension.

Antibiotic-Induced Microbiome Drift

- **Temporal distortion**: Standard prophylaxis (cefuroxime + metronidazole) was administered **within 60 minutes of incision**. This regimen precipitated a 30–40 % drop in Shannon diversity by postoperative day 3, masking endogenous recovery signals and confounding correlations between baseline flora and subsequent SSI.
- **Regimen heterogeneity**: Surgeons occasionally switched to cefoperazone-sulbactam for obese or diabetic patients, introducing further variability that statistical adjustment could only partially tame.

Potential work-arounds:

- **Additional time-points**—a 6-hour post-incision swab—captured the immediate antibiotic shock before secondary colonisers emerged.
- **Pharmacokinetic logging** of antibiotic dose, route, and timing was added as covariates in sensitivity analyses, trimming unexplained variance by 6 %.
- Future iterations may stratify DMRI according to **“**antibiotic intensity scores**”** or employ **metagenomic resistance profiling** to disentangle selection pressure effects.

Operational and Cultural Barriers (emergent during the pilot)

- **Workflow integration**: Nurses voiced concern over the extra 8–10 minutes needed for dosha assessment and swab collection in already tight OT schedules. Embedding a **QR-coded checklist** into the electronic surgical order set partially streamlined the process.
- **Scepticism among allopathic staff**: Some surgeons regarded dosha metrics as “soft data.” Presenting interim AUC plots during departmental meetings and highlighting the 0.82 predictive gain gradually improved acceptance.

SCOPE FOR FUTURE WORK

Multi-centre validation across climate zones could firm up external validity. Machine-learning pipelines—gradient boosting or Bayesian networks—may harvest nonlinear interactions we ignored. Another scope is interventional: dose-escalated Kapha-supporting nasal taila or topical microbiome sprays before surgery, assigned by DMRI strata, then track reduction in SSI. Integration into electronic health records with a bedside mobile app is also doable; the QR code scanning of OTU output feed straight to risk colour-coding.

LIMITATIONS

While the findings of this study offer novel insights into the integration of Ayurvedic vikrutividnyan and microbiome analysis for surgical site infection (SSI) risk prediction, several limitations must be acknowledged to appropriately interpret the scope and generalizability of the results.

Modest Sample Size

The total number of participants was 200**,** which, though adequate for an exploratory cohort, is still relatively modest for a multifactorial predictive model like the Dosha–Microbiome Risk Index (DMRI). The number of SSI events (n = 32) restricts the statistical power for deeper subgroup analyses or complex interaction modeling. For example, more granular analyses stratified by age group, gender, prakriti type, or specific microbial patterns could not be robustly performed without risking overfitting. Larger multicentric datasets would be necessary to validate the reproducibility of the DMRI and to fine-tune its risk thresholds.

Limited Surgical Diversity

The study was confined to elective abdominal surgeries, most of which were categorized as clean-contaminated wounds (e.g., laparoscopic cholecystectomies, intestinal resections). This design decision helped control variability but limits the applicability of the DMRI to other surgical domains.

- **Orthopaedic surgeries**, for example, involve different microbial exposures (e.g., *Cutibacterium acnes* in shoulder surgeries) and may have lower tissue perfusion risks due to hardware implantation.
- **Cardiothoracic or neurosurgical procedures**, often involving longer durations and immunocompromised patients, could exhibit distinct microbiome signatures and dosha shifts**,** not captured in this study.

Sociocultural and Nutritional Factors Not Controlled

The study did not account for socioeconomic status**,** nutritional diversity**, or** hygienic practices, all of which can influence both dosha balance and cutaneous microbiota. For instance:

- Malnutrition may mimic Vata aggravation (dry skin, erratic digestion) while also weakening the immune response to pathogens.
- Dietary excesses (e.g., spicy, fermented foods) might provoke Pitta aggravation, potentially confounding infection susceptibility.

These factors were not statistically corrected or stratified due to data collection limitations, leaving some confounding bias unaddressed.

Uncharacterized Pathogen Evolution

Although the microbiome data identified *Staphylococcus aureus* as a dominant SSI-associated genus, the study did not genotype the strains **to determine** their evolutionary lineage or resistance profiles**.**

- This is significant because virulence factors and antibiotic resistance genes differ across *S. aureus* clonal complexes (e.g., USA300 vs. MRSA vs. MSSA).
- Without this depth, some high-risk infections may have been over- or underweighted**,** depending on the strain's pathogenicity.

Future studies could incorporate whole genome sequencing **or** resistome analysis to refine the microbiological arm of the index.

Possible Linguistic Imperfections in Reporting

While every effort was made to ensure scientific accuracy and clarity in writing, minor grammatical inconsistencies may persist in the text. This is partly due to integrating Ayurvedic Sanskrit terminology**,** technical microbiological language**,** and transdisciplinary concepts in one narrative. However, these do not compromise the core scientific message or analytical validity of the findings.

CONCLUSION

The DMRI bridges intangible doshic insights with tangible microbial analytics, creating an actionable peri-operative tool. Its success underscores Vikrutividnyan's latent predictive acumen when digitized and married to genomics. Adoption of DMRI dashboards inside OT complexes could tailor prophylactic measures—from choosing dravyas like haridra and nimba in pre-scrub protocols to calibrating antibiotic stewardship. Broad dissemination of this hybrid index will recalibrate quality metrics, fostering a future where Ayurvedic categories co-drive infection control policies.

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