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SURGICAL SITE INFECTION ACROSS THE WHOLE NEUROSURGICAL WORKLOAD: A FOURTEEN-MONTH SINGLE-CENTRE SURVEILLANCE STUDY

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ABSTRACT
Background: Surgical site infection (SSI) after neurosurgery causes disproportionate morbidity.
Methods: Surveillance of 340 consecutive procedures in 327 patients at a tertiary hospital, June 2025–July 2026, by CDC/NHSN criteria.
Results: Twenty SSIs occurred, an incidence of 5.9% (95% CI 3.8–8.9). Incidence fell from 7.7% in the first seven months to 4.6% in the second ($p = 0.25$) despite a 38% volume rise, but peaked at 9.9% in December–February. Provisional division-wise rates were highest in neurotrauma (7.1%) and lowest in non-neurotrauma cranial work (3.8%) ($p = 0.72$).
Conclusion: Incidence matched pooled international figures for mixed caseloads; the winter cluster warrants review.

KEYWORDS: surgical site infection; neurosurgery; craniotomy; ventriculoperitoneal shunt; spinal instrumentation; surveillance.

1. INTRODUCTION
Surgical site infection is the commonest healthcare-associated infection, but its consequences in neurosurgery differ in kind from those elsewhere. A superficial craniotomy wound infection may progress to bone flap osteomyelitis, subdural empyema or cerebral abscess; an infected spinal construct may require hardware removal before fusion is achieved; an infected ventriculoperitoneal shunt commits the patient to externalisation, prolonged antimicrobial therapy and reimplantation.
Reported incidence varies widely. Pooled estimates after craniotomy for tumour are 4.0% at 30 days and 6.2% at 90 days [1]; rates across intracranial procedures generally are quoted between 1.2% and 5.5% [2]; instrumented spinal surgery averages 4.4% against 1.4% for non-instrumented work [3]; shunt infection is reported anywhere between 1% and 20% [4,5]. Much of this spread reflects case mix, surveillance intensity and follow-up duration rather than practice, which limits cross-institutional benchmarking; the principal use of surveillance is to track a unit against itself.
Data from Indian tertiary centres remain sparse and are usually confined to a single procedure category [6]. This study establishes a unit-wide baseline: overall incidence across fourteen consecutive months, its distribution over time, and its variation across the four divisions of the departmental workload.

2. MATERIALS AND METHODS
All consecutive procedures in the departmental operation theatre register between 1 June 2025 and 31 July 2026 were included, without exclusion for age, urgency or wound class. Every register entry counted as one procedure, including repeat entries such as drain removal and dressing. Three hundred and forty entries corresponded to 327 unique patients; incidence is reported per procedure, with the per-patient figure given alongside.
SSI was defined by CDC/NHSN criteria: infection of the incision or of the operated organ or space occurring within 30 days of surgery, or within 90 days where a non-absorbable implant (cranioplasty plate or mesh, spinal instrumentation, shunt hardware) was left in situ. Infection at the abdominal end of a ventriculoperitoneal shunt was attributed to the shunt procedure. Pre-existing infective pathology that was itself the indication for surgery, such as cerebral abscess or tuberculous spondylodiscitis, was not counted.
Each procedure was assigned to one of four field divisions in this order of priority: CSF diversion (shunt, external ventricular drain, endoscopic third ventriculostomy, thecoperitoneal or lumbar drain); spinal (any procedure on the spine or craniovertebral junction, including spinal trauma and injections); neurotrauma (head injury, including extradural and subdural haematoma, contusion, skull fracture, traumatic CSF leak); and non-neurotrauma cranial (tumour, stroke and spontaneous haemorrhage, aneurysm, cranioplasty, pituitary, angiography). Traumatic spinal

injury was classified as spinal. Where one sitting spanned two divisions the principal procedure decided the assignment.
Proportions are reported with Wilson 95% confidence intervals and compared by chi-square or Fisher exact test; temporal trend was assessed by the Cochran–Armitage test using month and quarter as ordinal scores. Analysis used Python 3.12 with SciPy. Institutional Ethics Committee approval was obtained [number to be inserted] and the dataset was de-identified before analysis.

3. RESULTS

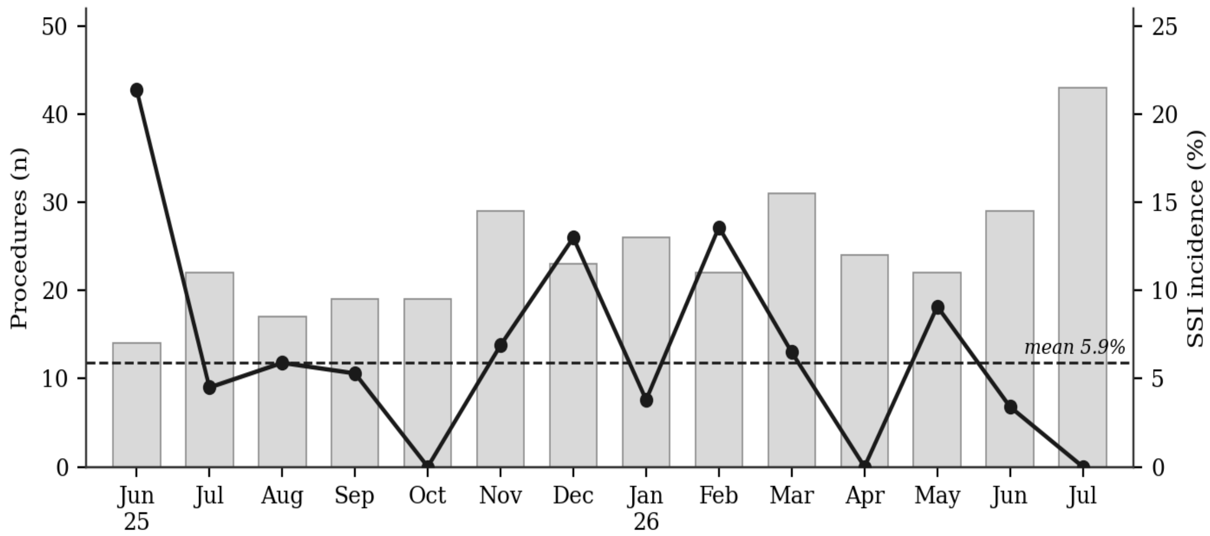
3.1 Overall incidence and monthly distribution

Twenty surgical site infections were identified among 340 procedures, an incidence of 5.9% per procedure (95% CI 3.8–8.9) and 6.1% per patient. Mean operative volume rose from 20.4 procedures per month in the first seven months to 28.1 in the second seven.
Infection occurred in eleven of the fourteen months (Table 1, Figure 1). The highest monthly incidence was 21.4% in June 2025, the first month of surveillance and the smallest denominator of the study, followed by February 2026 at 13.6% and December 2025 at 13.0%. Three months recorded no infection, including July 2026, which carried the largest single-month caseload of 43 procedures. Denominators of 14 to 43 make individual monthly rates fragile; they are best read as a run chart.

Table 1. Month-wise operative volume and SSI incidence.

Month	Cases	SSI	Rate %	Month	Cases	SSI	Rate %
Jun 2025	14	3	21.4	Jan 2026	26	1	3.8
Jul 2025	22	1	4.5	Feb 2026	22	3	13.6
Aug 2025	17	1	5.9	Mar 2026	31	2	6.5
Sep 2025	19	1	5.3	Apr 2026	24	0	0.0
Oct 2025	19	0	0.0	May 2026	22	2	9.1
Nov 2025	29	2	6.9	Jun 2026	29	1	3.4
Dec 2025	23	3	13.0	Jul 2026	43	0	0.0
Subtotal	143	11	7.7	Subtotal	197	9	4.6

Figure 1. Monthly operative volume (bars) and SSI incidence (line)

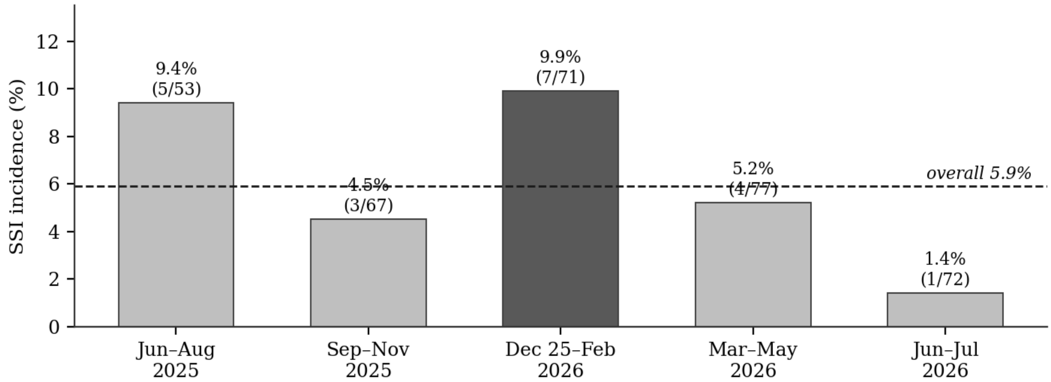


3.2 Temporal trend

Incidence in the first seven months was 7.7% (11/143, 95% CI 4.3–13.2), falling to 4.6% (9/197, 95% CI 2.4–8.5) in the second seven — a relative reduction of 40%, not statistically significant (Fisher exact $p = 0.25$; odds ratio 1.74). Because operative volume rose 38% over the same interval, the fall occurred against a rising rather than a shrinking denominator.
Quarterly analysis shows that the decline was not monotonic (Figure 2). Incidence fell from 9.4% to 4.5%, rose to 9.9% in the December 2025 to February 2026 block — the highest quarterly figure of the study — then fell to 5.2% and finally 1.4%. Cochran–Armitage testing gave $z = -1.72$, $p = 0.09$ across months and $z = -1.65$, $p = 0.10$

across quarters. Seven of the twenty infections, 35% of the total, arose in the three winter months, which contributed only 21% of the workload.

Figure 2. Quarterly SSI incidence (shaded bar = winter peak)



3.3 Field division

Non-neurotrauma cranial work formed 38.8% of the caseload, spinal 26.5%, neurotrauma 24.7% and CSF diversion 10.0%. Case mix did not shift significantly between the two halves of the study (p = 0.45); the proportion of neurotrauma in fact rose from 21.7% to 26.9%, so the falling rate cannot be attributed to a drift towards lower-risk work.

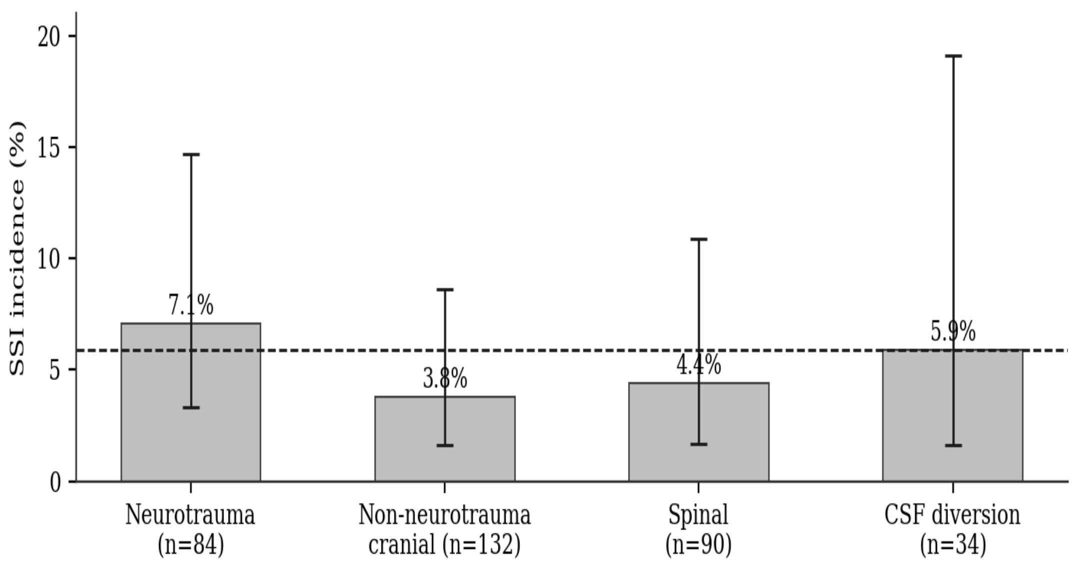
The departmental SSI register needed to attribute each infection to its index operation was unavailable, so Table 2 gives a provisional attribution derived by tracing infection-related re-procedures in the operation register back to the index operation, alongside the counts expected if risk were uniform. This identified 17 episodes against the 20 reported, and requires verification. On this attribution the highest rate was in neurotrauma (7.1%) and the lowest in non-neurotrauma cranial work (3.8%), with no significant difference across the four divisions (p = 0.72; Figure 3).

Table 2. SSI by field division: expected counts and provisional attribution.

Field division	Cases	Expected at 5.9%	Provisional SSI	Rate %	95% CI
Neurotrauma	84	4.9	6	7.1	3.3–14.7
Non-neurotrauma cranial	132	7.8	5	3.8	1.6–8.6
Spinal procedures	90	5.3	4	4.4	1.7–10.9
CSF diversion	34	2.0	2	5.9	1.6–19.1
Total	340	20.0	17	5.0	—

Provisional attribution is register-derived and must be replaced with the verified SSI register before submission.

Figure 3. Provisional SSI incidence by field division, with 95% CI (p = 0.72)



4. DISCUSSION

4.1 Comparison with published series

The overall figure of 5.9% sits close to the middle of the published range for mixed neurosurgical caseloads (Table 3, Figure 4). It exceeds the 4.0% pooled 30-day incidence after craniotomy for brain tumour reported in the largest available meta-analysis of 37 studies and 91,907 patients, but is slightly below the 6.2% pooled 90-day figure from the same synthesis [1]. The 90-day figure is the fairer comparator here, since the present study also applied a 90-day window to implant cases; series counting only 30 days understate the burden.

Against series confined to elective intracranial work the present rate is high. Reported incidence for intracranial procedures overall lies between 1.2% and 5.5% [2], and large elective series report figures at the lower end [7,8]. The discrepancy is explained by case mix rather than by practice: roughly a quarter of the present caseload was neurotrauma and a further substantial share was emergency decompression for spontaneous haemorrhage or malignant infarction. These are precisely the operations excluded from most elective cohorts [8], and they are the least amenable to the measures that drive elective rates down, since the patient cannot be optimised, the skin cannot be prepared in advance and the timing cannot be chosen.

Set against Indian data the present figure compares favourably. A recent prospective series from a central Indian tertiary centre reported an early SSI prevalence of 15.5% across elective neurosurgery and laparotomy combined [6], and Indian general surgical series commonly report 16–17% [9]. Neurosurgical wounds are predominantly clean, which accounts for much of this gap, but the comparison situates the unit within its own health system rather than against Western benchmarks alone.

Table 3. Present study in the context of published neurosurgical SSI rates.

Study / population	Design	Rate	Comment
Present study, all neurosurgery	Prospective, 340 procedures	5.9%	Mixed emergency and elective; 30/90-day
Lee et al. 2024 [1], craniotomy for tumour	Meta-analysis, 91,907 patients	4.0% / 6.2%	30-day / 90-day pooled
Colombo et al. 2025 [2], intracranial overall	Cohort, literature range	1.2–5.5%	Predominantly elective
Zhou et al. 2020 [3], spine surgery	Meta-analysis	4.4% / 1.4%	Instrumented / non-instrumented
Różańska et al. 2019 [10], ventricular shunt	Surveillance cohort	5.1%	Craniotomy 1.9%, fusion 2.2%
Kim et al. 2015 [11], cranioplasty after DC	Cohort, 78 patients	9.0%	All SSI cases had TBI aetiology
Lee et al. 2012 [4], paediatric VP shunt	Cohort, 333 shunts	10.5%	51% within 1 month of insertion
Central India 2025 [6], elective neurosurgery + laparotomy	Prospective, 721 patients	15.5%	Combined specialty denominator

4.2 The temporal pattern

The 40% reduction between the two halves of the study is the most substantive finding, and two features argue that it is more than noise: it occurred while volume rose by 38%, and the case mix did not shift towards easier work. The most likely explanation is a surveillance effect. The highest single monthly rate was in the first month of measurement, and the phenomenon by which auditing infection reduces it — through closer attention to prophylaxis timing, theatre discipline and drain management — is well described [10,12]. If any specific measure was introduced during the period it should be dated here, as this would materially strengthen the interpretation.

Against this stands the December-to-February peak of 9.9%, which interrupts what would otherwise be a clean decline. Three months carrying a third of the study's infections on a fifth of its workload is a cluster in its own right, and the overall trend should not be reported without it. Seasonal factors, altered staffing over the year-end period, a run of unusually complex emergency work, and chance are all plausible; only a second winter of surveillance will separate them.

4.3 Variation between divisions

The provisional ordering — neurotrauma highest, non-neurotrauma cranial lowest — is mechanistically plausible and consistent with published work. Traumatic scalp wounds may be contaminated at presentation, decompressive craniectomy creates a large subgaleal dead space beneath a long incision, and the patient is often catabolic and hyperglycaemic from polytrauma; decompressive craniectomy has been shown to raise wound infection risk fivefold in a cranial cohort [13]. Many of these patients later return for cranioplasty, itself carrying a reported infection rate of 9–11% [11,14], with traumatic brain injury repeatedly identified as the highest-risk aetiology [11].

CSF diversion ranked second. Shunt infection is a distinct entity driven by implanted hardware, a long subcutaneous tunnel and multiple incisions, with revision procedures carrying substantially higher risk than primary implantation [5]; published rates cluster around 5% in adult surveillance data [10] and reach 10.5% in paediatric series [4]. With only 34 procedures here the confidence interval spans 1.6% to 19.1% and no firm conclusion is possible.

The spinal figure of 4.4% masks an internal gradient. The spinal caseload ranged from epidural injection and vertebroplasty to multi-level instrumented fusion, and the pooled literature separates these clearly at 4.4% for instrumented against 1.4% for non-instrumented surgery [3]. Disaggregating the spinal division by instrumentation status is the single most informative refinement available, and requires no new data collection.

No between-division comparison approached significance, reflecting sample size rather than equivalence: demonstrating a doubling of risk in neurotrauma would require roughly 900 procedures.

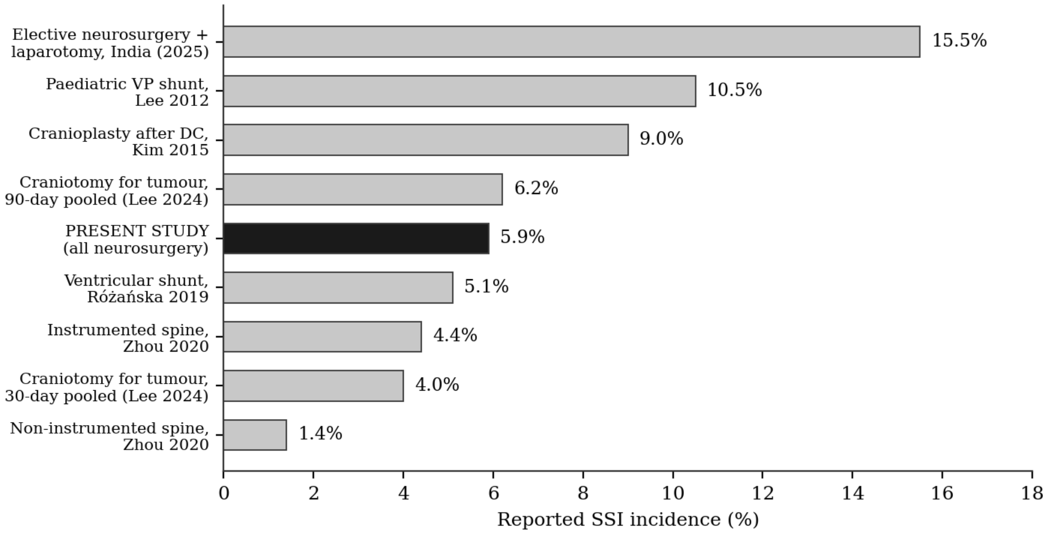
4.4 LIMITATIONS

- Twenty events across four divisions leaves all subgroup comparisons underpowered; absence of significance is not equivalence.
- Post-discharge infections managed elsewhere or with oral antibiotics alone will have been missed, biasing the reported rate downwards.
- Follow-up was not formally standardised to 30 and 90 days, so late implant-associated infection is incompletely ascertained.
- The denominator includes minor repeat entries such as drain removal and dressing, which are not procedures at risk and dilute the incidence estimate.
- Field division was assigned from free-text register fields and is subject to misclassification; division-wise attribution of infections is provisional.
- Age, sex, comorbidity, wound class, operative duration and microbiology were unavailable, so no risk-factor modelling or confounding adjustment was possible.

5. CONCLUSION

Surgical site infection complicated 5.9% of neurosurgical procedures over fourteen months, a figure consistent with pooled international data for mixed caseloads carrying a substantial emergency component. Incidence fell by 40% between the two halves of the period despite a 38% rise in volume, but the decline was interrupted by a winter cluster accounting for a third of all infections. Standardised follow-up, disaggregation of spinal work by instrumentation status and systematic capture of patient-level risk variables would move the unit from descriptive audit to risk-adjusted benchmarking.

Figure 4. Present study against published neurosurgical SSI rates



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Appendix. Tables awaiting patient-level data

The following analyses require the departmental SSI line-list, which was not available for this draft. Send, for each of the twenty infected patients: post-operative day of onset; field division of the index operation; age and sex; SSI class (superficial, deep, organ/space); whether an implant was in situ; organism and sensitivity; and management. For the denominator, age and sex for all 327 patients, emergency versus elective status, and — most valuable of all — whether each spinal case was instrumented.

Appendix Table A. Interval from operation to diagnosis of SSI.

Post-operative day	**SSI (n)**	**% of SSI**	**Cumulative %**	**Predominant division**
0–3				
4–7				
8–14				
15–21				
22–30				
31–60 (implant)				
61–90 (implant)				
Total	20	100.0		

Report as median (IQR) days overall and by division; compare by Kruskal–Wallis. Published shunt data give a median of about one month, with half of infections within 30 days [4] — a useful external comparator.

Appendix Table B. SSI by age group and sex.

Age group (years)	**Cases**	**SSI**	**Rate %**	**Male SSI**	**Female SSI**
< 18					
18–39					
40–49					

Age group (years)	Cases	SSI	Rate %	Male SSI	Female SSI
50–59					
60–69					
≥ 70					
Total	340	20	5.9		

Also report mean/median age of infected versus non-infected patients (Mann–Whitney U) and chi-square for trend across decades. Note that pooled craniotomy data find infected patients slightly younger, not older [1].

Appendix Table C. Microbiological profile.

Organism	n	% of isolates	Resistance of note
Staphylococcus aureus (MSSA)			
Staphylococcus aureus (MRSA)			
Coagulase-negative staphylococci			
Klebsiella pneumoniae			
Escherichia coli			
Acinetobacter baumannii			
Pseudomonas aeruginosa			
Polymicrobial			
No growth			
Total		100.0	