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Original Research Paper

Surgical Site Infection Rates: A Retrospective Study on the Effectiveness of Prophylactic Antibiotic Protocols

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ABSTRACT:
Background: Surgical Site Infections (SSIs) are a prevalent complication following surgical procedures, impacting patient recovery and healthcare resources. Effective prophylactic antibiotic use is critical in reducing the incidence of SSIs and improving surgical outcomes. **Objective**: To determine the role of different antibiotic prophylaxis in preventing surgical site infections. **Study Design**: Observational Study Design **Results**: The analysis of prophylactic antibiotic use in preventing Surgical Site Infections (SSIs) indicates a high adherence to appropriate indications (87%) and duration (91%) of antibiotic administration. However, timing compliance is lower (72% appropriate). Ceftriaxone is the most used antibiotic, followed by Metronidazole and their combination. Ampicillin use is associated with the highest number of SSIs, suggesting it may be less effective in SSI prevention compared to other antibiotics in the study's context. **Conclusion**: The study concludes that while adherence to antibiotic indication and duration is commendable, improving the timing of administration is crucial. The choice of antibiotic significantly impacts SSI outcomes, with ceftriaxone being preferred and ampicillin linked to higher SSI rates, underscoring the need for judicious antibiotic selection.

Keywords: Surgical Site Infections, Prophylactic Antibiotics, SSI Prevention, Antibiotic Stewardship, Postoperative Care

INTRODUCTION:

Surgical site infections (SSIs) are defined as infections that occur at or in proximity to the site of a surgical incision within 30 days of the operation, or within one year if an implant is left in situ [1]. The Centers for Disease Control and Prevention (CDC) have identified that these infections are alarmingly frequent, with an estimated 500,000 cases occurring every year across the United States. Dominating post-operative nosocomial infections, SSIs account for about 40% of infections acquired in hospitals by surgical patients [2]. The financial burden is significant, with the cost of treating an SSI patient being nearly triple that of a surgical patient without an infection in the initial eight weeks following discharge. The impact on patient well-being is profound, as evidenced by an increase in hospital readmission rates—patients with SSIs are five times more likely to be readmitted [3]. Moreover, there is a 60% increase in the likelihood of these patients requiring intensive care unit services, and a twofold increase in the mortality rate compared to their counterparts without infections [1-3].

Surgical Site Infections (SSIs) persist as a significant concern within the realm of postoperative care, posing challenges to patient safety, recovery outcomes, and healthcare systems globally. Despite advancements in aseptic surgical techniques and the implementation of rigorous infection prevention protocols, SSIs remain a common complication, affecting a substantial percentage of patients undergoing surgical procedures. The Centers for Disease Control and Prevention (CDC) categorizes SSIs into superficial incisional, deep incisional, and organ/space infections, each with distinct clinical features and management strategies [4, 5].

The prevalence and impact of SSIs are well-documented in the literature, with studies reporting variations based on surgical type, patient demographics, and healthcare settings. Certainly, SSIs contribute to increased hospital stay lengths, additional surgical interventions, and escalated healthcare costs. Moreover, SSIs are associated with increased morbidity and mortality rates, underlining the critical need for effective prevention and management approaches [4-8].

Risk factors for SSIs are multifaceted, encompassing patient-related factors (e.g., age, comorbidities, nutritional status), procedural factors (e.g., surgery duration, type of surgical procedure), and environmental factors within the operating room. Prophylactic antibiotic administration, as recommended by guidelines from the American College of Surgeons and Surgical Infection Society, plays a pivotal role in SSI prevention. However, the optimal selection, timing, and duration of antibiotic prophylaxis remain subjects of ongoing research and debate [7, 8].

Emerging antibiotic resistance poses a significant challenge to SSI prevention, necessitating judicious use of antibiotics and the adoption of antimicrobial stewardship programs. The development of multidrug-resistant organisms complicates the choice of prophylactic antibiotics and underscores the importance of tailored antibiotic strategies based on local microbiology patterns and resistance profiles [8-10].

In developing countries, the battle against SSIs is exacerbated by resource limitations, higher baseline rates of infectious diseases, and gaps in adherence to infection prevention protocols. However, there is need for context-specific strategies that address the unique challenges of these settings, including infrastructure improvements, education, and training in infection control practices [11].

The introduction of novel technologies and predictive analytics offers promising avenues for enhancing SSI prevention [12]. Innovations in surgical equipment, wound care products, and diagnostic tools are being explored for their potential to reduce SSI rates.

In conclusion, SSIs represent a complex interplay of microbial, patient, procedural, and environmental factors, demanding a comprehensive and multidisciplinary approach to prevention and management. Continued research, innovation, and adherence to evidence-based practices are paramount to reducing the burden of SSIs and enhancing patient care outcomes in the surgical setting.

MATERIALS AND METHODS:

To investigate the effectiveness of prophylactic antibiotic protocols in preventing Surgical Site Infections (SSIs), we designed an observational study focused on adult patients undergoing clean or clean-contaminated surgical procedures. This methodology outlines our comprehensive approach to data collection, analysis, and ethical considerations.

The study span is of one-year starting from January 1, 2020, to December 31, 2020. Our target population includes adults aged 18 and above who have undergone specified surgical procedures. We included patients who received prophylactic antibiotics in alignment with the Surgical Care Improvement Project (SCIP) guidelines and compared their outcomes with those who did not, following our predefined inclusion and exclusion criteria. Specifically, we excluded pediatric patients, individuals with pre-existing infections at the surgical site, cases with incomplete medical documentation, and patients undergoing emergency surgeries to ensure a homogenous study group.

Data extraction from medical charts involved collecting information on patient demographics (such as age, gender, and existing comorbidities), details of the surgical procedure (including type, duration, and cleanliness classification), antibiotic administration specifics (type, timing relative to incision, and dosage) and post operative outcome. SSIs were identified based on the CDC's criteria within 30 days after the operation.

This was a usual practice to give prophylactic antibiotics to every patient undergoing surgery. While conducting this observational study, we didn't make any changes with the usual practice. For our statistical analysis, we first employed descriptive statistics to summarize the collected data. All patients were given prophylactic antibiotics. The patients were segregated into groups based on the type of prophylactic antibiotic given and prognosis in terms of development of SSI.

Prior to conducting this study, we sought and obtained approval from the institutional review boards (IRBs) of all participating hospitals, ensuring our research adhered to ethical standards. Given the study's observational and retrospective nature, patient consent was deemed unnecessary; however, we rigorously maintained patient confidentiality throughout the research process.

Acknowledging potential limitations is crucial, including the retrospective design's reliance on accurate documentation and the challenge of controlling for all possible confounding factors. Despite these challenges, our methodology is designed to yield significant insights into the role of prophylactic antibiotic protocols in SSI prevention, aiming to enhance patient care quality and safety in surgical practices.

Inclusion Criteria:

1. **Patient Demographics**: Adults aged 18 years and older undergoing surgical procedures.
2. **Type of Surgery**: Patients undergoing clean or clean-contaminated surgical procedures as defined by the CDC.
3. **Use of Prophylactic Antibiotics**: Patients who have been administered prophylactic antibiotics according to the SCIP guidelines.
4. **Hospital Stay**: Patients who had a hospital stay allowing for the monitoring of SSIs as defined (within 30 days post-operation or within one year for procedures involving implants).
5. **Record Availability**: Patients with complete medical records detailing pre-operative, intra-operative, and post-operative care, including antibiotic administration times, types, and doses.

Exclusion Criteria:

1. **Age Below 18**: Pediatric patients, given different considerations for antibiotic prophylaxis and SSI risk in children.
2. **Non-Adherence to SCIP Guidelines**: Patients for whom prophylactic antibiotic protocols were not followed according to SCIP guidelines unless the study specifically aims to compare adherence vs. non-adherence outcomes.
3. **Pre-existing Infections**: Patients with existing infections at the surgical site before the operation.
4. **Incomplete Documentation**: Surgical cases lacking comprehensive documentation on prophylactic antibiotic administration (timing, dosage, type) or missing follow-up data on SSI occurrence.
5. **Emergency Surgeries**: Depending on the study's focus, emergency surgeries might be excluded due to the differing protocols for prophylactic antibiotic use and higher inherent SSI risk.
6. **Surgeries Involving Multiple Procedures**: Surgeries involving multiple procedures across different cleanliness categories (clean, clean-contaminated, contaminated, and dirty) might be excluded to maintain homogeneity in the study population.

RESULTS:

The study was conducted on 100 patients considering the including and excluding criteria. Most of the patients were male showing male preponderance by n=64, with male to female ratio of 1.7. The summarized data from the table 1 showcases an analysis focused on the prevalence of a specific condition across various age groups, with an additional lens on gender distribution and the statistical significance of gender disparities within each age category. Notably, the age groups of 25-35 years and 55-75 years emerge as the most affected, constituting 28.0% and 31.0% of the cases, respectively, highlighting a significant burden of the condition among these demographics. Conversely, the age group of 35-55 years exhibits the lowest frequency, accounting for just 11.0% of the cases, indicating a lower prevalence of the condition within this demographic.

A deeper dive into gender distribution reveals a consistent pattern across all age groups, with males showing a higher frequency of the condition compared to females. This trend is particularly marked in the 25-35 years age group, where males outnumber females by nearly a 2:1 ratio. However, the smallest gender disparity is observed in the youngest age group (18-25 years), suggesting a more balanced prevalence of the condition among younger individuals.

The statistical analysis, as indicated by the p-values, sheds light on the significance of the observed gender differences. The age group of 55-75 years shows the most pronounced gender disparity (p=0.005), suggesting a statistically significant association between gender and the prevalence of the condition in this demographic. On the other hand, the 18-25 years age group displays no significant gender difference (p=0.5), implying that gender does not play a significant role in the prevalence of the condition among younger individuals.

In summary, the analysis underscores a variable prevalence of the condition across age groups, with a notable increase in middle-aged to elderly populations. Additionally, the data suggest a generally higher prevalence in males across all age groups, with significant gender differences in certain demographics. This information could be pivotal for healthcare providers and researchers in tailoring interventions and further investigating the underlying causes of the condition's distribution.

Age	Frequency	Percentage	Gender		p-Value
			Male	Female	
18-25years	13	13.0%	9	4	0.5
25-35 years	28	28.0%	18	10	0.01
35-55 years	11	11.0%	8	3	0.02
55-75 years	31	31.0%	17	14	0.005
>75 years	17	17.0%	12	5	0.04

Table 1. Demographic data of 100 selected patients

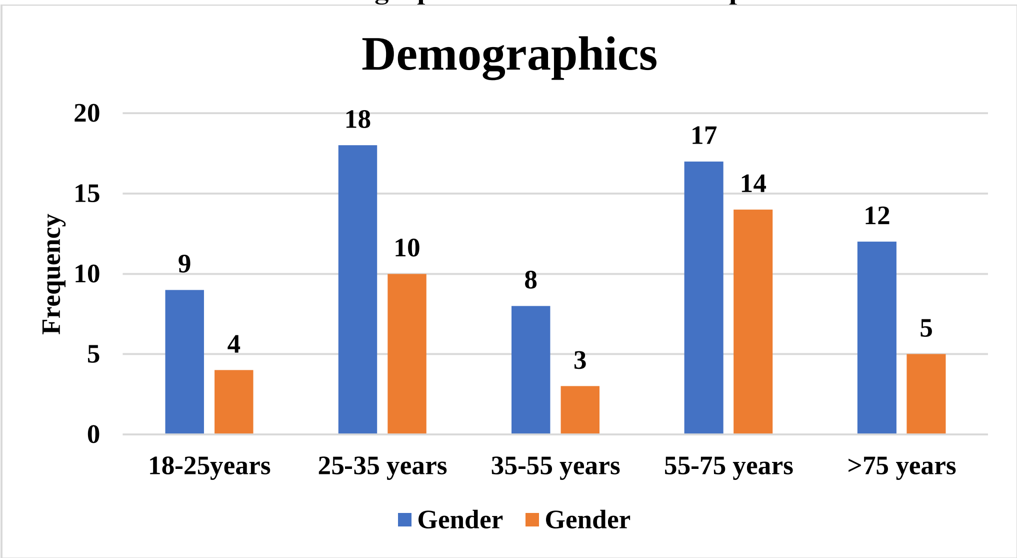

Figure 1. Gender based stratification in different age groups.

Most surgeries were elective, with 83 cases accounting for 8.4% of the total, whereas emergency surgeries comprised only 1.7% with 17 cases. Regarding the type of surgery, 'clean' surgeries were predominant, representing 8.8% of surgeries with 87 cases. 'Clean-contaminated' surgeries were less common, constituting only 1.3% with 13 cases. Overall, elective and clean surgeries were more frequently performed compared to emergency and clean-contaminated surgeries.

Source of Admission	Frequency	Percentage
Emergency	17	1.7%
Elective	83	8.4%
Type of Surgery	**Frequency**	**Percentage**
Clean	87	8.8%
Clean-contaminated	13	1.3%

Table 2. Clinical data of 100 patients included in the study.

For the indication of antibiotics, 87% were deemed appropriate, while 13% were not. This suggests a high level of accuracy in choosing when to administer antibiotics. Regarding the duration of antibiotic use, 91% of cases complied with recommended guidelines, and only 9% fell outside these recommendations, indicating strong adherence to established durations for antibiotic therapy. The timing of antibiotic administration showed a lower compliance rate, with 72% being appropriate and 28% not aligning with the recommended timing protocols. Overall, the cumulative data reflects that 83.3% of antibiotic prescriptions were appropriate across the measured categories, while 16.7% were not. This overall rate points to a generally high level of adherence to antibiotic usage guidelines, though there is room for improvement, particularly in the timing of administration. Figure 2.

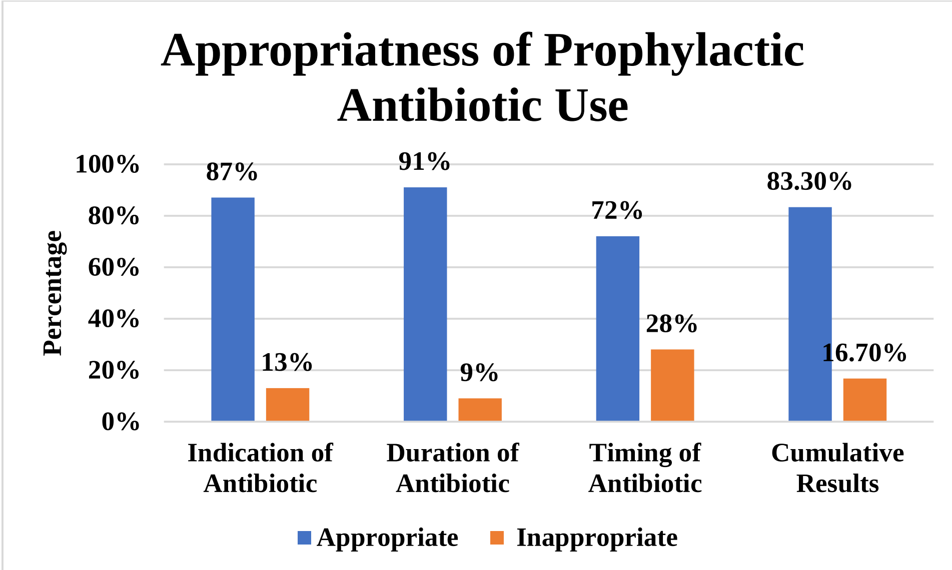

Figure 2. Appropriateness of Prophylactic Antibiotic Use

The pie chart Fig.3 presents the distribution of antibiotics used for prophylaxis. Ceftriaxone is the most used antibiotic, accounting for 71.5% of the cases. Metronidazole alone is used less frequently, making up 17.3% of usage. The combination of Ceftriaxone and Metronidazole represents 9.7% of the prophylactic antibiotic use. Ampicillin is the least used, constituting only 1.5% of the total. This data indicates a strong preference for Ceftriaxone as a prophylactic antibiotic in clinical settings.

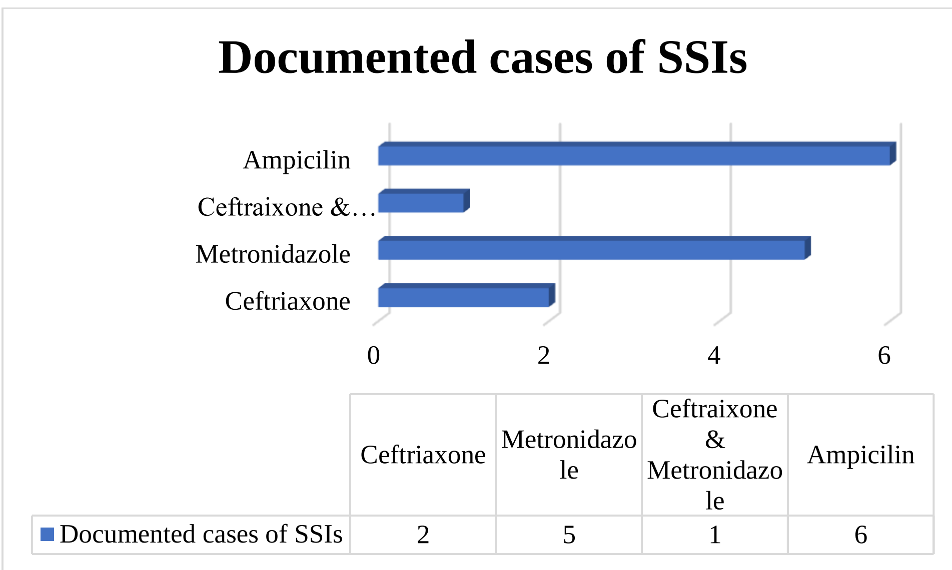

Figure 3. Documented cases of SSIs in each group of prophylactic antibiotics.

Out of 100 there were 14 cases of SSIs of various degrees. Nine were mild, 3 were moderate and 2 were severe.
Figure 3, bar chart representing the number of documented cases of Surgical Site Infections (SSIs) associated with the use of different antibiotics for prophylaxis. From this figure we can conclude that;

- Ampicillin is associated with the highest number of SSIs, with a total of 6 documented cases.
- Metronidazole is linked to 5 documented cases of SSIs.
- Ceftriaxone is associated with 2 documented cases.

- The combination of Ceftriaxone and Metronidazole shows the lowest number of SSIs, with only 1 documented case.

This data suggested that Ampicillin was less effective in preventing SSIs compared to the other antibiotics or combinations. Meanwhile, the combination of Ceftriaxone and Metronidazole indicated a more effective prophylactic regimen, as evidenced by the lower number of SSIs. However, it is important to note that these conclusions can only be tentative without further context on the dosages, timing of administration, types of surgical procedures, and patient risk factors. For a comprehensive analysis, these additional variables should be considered alongside the antibiotic choice to understand the full scope of factors contributing to the incidence of SSIs.

DISCUSSION:

In 2002, the Centers for Medicare and Medicaid Services (CMS), in partnership with the CDC, launched the Surgical Infection Prevention Project, aimed at establishing evidence-supported guidelines for the judicious use of prophylactic antibiotics in patients undergoing surgeries deemed clean-contaminated [13, 14]. The following year, this initiative was expanded into the Surgical Care Improvement Project (SCIP) through collaboration with CMS, CDC, and ten other national entities, integrating the initial project's measures into SCIP, thereby promoting widespread adoption [15].

SCIP's publicly reported performance metrics are designed to curtail the occurrence of postoperative surgical site infections. The primary infection control measures encompass the following recommendations:

- Prophylactic antibiotics should be administered within one hour prior to making the surgical incision, extending to two hours for those receiving vancomycin or fluoroquinolones.
- The selection of prophylactic antibiotics must be tailored to the surgery being performed.
- The cessation of prophylactic antibiotics should occur within 24 hours after surgery ends, extended to 48 hours post-cardiothoracic surgery.
- The regulation of blood glucose levels to below 200 mg per dL (11.10 mmol per L) the morning following cardiac surgery.
- The method of hair removal at the surgical site should be chosen based on its appropriateness for the procedure and site (e.g., using clippers or depilatory methods, or opting not to remove hair).
- Ensuring patients who have undergone colorectal surgery maintain a body temperature of at least 96.8°F (36°C) within the first 15 minutes after exiting the operating room [16-18].

Through the establishment of these guidelines, SCIP aims to foster a standardized approach to reducing SSIs by emphasizing the critical timing for antibiotic administration, ensuring the appropriateness of antibiotic choice, and underscoring the importance of specific postoperative care practices [19]

The aim of administering prophylactic antibiotics is to achieve and maintain adequate antibiotic levels in serum and tissues throughout the duration of a surgical operation. An examination of data from 2,847 individuals undergoing either clean or clean-contaminated surgical operations indicated that those who were given antibiotic prophylaxis within two hours prior to making the surgical incision experienced a notably low surgical site infection (SSI) rate of 0.6% [20-22]. In stark contrast, those who were given prophylactic antibiotics over three hours after the incision saw a doubling in the rate of SSIs. Moreover, administering antibiotics over two hours before the incision was associated with an approximately sixfold increase in SSI risk [23].

Further evidence from a study on total hip replacements demonstrated the minimal risk of SSIs when the chosen antibiotic was given within one hour prior to the incision. This finding is supported by a recent study across 29 hospitals in the U.S., which found that administering antibiotics within 30 minutes prior to the incision could potentially lower SSI risks even further. Additionally, a meta-analysis of randomized controlled trials highlighted that administering antibiotic at or just before the onset of anesthesia significantly reduced infection rates in spinal surgery patients [24].

Regarding the necessity for repeated antibiotic infusion, consensus and research predominantly advocate for a single dose administered within one hour before the incision. Nonetheless, for surgeries extending beyond four hours or involving significant blood loss (exceeding 1,500 mL), an additional dose may be warranted. This approach is validated by a study on cardiac surgery patients, where those undergoing procedures longer than four hours saw a reduction in SSI rates from 16% to 7.7% with additional dosing of cefazolin. Similarly, a study on colorectal surgery patients linked low gentamicin levels at the time of wound closure with a heightened SSI risk [25, 26].

Antibiotic prophylaxis should be tailored to the specific surgery, aligning with SCIP guidelines and targeting the most likely pathogens without necessarily covering all potential microbes. The choice of antibiotic should be informed by local resistance patterns, with prophylaxis recommended for all clean-contaminated procedures and select clean procedures where an SSI would be particularly detrimental (e.g., prosthetic joint implantation). While patients undergoing contaminated or dirty procedures often receive targeted antibiotic therapy for existing infections, cephalosporins are generally preferred for their efficacy against common skin pathogens like Staphylococcus aureus and Streptococcal species. In some cases, particularly for certain gynecologic or gastrointestinal surgeries, combinations of antibiotics may be recommended [27].

The observed high adherence to appropriate indications (87%) and durations (91%) for prophylactic antibiotic use reflects a commendable compliance with current clinical guidelines. This compliance is crucial for preventing surgical site infections (SSIs) and minimizing the risk of antibiotic resistance. However, the lower compliance in the timing of antibiotic administration (72% appropriate) suggests an area for improvement. Timely administration is critical to ensure optimal antibiotic tissue levels during surgery, and delays or premature administration could compromise the efficacy of prophylaxis [28-30].

The predominance of ceftriaxone in prophylactic use (71.5%) aligns with its broad-spectrum activity and favorable pharmacokinetic profile, making it a popular choice for preventing a wide range of infections in surgical patients. The utilization of metronidazole (17.3%) reflects its use in surgeries where anaerobic bacterial coverage is desired, particularly in gastrointestinal or gynecological procedures.

The combined use of ceftriaxone and metronidazole (9.7%) likely represents cases where both aerobic and anaerobic coverage is essential, such as in colorectal surgeries. However, the relatively low use of ampicillin (1.5%) may point to its narrower spectrum of activity and the availability of alternatives with better efficacy or resistance profiles.

The cumulative results showing an 83.3% overall appropriateness rate for antibiotic prophylaxis are encouraging. Still, the 16.7% rate of non-appropriateness, particularly in the timing of administration, highlights the need for continued education and quality improvement initiatives. Enhancing adherence to prophylactic antibiotic timing could further reduce the incidence of SSIs.

Furthermore, the varied antibiotic usage suggests a tailored approach to prophylaxis, which is a positive indication of personalized healthcare. However, it also emphasizes the need for ongoing surveillance of antibiotic effectiveness and resistance patterns.

In conclusion, while the results demonstrate a strong adherence to guidelines in most aspects of antibiotic prophylaxis, focused efforts on improving the timing of administration could enhance the efficacy of SSI prevention. Future research should aim to identify barriers to timely administration and develop strategies to overcome these challenges. Additionally, monitoring trends in antibiotic efficacy and resistance will remain imperative to inform prophylactic antibiotic choice.

Conflict of Interest: None

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