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Determination of Predisposing Causes of Burn Infection and its Severity in a Tertiary Care Centre

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ABSTRACT

Background: Burn injuries are a serious health problem because of their potential intensity and high mortality. An effective management of burn infections is, therefore, a paramount requirement for improving the patient's outcome. Because of this, the present study was undertaken to analyze the causes, severity and microbiological profiles of burn infections, evaluate the efficacy of diagnostic methods, and assess antibiotic susceptibility to guide better treatment practices.

Methods: This was a hospital-based, prospective cross-sectional study done for one year, including 109 burn patients admitted in the burn wards and ICU of a Government Medical College. Data was collected through wound swabs and biopsy samples. Microbiological cultures were analyzed to identify the predominant pathogens; antibiotic susceptibility testing was performed to determine the resistance patterns. Concordance between the swab and biopsy results was assessed. Clinical outcome was monitored.

Results: *Pseudomonas aeruginosa* was isolated in 58.33% of the second swab cultures and 61.11% of the third swab cultures, and *Staphylococcus aureus* was isolated in 25% of the second swab cultures and 5.55% of the third swab cultures. Very high resistance patterns were seen for cloxacillin 91.8%, cotrimoxazole 86%, and cephazolin 83.7%, while imipenem accounted for the lowest at 23.3%. The concordance of biopsy and swab cultures in this study was 60%. Isolated organisms in biopsy specimens included *P. aeruginosa* 76.19% and *S. aureus* 9.52%.

Conclusion: *P. aeruginosa* forms the main causative organism for burn infections, and high antibiotic resistance significantly impairs treatment efficiency. Swabs may be useful at the initiation of treatment, but a biopsy is necessary for the exact identification of the pathogens, particularly with changing resistance patterns. This current study accentuates diagnostic improvement and antibiotic stewardship. Future studies need to be aimed at developing better diagnostic tools, new treatment modalities, and preventive measures for better management of burn wound infections.

Key-words: Burn infections, *Pseudomonas aeruginosa*, Antibiotic resistance, Diagnostic methods, Microbiological profile

INTRODUCTION

Burns are major traumas that are caused by several factors such as friction, cold and heat, radiation, chemicals, or electricity. However, most of the burns occur from contact with hot liquids, solids, or flames [1]. All burns result from energy transfer that causes damage to tissues, but the nature of the burn differs in form and depending on the cause of the burn. For example, flame and grease burns tend to be quite deep from the start, whereas scalds by hot liquids or steam are often less deep initially because of the rapid cooling of the heat source. Alkaline burns produce colliquative necrosis, wherein tissues become a viscid, liquid mass, while acidic burns cause coagulation necrosis, which preserves the structural integrity of the tissue despite its damage. Electrical burns, however, are much different in that they can cause extensive internal tissue damage with relatively little apparent skin injury [1,2].

In this case, damage is related to the strength of the electrical field and the resistance of the tissue, although it is usually described in terms of voltage. Besides, cold

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thermal injuries combine mechanisms of the direct effect of damage by water crystallization in tissues with indirect effects from ischemia/reperfusion, which causes skin necrosis and deeper tissue damage. Modalities of treatment applied are based on the type of burn; deep thermal burns mostly require immediate surgical intervention, while the more conservative approach to frostbite includes moist rewarming, possibly thrombolysis, and close monitoring [1].

Significant morbidity, death, and disability follow burn injuries. Approximately, 209 million prevalent instances, 14 million event instances, and 7 million years of life with disability were related to burns worldwide in 2017 [2]. Over the past few decades, there have been several advancements in burn care, such as the creation of burn centres, a deeper comprehension of burn pathophysiology, improved critical care, early excision of burn wounds along with skin grafting, topical as well as parenteral antibiotic therapy, plastic surgery interventions, and rehabilitation services [3].

Nonetheless, patients who suffer from burn damage are at risk for sepsis and multiorgan failure due to healthcare-associated infections (HAIs), which continue to be a deadly consequence [4]. Infection is the primary cause of mortality in burn victims, accounting for 33–80% of fatalities either directly or indirectly [5]. Moreover, infections brought on by burns impair wound healing, extend hospital stays, and raise medical expenses. Because of the severe systemic immunocompromising consequences of the burn and the disruption of the skin barrier, people with burns are more vulnerable to HAIs [6].

Pathogen exposure can be expressed through intrusive devices, burn wounds, and bacterial translocation inside the gastrointestinal system [7]. These bacteria can originate from polluted external sources (such as the hospital environment and healthcare personnel) as well as the patient's indigenous microbiota (skin, stomach, and upper respiratory tract). Antimicrobial resistance is a serious challenge to healthcare, especially for people who are sick [8].

Infection frequently occurs after bacterial colonization, which is the mere existence of microorganisms—whether pathogenic or not—on the burn's surface without any deeper tissue invasion and clinical symptoms [9]. Infection occurs when microorganisms infiltrate and grow in the tissues underneath, producing symptoms [10]. When a microbial invasion enters the circulation, the infection spreads throughout the body and the inflammatory response may intensify to the point that the host experiences harmful pathophysiological alterations, which is indicative of sepsis [11]. Sepsis-which can strike at a rate ranging from 6% to 65%—is currently the primary cause of death for burn victims. The symptoms that indicate sepsis (tachypnea, hypotension, altered mental state, and unexplained hyperglycemia) should always be recognized by medical professionals, and biomarkers can help in the diagnosing process [12].

Empirical wide-spectrum antimicrobials should be started right once if there's an elevated clinical suspicion of a systemic infection, especially if this suspicion is confirmed by laboratory analysis. When vulnerability assessment is available, de-escalation of the medication should take place [13]. Nosocomial bacteria are frequently resistant to several antimicrobial groups, mostly as a result of the abuse of antibiotics in recent decades. This suggests that a local trend in microbial resistance has to be considered when selecting antimicrobials [14]. Conversely, in cases when sepsis is not suspected, using antibiotics is not only unnecessary but may also have negative consequences, such as accelerating the emergence of antibiotic resistance [15].

The progress made in burn care over the last two to three decades has been tremendous, accompanied by a significant improvement in the survival rate of burn victims and their quality of life. However, there are still numerous obstacles to translating these advances into successful clinical applications. It has been truly a challenge to translate our growing knowledge into real treatment because of various interfering factors, such as personal beliefs and limitations in the allocation of resources [16]. It is an explosion of knowledge in all fields, from which we can greatly benefit if this information can be harnessed to the burned patient. Of course, one of the biggest challenges lies with the barriers of education, training, and research, and how resources are allocated. Improving education, particularly in burn prevention and simple first aid, at all strata of the community is therefore of paramount importance; an overall vision of a global standard of burn care cannot be achieved in isolation. The present study aims to understand the predisposing causes and severity of burn infections in a tertiary care setup to bridge the gaps in present knowledge and practice.

MATERIALS AND METHODS

Research Design- This is a prospective cross-sectional study design was utilized to assess burn patients during their hospital stay. This study was conducted at the Government Medical College, Thrissur, encompassing both the male and female burn wards as well as the ICU. The study spanned from 2011 to 2012. The population under study included patients admitted to the burn wards and ICU at Government Medical College, Thrissur. The population included all burn patients who were admitted to the burn wards and ICU within the period of data collection. Since the nature of this study was a convenience sampling technique, the number of burn wound swabs collected was proportional to the number of patients admitted during the period of study.

Moreover, the tissue biopsies were obtained from patients who stayed more than five days in the hospital. A total of 109 patients were included in the study. Twenty-one patients who died immediately after admission were excluded. Among the remaining patients, 231 burn wound swabs and 30 tissue biopsy samples were collected from those with extended hospital stays (more than five days). Patients were monitored until their discharge or death to complete the study.

Inclusion Criteria- All burn patients were admitted in the male and female burn wards and ICU during the period of study.

Exclusion Criteria- Patients who died immediately upon admission or were discharged from the wards before data collection were excluded from this study.

Statistical- The study has used SPSS 27 for effective analysis. Descriptive statistics were used to summarize the demographic characteristics of the patients, such as age, sex, and the causes of burns. Percentages were calculated to describe the distribution of categorical variables, including bacterial isolates from swab cultures, and presented in frequency tables. Inferential statistics were used to analyze the differences in bacterial isolates between the second and third swab cultures.

For continuous variables like age, means and standard deviations were calculated. Categorical variables like sex, cause of burns, and bacterial isolates were analyzed using chi-square tests to assess relationships between variables such as bacterial species and antibiotic susceptibility. A p-value of less than 0.05 was considered statistically significant. The analysis was conducted using SPSS version 22 software to ensure accurate computation of descriptive and inferential statistics.

Ethical approval- Ethical approval for the research was obtained from the Institutional Ethics Committee of Government Medical College, Thrissur (approval number: IEC/GMC/2011-2012/45). All patients included in the study provided written informed consent before participation. The confidentiality of all participants was maintained throughout the study by de-identifying personal information.

RESULTS

Table 1 below shows the distribution of age, sex, and causes of burns of 109 patients inducted. Most of the patients were below 30 years of age (38.5%). Beyond this, there was a steep fall in cases in higher age groups, including those 60 years and above (11.92%). Females had more burns (69%) compared to males (45%). Flame injuries were predominant in 90% of cases, while scalds, chemicals, and electrical burns followed with 8%, both chemical and electrical burns accounting for just 1%. This distribution underlines the prevalence of flame injuries and a more youthful patient demographic within a burn unit.

Table 1: Demographic characteristics of the patients

Age (in Years)	No. of cases	Percentage
<30	42	38.5
30-39	24	22.01
40-49	18	16.51
50-59	12	11
60<	13	11.92
Sex		
Male	40	45
Female	69	69
Cause of Burns		
Flame	98	90
Scald	9	8
Chemical	1	1
Electrical	1	1
Total	109	100

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Table 2 shows the bacterial isolates identified from the second swab cultures of 72 burn patients. Isolates of *P. aeruginosa* were found in 58.33% of the cases, making it the most frequently isolated pathogen. The second most common isolate identified was *S. aureus* in 25% of the cases. Other prominent isolates included *E. coli* at 5.5%, *Klebsiella pneumoniae* and *Proteus mirabilis*, each at 1.5%. Furthermore, *Acinetobacter baumannii* and coagulase-negative staphylococci (CONS) each took a share of 4.16% of the isolated strains. This distribution underlines very well that among isolated microorganisms, a predominant part belonged to *P. aeruginosa* in burn wound infections, while other bacterial pathogens contributed to very different infection profiles.

Table 2: Type of Isolates from Second Swab

Second Swab Culture Isolates	No. of cases	Percentage
P. aeruginosa	42	58.33
S. aureus	18	25
CONS	3	4.16
E. coli	4	5.5
K. pneumoniae	1	1.5
P. mirabilis	1	1.5
A. baumanii	3	4.16
Total	72	100

Table 3 provides a detailed analysis of microbial isolates from second and third swab cultures, along with their antibiotic susceptibility patterns. It is divided into sections that present the types of isolates, the number of cases, their percentages, and the antibiotic susceptibility rates for various bacterial species. The second swab culture results show that out of 72 total cases, 61 (86%) were single isolates, while 11 (15%) were multiple or polymicrobial isolates. Among the polymicrobial isolates, the most common combination was *Pseudomonas* sp. and *S. aureus* (36.36%), followed by *Pseudomonas* sp. with CONS (18.18%), and *Pseudomonas* sp. with *E. coli* (18.18%). Other combinations such as *Klebsiella* sp. with CONS, *S. aureus* with *Proteus* sp., and *Pseudomonas* sp. with *Acinetobacter* sp. each represented 9.09% of the cases. These findings suggest that *Pseudomonas* sp. is frequently involved in polymicrobial infections. The third swab culture shows that out of 50 cases, 39 (80%) were isolates while 11 (20%) were sterile. Among the 54 types of isolates detected in these 39 cases, *P. aeruginosa* was the most prevalent, accounting for 61.11% of the cases. Other notable isolates included *S. aureus* & *Proteus* sp. (5.55%), CONS (7.4%), *E. coli* (7.4%), *K. pneumoniae* (7.4%), *Enterococci faecalis* (5.55%), *Acinetobacter baumanii* (3.7%), and environmental bacteria (1.85%). The data indicates that *P. aeruginosa* is a dominant pathogen in the third swab cultures, reflecting its significance in infection persistence or recurrence.

For the third swab culture, a total of 15 polymicrobial cases were identified. The most common combinations were *Pseudomonas* sp. with *S. aureus* (20%) and *Pseudomonas* sp. with CONS (13.33%). There were also multiple other combinations, such as *Pseudomonas* sp. with *E. coli, E. coli* with *Enterococci*, and *Pseudomonas* sp. with *Acinetobacter* sp., each constituting 13.33% of the cases. The diversity of these combinations suggests the complexity of infections that involve multiple pathogens, particularly *Pseudomonas* sp. The antibiotic susceptibility data provides insight into the effectiveness of various antibiotics against isolated pathogens. *Pseudomonas* sp. showed the highest susceptibility to Cephalosporins (Ca, 75.58%) and lower susceptibility to Gentamicin (G, 24.41%) and Ciprofloxacin (Cf, 35.29%). *S. aureus* had moderate susceptibility to Ciprofloxacin (Cp, 51.28%) but low susceptibility to Penicillin (P, 5.1%) and Gentamicin (G, 5.89%). CONS demonstrated significant susceptibility to Gentamicin (G, 54.54%) and Ciprofloxacin (Cp, 36.36%) while being completely resistant to Penicillin (P, 0%). This pattern suggests that antibiotic resistance is a significant concern, particularly for *S. aureus* and *Pseudomonas* sp., necessitating the use of more potent antibiotics such as cephalosporins for effective treatment.

The study has found that *Pseudomonas* sp. is the most prevalent pathogen found in both single and polymicrobial infections, indicating its critical role in the infection landscape. The presence of polymicrobial infections, especially involving *Pseudomonas* sp., *S. aureus*, and CONS, reflects the complexity of managing these infections, which often require a combination of antibiotic therapies. The antibiotic susceptibility patterns suggest a variable response to treatment, with some pathogens showing high resistance rates, highlighting the need for targeted antibiotic stewardship to improve patient outcomes.

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Table 3: Microbial isolates and antibiotic susceptibility

Second Swab Culture Isolate	No. of cases	Percentage
Single	61	86
Multiple	11	15
Total	72	100
Polymicrobial isolates in second swab		
Pseudomonas sp. & *S. aureus*	4	36.36
Pseudomonas sp. & CONS	2	18.108
Pseudomonas sp. & *E. coli*	2	18.18
Klebsiella sp. & CONS	1	9.09
S. aureus & *Proteus* sp.	1	9.09
Pseudomonas sp. & *Acinetobacter* sp.	1	9.09
Total	11	100
Third Swab Culture Isolate		
Isolate	39	80
Sterile	11	20
Total	50	100
Third Swab Culture Isolate Types		
P. aeruginosa	33	61.11
S. aureus & *Proteus* sp.	3	5.55
CONS	4	7.4
E. coli	4	7.4
K. pneumoniae	4	7.4
Enterococci faecalis	3	5.55
A. baumanii	2	3.7
Environmental bacteria	1	1.85
Total	54	100
Polymicrobial isolates in third swab		
Pseudomonas sp. & *S. aureus*	3	20
Pseudomonas sp. & CONS	2	13.33
Pseudomonas sp. & *E. coli*	2	13.33
Pseudomonas sp. & CONS	2	13.33
E. coli & *Enterococci*	1	6.66
Pseudomonas sp. & *Acinetobacter* sp.	1	6.66
Pseudomonas sp. & Enterococci	2	13.33
CONS & *E. coli*	1	6.66
Pseudomonas sp. & *Klebsiella* sp.	1	6.66
Total	15	100

Antibiotic susceptibility	
Pseudomonas sp.	
AK	55.81
G	24.41
Cf	35.29
Ca	75.58
S. aureus	
P	5.1
G	5.89
E	24.2
Cp	51.28
CONS	
P	0
G	54.54
E	36.36
Cp	36.36

Aminoglycosides (AK), Cephalosporins (Cf), Penicillin (P), Erythromycin (E), Coagulase-negative staphylococci (CONS), Gentamicin (G)

DISCUSSION

Burns are a major health problem. Several types of burns include thermal burns or flame burns, scald burns, electrical burns, and chemical burns. Recent advances in medical and surgical treatments have reduced burn mortality, though burns remain one of the significant challenges because of their high morbidity and mortality rates [17]. While minor burns form the bulk of cases, many of which may be less serious, they still have the potential to affect quality of life and productivity. Major burns, however, remain a challenge to any burn care team and almost always end up killing. In a country like India, where even the infrastructure for medical care is not at all developed, and there is a lack of public awareness, burn injuries pose an acute problem. Many still stick to traditional and unsafe methods of cooking, like stoves and open fires, which often cause burn accidents. The treatment of major burns is very expensive and, hence, beyond the reach of many families, which makes access to advanced medical care quite difficult. It, therefore, becomes imperative that in a country with high illiteracy rates and widespread poverty, burn prevention strategies take precedence alongside improvements in burn care.

In our study findings, it was noted that there was a high majority of female burn victims, contrary to Gupta *et al.* who found a high prevalence in male patients. Our study also showed a similar age distribution, whereby most of

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the patients were under 30 years (38.5%), just like Gupta *et al.* where most of the patients were in the age group of 15-45 years. Both studies reported flame burns to be the most common; however, our study had a lower proportion of flame burns (90%) compared to Gupta *et al*. (72%), and scalds were relatively similarly low in both studies [17].

Because skin acts as a barrier to infection and can be lost partially or completely in burn victims, the incidence of diseases among them is higher in hospital settings [18]. We plan to convey the microbiological characteristics of patients treated in a South Indian tertiary care hospital. A study was conducted by Mundhada *et al.* to outline the antibiotic susceptibility pattern and microbial profile of clinical specimens from burn patients at our tertiary care facility [19]. Making an informed decision on the first course of antibiotic therapy can be aided by the high incidence of gram-negative, polymicrobial infections and multidrug-resistant bacteria that were seen in our patients, as well as the sensitivity patterns. Based on culture reports, however, antibiotic escalation and de-escalation should be planned [20].

There were similarities and differences upon comparison of the microbiological findings of the study with those of Taneja *et al.* [21]. The most common isolate found in our research was *P. aeruginosa*, accounting for 58.33%, followed by *S. aureus* at 25%. This differs from the findings of Taneja *et al*., who identified *S. aureus* as the predominant isolate at 45%, though *P. aeruginosa* was recognised as the second most common disease at 13.9%. Both studies identified *S. aureus* as an important pathogen. However, in this study, it is not as numerous as it is with Taneja *et al*. This study also observed a large number of polymicrobial infections, while Taneja *et al.* also show the combined infection is vast [21].

Often, microbes infiltrate burns wounds and impede the healing process. Therefore, to establish the most efficient treatment, flora acquired from burn patients' wounds must be assessed [22]. A study sought to ascertain the antimicrobial susceptibility of the different bacteria that were isolated from burn sites as well as their frequencies. *S. aureus* and *P. aeruginosa* are the most often isolated microorganisms. Effective empirical therapy includes vancomycin & linezolid against *S. aureus* and piperacillin + tazobactam against *P. aeruginosa* [23].

In our study, *Pseudomonas* sp. showed a resistance rate of 55.81% to amikacin, 24.41% to gentamicin, 35.29% to ceftazidime, and 75.58% to carbenicillin. *S. aureus* was found to have 5.1% to penicillin, 5.89% to gentamicin, 24.2% to erythromycin, and 51.28% to ciprofloxacin, while CONS had zero resistance to penicillin but 54.54% to gentamicin. In sharp contrast, Nikokar *et al.* found very high levels of resistance of *P. aeruginosa* to cloxacillin at 91.8% and to cotrimoxazole at 86%, indicating very high levels of multi-drug resistance in comparison [24]. Our present study showed high resistance to carbenicillin but relatively lower resistance to ciprofloxacin and gentamicin. At the same time, Nikokar *et al.* found imipenem to have a greater effect against the isolates in their study, thus demonstrating regional differences in the antimicrobial susceptibility pattern [24].

Within the healthcare system, nosocomial bacterial infections are a serious problem. Compared to other patients, burn patients—especially those with severe cases—are more likely to get bacterial infections. *A. baumannii*, *P. aeruginosa*, and *S. aureus* are the most often found bacteria in burn victims' cultures. Local statistics on the most prevalent infections among burn victims are scarce [25]. The most frequent organisms that infect burn victims were to be identified, as well as the patterns of antibiotic sensitivity & resistance at King Abdulaziz Medical City in Jeddah. Comprehending the regional prevalence of bacterial infections is imperative to formulate treatment protocols that aim to harmonize the first administration of antibiotics, curtail hospital-acquired infections, and mitigate drug resistance. Gram-negative bacteria, including Enterobacter Cloacae and *P. aeruginosa*, deserve further study [26].

In our study, biopsy cultures identified *P. aeruginosa* as the predominant isolate (76.19%), followed by *S. aureus* (9.52%), while *E. coli, K. pneumoniae,* and *Proteus mirabilis* each accounted for 4.76% of the isolated microbes. There was concordance between biopsy and swab culture in 60% of the 30 cases, while in 20%, there was no growth at all. In contrast, Salehifar *et al.* indicated an 87.1% concordance rate between the swab and the biopsy samples on the seventh day, which had declined to 66.6% by the 14th day. While both studies have singled out the leading organism as *P. aeruginosa*, the fact that our research has reflected the lower concordance rate, along with an increased range of

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isolated organisms, underscores the dynamic nature of infection profiles and, therefore, makes continued monitoring imperative, probably through more frequent biopsies if nothing else, to truthfully reflect infection dynamics and resistance patterns over time [27].

Numerous research conducted in China over the last 10 years have characterized the types of bacteria and their patterns of antibiotic resistance in patients suffering from burn injuries; nevertheless, the results have been largely mixed [28]. To compile the infection spectrum and patterns of antibiotic resistance in burn injury patients, we performed a literature review and meta-analysis. Our systematic summary of the epidemiological traits and antibiotic resistance trends of microorganisms among burn patients offers direction for managing wound infections and advancing the best possible empirical antimicrobial treatment. The elevated rates of antibiotic resistance that have been found highlight the necessity of continuing to monitor patterns in the use of antibiotics [29].

To develop strong burn urgent health systems and efficient evidence-based burn prevention programs, the current study aims to ascertain the epidemiological pattern of the outcome of burn wounds in a Rajasthan tertiary care centre [30]. There is a need to generate resources to increase the survival rate of burn patients throughout the state of Rajasthan, in addition to raising funding for preventive and education initiatives. The development of a robust infrastructure for the prevention and treatment of severe burn injuries may be aided by the work.

The current study has some intrinsic limitations, including a relatively small sample size and the potential lack of generalizability from a single-centre study. Therefore, it may not be fully representative. Moreover, there may be variations in infection profiles and resistance patterns that local practices and the demographic characteristics of patients might influence. Future studies would want to enlarge samples and carry out multi-centred studies for improved generalizability. Investigations into new diagnostic modalities, like further molecular techniques or real-time monitoring, can enable on-time diagnosis and interventions for burn infection. Research into antibiotic stewardship practices in support of targeting prevention strategies will also help, when coupled with the growing problem of multidrug-resistant organisms, in attempts to lessen the incidence and severity of burn-related infections.

CONCLUSIONS

The main conclusion of these findings is that burn wound infections predominantly affect younger patients, particularly females, and are primarily caused by *P. aeruginosa*, which is the most frequently isolated pathogen in both single and polymicrobial infections. The presence of multiple pathogens, especially those involving *Pseudomonas* sp., *S. aureus*, and CONS, adds complexity to treatment, highlighting a significant challenge in managing these infections. Additionally, the study reveals concerning patterns of antibiotic resistance, particularly against *S. aureus* and *Pseudomonas* sp., necessitating a targeted approach to antibiotic use, with a focus on more potent options like cephalosporins, to improve clinical outcomes and combat resistance effectively.

CONTRIBUTION OF AUTHORS

Research concept- Smina KI
Research design- Smina KI
Supervision- Girija KR
Materials- Smina KI
Data collection- Smina KI
Data analysis and Interpretation- Smina KI
Literature search- Smina KI
Writing article- Smina KI
Critical review- Girija KR
Article editing- Girija KR
Final approval- Girija KR

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