

# Outcome of delayed presentations of open traumatic hand infections: a prospective cohort study

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## ABSTRACT

**Objective:** To evaluate the outcomes of delayed presentation in patients with open hand infections managed at Civil Hospital Karachi (CHK), with a focus on hospital stay, surgical interventions, and operative duration, to inform clinical decision-making and policy planning.

**Methods:** A prospective observational study was conducted at the Plastic Surgery Department, CHK, Pakistan from January to June 2022. Ethical approval was obtained from the Institutional Review Board of Dow University of Health Sciences (IRB-2354/DUHS/Approval/2021/708). A total of 188 patients aged 18–65 years with clinically confirmed hand infections were enrolled. Patients were stratified into delayed (>24 hours) and non-delayed (≤24 hours) presentation groups. Exclusion criteria included burn injuries, postoperative infections, and chronic inflammatory disorders. Data were collected on demographics, clinical presentations, comorbidities, severity of infection, microbiology, surgical intervention, and outcomes. Statistical analysis was performed using SPSS version 24, with significance set at  $p \leq 0.05$ .


**Results:** Of 188 patients, 94 (50%) had delayed presentation. The mean age was  $39.56 \pm 12.05$  years; 88.8% were male. *Pseudomonas aeruginosa* (59%) and MRSA (35.6%) were the most common organisms. Mild, moderate, and severe infections were noted in 35.6%, 36.7%, and 27.7% of patients, respectively. Debridement was the most common surgery (76.6%). Delayed presentation was significantly associated with longer hospital stay ( $10.44 \pm 2.45$  vs.  $4.29 \pm 0.65$  hours), more frequent surgeries ( $2.32 \pm 0.49$  vs.  $1.01 \pm 0.01$ ), and longer operative time ( $1.57 \pm 0.56$  vs.  $0.47 \pm 0.09$  hours) ( $p < 0.001$  for all).

**Conclusion:** Delayed presentation in open hand infections is significantly associated with worse clinical outcomes. Early recognition and timely intervention are essential to reduce morbidity and healthcare burden.

**Keywords:** Infections (MeSH); Hand Infection (Non-MeSH); *Pseudomonas aeruginosa* (MeSH); Methicillin-Resistant *Staphylococcus aureus* (MeSH); Operative Time (MeSH); Length of Stay (MeSH); Debridement (MeSH); Prolonged Hospital Stay (Non-MeSH).

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window within which surgical intervention should ideally occur to minimize infection risk, remains a topic of debate.<sup>6</sup> Traditionally, this period is defined as the first six hours following injury, during which prompt irrigation, debridement, and application of sterile surgical technique can significantly reduce infection rates. Delays beyond this window have been associated with increased risk of infection and poorer outcomes.<sup>7</sup>

Dr. Ruth K. M. Pfau Civil Hospital Karachi (CHK) is one of Pakistan's largest tertiary referral hospitals, serving as a crucial center for complex trauma management, including a significant number of severe hand injuries. A substantial portion of these injuries involves open wounds susceptible to infection, particularly when definitive care is delayed. Despite this considerable clinical burden, there remains a considerable deficiency in local epidemiological and clinical outcome data regarding delayed management of hand infections in Pakistan. Current literature predominantly originates from high-income countries, which have distinct patient demographics, healthcare infrastructure, and resources. Consequently, evidence derived from these settings may not accurately reflect the situation or adequately inform treatment guidelines applicable to local contexts. Addressing this critical gap is essential to developing effective clinical protocols, public health strategies, and targeted policies. Therefore, this study was planned to bridge this knowledge gap by examining clinical outcomes associated with delayed treatment of

## INTRODUCTION

Hand infections are common incidences that typically result from injury or accident that leads to tissue damage, loss of mobility, and irreversible impairment when left untreated.<sup>1</sup> Comprehensive epidemiological data regarding hand infections are limited.<sup>2</sup> It is noted that roughly two-thirds of such infections affect men, commonly occurring at an average age of 40. Furthermore, over a third of these cases are associated with trauma.<sup>3</sup>

It has been estimated that 60 percent of hand infections are triggered by *Staphylococcus aureus*, with 86 percent of cultures growing only a single organism.<sup>3-5</sup> Recent research showed that 60-90 percent of all cultures are combined, with streptococci and staphylococci present in nearly equal amounts.<sup>3</sup>

Delayed treatment of hand injuries is associated with poor functional outcomes, prolonged disability, and reduced earning capacity.<sup>1</sup> The concept of the "golden period", a critical time

open hand infections at CHK, providing essential region-specific evidence to guide clinical decision-making and inform policy formulation.

## METHODS

This prospective observational study was conducted from January to June 2022, at the Plastic Surgery Department at Dr. Ruth K. M. Pfaul Civil Hospital Karachi (CHK), one of Pakistan's largest tertiary referral hospitals. Ethical approval was granted by the Institutional Review Board of Dow University of Health Sciences (Ethical approval #: IRB - 2354/DUHS/Approval/2021/708). Additionally, informed consent was obtained in writing from each patient prior to their inclusion in the study.

**Inclusion criteria:** Patients aged 18-65 years, regardless of gender, exhibiting distinct clinical manifestations of hand infection, including erythema, localized swelling, tenderness, and presence of pus exudate were included.

**Exclusion criteria:** Those who had hand injuries due to postoperative infection or who were presented with burn injuries were excluded. Patients with underlying conditions that could influence infection outcomes, such as chronic inflammatory disorders or prior hand surgeries were also excluded.

Open Epi sample size was calculated by taking statistics of prolonged hospital stay as 30.8%<sup>7</sup> in patients with hand infection and considering 20% difference in patients with no prolonged hospital stay as 50.8%, power of test as 80% and 95% confidence level. The estimated sample size came out as 94 in each group.

Hand infection was defined as presence of erythema, swelling, tenderness and pus exudate.<sup>8</sup> Delayed presentation was defined as presentation of patient after 24 hours of injury whereas prolonged hospital stay was defined as hospital stay of more than six days.<sup>8</sup>

Patients received treatment tailored to the severity and site of infection, and extent of soft tissue involvement. As per departmental protocol, initial management upon admission included administration of analgesics, antipyretics, and broad-spectrum

antibiotics, typically amoxicillin-clavulanic acid or ceftriaxone, selected based on clinical judgment and availability, with adjustments made upon culture and sensitivity results. Wound swabs were obtained for microbiological analysis, and affected limbs were elevated to reduce edema. Physiotherapy was initiated as indicated, in accordance with departmental rehabilitation guidelines. All patients were followed until discharge to evaluate the primary outcome variable: prolonged hospital stay.

Patients were categorized into three groups-mild, moderate, and severe infections-based on clinical assessment at presentation, adapted from the Modified Eron Classification for skin and soft tissue infections. Mild infections were defined as localized superficial involvement confined to skin and subcutaneous tissue, with minimal erythema, swelling, and absence of systemic signs such as fever or tachycardia. Moderate infections involved deeper soft tissues, including fascia or tendon sheaths, and were characterized by purulent discharge, localized abscesses, or spreading cellulitis, often accompanied by low-grade fever. Severe infections were identified by extensive tissue involvement with systemic features such as high-grade fever ( $>38.5^{\circ}\text{C}$ ), leukocytosis, tachycardia, hypotension, or signs of necrosis, deep abscesses, or impending functional compromise. This classification aided in stratifying patients and guiding therapeutic interventions based on severity of presentation.<sup>9</sup>

Information was collected regarding the baseline characteristics such as age, gender, height, weight, body mass index (BMI), duration of hand injury, presenting complaint, mechanism of injury, and presence of comorbidities. Moreover, clinical characteristics such as type of surgery, cultured organism, severity of the infection, and outcome variables such as length of hospital stay, frequency of needed operation, and operative time duration were noted.

Statistical Package for Social Sciences (SPSS) version 24 was used for the purpose of statistical analysis. Quantitative variables were explored

using mean and standard deviation, while qualitative variables were expressed in frequencies and percentages. The association of delayed presentation with baseline characteristics were explored using the Chi-Square/Fisher-Exact test. Whereas the mean difference of length of hospital stays, frequency of needed operations, and operative time duration were explored using independent t-test. The p-value of  $\leq 0.05$  was considered as significant.

## RESULTS

Of 188 patients with hand infection, 94 (50%) of the patients had delayed presentation and 94 (50%) had non-delayed presentation. The mean age of the patients was  $39.56 \pm 12.05$  years. There were 92 (48.9%) patients with  $\leq 40$  years and 96 (51.1%) with  $>40$  years of age. In comparison to women, men were higher; i.e., 167 (88.8%) and 21 (11.2%) respectively. The mean duration of the disease was  $2.26 \pm 0.71$  days. There were 131 (69.7%) patients with  $\leq 2$  days and 57 (30.3%) with  $>2$  days of duration of disease. Pain and pus discharge were reported by 66 (35.1%) patients each. Erythema was reported by 22 (11.7%) and swelling by 34 (18.1%) patients. Road traffic accidents were the most common mechanism of injury reported by 102 (54.3%) and machine injury by 86 (45.7%) patients. The findings of the culture showed that *Pseudomonas Aeruginosa* was reported by 111 (59%), MRSA by 67 (35.6%), and *Klebsiella Pneumoniae* by 10 (5.3%) patients.

Mild severity of infection was reported by 67 (35.6%), moderate by 69 (36.7%), and severe by 52 (27.7%) patients. Debridement was the most common surgery reported by 144 (76.6%) and digital amputation by 44 (23.4%) patients. Co-morbidities showed that diabetes mellitus was reported by 64 (34%) and hypertension by 67 (35.6%) patients. There was an insignificant difference of baseline and clinical characteristics among patients with delayed and non-delayed presentation (p-value  $> 0.05$ ) (Table I). The overall mean length of hospital stay was  $7.36 \pm 3.56$  hours, frequency of needed operation was  $2.32 \pm 0.49$ , whereas duration of operative time was

**Table I: Demographic, clinical, and surgical characteristics of patients with and without delayed presentation of hand infections (n= 188)**

Variable		Delayed Presentation		p-value
		Yes (n=94)	No (n=94)	
Age (years)	Mean $\pm$ SD	38.45 $\pm$ 12.16	40.60 $\pm$ 11.90	0.211 <sup>a</sup>
	$\leq 40$	49 (53.3)	43 (46.7)	0.381 <sup>b</sup>
	<40	45 (46.9)	51 (53.1)	
Gender	Female	14 (66.7)	7 (33.3)	0.105 <sup>b</sup>
	Male	80 (47.9)	87 (52.1)	
Height, m		1.67 $\pm$ 0.10	1.68 $\pm$ 0.10	0.749 <sup>a</sup>
Weight, kg		67.31 $\pm$ 11.77	67.44 $\pm$ 11.68	0.936 <sup>a</sup>
BMI, kg/m <sup>2</sup>		24.75 $\pm$ 4.58	24.66 $\pm$ 4.62	0.887 <sup>a</sup>
Duration of injury (days)	Mean $\pm$ SD	2.28 $\pm$ 0.72	2.25 $\pm$ 0.70	0.838 <sup>a</sup>
	$\leq 2$	65 (49.6)	66 (50.4)	0.874 <sup>b</sup>
	<2	29 (50.9)	28 (49.1)	
Presenting Complaint	Erythema	11 (50.0)	11 (50.0)	0.981 <sup>b</sup>
	Pain	34 (51.5)	32 (48.5)	
	Pus Discharge	33 (50.0)	33 (50.0)	
	Swelling	16 (47.1)	18 (52.9)	
Mechanism of injury	Machine injury	43 (50.0)	43 (50.0)	1.00 <sup>b</sup>
	Road Traffic Accident	51 (50.0)	51 (50.0)	
Cultured Organism	Klebsiella Pneumoniae	4 (40.0)	6 (60.0)	0.545 <sup>b</sup>
	MRSA	31 (46.3)	36 (53.7)	
	Pseudomonas Aeruginosa	59 (53.2)	52 (46.8)	
Severity of Infection	Mild	32 (47.8)	35 (52.2)	0.876 <sup>b</sup>
	Moderate	36 (52.2)	33 (47.8)	
	Severe	26 (50.0)	26 (50.0)	
Type of Surgery	Digital amputation	20 (45.5)	24 (54.5)	0.491 <sup>b</sup>
	Debridement	74 (51.4)	70 (48.6)	
Comorbidities	Diabetes Mellitus	64 (51.6)	60 (48.4)	0.538 <sup>b</sup>
	Hypertension	62 (51.2)	59 (48.8)	0.648 <sup>b</sup>

MRSA: Methicillin-resistant Staphylococcus aureus, a: Independent t-test applied, b: Chi-square/Fisher Exact test applied, p-value  $\leq 0.05$  considered as significant

1.02  $\pm$  0.68 hours. The mean length of hospital stay was significantly higher among patients with delayed presentation as compared to the patients with non-delayed presentation, i.e., 10.44  $\pm$  2.45 vs. 4.29  $\pm$  0.65 hours respectively (p-value <0.001). The mean duration of operative time was

significantly higher among patients with delayed presentation as compared to the patients with non-delayed presentation, i.e., 1.57  $\pm$  0.56 vs. 0.47  $\pm$  0.09 respectively (p-value <0.001). Moreover, prolonged hospital stay was significantly higher among patients with delayed presentation as compared to

the patients without delayed presentation (Table II).

## DISCUSSION

This study demonstrated that delayed presentation in patients with open hand infections significantly prolongs hospital stay, increases the number of surgical interventions, and extends operative duration, emphasizing the critical need for prompt management of these injuries. These findings highlight the detrimental effects delayed treatment can have on clinical outcomes, reinforcing the necessity for immediate and precise care in hand trauma.

Hand injuries necessitate immediate treatment and precise management.<sup>10</sup> If this goal is not met, patients may suffer from a decrease in their quality of life. There has been substantial discussion in the literature about the concept of a "golden period," or the time period during which lacerations should be surgically addressed.<sup>11,12</sup> Several studies have since concluded that the idea of a "golden period" does not exist;<sup>13-15</sup> nevertheless, a comprehensive literature search has shown that no study from Pakistan that evaluated patients treated beyond 24 hours after sustaining a hand injury is available. The "golden period" for surgical intervention in open traumatic injuries is traditionally considered to be within six hours post-injury. This is based on early surgical principles suggesting that interventions within this time frame may significantly reduce the risk of infection. However, more recent studies argue that the 24-hour window may also be acceptable in selected cases, particularly when initial wound contamination is minimal and proper wound care is promptly initiated. In the context of hand trauma, where functional preservation is critical and infection risk is high, early intervention ideally within 6 hours is still widely regarded as best practice.

The current study found no association between delayed presentation and infection severity or cultured organisms. In contrast, Pavan F, et al., reported that patients presenting after 24 hours were nearly three times more likely to develop infections, suggesting that early intervention may reduce infection risk and that a double peak in

**Table II: Comparison of outcomes based on delayed presentation of hand infections**

Variables	Delayed Presentation		p-value
	Yes	No	
Length of hospital stay (hours)	10.44 ± 2.45	4.29 ± 0.65	<0.001
Frequency of needed operations	2.32 ± 0.496	1.01 ± 0.01	<0.001
Operative time duration (hours)	1.57 ± 0.56	0.47 ± 0.09	<0.001

Independent t-test applied, p-value ≤ 0.05 considered as significant

infection rates may exist.<sup>7</sup> Nonetheless, the present findings align with this by showing that delayed presentation is significantly associated with longer hospital stays and operative times. Similarly, Dastagir K, et al., observed that late-presenting patients with hand infections required more procedures and had extended inpatient stays.<sup>16</sup>

In the current study, 35% of patients had mild, 36% moderate, and 27% severe infections. Although no significant association was found between delayed presentation and infection severity, a significant proportion of delayed cases exhibited moderate to severe infections. MRSA and *Pseudomonas aeruginosa* were more frequently isolated in delayed cases, though not statistically significant. Overall, *Pseudomonas aeruginosa* and MRSA were the most identified pathogens, differing from global trends where *Staphylococcus aureus* and *Streptococcus* species predominate. This variation may reflect contextual factors such as delayed presentation following inappropriate wound care or non-sterile remedies, and prior exposure to broad-spectrum antibiotics at Civil Hospital Karachi, a high-volume tertiary referral center, potentially promoting colonization by resistant organisms.

The current study found that the average age of patients presenting with both delayed and non-delayed hand infections was approximately 40 years, comparable to Juon BH, et al.'s findings of a mean age of 43 years.<sup>13</sup> Like our results, their study reported no significant impact of early versus delayed surgical intervention on infection rates, complications, or pain severity. Likewise, Davies J, et al., found that delayed surgery did not increase the incidence of surgical site infections,<sup>17</sup>

and Baldwin AJ, et al., observed no significant rise in infection risk during the COVID-19 pandemic despite widespread delays and altered surgical practices.<sup>18</sup> These findings align with our results, suggesting that delayed presentation alone may not be the sole determinant of infection risk.

Although our study did not identify a statistically significant difference in infection rates, complications, or pain severity between early and delayed interventions, this does not render timing irrelevant. Outcomes are likely influenced by multifactorial variables, including host immunity, wound contamination, prior antibiotic use, and quality of initial care. In some cases, delayed presentations may have involved inappropriate initial treatment or self-medication, which could mask the true impact of delayed intervention. Broad-spectrum antibiotic use before hospital presentation may also have minimized clinical differences between groups.

The management of hand injuries has become increasingly challenging for primary care physicians and orthopedic surgeons due to neglected wounds, antibiotic resistance, specific bacterial pathogens, and delays in presentation often linked to financial constraints and limited healthcare access.<sup>1,6,8,19,20</sup>

A recent study by Reasoner K, et al., also identified fracture type as a significant predictor of infection or poor outcomes in open hand fractures.<sup>21</sup> While prompt surgical intervention is a cornerstone of trauma care, emerging evidence suggests that short delays, in the absence of gross contamination or vascular compromise, may not significantly impact infection rates or complications.<sup>4</sup> Nevertheless, factors such as operating room availability and limited resources in high-volume

centers can cause avoidable delays. The absence of consistent local data on the clinical and functional impact of such delays highlights the need for studies like ours, which assess real-world outcomes in resource-limited settings.

The current study holds significant value as, to our knowledge, it is the first from Pakistan to report outcomes of delayed hand infection management in a local cohort. However, several limitations warrant consideration. Firstly, this descriptive observational study included only patients presenting with hand infections. A comparative design involving all hand trauma cases—infected and non-infected—would allow for stronger inferences and identification of risk factors influencing infection development, severity, and outcomes. Secondly, the study focused solely on hospital stay as the primary outcome. Other important clinical endpoints such as complication rates, pain severity, and functional recovery were not assessed due to the lack of long-term follow-up. Future research should incorporate standardized outcome measures to capture these aspects comprehensively.

Additionally, key effect modifiers, including mechanism of injury, urban vs. rural residence, socioeconomic status, timing of injury, and timing of surgery, were not fully analyzed. Among these, the mechanism of injury is particularly crucial as it directly impacts tissue damage, severity and infection risk. Addressing these limitations in future comparative and longitudinal studies will strengthen the evidence base for improving the management of hand trauma and infections in resource-limited settings.

## CONCLUSION

The study demonstrated that delayed presentation in patients with hand infections was significantly associated with prolonged hospital stay, longer operative time, and increased need for surgical interventions, thereby meeting the study objective. However, no significant association was found between delayed presentation and infection severity, suggesting that other factors may influence clinical progression. These findings highlight the importance of early medical attention to improve outcomes and optimize



resource use.

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### AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

**MNK & SS:** Conception and study design, acquisition, analysis of data, drafting the manuscript, critical review, approval of the final version to be published

**SH:** Analysis and interpretation of data, drafting the manuscript, approval of the final version to be published

**AK & NZ:** Acquisition, analysis and interpretation of data, critical review, approval of the final version to be published

**RM:** Conception and study design, critical review, approval of the final version to be published

*Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.*

### CONFLICT OF INTEREST

Authors declared no conflict of interest, whether financial or otherwise, that could influence the integrity, objectivity, or validity of their research work.

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### DATA SHARING STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request



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