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The Orthopaedic Burden of Rock-Climbing Injuries in Singapore

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ABSTRACT

Introduction: With increasing popularity of rock-climbing, both recreationally and competitively, its related injuries are increasing, leading to greater healthcare demands. This study aims to evaluate orthopaedic injury patterns and associated inpatient and outpatient costs from rock-climbing accidents.
Materials and methods: A retrospective review was conducted on patients admitted to the department of orthopaedic surgery between January 2017 and December 2023 for rock-climbing-related injuries. Data on demographics, injury patterns, outcomes, and costs were analysed.
Results: A total of 21 patients were included, with a mean age of 27.4 years and 76.2% female. Injuries occurred during bouldering (47.6%) and sport climbing (52.4%), with 90.5% resulting from falls. Fractures occurred in 95.2% of cases; 60% sustained multiple fractures, and 10% had open fractures. Lower limb injuries predominated. Surgery was required in 90.5% of patients, of whom 36.8% underwent a second procedure. The mean hospital stay was 11.0 days, and average hospitalisation leave lasted 78.5 days. Median inpatient and outpatient costs were S$7,056.92 and S$710.78, respectively. Higher inpatient costs were associated with multiple injuries, open fractures, and high-dependency admissions, while outpatient costs were influenced by gender, fall height, injury severity, and multiple surgeries.
Conclusion: Rock-climbing injuries impose substantial financial and healthcare burdens, costing patients nearly 1.5 months' wages for inpatient care. Although 11% lower than PMD- and motorcycle-related injuries, its total expenses, including rehabilitation and societal costs, are likely higher. These findings highlight the need to emphasise on preventive measures and enhanced safety protocols to reduce injury rates and mitigate economic impact.

Keywords:
rock-climbing, bouldering, sport climbing, healthcare costs, health burden

INTRODUCTION

Rock-climbing is increasing in popularity worldwide since its debut in the Olympics in 2020, Tokyo. In recent years, there is an increasing number of indoor climbing gyms available in Singapore[1]. With increasing accessibility to the sport, an increase in rock-climbing injuries is expected[2,3]. The sport includes multiple disciplines such as bouldering, top-rope climbing and lead climbing[4]. With various disciplines, injuries can range from the inherent risk of falling and hitting objects or the ground, to stress-related overuse climbing injuries due to the unique forces placed on the musculoskeletal system[5,6]. As a result, there is an associated increase in demand for healthcare resources to manage the injuries[7].

To our knowledge, there are only two studies in the current literature that studies the healthcare and financial burden of these climbing-related injuries. Forrester *et al* reported the cost of climbing-related injuries to the US health care system to be approximately 102 million USD for the five-year period, averaging 20 ± 9.5 million USD per year[7]. Krieger *et al* reported the total inpatient and outpatient cost of outdoor climbing-related injuries in Switzerland to have an average of 20,746 CHF and 1,328 CHF, respectively[8]. While these studies highlight the overall financial burden of climbing injuries, they do not explore how specific injury patterns contribute to these costs. In terms of studying rock-climbing injury patterns, Lim *et al* has previously reported that majority (90.9%) of rock-climbing injuries tend to be due to falls with 95.5% of these injuries resulting in fractures and 90.9% of them requiring surgery[9]. Understanding these injury patterns and its impact on associated inpatient and outpatient costs can allow for targeted preventive measures to be put in place, ultimately reducing both the frequency of injuries and the associated healthcare and financial burdens.

The main objective of this study is the evaluate the inpatient and outpatient costs and orthopaedic injury pattern of patients admitted to the Department of Orthopaedic Surgery

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in a tier two trauma centre following rock-climbing injuries over a seven-year period in Singapore.

MATERIALS AND METHODS

This is a retrospective observational study in which the institutional review board granted a waiver for informed consent, as only retrospective and de-identified data were used. All patients admitted to the Department of Orthopaedic Surgery with injuries related to rock climbing between January 2017 and December 2023 were included in a registry. This was accomplished by thoroughly reviewing admissions during the study period and identifying those hospitalised due to rock-climbing accidents.

Patients who were admitted from the Emergency Department (ED) or from the Orthopaedic Outpatient Clinic were included in the study. These excluded patients admitted under other specialties, those who died on scene, en route to the hospital, or discharged from the ED. Those who declined surgery, discharged against medical advice or managed exclusively in the outpatient setting were also excluded from the study.

The study collected demographic data, information on the type of rock-climbing, injury mechanisms, the nature and type of injuries sustained and outcomes of the injury, including admission disposition, number of surgeries (if any), length of stay (LOS), duration of hospitalisation leave (dHL), and the need for a second admission for further surgery related to the same orthopaedic injury.

Inpatient costs were totalled to include hospitalisation fees, surgical and anaesthesia costs, and inpatient rehabilitation expenses. Outpatient costs were calculated based on consultation fees for each visit and physiotherapy costs. These costs were analysed separately for first and second admissions when applicable.

After tabulation of results, data analysis was performed using IBM SPSS Statistics 29.0 software [IBM Corp. Armonk, NY]. Descriptive statistics for patient demographics and clinical characteristics were presented as counts and percentages for categorical data, means ± standard deviations (SD) for normally distributed data, and medians with interquartile ranges (IQR) for non-normally distributed data. To compare total inpatient and outpatient costs, the Shapiro-Wilk test was used to determine if the data followed a normal distribution and if the variances were equal across categories. For normally distributed data, t-tests or one-way ANOVA were applied to assess the significance of each factor's impact on costs. For non-normally distributed data, non-parametric tests, such as the Mann-Whitney U-test or Kruskal-Wallis test, were used to evaluate the significance of each factor's effect on costs. A bivariate Pearson correlation test was used to examine the relationship between length of stay (LOS) and duration of hospitalisation leave (dHL) with total inpatient and outpatient costs. The level of significance was set at $p < 0.05$.

RESULTS

During the study period from January 2017 to December 2023, a total of 21 patients with rock-climbing-related injuries were admitted to the Department of Orthopaedic Surgery.

The mean age was 27.4 ± 7.9 years and 76.2% (16/21) of patients were female. Among ten patients with available BMI, 4 of them were overweight with BMI >23kg/m2. Of the 21 patients, ten (47.6%) had an injury from bouldering while 11 (52.4%) had an injury from sport climbing. Overall, 19 (90.5%) of the patients fell from height with 20 (95.2%) sustaining fractures, of which 12 (60%) sustained 2 or more fractures, and 2 (10%) sustained open fractures. Lower limb injuries (n=16, 76.2%) were more common than upper limb (n=3, 14.3%) and spine (n=5, 23.8%) injuries. Amongst the male patients, majority (60%) sustained an upper limb fracture while the remaining 2 (40%) sustained a lower limb fracture and shin laceration, respectively. In contrast, amongst the female patients, majority, 11 (68.8%) sustained lower limb fractures and 5 (31.3%) of them sustaining an isolated or concomitant spine fracture. None of the female patients sustained an upper limb fracture.

Nineteen (90.5%) underwent surgery, of which 7 (36.8%) required a second surgery related to the initial injury for reasons such as removal of implants, change of implants or additional ligamentous repair. The mean LOS was 11.0 + 14.7 days and 95.2% of patients were admitted to the general ward and required an average dHL of 78.5 + 38.8 days. Overall, the total inpatient and outpatient costs from their first admission was S$7,056.92 (4,117.94 – 12,047.89) and S$702.16 (416.83 – 1,951.99), respectively. The total inpatient and outpatient costs for the first and second admission (if applicable) combined was S$7,056.92 (4,526.79 – 15,829.9) and S$710.78 (416.83 – 2,442.68), respectively.

Analysis of variables that could have affected the total inpatient and outpatient costs during their first admission was performed, as shown in Table I. With reference to Table I, there is evidence that the number of regions injured ($p=0.006$), number of fractured bones ($p=0.007$), open fractures ($p=0.002$) and high dependency admission ($p<0.001$) was positively associated with the total inpatient bill. Additionally, LOS (ρ 0.949, $p<0.001$) and dHL (ρ 0.544, $p=0.011$) was positively associated with the total inpatient bill.

With reference to Table I, there is evidence that female gender ($p=0.010$), falling from height ($p=0.047$), open fractures ($p<0.001$), high dependency admission ($p<0.001$), requiring multiple surgeries ($p=0.024$) and a second surgery

Table I: Summary table of total inpatient and outpatient costs of rock-climbing associated injuries during first admission.

Variable	No. (%) of patients	Total Inpatient Cost (S$) Median (IQR)	p-value	Total Outpatient Cost (S$) Median (IQR)	p-value
Age (years)			0.088		0.128
<30	16 (76.2%)	6,608.00 (4,117.94 – 12,047.89)		706.47 (398.70 – 1,608.25)	
>30	5 (23.8%)	7,679.48 (7,056.92 – 16,799.69)		684.69 (434.95 – 3,393.37)	
Gender			0.208		0.010
Female	16 (76.2%)	9,568.14 (4,736.29 – 16,799.69)		1,028.29 (610.73 – 3,393.37)	
Male	5 (23.8%)	6,943.94 (2,868.87 – 7,056.92)		350.25 (349.55 – 434.95)	
Smoker			0.533		0.234
Yes	2 (9.5%)	4,962.90 (2,868.87 – 7,056.92)		392.60 (350.25 – 434.95)	
No	19 (90.5%)	7,679.48 (4,736.29 – 16,041.15)		q0.78 (446.10 – 2,295.72)	
BMI (kg/m2)			0.762		0.556
<23	6 (60%)	12,047.89 (6,943.94 – 16,041.15)		446.10 (350.25 – 1,608.25)	
>23	4 (40%)	13,548.52 (7,516.82 – 25,665.27)		1,721.15 (772.64 – 2,844.55)	
Type of rock climbing			0.349		0.904
Bouldering	10 (47.6%)	5,406.16 (3,515.18 = 11,172.62)		806.08 (392.60 – 2,844.55)	
Sport climbing	11 (52.4%)	7,679.48 (5,530.94 – 16,420.42)		5,721.00 (3,515.18 – 17,317.26)	
Mechanism of Injury			0.057		0.047
Fall from height	19 (90.5%)	7,679.48 (4,940.27 – 16,041.15)		710.78 (446.10 – 2,295.72)	
Others	2 (9.5%)	1,905.07 (941.26 – 2,868.87)		214.62 (78.98 – 350.25)	
Fall height (m)			0.111		0.125
<6m	17 (94.4%)	7,056.92 (4,736.29 – 10,297.35)		702.16 (440.53 – 1,721.15)	
>6m	1 (5.6%)	172,336.95 (NA)		15,197.68 (NA)	
No. of regions			0.006		0.254
Single region	18 (85.7%)	6,408.00 (2,868.87 – 8,838.92)		693.43 (374.48 – 1,377.41)	
Multiple regions	3 (14.3%)	34,530.84 (25,285.87 – 103,433.		2,295.72 (1,370.91 – 8,746.70)	
Region of Injury					
Isolated injury			0.791		0.093
Upper limb	3 (14.3%)	6,943.41 (4,906.41 – 7,000.43)		350.25 (349.90 – 392.60)	
Lower limb	13 (61.9%)	5,872.05 (4,117.94 – 10,297.35)		710.78 (610.73 – 1,608.25)	
Spine	2 (9.5%)	4,869.84 (1,119.52 – 8,620.16)		702.16 (416.83 – 1,951.99)	
Combined Injury					
Lower limb and spine	3 (14.3%)	34,530.84 (25,286.00 – 103,433.90)		2,295.72 (1,370.91 – 8,746.70)	
Injury sustained			0.095		0.105
Fracture	20 (95.2%)	7,368.20 (4,736.29 – 16,041.15)		706.47 (434.95 – 2,295.72)	
Non-fracture	1 (4.8%)	941.26 (NA)		78.98 (NA)	
No. of fractures ^			0.007		0.335
Single fracture	8 (40%)	3,493.41 (2,294.07 – 7,056.92)		572.87 (350.25 – 910.00)	
Multiple fractures	12 (60%)	11,172.62 (6,408.00 – 19,657.56)		924.37 (528.42 – 2,844.55)	
Open vs Closed fractures ^			0.002		<0.001
Open fracture	2 (10%)	88,227.45 (4,117.94 – 172.336.95)		9,350.93 (3,504.18 – 15,197.69)	
Closed fracture	18 (90%)	7,368.20 (4,838.28 – 14,044.52)		693.43 (416.83 – 1,377.41)	
Admission disposition			<0.001		<0.001
General ward	20 (95.2%)	7,000.43 (4,117.94 – 12,047.89)		693.43 (398.70 – 1,608.25)	
High dependency	1 (4.8%)	172,336.95 (NA)		15,197.68 (NA)	
No. of operation(s)			0.495		0.024
None	2 (9.5%)	4,869.84 (1,119.52 – 8,620.16)		NA *	
Single	16 (76.2%)	6,464.49 (3,493.41 – 11,172.62)		693.43 (416.83 – 1,377.41)	
Multiple	3 (14.3%)	34,530.84 (20,737.39 – 103,433.90)		2,295.72 (1,322.64 – 8,746.70)	
Additional operation #			0.055		<0.001
Yes	7 (36.8%)	16,799.69 (8,494.08 – 28,523.15)		3,393.37 (1,951.99 – 3,870.54)	
No	12 (63.2%)	6,408.00 (2,581.47 – 8,259.20)		440.53 (349.90 – 706.47)	

^ Excluding the single patient who did not sustain a fracture
# Across patients with surgeries done on first admission
* Both patients who were managed conservatively were lost to follow-up

Table II: Summary table of total inpatient and outpatient costs of rock-climbing associated injuries during first and second admission(s) if any.

Variable	No. (%) of patients	Total Inpatient Cost (S$) Median (Interquartile Range)	p-value	Total Outpatient Cost (S$)	Median (IQR)
Age (years)			0.445		0.893
<30	16 (76.2%)	6,408.00 (4,526.79 – 15,829.69)		791.41 (398.70 – 1,718.52)	
>30	5 (23.8%)	7,679.48 (7,056.92 – 18,593.36)		684.69 (434.95 – 4,869.65)	
Gender			0.208		0.007
Female	16 (76.2%)	9,568.14 (4,736.29 – 18,593.36)		1,028.29 (702.16 – 4,826.92)	
Male	5 (23.8%)	6,943.94 (2,868.87 – 7,056.92)		350.25 (349.55 – 434.95)	
Smoker			0.533		0.234
Yes	2 (9.5%)	4,962.90 (2868.87 – 7,056.92)		392.60 (350.25 – 434.95)	
No	19 (90.5%)	7,679.48 (4,736.29 – 16,041.15)		872.03 (446.10 – 3,166.83)	
BMI (kg/m2)			0.762		0.556
<23	6 (60%)	15,829.69 (6,943.94 – 16,041.15)		446.10 (350.25 – 1,718.52)	
>23	4 (40%)	14,445.36 (7,516.82 – 30,097.55)		2,156.70 (772.64 – 4,018.24)	
Type of rock climbing			0.349		0.778
Bouldering	10 (47.6%)	5,721.00 (3,515.18 – 13,063.52)		891.02 (550.43 – 1,432.55)	
Sport Climbing	11 (52.4%)	7,679.48 (5,735.37 – 17,317.26)		684.69 (392.60 – 3,996.88)	
Mechanism of Injury			0.057		0.047
Fall from height	19 (90.5%)	7,679.48 (5,569.93 – 16,041.15)		872.03 (446.10 – 3,166.83)	
Others	2 (9.5%)	1,905.07 (941.26 – 2,868.87)		214.62 (78.98 – 350.25)	
Fall height (m)			0.111		0.125
<6m	17 (94.4%)	7,056.92 (4,736.29 – 10,297.35)		710.78 (440.53 – 2,156.70)	
>6m	1 (5.6%)	184,949.53 (NA)		19,104.28 (NA)	
No. of regions			0.006		0.254
Single region	18 (85.7%)	6,408.00 (2,868.87 – 8,838.92)		706.47 (374.48 – 1,432.55)	
Multiple regions	3 (14.3%)	41,601.74 (28,821.45 – 113,275.64)		3,166.83 (1,806.47 – 11,135.55)	
Region of Injury					
Isolated injury			0.791		0.093
Upper limb	3 (14.3%)	6,943.94 (4,906.41 – 7,000.43)		350.25 (349.90 – 392.60)	
Lower limb	13 (61.9%)	5,872.05 (4,526.79 – 10,297.35)		872.03 (684.69 – 1,718.52)	
Spine	2 (9.5%)	4,869.84 (1,119.52 – 8,620.16)		710.78 (416.83 – 2,442.68)	
Combined Injury					
Lower limb and spine	3 (14.3%)	41,601.74 (28,821.45 – 113,275.64)		3,166.83 (1,806.47 – 11,135.55)	
Injury sustained			0.095		0.105
Fracture	20 (95.2%)	7,368.20 (4,736.29 – 16,041.15)		791.41 (434.95 – 3,166.83)	
Non-fracture	1 (4.8%)	941.26 (NA)		78.98 (NA)	
No. of fractures ^			0.007		0.250
Single fracture	8 (40%)	3,697.83 (2,294.07 – 7,056.92)		572.87 (350.25 – 910.00)	
Multiple fractures	12 (60%)	13,063.83 (6,408.00 – 21.966.42)		1,009.30 (565.40 – 4,018.24)	
Open vs Closed fractures ^			0.674		<0.001
Open fracture	2 (10%)	94,738.16 (4,526.79 – 184,949.53)		11,965.60 (4,826.92 – 19,104.28)	
Closed fracture	18 (90%)	7,368.20 (5,153.11 – 15,935.42)		706.47 (416.83 – 1,432.55)	
Admission disposition			0.095		<0.001
General ward	20 (95.2%)	7,000.43 (4,526.79 – 15,829.69)		706.47 (398.70 – 1,718.52)	
High dependency	1 (4.8%)	184,949.53 (NA)		19,104.28 (NA)	
No. of operation(s)			0.010		0.434
None	2 (9.5%)	4,869.84 (1,119.52 – 8,620.16)		NA *	
Single	16 (76.2%)	6,464.49 (3,697.83 – 13,063.52)		706.47 (416.83 – 1,432.55)	
Multiple	3 (14.3%)	41,601.74 (24,272.84 – 113,275.64)		3,166.83 (1,758.19 – 11,135.56)	
Additional operation #			0.043		<0.001
Yes	7 (36.8%)	18,593.36 (10,699.81 – 33,470.61)		4,826.92 (2,442.68 – 5,246.18)	
No	12 (63.2%)	6,408.00 (2,581.47 – 8,259.20)		440.53 (349.90 – 706.47)	

^ Excluding the single patient who did not sustain a fracture
# Across patients with surgeries done on first admission
* Both patients who were managed conservatively were lost to follow-up

(p<0.001) was positively associated with the total outpatient bill. Additionally, LOS (ρ 0.912, p<0.001) and dHL (ρ 0.674, p=0.002) was positively associated with the total outpatient bill.

Analysis of factors that could have affected the total inpatient and outpatient costs during their first and second admission (if applicable) was performed, as shown in Table II.

With reference to Table II, there is evidence that the number of regions injured (p=0.006), number of fractured bones (p=0.007), number of surgeries required (p=0.010) and requirement of a second surgery (p=0.043) was positively associated with the total inpatient bill. Additionally, LOS (ρ 0.952, p<0.001) and dHL (ρ 0.546, p=0.010) was positively associated with the total inpatient bill.

With reference to Table II, there is evidence that female gender (p=0.007), falling from height (p=0.047), open fractures (p<0.001), high dependency admission (p<0.001), requirement of a second surgery (p<0.001) was positively associated with the total outpatient bill. Additionally, LOS (ρ 0.909, p<0.001) and dHL (ρ 0.683, p=0.001) was positively associated with the total outpatient bill.

DISCUSSION

Several studies have reported approximately 10 – 15% of patients requiring hospitalisation after a rock-climbing accident[7,10]. A study by Forrester *et al* published in 2018 analysed climbing-related injuries in the United States (US) reported that these injuries cost the US healthcare system approximately $102 million over a five-year period, averaging $20 million annually[7]. These findings underscore the significant economic impact of climbing-related injuries on healthcare systems.

Our study shows that the median total inpatient cost was S$7,056.92 and outpatient cost was S$702.16. The median gross monthly income of full-time employed Singapore residents ranged from S$4,232 to S$5,197 between 2017 to 2023. This suggests that a patient who required admission for orthopaedic injuries as a result of a rock-climbing-related accident could be spending almost 1.5 months' worth of wages on medical treatment.

A study by Krieger *et al* done in Switzerland in 2022 studying the cost of outdoor-climbing related injuries reported inpatient and outpatient costs averaging at CHF$20,746 (approximately S$30,947.22) and CHF$1,328 (approximately S$1,981) which appears to be significantly higher than the average costs recorded in our study[8]. Another study by Forrester *et al* in 2018 reported mean individual hospitalisation cost of USD$64,929 (approximately S$87,874.91) due to injuries from mountain climbing, rock-climbing or wall climbing[7]. However, both these studies included injuries incurred from mountain climbing and outdoor climbing which may potentially result in a higher degree of polytrauma therefore resulting in a higher average inpatient cost compared to our study. To our knowledge, there is no other literature that has studied the financial impact of rock-climbing related injuries.

A study by Ang *et al* in 2020 reported the median total inpatient cost per patient of Personal Mobility Devices (PMD)- related injuries to be S$7835.01, which was reportedly not significantly different from treatment costs incurred from motorcycle-related injuries[11]. The median total inpatient cost incurred from climbing-related injuries in our study is not significantly different (approximately 11% lower) in comparison to PMD-related injuries. In conclusion, the costs associated with climbing-related injuries, though slightly lower than those of PMD and motorcycle-related injuries, still reflect a significant financial and healthcare burden. This comparison underscores the need for a greater focus on preventive strategies to reduce the economic impact of such injuries and optimise the allocation of healthcare resources.

Additionally, our study reported the mean LOS and dHL of 11.0 days and 78.5 days. Over the duration of rehabilitation and recovery while on hospitalisation leave, the patients also sustained productivity and economic losses[12]. When the inclusion of healthcare and societal costs is factored into the analysis, the actual total cost is expected to be higher than values presented in this study.

Our study shows that in terms of injury pattern, majority of the patients sustained fractures (95.2%) of which the number of regions injured, number of fractured bones and the presence of an open fracture are associated with increased total inpatient costs.

In polytrauma patients with more regions injured and fractured bones, they tend to incur significantly higher total inpatient costs due to extended LOS, often necessitate surgical intervention[13], potentially multiple surgical interventions[14] and a longer duration of rehabilitation and long-term care[15]. This highlights the importance of directing resources toward effective injury prevention and timely surgical care to address the demands of such injuries efficiently.

Similarly, open fractures may result in higher inpatient costs due to the possible necessity for multiple surgeries, including the use of external fixators, and an increased risk of infection that may require multiple further debridement operations. A study by Hoekstra *et al* on open tibial fractures found that total healthcare costs were nearly double compared to closed fractures, with hospitalisation being the major contributor[16]. Additionally, Haidari *et al* reported that direct healthcare costs for patients with a single occurrence of fracture-related infection after long bone fracture treatment are three times higher compared to non-infected patients[17].

In terms of mechanism of injury, patients who sustained injuries from falling from height incurred higher total inpatient costs compared to those who were injured due to other reasons such as lacerations or grip injuries, though not statistically significant. Falls from a height of six meters (approximately 20feet) are considered significant mechanisms of injury, often warranting trauma team activation. This threshold is supported by various trauma protocols and guidelines[18]. In our study, only a single patient fell from higher than six meters, at ten meters. This patient incurred a total inpatient bill from all admissions related to the injury at S$184,949.53 which is significantly higher than the median cost of the other patients who fell from a height of less than six meters. Additionally, this patient required high dependency admission, which significantly contributes to the overall total inpatient bill, as reported in our study. Our study, however, was not able to adequately assess the association with fall height to total inpatient costs, likely due to a small study population.

Our study also shows that patients who require a second admission and surgery is associated with increased overall total inpatient costs. Majority of our study population sustained lower limb fractures, of which a majority of them underwent a second surgery due to reasons such as removal or change of implant and ligament repair. Literature have reported a range of 17 to 27% of ankle fracture patients requiring implant removal[19-21]. With majority of rock-climbing accidents resulting in lower limb fractures requiring admission, the additional possible need for removal of implants contributes to the overall inpatient costs incurred by patients.

In terms of demographics, interestingly, our study shows that females have a positive correlation with total outpatient costs. Studies have shown that being female is positively correlated with higher total healthcare costs compared to males[22]. This discrepancy may be explained by women experiencing greater daily fluctuations in mood compared to men, associated with improvements or setbacks in their recovery process which may result in a longer duration of rehabilitation and more frequent outpatient follow-ups, thereby increasing total outpatient costs[23]. Additionally, this may be contributed by the finding that majority of our female study population sustained lower limb fractures compared to the males. Rehabilitation requirements between upper and lower limb fractures differ due to anatomical and functional distinctions, with lower limb fractures often necessitating more extensive rehabilitation compared to upper limb fractures[24]. To our knowledge, there is no literature that studies the impact of gender on outpatient costs specific to rock-climbing related injuries and further studies should be done to assess their correlation.

In terms of mechanism of injury, our study shows that falling from height and requiring high dependency admission is associated with higher total outpatient costs. Due to reasons of higher degree of polytrauma and extent of injuries, which also has positive correlation total inpatient cost, they may more frequent follow-ups and longer duration of rehabilitation thereby resulting in higher total outpatient costs.

Lastly, in terms of injury patterns, sustaining an open fracture is associated with higher total outpatient costs. Open fractures are more susceptible to infections such as osteomyelitis and non-union[25,26]. This necessitates more frequent outpatient visits, imaging studies, and sometimes additional interventions, all contributing to higher costs. Furthermore, most patients with open fractures end up developing some degree of functional disability[27], and the resulting impact on employment opportunities further contributes to the increased costs in addition to the values highlighted in this study.

Overall, the health and financial burden on individuals and society can be reduced with further emphasis on preventive measures with comprehensive safety protocols, implementation of mandatory belay certifications and regular inspections of climbing facilities[9].

This study has several limitations. Firstly, the small sample size of 21 patients, all requiring admission, may not be fully representative, as it excludes those who were followed-up as outpatients and did not differentiate between indoor and outdoor climbing which could influence the findings. Secondly, the retrospective design relied on the accuracy of the registry and electronic medical records, and there were no records regarding patients' inability to work or certificates of incapacity for work. Thirdly, the Singapore healthcare system is heavily subsidised, and costs vary depending on whether patients opt for private or subsidised care, making direct comparisons with other countries difficult. Finally, the study did not account for the costs of further outpatient follow-ups or inpatient rehabilitation following transfer to a step-down institution, suggesting the need for future research with a larger cohort and extended study duration to enhance reliability and representation. The socioeconomic burden of rock-climbing-related injuries in terms of productivity loss, long-term work absence as well as loss of quality of life needs to be studied further.

CONCLUSION

With increasing popularity and accessibility of rock climbing as a sport since its debut in the Olympics, it imposes a significant health and financial cost to both the individual and society. Therefore, it is crucial to emphasise the importance of preventive measures, with implementation of comprehensive safety protocols and mandatory belay certifications. Through the combined efforts of climbers, facility managers, and healthcare professionals, the risk of severe injuries in rock-climbing can be significantly reduced, helping to maintain the sport as both safe and enjoyable for everyone.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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