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Characteristics of burn injury during COVID-19 pandemic in Tokyo: A descriptive study

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ABSTRACT

Introduction: Coronavirus disease 2019 (COVID-19) has drastically changed everyday life worldwide. This study aimed to determine how COVID-19 affected the characteristics and outcomes of patients with severe burn injury by examining a city-wide burn database in Tokyo.

Patients and methods: A descriptive study was conducted in 14 burn centers using the Tokyo Burn Unit Association registry from 1999 to 2020. The pandemic started in 2020, while the stay-at-home order lasted from April to May. The demographics, mechanisms, severity, and clinical outcomes were assessed before and during these two time periods.

Results: In total, 7061 patients with burn injury were enrolled. During the pandemic, there were less patients during the pandemic than previous years, except for April–May; this decreased toward the end of 2020. There were also more scald/contact burns in the upper extremity, less intended and assault injuries, shorter length of hospital stay, and lower in-hospital mortality. During the stay-at-home order, there was increased incidence of flame burns, inhalation injuries, and in-hospital mortality, as well as higher total body surface area of full-thickness burns.

Conclusions: This study described the characteristics of burns during the COVID-19 pandemic. The association between the stay-at-home order and severity of burns should be further examined.

1. Introduction

Coronavirus disease 2019 (COVID-19) has drastically changed everyday life across the world [1]. As severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) can be transmitted by close contact and/or aerosol that is generated when someone speaks or coughs [2], several governments have issued various policies to counteract the pandemic, such as social distancing, stay-at-home orders, and citywide lockdowns [3,4]. Given that the characteristics and clinical consequences of burn injuries are significantly dependent on lifestyle, healthcare system, and the socioeconomic state of each region [5], the COVID-19 pandemic has also affected patients suffering from burn injury [6,7].

The impact of COVID-19 pandemic on burn injury patients differs depending on each region. A burn center in the US has reported increased burn center admissions and a higher number of school-age children suffering from burn injuries than usual [8]. A pediatric burn center in Turkey also revealed a higher number of admissions and increased burn area among hospitalized patients [9]. Conversely, reduced admission with the same demands on burn intensive care unit (ICU) was reported by a regional burn center in Canada [10], and significant decreases of hospitalization due to burn injuries were found in several burn centers across the UK [11–13]. Moreover, no significant changes in burn injury admission and mortality by burns were observed in Brazil [14].

These contradicting results may have been introduced by the differences in study settings: targeted population, study design (single- vs. multi-center), variance in healthcare systems, and the presence or absence of stay-at-home order. Accordingly, in an effort to capture the influence of COVID-19 on the characteristics and outcomes of patients with considerably severe burn injury at an urban area, we examined a citywide burn database in Tokyo, Japan, wherein infrastructure and health systems are well-organized. We compared the features of burn

Abbreviations: COVID-19, Coronavirus disease 2019; SARS-CoV-2, Severe acute respiratory syndrome coronavirus 2; TBUA, Tokyo Burn Unit Association; TBSA, Total body surface area; LOS, Length of hospital stay; BI, Burn index; PBI, Prognostic burn index; ED, Emergency department.

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injuries between patients during and before the COVID-19 pandemic, as well as between those under and without the stay-at-home order.

2. Material and Methods

2.1. Study design and settings

We conducted a retrospective descriptive study using a Japanese citywide burn registry that was established in 1984. The registry has been maintained by the Tokyo Burn Unit Association (TBUA), which comprises 14 participating burn centers in Tokyo, the Tokyo Fire department, and the Tokyo Metropolitan Government.

The TBUA developed criteria for the designation of burn centers and pre- and inter-hospital patient transportation, wherein patients with moderate-to-severe burn injuries or complicated injuries (i.e., chemical injuries, electrical injuries, or burn injuries involving the face or genitalia) are transported directly from the scene or transferred from non-burn centers. Around 300–400 burn injuries regularly occur among more than 10 million inhabitants in the Tokyo Metropolis (official name of Tokyo city, a capital of Japan), and the TBUA covers more than 90% of severe burn cases [15]. The data of patients who needed admission or died prior to admission were collected; this was entered into the online data collection portal by the attending physicians or volunteer registrars designated by each hospital. This study was approved by the Institutional Review Board of the Keio University School of Medicine (application number, 20190101). The requirement for informed consent was waived because of the anonymous nature of the data being used.

Sporadic COVID-19 cases were noted in Japan since January 2020; then, in the following month, more than 700 patients with COVID-19 who were evacuated from the cruise ship Diamond Princess were admitted to hospitals around Tokyo. When the World Health Organization declared COVID-19 as a global health emergency, multiple clusters and community transmission were observed in the Tokyo Metropolis [16]. The Japanese Government declared a state of emergency, and the governor of Tokyo Metropolis announced a stay-at-home order on April 7, 2020, which ended on May 25, 2020. Under the stay-at-home order, people were to refrain from going outside unless for urgent or essential needs, and most non-essential businesses were voluntary closed. Legally enforceable lockdown was not ordered in Tokyo Metropolis.

2.2. Study population

We retrospectively screened cases in the TBUA registry (patients who fulfilled criteria according to the designation of burn centers in Tokyo Metropolis) and included patients who presented with burn injury at all participating centers from 1999 to 2020. Patients with unknown or missing data on years of injury were excluded.

2.3. Data collection and definition

Available patient data included age, gender, mechanism of burn injury, causes of burn injury, (e.g., intended injury and work-related injury), anatomic location of burns, total cutaneous burn area (e.g., full- and partial-thickness burns in the total body surface area [TBSA]), presence of inhalation injury, time of injury, time of hospital arrival, length of hospital stay (LOS), and survival status.

The assessment and diagnosis of burn injury, including the determination of the size and depth of cutaneous burns and recognition of inhalation injury, were conducted by an attending physician on hospital arrival and confirmed by a board-certified burn surgeon. The burn index (BI) was calculated as the full-thickness burn area + 1/2 partial-thickness burn area, while the prognostic burn index (PBI) was calculated as BI + age. A patient presenting later than 6 h after the injury at a participating burn center was considered delayed arrival.

Patients who had presented at a participating burn center in 2020 were considered as presenting during the pandemic, because the first COVID-19 case in Tokyo was reported in January 2020. Patients who presented at a participating burn center from April–May 2020 were considered as presenting under the stay-at-home order, because the order was announced between April 7 and May 25, 2020.

2.4. Outcome measures

The outcomes of this descriptive study included the number of patients per month and clinical characteristics of their burn injuries, categorized into demographics, mechanisms, causes, anatomic locations, severities, and clinical consequences. These outcomes were compared between patients before and during pandemic, as well as between those under the stay-at-home order and those who were not.

2.5. Statistical analysis

Descriptive statistics are presented as their median (interquartile range) or number (percentage). The number of patients per month during the pandemic was compared with the monthly average of those before pandemic using chi-square test; this data was described along with the number of patients who were newly diagnosed with COVID-19 in Tokyo. The clinical characteristics of burn injuries were compared using the Mann–Whitney *U* test, chi-square tests, or Fisher's exact test as appropriate, and a two-sided α threshold of 0.05 was considered statistically significant. Because of the lack of power analyses for each outcome in the descriptive study, results are shown using standardized difference to avoid overseeing potentially important differences, wherein a standardized difference greater than 0.2 was considered as a non-negligible difference. All statistical analyses were conducted using SPSS, version 26.0 (IBM, Armonk, NY), and Microsoft Excel (Microsoft, Redmond, WA).

3. Results

In total, 7061 eligible patients with burn injury were enrolled in this study. Among them, 203 patients presented at a participating burn center during the COVID-19 pandemic, whereas 343 suffered from burn injuries annually on average before pandemic (Table 1).

The number of patients per month during the pandemic was significantly lower than the monthly average of those before pandemic ($p < 0.001$), except for April when the stay-at-home order was announced (Fig. 1). Before the pandemic, more patients suffered from burn injuries during the winter season (November to March) than in the other months. In contrast, during the pandemic, the number of patients gradually decreased toward the end of year, along with an increasing number of newly diagnosed COVID-19 patients. The annual numbers of patients in the study period were also shown in Fig. 2, in which fewer burn patients were admitted during the pandemic compared with the previous years.

Table 1 summarizes the characteristics of patients with burn injury before and during the pandemic. Patients during the pandemic were older and they were mostly females. More patients during the pandemic had scald or contact burns (78 [38.5%] vs 2224 [33.4%]) and injured their upper extremity (64 [31.5%] vs 1386 [20.2%]) compared to before the pandemic. Conversely, less patients during the pandemic suffered from intended burns (9 [4.4%] vs 584 [8.5%]), assault injuries (14 [6.9%] vs 718 [10.5%]), head and/or neck injuries (37 [18.2%] vs 1685 [24.6%]), and associated inhalation injuries (74 [36.5%] vs 2877 [42.0%]). Regarding the severity and outcomes of burn injuries, a slightly higher %TBSA of partial-thickness burns (4 [1–10] vs 3 [0–10] %TBSA), shorter LOS (3 [1–13] vs 5 [1–18] days), and lower in-hospital mortality (18 [8.9%] vs 817 [11.9%]) were seen in patients during pandemic compared to before the pandemic.

Table 2 summarizes the characteristics of patients under the stay-at-home order compared to those that were not. In total, 54 patients were transported during the period of the stay-at-home order; the monthly

Table 1
Characteristics of Patients with Burn Injury During and Before Pandemic.

	During pandemic		Before pandemic		P value	SMD
Case	203		6858			
Case/year	203		343			
Age, years, *median (IQR)*	58	(34–77)	50	(28–68)	**<0.001**	**−0.225**
Age < 18 years, *n (%)*	28	(13.9%)	974	(14.2%)	0.887	0.012
Sex, male, *n (%)*	112	(55.2%)	4189	(61.1%)	**<0.001**	0.120
Mechanism of burn injury, *n (%)*					**<0.001**	
Scald or Contact	78	(38.5%)	2224	(33.4%)		−0.126
Flame	77	(37.9%)	2624	(38.3%)		0.007
Electrical	4	(2.0%)	155	(2.3%)		0.020
Chemical	3	(2.2%)	148	(1.5%)		0.051
Explosion	8	(3.9%)	346	(5.0%)		0.053
Cause of burn injury, *n (%)*						
Intended injury	9	(4.4%)	584	(8.5%)	**0.028**	0.166
Injury by others	14	(6.9%)	718	(10.5%)	**<0.001**	0.127
Work-related injury	22	(10.8%)	1081	(15.8%)	0.188	0.145
Injury at closed space	184	(90.6%)	5942	(86.6%)	0.426	−0.126
Anatomical location, *n (%)*						
Head and/or neck	37	(18.2%)	1685	(24.6%)	**0.038**	0.155
Upper extremity	64	(31.5%)	1386	(20.2%)	**<0.001**	**−0.261**
Lower extremity	35	(17.2%)	1068	(15.6%)	0.519	−0.045
Upper and lower extremities	0	(0.0%)	74	(1.1%)	0.277	0.148
Trunk	20	(9.9%)	682	(10.1%)	0.965	0.003
Face	57	(28.1%)	2176	(31.7%)	0.270	0.080
Hand	26	(12.8%)	920	(13.6%)	0.757	0.018
Perinium	9	(4.4%)	280	(4.1%)	0.804	−0.017
Severity of injury						
Total burn area, %TBSA, *median (IQR)*	5	(1–14)	5	(1–15)	0.461	0.111
Burn area (partial thickness), % TBSA, *median (IQR)*	4	(1–10)	3	(0–10)	**0.037**	−0.062
Burn area (full thickness), % TBSA, *median (IQR)*	0	(0–1)	0	(0–3)	0.486	0.092
Associated inhalation injury	74	(36.5%)	2877	(42.0%)	**0.006**	0.113
Burn index, *median (IQR)*	3	(1–9)	3	(1–8)	0.324	0.138
Prognostic burn index, *median (IQR)*	61	(38–81)	57	(32–79)	0.111	−0.104
Time from injury to arrival, h, *median (IQR)*	1.2	(0.8–3.8)	1.2	(0.8–3.5)	0.857	0.022
Delayed arrival on hospital*, *n (%)*	20	(12.6%)	509	(9.0%)	0.118	−0.087
Clinical outcomes						
Length of hospital stay, *days, median (IQR)*	3	(1–13)	5	(1–18)	**<0.001**	**0.264**
In-hospital mortality, *n (%)*	18	(8.9%)	817	(11.9%)	**<0.001**	0.100

IQR = Interquartile Range, TBSA = Total Body Surface Area, *Delayed arrival on hospital is defined as hospital arrival more than or equal to 6 h after injury

numbers of patients were relatively higher than those in the months without the stay-at-home order (Fig. 1). Patients under the stay-at-home order had more flame burns (23 [42.6%] vs 54 [36.2%]) but fewer scald or contact burns (19 [35.2%] vs 59 [39.6%]). While the other characteristics and consequences of burn injuries were statistically comparable between patients regardless of the stay-at-home order, there were several non-negligible differences. Relatively, more patients under the stay-at-home order suffered from injuries at closed space (52 [96.3%] vs 132 [88.6%], standardized difference = 0.295) and had associated inhalation injuries (26 [48.1%] vs 48 [32.2%], standardized difference = 0.329). Moreover, relatively higher %TBSA of full-thickness burns (0 [0–4] vs 0 [0–1], standardized difference = 0.361), PBI (62 [48–86] vs 60 [34–80], standardized difference = 0.257), and in-hospital mortality (8 [14.8%] vs 10 [6.7%], standardized difference = 0.264) were observed in patients under the stay-at-home order.

The time from burn injury until hospital arrival was comparable between patients before and during the pandemic, while this was relatively shorter in patients under the stay-at-home order compared to those who were not (1.1 [0.7–3.1] vs 1.3 [0.8–4.3] h, standardized difference = 0.407). Furthermore, the incidence of delayed hospital arrival ≥ 6 h after injury was similar before and during the pandemic, whereas it occurred relatively less in months with the stay-at-home order than in those without (2 [5.0%] vs 18 [15.1%], standardized difference = 0.315).

4. Discussion

This descriptive study revealed characteristics of burn injuries in Tokyo during the COVID-19 pandemic, wherein there were significantly less patients than usual, but more scald or contact burns in the upper extremity with better clinical outcomes were identified. Moreover, relatively more patients were transported to burn centers during the period of the stay-at-home order, compared to outside this time period. More flame burns, injuries in closed spaces, associated inhalation injuries, and slightly increased severity of burn injuries were also observed during the stay-at-home order months.

This study showed a decreased number of burn injury patients during the pandemic; this was similar to reports from other more economically developed countries, such as Canada, the US, and the UK [10,12,17,18]. In Toronto, Canada, there was a 33% decrease in burn injury admissions at a burn center during a 5-month period within the pandemic [10]. Moreover, in Birmingham, UK, a 50% reduction of admissions at a burn ward was noted as well [12]. On the other hand, a burn center in the US reported increased admissions after the outbreak of COVID-19, although pediatric patients accounted for a large portion of the increase [8]. Considering that no increase in the proportion or number of pediatric patients was identified in this study, the discrepancy between studies might have been introduced by age-specific changes in the number of burn injuries presenting at burn centers during the pandemic. It should be noted that a pediatric burn center in the US suggested the closure of most pediatric offices had affected the number of pediatric burn patient emergency department (ED) visits [19]. Furthermore, the similar reduction of incidence has been observed in other diseases, such as severe trauma, fractures, during the pandemic [20–22].

While various studies have reported the reduction of burn injuries under stay-at-home orders or during lockdown periods [11,12,23,24], the number of patients during the stay-at-home order did not decrease in this study. This may be because Tokyo citizens were only asked, rather than mandated, to refrain from going outside. As less restriction would have relatively less impact on lifestyles, the reduction of patients under the stay-at-home order would likely be less than other regions. Notably, the differences in socioeconomic situation have also affected the changes of burn injuries even within the same country [14]. Another reason could be the localization of burn patients at burn centers due to temporary shutdown of wound clinics during the stay-at-home order; this was also observed in other regions [11,25]. Notably, the relatively

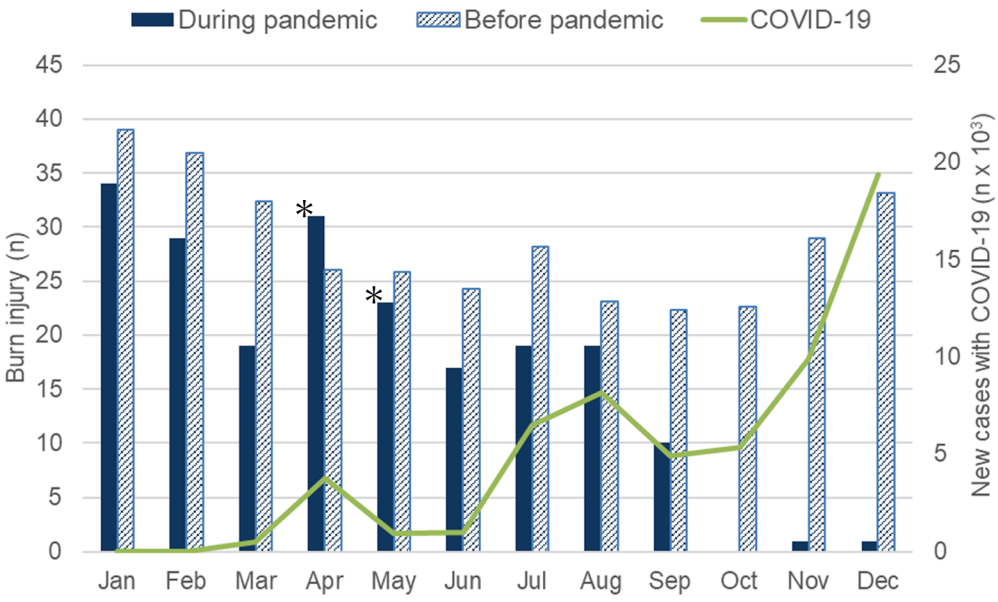

Fig. 1. Number of patients during COVID-19 pandemic The number of patients per month during the pandemic (solid bar) was significantly lower than the monthly average before the pandemic (stripe bar) ($p < 0.001$), except for April and May when the stay-at-home order was announced (*). The number of patients in April and May was relatively higher than those in the months without the stay-at-home order. Before the pandemic, more patients suffered from burn injuries in the winter (November to March), while during the pandemic, the number of patients gradually decreased toward the end of year along with the increasing number of newly diagnosed COVID-19 patients (solid line).

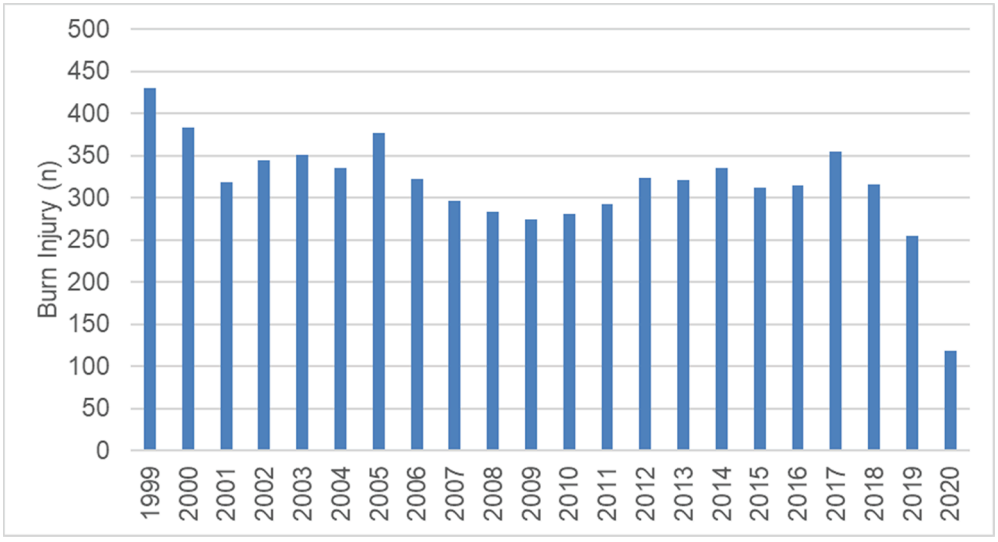

Fig. 2. Annual number of burn patients in the study period Fewer burn patients were admitted during the pandemic compared with the previous years.

shorter duration from burn injury to hospital arrival is reflective of the directness of transportation to burn centers.

During the pandemic, the mechanism of burn injuries has been changed across the world. Scald burns occurring in the kitchen [13], friction injuries due to treadmills at home [26], injuries from steam inhalation [11], and alcohol burns with an increased usage of alcoholic solutions [27] were all reported during the COVID-19 pandemic. In general, scald and/or contact burns in the hands/upper extremities at home have increased during the pandemic; the results of our study support this finding. Less intended and/or assault burn injuries were also observed in this study, likely because social activities decreased in frequency after the outbreak of COVID-19. Along with high frequency of burn injuries among females, such differences in mechanism of burns should be emphasized in the management of burn patients during the pandemic.

The major mechanism of burn injuries under stay-at-home orders or lockdowns is universally reported as flame burns [12,19,24], and similar results were obtained in this study. The relatively higher incidence of injuries in a closed space and inhalation injuries is likely due to the prolonged stay of people at home. The relationship between work-related injuries and the stay-at-home order/lockdown was unclear in previous studies [12,28], but this study found no association between them.

Regarding the severity and outcomes of burn injuries, patients during the pandemic had shorter LOS and lower in-hospital mortality, whereas the difference in severity of burn injury was trivial. As suggested in a previous study, the LOS would have been shortened to avoid the risk of COVID-19 infection during the hospital stay [29], or simply due to historical improvements in health care. Furthermore, a certain proportion of patients, such as those with severe burn injuries, is expected to remain constant during the pandemic. In contrast, however, relatively higher %TBSA of full-thickness burns, PBI, and in-hospital mortality were all identified during the stay-at-home order in this study. While the severity of injury under the stay-at-home order/lockdown was conflicting in past studies [9,11,12,19,24,29], an increased burn area was frequently observed, particularly in the pediatric population [9,11,19]. Considering that these results were not statistically significant, further studies are needed to validate the association

Table 2
Characteristics of Patients with Burn Injury Under and Without Stay-At-Home Order.

	Under stay-at-home order		Without stay-at-home order		P value	SMD
Case	54		149			
Case/month	27		15			
Age, years, *median (IQR)*	60	(41–82)	56	(28–77)	0.173	**−0.227**
Age < 18 years, *n (%)*	5	(9.3%)	23	(15.5%)	0.253	0.189
Sex, male, *n (%)*	29	(53.7%)	83	(55.7%)	0.797	0.040
Mechanism of burn injury, *n (%)*					**0.022**	
Scald or Contact	19	(35.2%)	59	(39.6%)		0.091
Flame	23	(42.6%)	54	(36.2%)		−0.130
Electrical	1	(1.9%)	3	(2.0%)		0.012
Chemical	0	(0.0%)	3	(2.0%)		**0.203**
Explosion	2	(3.7%)	6	(4.0%)		0.017
Cause of burn injury, *n (%)*						
Intended injury	4	(7.4%)	5	(3.4%)	0.194	−0.180
Injury by others	3	(5.6%)	11	(7.4%)	0.914	0.074
Work-related injury	6	(11.1%)	16	(10.7%)	0.322	−0.012
Injury at closed space	52	(96.3%)	132	(88.6%)	0.426	**−0.295**
Anatomical location, *n (%)*						
Head and/or neck	12	(22.2%)	25	(16.8%)	0.375	−0.138
Upper extremity	12	(22.2%)	52	(34.9%)	0.086	**0.283**
Lower extremity	7	(13.0%)	28	(18.8%)	0.331	0.160
Upper and lower extremities	0	(0.0%)	0	(0.0%)	NA	0.000
Trunk	6	(11.1%)	14	(9.4%)	0.717	−0.057
Face	15	(27.8%)	42	(28.2%)	0.954	0.009
Hand	5	(9.3%)	21	(14.1%)	0.478	0.151
Perinium	1	(1.9%)	8	(5.4%)	0.45	0.189
Severity of injury						
Total burn area, % TBSA, *median (IQR)*	5	(0–16)	5	(2–13)	0.464	−0.144
Burn area (partial thickness), % TBSA, *median (IQR)*	3	(0–10)	4	(1–10)	0.269	0.046
Burn area (full thickness), % TBSA, *median (IQR)*	0	(0–4)	0	(0–1)	0.769	**−0.361**
Associated inhalation injury	26	(48.1%)	48	(32.2%)	0.089	**−0.329**
Burn index, *median (IQR)*	2	(0–9)	3	(1–7)	0.362	−0.172
Prognostic burn index, *median (IQR)*	62	(48–86)	60	(34–80)	0.254	**−0.257**
Time from injury to arrival, h, *median (IQR)*	1.1	(0.7–3.1)	1.3	(0.8–4.3)	0.198	**0.407**
Delayed arrival on hospital*, *n (%)*	2	(5.0%)	18	(15.1%)	0.107	**0.315**
Clinical outcomes						
Length of hospital stay, *days, median (IQR)*	2	(1–10)	3	(2–13)	0.704	0.007
In-hospital mortality, *n (%)*	8	(14.8%)	10	(6.7%)	0.180	**−0.264**

IQR = Interquartile Range, TBSA = Total Body Surface Area, *Delayed arrival on hospital is defined as hospital arrival more than or equal to 6 h after injury.

between stay-at-home orders and the severity of burn injuries.

The results of this study must be interpreted within the context of the study design. We analyzed the TBUA registry, which only includes patients who fulfilled criteria as designated by the burn centers of Tokyo Metropolis. Although the results capture the characteristics of most patients with moderate-to-severe burn injuries or complicated injuries, the changes in minor burn injuries seen in some local injury facilities during pandemic are not reflected in this study. Another limitation is that the details of management for burn injuries, such as fluid administration and surgery, were not available in the registry. Thus, our results on outcomes could have differed depending on the strategy for burn management. Finally, because this is a descriptive study, our results are not conclusive. No hypothesis was generated before the study, and sample size calculation was not performed; thus, statistical significance in this study should be interpreted with great caution. Particularly, variables with high standardized difference need to be reexamined in future studies.

5. Conclusions

The number of patients at burn centers in Tokyo decreased during the COVID-19 pandemic, whereas slightly more patients were observed in months under the stay-at-home order. The major mechanism of injury was scald or contact during the pandemic, while flame injury was the most common during the stay-at-home order. Shorter LOS and decreased in-hospital mortality following burn injuries were noted during the pandemic. The association between the stay-at-home order and severity of burn injuries should be further examined.

Consent/ethical approval

This study was approved by the Institutional Review Board of the Keio University School of Medicine (application number, 20190101). The requirement for informed consent was waived because of the anonymous nature of the data being used.

7. Availability of data and materials

The data related to this study was used under license from the Tokyo Burn Unit Association, and restrictions apply to the public availability of these data. The data is available from the authors upon reasonable request and with permission from the Tokyo Burn Unit Association.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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