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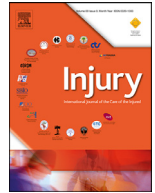
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The COVID-19 Pandemic: The effect on open lower limb fractures in a London major trauma centre - a plastic surgery perspective

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ABSTRACT

Background: COVID-19 has created huge pressures on healthcare systems. The ongoing provision of major trauma services during this time has proved challenging. We report our experience of managing open lower limb fractures (oLLFs) during the pandemic in a London major trauma centre (MTC).

Methods: This was a prospective study of all open lower limb fractures presenting to our unit over the initial 48 days of UK government lockdown - 24th March till 10th May 2020. Results were compared to the same time period in 2019 retrospectively. Epidemiological data, mechanism, Gustilo-Anderson (G-A) severity grading, time to initial debridement and definitive coverage were analysed.

Results: There was a 64% reduction in emergency department (ED) attendances (25,264 vs 9042). There was an 18% reduction in oLLFs (22 vs 18). Approximately three-quarters of injuries were in males across both cohorts (77% vs 78%) and tended to occur in younger patients (median age, 37 vs 35). Road-traffic accidents (RTAs) were the most common injury mechanism in both 2019 and lockdown, but a rise in jumpers from height was seen in the latter. A similar pattern of G-A severities were seen, however only 3 injuries during lockdown required major soft tissue reconstruction. There was no significant difference in times taken for initial debridement ($p = 0.72786$) or definitive wound coverage ($p = 0.16152$). A greater proportion of independent operating was seen during lockdown between orthopaedics and plastic surgery.

Conclusions: Despite government lockdown measures, oLLFs still placed significant burden on our MTC. Notwithstanding significant staffing alterations and theatre pressures, we have been able to ensure these lower limb emergencies remain a surgical priority and have managed to utilise resources appropriately.

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Background

Since it was first recognised in December 2019, Coronavirus Disease 19 (COVID-19) has subsequently created huge pressures for healthcare systems worldwide. The National Health Service (NHS) in the United Kingdom (UK) has certainly not been spared, with the UK recording the highest death toll in Europe at the time of writing this article [1]. As the incidence of coronavirus grew, leading to a rising inpatient numbers, a nationwide lockdown was announced by the Prime Minister on 23rd March 2020, to try and curb the virus spread. This was then followed by the first easing of restrictions on 10th May 2020 [2].

Throughout this time, hospitals have been placed under huge strain and have had to try and adapt quickly, including increasing

total inpatient capacity, creation of COVID-19 zones/wards, as well as the re-deployment of staff from their usual areas of work. Major trauma centres have had the additional pressures of still providing trauma services throughout this time. Trauma patients require rapid assessment, often in resuscitation zones of the emergency department (ED), who will already be dealing with the COVID-19 patient influx and the additional time-consuming challenges associated with their management. Increased competition for radiology, access to theatres, ventilators and a physical inpatient space can lead to delays in trauma patient management.

Open lower limb injuries have an incidence of 3.4 per 100,000 and their management requires a high resource burden [3,4]. Set timelines for their management should follow BOAST4 (BOA Standards for Trauma and Orthopaedics) guidelines [5]. Across all surgical specialties it became clear that there would be an increased emphasis on managing patients non-operatively and decreasing face-to-face contact where possible [6,7]. In response to COVID-19, specific guidance for the management of trauma during the pan-

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demic was issued by the British Orthopaedic Association (BOA) and the British Association of Plastic Reconstructive and Aesthetic Surgeons (BAPRAS). Points emphasised included that patients 'should only be admitted to hospital if there is no alternative', the 'capability for performing emergency life and limb-threatening surgery should be maintained at all major trauma centres and 'high quality care to major trauma patients should be maintained to the greatest possible extent...while ensuring that critical resources are preserved as far as possible.'⁴ All patients who are 'obligatory inpatients' must have their '[treatment expedited] to avoid pre-op delay and expedite rehab to minimise length of stay [6,8].

Further additional guidance included the scope for considering alternative techniques for patients who required soft tissue reconstruction, to avoid multiple operations or critical care admission and to consider early amputation in those where limb salvage would have an uncertain outcome [7].

In this study, we aim to report our experiences of managing major lower limb trauma during the COVID-19 pandemic in a major trauma centre (MTC) in London.

Materials & Methods

A prospective study was performed analysing all patients that were admitted to the Royal London Hospital MTC with lower limb injuries which required treatment under BOAST4 principles. This included all open fractures of long bones, hind foot or mid foot. Open fractures to the forefoot or digits were excluded. The study period covered the initial 48 day UK lockdown - 24th March till 10th May 2020. Data was collected from the same time period in 2019 retrospectively to act as a control group for comparison.

Epidemiological data, mechanism and Gustilo-Anderson (G-A) severity grading, time to initial debridement and definitive coverage were collected and analysed. Low energy injuries were defined as falls from standing height or less, with high energy trauma being defined as any other trauma. Data regarding staffing and operating logistics was obtained from relevant departmental leads.

Statistical Analysis

The 'R project for Statistical Computing' was used for statistical analysis. Statistical significance was taken at the 95% confidence interval. The Mann Whitney U test was used to identify statistical significance.

Results

Departmental Changes

Staffing: Throughout lockdown all plastic surgery doctors at Senior House Officer (SHO) level (postgraduate year 2-4, PGY) were seconded to assist in critical care. This was then followed by 33% of those at registrar level (PGY 5-10) and 14% of consultants. An average of three members of the remaining team were in isolation at any one point. Orthopaedic SHOs were re-deployed on a rotational policy. Of the orthopaedic registrars and fellows, on average 19% of the department were in isolation at any one point. All emergency theatre lists required for the treatment of oLLFs could be staffed adequately with surgeons, due to a greater number of consultants being available compared to pre-lockdown. This in part, was due to the cancellation of routine elective operating. This allowed registrars to help offset the loss of the SHOs by concentrating more on clerking patients.

Theatres: Adult surgery across all specialties had to be concentrated into 2-3 staffed theatres, with paediatric surgery streamlined into 1-2 theatres. This resulted in different surgical specialities competing for access, which varied depending on anaesthetic

Table 1
Patient Age Demographics.

		n	%	Median Age	Range
Lockdown	Total	18		37	15-89
	Male	14	78	33	15-89
	Female	4	22	57	27-83
2019	Total	22		35	15-83
	Male	17	77	28	15-55
	Female	5	23	41	20-83

and theatre staff availability, and post-op recovery capacity. Locations of these theatres were split into 'COVID positive' and 'COVID negative' zones. Remaining theatres and anaesthetic rooms were used for extensions of critical care. For all patients, full personal protective equipment (PPE) was used. A maximum of two surgeons per speciality was enforced with a preference for consultant operating, if available. To increase theatre capacity for definitive soft tissue reconstruction procedures to take place, extra lists in private hospitals were utilised for appropriate patients.

Patient Demographics

There was an overall large reduction in the number of patients presenting to the Royal London Hospital MTC during lockdown.

In 2019 there a total of 25,264 patients presenting to the Royal London Hospital emergency department (ED). There were 22 patients admitted with an open lower limb fracture (oLLF). Male patients accounted for 77% (n=17), with a median age of 28 (range = 15-55). For females (n=4) the median age was higher, at 41 (range = 20-83). A total of 18% of oLLF patients had an underlying diagnosed mental health disorder.

During the 48 day initial lockdown period, 9,042 patients presented to the ED, representing a 64% reduction in attendances. Altogether, 18 patients suffered an oLLF. Of these, 78% were male (n=14) with a median age of 33 (range = 15-89). The median age for females was once again higher, at 57 (range = 27-83). Of note, 35% of oLLF patients had an underlying mental health disorder.

Table 1 displays full age demographics in tabular form. Fig. 1 helps to illustrate the spread of ages seen. During lockdown, 3 patients tested positive for coronavirus (17%), 9 tested negative (55%) and 5 were not tested (28%).

Injury Characteristics

In 2019, 82% of injuries were classified as high-energy trauma (n=18, median age = 33). Polytrauma was sustained by 4 patients (where another area or system is injured in addition to an oLLF, 18% of whole cohort). All of these patients were male, with a median age of 35. Road traffic accidents (RTAs) were the most common mechanism (55%), followed by falls (23%). Jumping from height accounted for 5% (this patient had an underlying depressive diagnosis). Open tibia and/or fibula injuries were by far the most common injury (86%, n= 19). No patient's sustained more than 1 oLLF.

During lockdown, 89% of injuries were due to high-energy trauma (n=16, median age = 27). Polytrauma was sustained by 8 patients (44% of whole cohort). All of these patients were again male, with a median age of 29. Open tibia and/or fibula injuries were again the most common injury location (71%, n= 12), followed by open femoral injuries (22%). RTAs accounted for 35% of presentations. Those jumping from height contributed 29%, of these 60% had an underlying mental health diagnosis. No patients sustained more than 1 oLLF. Tables 2 and 3 provide a further comparative breakdown of these results. The majority of patients within the lockdown cohort suffered G-A type II open fractures

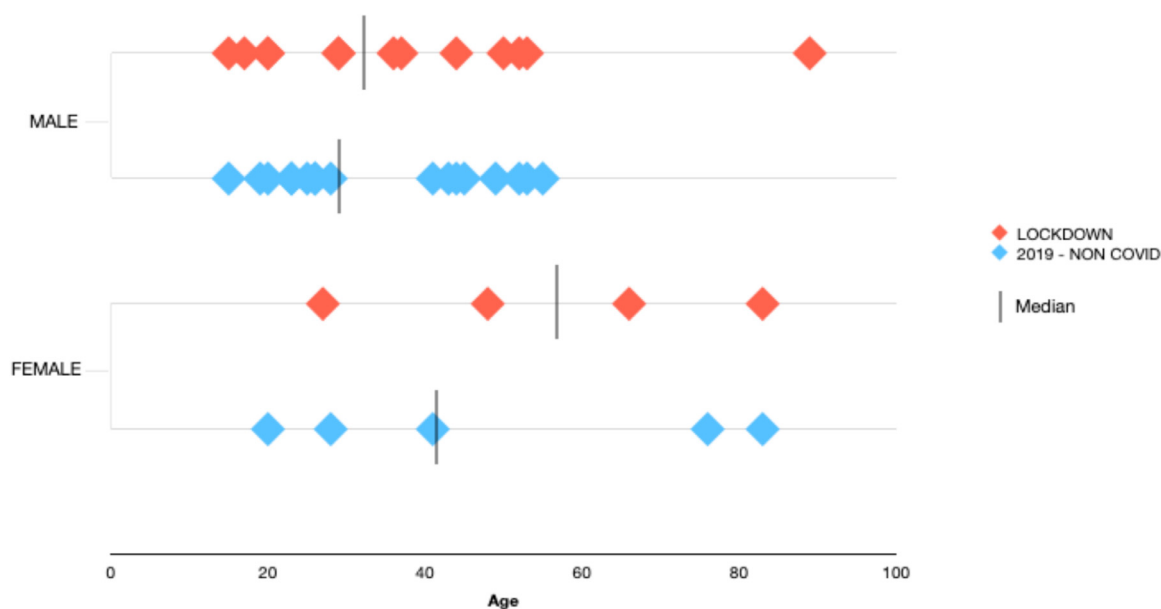


Fig. 1. Patient Age Demographics.

Table 2
Open fracture mechanism.

Mechanism of Injury	2019	Lockdown
RTA (patient is driver/passenger)	6	5
RTA (patient is pedestrian)	6	1
Jump from height	1	5
Fall from height	3	0
Fall from standing	2	3
Crush injury	2	2
Gunshot wound	1	0
Sporting related	1	1

Table 3
Open fracture location.

Injury	2019	Lockdown
Open Femur	2	4
Open Tibia/Fibula	19	12
Open Midfoot	0	1
Open Hindfoot	1	1

(56%), followed by IIIA and IIIB (17% each) and then I (11%). No patient suffered a type IIIC fracture. In 2019, type II open fractures also predominated (59%), followed by IIIB (18%), IIIA (14%), I and IIIC (5% each).

Management

Coverage Type: During lockdown 15 patients underwent direct closure at the time of initial debridement and temporary/permanent fixation (83%). A single patient underwent a primary below knee amputation (6%). The remaining 2 patients underwent flap coverage on their second look in theatre - 1 local flap (transposition type) and 1 anterolateral thigh free flap (FF) (6% each).

Comparatively in 2019, 73% of injuries underwent primary direct closure (n=16) with 5% requiring an additional split skin graft (n=1). Delayed below knee amputation (previously had initial debridement in theatre) occurred in 9% (n= 2) and 14% underwent FF coverage- 2x Antero-Lateral Thigh FF, 1x Medial Sural Artery Perforator FF) at second look. Fig. 2 helps to illustrate the relationship between G-A severity and coverage type by cohort.

Speciality presence at initial debridement: During lockdown, only 11% of operations had both orthopaedic and plastic surgeons present at initial debridement (n=2), however all cases had been previously discussed at a virtual MDT meeting (containing both orthopaedic and plastic senior decision makers). Orthopaedics were solely present in 72% of cases (n=13), whereas 17% had plastics only (n=3). This compares to 59% of cases being joint in 2019 (n=13), 36% orthopaedics alone (n=8) and 5% plastics alone (n=1).

Time until initial debridement: During lockdown, high energy trauma patients (HETPs) underwent debridement on average at 31 hours post injury. In 2019, this occurred at 36 hours. This difference was not found to be significant ($p = 0.72786$). 13% of HETPs in lockdown underwent surgery <12hours post injury, compared to 6% during 2019.

For low energy trauma patients (LETPs) during lockdown, initial debridement was performed on average at 24 hours post injury. In 2019, this was at 31 hours. 50% of LETPs in lockdown underwent surgery <24 hours post injury, compared to 25% in 2019. Sample sizes were too small to facilitate statistical comparison.

Time until definitive coverage: During lockdown definitive coverage of an open fracture was achieved on average at 38 hours post injury, with 89% of patients not exceeding the 72 hour BOAST4 guideline. In 2019, the average time till coverage was 47 hours post injury (77% within 72 hours). This observed difference in definitive coverage time was not found to be statistically significant ($p = 0.16152$).

Length of stay: For all patients, the average length of stay (ALOS) patients in 2019 was 12 days, compared to 9 days in lockdown. For those with isolated oLLFs (not polytrauma patients) the ALOS in 2019 was 11 days, compared to 6 days in lockdown.

Discussion

We have identified only a minimal decrease in oLLF injuries during lockdown, despite a significant (64%) decrease in ED attendances compared with the same timeframe in 2019. This is surprising, given it would have been fair to expect a more dramatic reduction in the frequency of oLLF after the imposition of lockdown rules. This assumption would also translate into polytrauma cases, where we also saw an increase in cases during lockdown. All polytrauma cases that presented to our unit involved RTAs or

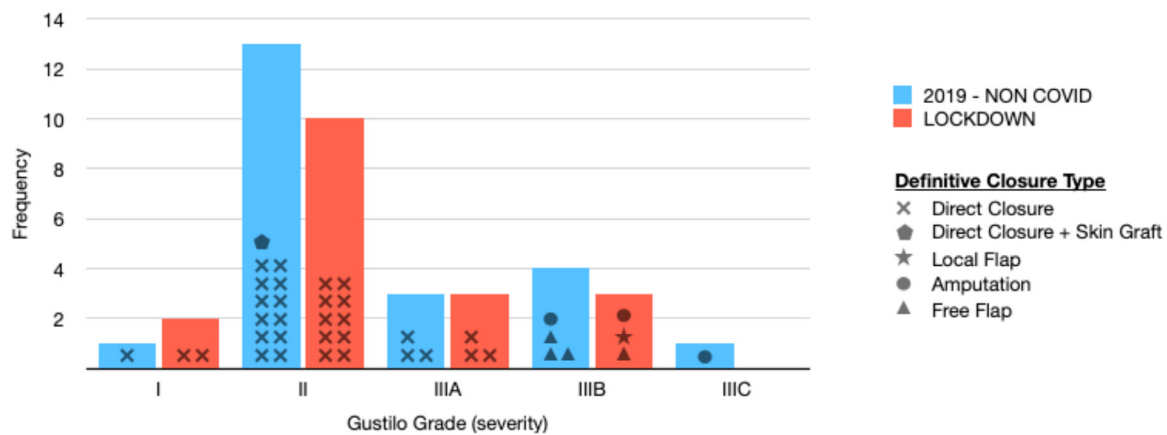


Fig. 2. Frequency of injury severities as per Gustilo-Anderson categorisation, along with definitive closure types utilised.

jump from height as their mechanism, with the exception of one gunshot related incident in the 2019 cohort. We observed an ongoing mixed severity pattern with a similar spread (as illustrated in Fig. 2). The long bones of the lower limb were the most commonly affected in both cohorts, in line with a recent literature review by Elniel and Giannoudis (2018), along with a G-A grading of II [9].

The overall trends seen across both cohorts were that oLLF were more likely to occur in younger patients with high energy trauma and occur in males - also echoed by Elniel and Giannoudis, (2018). While the low numbers in this comparison study make statistical analysis of injury mechanisms not possible, trends can be inferred. Although there was an overall reduction in their incidence during lockdown, oLLFs caused by RTAs were still the most common injury mechanism, with 38% of high energy injuries caused by them. Of those where the patient was not a pedestrian, the median ages in lockdown and 2019 respectively were 36 and 29 years old. Trips in motorised vehicles have declined up to 45% over the lockdown period [10], with the majority of the public heeding government rules on staying at home and leaving for essential trips only. The decrease in traffic seen has not appeared to translate into an overall proportional drop in RTAs however (where the patient was a driver or passenger). All incidents involved documented 'high speed', with 80% involving motorbikes/mopeds. Transport for London has found increases in average speeds in some areas of the capital by greater than 50%, linked to emptier roads. The Metropolitan Police stated there had been an increase in drivers caught speeding in the capital by 71% [11], some travelling even greater than 130mph [12]. Known significant risk factors for both RTAs and greater risk taking are younger age and being male [13,14]. An ongoing social study by University College London (UCL), with over 85,000 respondents, has demonstrated that compliance with lockdown measures is much lower in this grouping [15]. The World Health Organisation even felt it was necessary to specifically reinforce that young people were "not invincible" to COVID-19 [16]. Overall, it is likely that a combination of breaking lockdown, speeding and greater risk taking has helped to sustain the number of RTA associated oLLFs. Furthermore, a steep rise in home delivery of takeaways and same-day orders may also have contributed, as these companies often employ a young workforce, who in turn often use motorbikes/moped for rapid delivery throughout London [17,18]. The number of patients being a pedestrian involved in a RTA comparatively decreased by 83%, likely linked to less people being outside.

Our study observed a large percentage increase in the incidence of attempted suicide by jumping from height. All lockdown patients with this mechanism were under 38 years old and 80% were male. A previously diagnosed mental health disorder was found in

60%. In fact, overall, we saw a rise in incidence of oLLFs in those with a mental health diagnosis - 35%, compared to 18% in 2019. Evidence from the same UCL social study and comments by authors in The Lancet Psychiatry have suggested worsening symptoms over lockdown for these patients as well as likely increased presentation of new mental health issues, especially linked with loss of employment, financial stressors and stretched crisis helplines [15,19].

Open LLFs are complex limb-threatening injuries and involve the loss of complete skin and soft tissue coverage over the site of injury. This predisposes to infection, with potential catastrophic consequences. On average, the time taken until initial debridement for both HETPs and LETPs improved during lockdown, despite only an 18% reduction in caseload. The average time for definitive coverage of injuries was also improved upon. The lack of a statistically significant difference between the 2019 and lockdown cohorts implies that the provision of a reliable trauma service was achieved despite COVID-19 pressures. It is likely that increased seniority presence across all departments helped achieve this by speeding up both decision making and management processes (e.g. surgical time, anaesthetising, discharging of patients to free up beds). Conversely, this will possibly have had a negative impact upon training opportunities for juniors.

Ideally time until definitive oLLF coverage should be within 72 hours. This was achieved in 89% of patients during lockdown ($n = 16$) compared to 77% in 2019 ($n=17$) and this was not found to be statistically significant. This improvement is likely as a result of access to private sector theatre space during lockdown. When similar procedures are planned for theatres within the MTC, they are often subject to cancellation or delay in the event of new, life-threatening trauma presentations to the hospital. Like time until debridement, the timestamp of when definitive coverage should occur continues to be challenged.

Despite a similar pattern of G-A injuries, the ALOS within lockdown was 25% lower for all patients with oLLFs, and 45% lower for those with an isolated oLLF (not polytrauma patients). Again, it is likely that increased consultant presence for operating and key decision making (management plans and discharge dates) helped to lower this greatly, something which was requested by senior management and stipulated in revised guidance for orthopaedic teams [7].

Over both periods, FFs were only required for those with G-A IIIB injuries ($n=4$). Guidance to plastic surgeons for COVID-19 stated that 'alternative techniques [should be considered] for patients who require soft tissue reconstruction to avoid multiple operations or the need for critical care input'.⁵ Although the proportion of patients requiring flap reconstruction (local or free) was small, at no point did the team feel coverage choice was influenced by the need for a

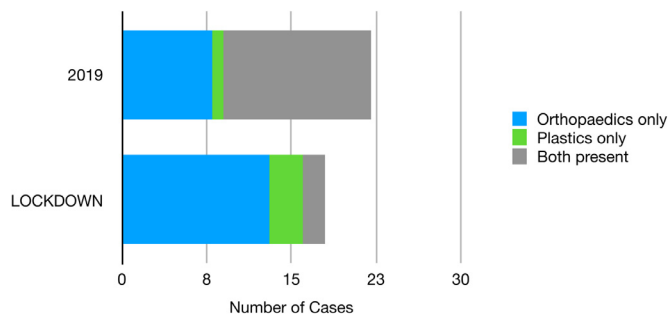


Fig. 3. Comparison of specialties present during cases in 2019 versus the lockdown period at initial debridement.

more 'simple' operation. Skin substitutes or dermal scaffolds were available in our MTC, however they were not deemed to be required.

Despite BOAST4 guidelines stipulating combined orthopaedics and plastics involvement at initial debridement, a large increase in independent operating was seen during lockdown, as highlighted in Fig. 3. This was most likely due to a combination of more senior-led orthopaedic operating and reduction in the total number of staff allowed in theatres at any one time. Consequently a greater proportion of simple direct closure cases were managed purely by orthopaedics during lockdown. Where plastics operated alone, this was for all G-A IIIB cases ($n = 3$), where greater soft tissue management was likely to be required from the outset - primary below-knee amputation, debridement of significant foot devolving with underlying mid-foot fracture (for k wire fixation) and where no orthopaedic involvement was necessary for fracture fixation (casting alone for a tibial fracture). Whilst independent operating likely increased frequency and speed of cases, we still do not advocate this as routine.

In summary, this study provides valuable information in terms of the epidemiology and management of oLLFs at a busy major trauma centre during the COVID-19 pandemic. Despite a significant drop in ED footfall, the number of oLLF patients presenting to our unit hardly decreased. RTAs were still the most common mechanism of injury despite almost a 50% reduction in traffic on the roads. A combination of breaking lockdown, speeding and greater risk taking has likely had an influence on the results seen. The lack of a significant difference in the management of these patients between cohorts has demonstrated that lower limb emergencies have remained a surgical priority and that staff have managed to utilise resources appropriately.

Conclusion

Major trauma still continues to require efficient treatment, even in times of a pandemic. Greater senior input has shown to be a necessity in order to help expedite oLLF management. It is important that any positive changes made throughout this time continue to be harnessed and built upon, with our unit continuing to explore the role of using NHS funded private operating lists for definitive soft tissue coverage.

Funding

None.

Ethics approval

Not required.

Declaration of Competing Interest

None.

References

- [1] M. Roberts, BBC. Coronavirus: UK daily death figure dips to lowest since day after lockdown. <https://www.bbc.co.uk/news/uk-52699483> (accessed 5 June 2020).
- [2] N. Triggle, BBC. Boris Johnson speech: PM unveils 'conditional plan' to reopen society. <https://www.bbc.co.uk/news/uk-52609952> (accessed 5 June 2020).
- [3] Court-Brown CM, Bugler KE, Clement ND, Duckworth AD, McQueen MM. The epidemiology of open fractures in adults. A 15-year review. *Injury* 2012;43:891–7.
- [4] Larsen P, Elsoe R, Hansen SH, Graven-Nielsen T, Laessoe U, Rasmussen S. Incidence and epidemiology of tibial shaft fractures. *Injury* 2015;46:746–50.
- [5] BOA. BOAST - Open Fractures. <https://www.boa.ac.uk/resources/boast-4-.pdf> (accessed 5 June 2020).
- [6] NHS. Clinical guide for the management of patients requiring plastics treatment during the Coronavirus pandemic. <https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/03/specialty-guide-management-of-patients-requiring-plastics-treatment-v1.pdf> (accessed 5 June 2020).
- [7] BOA. Management of patients with urgent orthopaedic conditions and trauma during the coronavirus pandemic. <https://www.boa.ac.uk/resources/covid-19-boasts-combined.html> (accessed 6 June 2020).
- [8] NHS. Clinical guide for the management of major trauma patients during the coronavirus pandemic. <https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/03/C0070-specialty-guide-major-trauma-clinical-guide-27-march-2020.pdf> (accessed 5 June 2020).
- [9] Giannoudis PV. Open fractures of the lower extremity. *Current insights into their management and clinical outcomes. EFORT Open Reviews* 2018;3(5).
- [10] J. Parkinson, BBC. Coronavirus: Traffic 'reaching early 1970s levels'. <https://www.bbc.co.uk/news/uk-52461913> (accessed 6 June 2020).
- [11] BBC. Huge increase in speeding drivers during London lockdown. <https://www.bbc.co.uk/news/uk-england-53215121> (accessed 29 June 2020).
- [12] S. Volpe, Ham & High. Coronavirus speeding warning: Top cop says dangerous drivers are putting key workers' lives at risk as Met appeals for help over serious incidents. <https://www.hamhigh.co.uk/news/health/coronavirus-has-seen-speeding-rise-warns-top-london-traffic-cop-1-6602519> (accessed 29 June 2020).
- [13] H. Kumpula, M. Paavola. Injuries and risk-taking among young people in Europe - The European Situation analysis (September 2008). <https://www.eurosafe.eu.com/uploads/inline-files/Adrisk%20European%20Situation%20Analysis%20080716%20.pdf> (accessed 9 June 2020).
- [14] BRAKE. Driver gender. <https://www.brake.org.uk/facts-resources/1593-driver-gender> (accessed 9 June 2020).
- [15] Fancourt D, Bu F, Mak HW, Steptoe A. COVID-19 Social Study. Results Release 2020;8. https://b6bdcb03-332c-4ff9-8b9d-28f9c957493a.filesusr.com/ugd/3d9db5_1806a0f44fc145bfae64ab7567413bff.pdf.
- [16] BBC. Coronavirus: Young people are not 'invincible', WHO warns. <https://www.bbc.co.uk/news/world-51982495> (accessed 9 June 2020).
- [17] M. Iqbal. Deliveroo Revenue and Usage Statistics (2020) <https://www.businessofapps.com/data/deliveroo-statistics/> (accessed 9 June 2020).
- [18] J. Clark. Just Eat Takeaway orders soar 50 per cent amid coronavirus lockdown. <https://www.cityam.com/just-eat-takeaway-orders-soar-50-per-cent-amid-coronavirus-lockdown/> (accessed 9 June 2020).
- [19] Gunnell D, Appleby L, Arensman E, Hawton K, John A, Kapur N, et al. Suicide risk and prevention during the COVID-19 pandemic. *The Lancet Psychiatry* 2020;7(6):468–71.