ORIGINAL ARTICLE

UDC: 616-001-083.98::617.576
DOI: https://doi.org/10.2298/VSP200308035N

Evaluation of hand injury management at the emergency department – are we getting better?

Zbrinjavanje povreda šake u urgentnom centru – da li napredujemo?

Jelena Nikolić*†, Marija Marinković*†, Dragana Leković†, Isidora Djozić†

***University of Novi Sad, Faculty of Medicine, Novi Sad, Serbia; †University Clinical Center of Vojvodina, Clinic for Plastic and Reconstructive Surgery, Novi Sad, Serbia**

Abstract

Background/Aim. Hand injuries are one of the most common injuries seen in emergency departments. Inadequate treatment can lead to prolonged healing, complications, significant morbidity, and serious disability. The aim of this study was to evaluate the epidemiology, risk factors, and treatment of hand injuries in one tertiary care level clinical center. **Methods.** This study was designed as a descriptive retrospective epidemiological study that involved all patients with hand injuries treated at the University Clinical Center of Vojvodina, Novi Sad, Serbia for seven years. The authors collected sociodemographic and clinical data such as age, gender, mechanism of injury, type of injury, days of hospitalization, type of defect reconstruction, the time of injury, the timing of surgery, and reasons for operative treatment delay. For every hospitalized patient the Modified Hand Injury Severity Score (MHISS) was calculated. All data were analyzed using SPSS IBM 21.0 software. **Results.** From 2012 to 2018, 34,796 patients were treated for hand injury at the University Clinical Center of Vojvodina, with 554 (1.6%) hospitalized patients. The mean age of patients was 43.2 years; the majority of them (87.55%) were men, and most (47.2%) were injured at home. Most injuries occurred during knife handling. The average length of stay for hospitalized patients was 4 days. MHISS score for most patients was over 50 and was classified as severe. It was noticed that the waiting time for operation became shorter throughout the selected years. **Conclusion**. Hand injuries present a complex problem that can sometimes be underestimated by patients. The requirement of highly specialized hand surgeons, sometimes special equipment (e.g., microscope), multiple operations, prolonged rehabilitation, possible invalidity, and high cost of treatment calls for careful evaluation of the problem and the development of proper strategies in order to be able to lower the costs and obtain better medical care for all people with higher injury risk.

Key words:
emergency service, hospital; hand injuries; reconstructive surgical procedures; risk factors; trauma severity indices; treatment outcome.

Apstrakt

Uvod/Cilj. Povrede šake spadaju među najčešće povrede koje se sreću u urgentnim centrima širom sveta. Neadekvatno lečenje može dovesti do produženog zarastanja, komplikacija, značajnog morbiditeta i invaliditeta. Cilj rada bio je da se sagledaju epidemiologija, faktori rizika i tretman povreda šake u jednom tercijarnom kliničkom centru. **Metode.** Studija je dizajnirana kao deskriptivna retorspektivna epidemiološka studija koja je obuhvatila sve pacijente sa povredama šake lečene u Univerzitetskom kliničkom centru Vojvodine u Novom Sadu, Srbija u sedmogodišnjem periodu. Analizirani su opšti sociodemografski i klinički podaci: starost, pol, mehanizam povrede, tip povrede, dužina hospitalizacije, način rekonstrukcije defekta, vreme povrede, dužina čekanja na operativno zbrinjavanje i razlozi za odlaganje operativne intervencije. Za svaku povredu lečenu u hospitalnim uslovima izračunat je modifikovan skor za procenu težine povrede šake (MHISS). U obradi podataka korišćen je softverski paket SPSS IBM 21.0. **Rezultati.** U analiziranom periodu (2012.–2018. godine) tretirano je 34 796 pacijenata sa povredama šake, od kojih je hospitalizovano 554 (1,6%) pacijenata. Prosečna starost hospitalizovanih povređenih pacijenata bila je 43,2 godine; 87,55% pacijenta činili su muškarci, a povrede su većinom (47,2%) nastale u kućnim uslovima. Najčešći uzrok povreda bilo je rukovanje oštricom noža. Prosečna dužina hospitalizacije iznosila je 4 dana. Vrednost MHISS kod većine je iznosila preko 50, što se klasifikuje kao teška povreda. Uočen je trend smanjenja dužine čekanja na operativno lečenje tokom posmatranih godina. **Zaključak.** Povrede šake predstavljaju kompleksan problem koji pacijenti nekada potcenjuju. Potreba za hirurzima visoko specijalizovanim za šaku i, ponekad, specifičnom opremom (npr. mikroskop), višestruke operativne intervencije, dugotrajna rehabilitacija, potencijalni invaliditet i visoki troškovi lečenja ukazuju na po

Correspondence to: Jelena Nikolić, University of Novi Sad, Faculty of Medicine, University Clinical Center of Vojvodina, Clinic for Plastic and Reconstructive Surgery, Hajduk Veljkova 1–9, 21 000, Novi Sad, Serbia. E- mail: JELENA.NIKOLIC@mf.uns.ac.rs

trebu da se ovaj problem pažljivo proceni i kreira adekvatna strategija kako bi se smanjili ukupni troškovi i pružio bolji tretman osobama izloženim većem riziku od povrede.

Ključne reči:
hitna služba, bolnica; šaka, povrede; hirurgija, rekonstruktivna, procedure; faktori rizika; povrede, indeksi težine; lečenje, ishod.

Introduction

Hand injuries are one of the most common injuries seen in emergency departments (EDs). As almost every human activity involves hands, they are the most exposed part of the body and thus are often prone to different kinds of injuries such as lacerations, cuts, crush injuries, amputations, sprains, infections, fractures, burns, etc. Most hand injuries are minor and usually heal without problems. People are used to getting small burns while cooking, cuts while working, or being scratched while playing with animals, so one may often underestimate the level of injury and try to solve problems with inadequate home remedies or improvised treatment in a nonsterile environment. Postponed or inadequate treatment can lead to prolonged healing, complications, long-term morbidity, and even serious disability. As in leisure and home activities, occupational hand injuries contribute significantly to the total count of injuries [1].

It is estimated that between 16% to 30% of all emergency visits occur due to hand injuries in the USA [1]. The United States Bureau of Labor Statistics reported that hand injuries are the second most common injury resulting in days away from work (DAFW). Incidence rates for non-fatal hand injuries involving DAFW per 10,000 full-time workers for 2018 in the USA report the highest rates for the upper arm in total (28.6/10,000 workers) and 12.3/10,000 workers just for hand [2]. In the national statistical analysis for occupational injuries in the Republic of Serbia, the upper arm was the most often (46.64%) affected part of the body, with fingers being injured in 18.41% of all cases [3]. Finger injuries were also the most frequent (38.4%) injuries of upper extremities observed in EDs in the USA, as published by Ootes et al. [4] in a broad epidemiological study that involved 92,601 patients. The same study estimated that the average USA resident had a 1 in 88 chance of presenting in ED with upper arm injury during their lifetime.

Among many hazardous occupations, according to statistics from the USA, crop harvesting with machinery (106.4/10,000 workers) and working with narrow fabric mills (112.9/10,000 workers) are considered the most dangerous jobs [2]. This is taken as a very important risk factor at work, as the region of Vojvodina is a typical agricultural area with many workers employed in such a risky occupational environment. These injuries are often highly mutilating and involve multiple finger amputations and defects of vital neurovascular structures, leaving limited surgical options for reconstruction (Figures 1 and 2).

The aim of this study was to get a closer insight into the treatment of hand injuries at the University Clinical Center of Vojvodina, Novi Sad, Serbia, a tertiary care level center, and to present epidemiological data on hand injuries in previous years in order to analyze potential risk factors that could lead to injury. Another aim was to evaluate medical treatment strategies that patients received upon ED admission so that targeted strategies for prevention, risk management, and better medical treatment can be suggested. Creating public health initiatives based on the national injury registry could allow professionals to target current problems and thus better allocate limited resources.

Methods

This study was designed as a descriptive retrospective epidemiological study that included patients treated for hand injury at the ED of the University Clinical Center of Vojvodina for seven years (2012–2018). All data was obtained from medical documentation and the local electronic database. Authors collected sociodemographic and clinical data such as age, gender, education level, qualification for the job that led to injury, mechanism of injury, type of injury, days of hospitalization, type of defect reconstruction/treatment, timing of injury, waiting time in ED, timing of the operation,

Fig. 1 – Hand injury caused by corn harvester.

Fig. 2 – Hand injury in agriculture.

perceived cause of the occupational injury, and reasons for operative treatment delay. Following factors were noted as the reasons for operative treatment delay: alcohol abuse, the time elapsed from last food intake, preoperative evaluation of the patient (diagnostic procedures and therapy), bad general health condition or other injuries that postponed operation, operating room (OR) availability, and disposal of specialist medical staff. For every patient, the Modified Hand Injury Severity Score (MHISS) was calculated. All data were analyzed using SPSS 21.0 (IBM Corp. Armonk, NY, USA). For numerical and categorical variables, mean and standard variation were calculated with descriptive analysis and was displayed as such in various graphical manners.

Results

This study included 34,796 patients with hand injuries treated at the University Clinical Center of Vojvodina during the 2012–2018 time period, with 554 (1.6%) hospitalized for treatment. The average mean age of hospitalized cluster was 43.2 [standard deviation (SD) ± 15.58] years. Most of the patients were men, 485 (87.55%), while there were just 69 women (12.45%). Among them, 51% of injuries occurred at home, 15.7% at off-duty work, 14% at on-duty work, 13% in road traffic accidents, and 6.3% during leisure activities.

Injuries that occurred as work-occupational hand injuries (77; 13.9%) were also independently analyzed. The mean age of the patients injured while working was 40.92 ± 15.03 years. The trend of incidence of such injuries is shown in Figure 3.

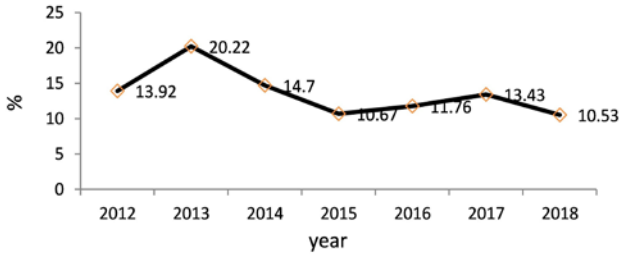

Fig. 3 – Yearly incidence of work-occupational injuries.

As a perceived cause of injury that occurred at work, patients specified the following causes: not being well (6; 7.7%), working faster than usual due to time restraints (29; 37.67%), not being experienced (first time doing something) (6; 7.8%), working overtime (12; 15.6%), not being familiar with the equipment (11; 14.29%), faulty equipment (6; 7.8%), injury caused by other person's actions (4; 5.2%), and being distracted (3; 3.9%).

Most of the patients who were required to wear safety gloves at work according to safety standards did wear protective gloves during injury (40/61; 65.57%).

Most injuries occurred while handling sharp items such as knife blades. The distribution of mechanisms of hand injuries/tools is shown in Figure 4.

The average length of stay in the hospital after a hand injury in a hospitalized group of patients was 4.07 days. Figure 5 presents the length of hospital stay for various mechanisms/tools of injury.

For all hospitalized patients, MHISS was calculated and compared with the mechanism/tool of injury as presented in Figure 6. All patients, according to MHISS, had severe hand injuries, but for groups with glass and blunt injuries, the injuries were categorized as moderate.

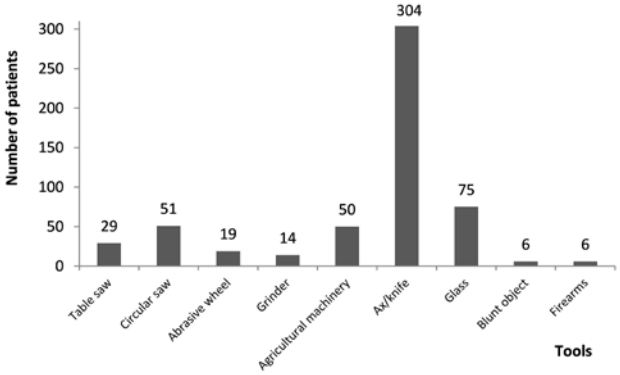

Fig. 4 – Distribution of injury mechanisms/tools.

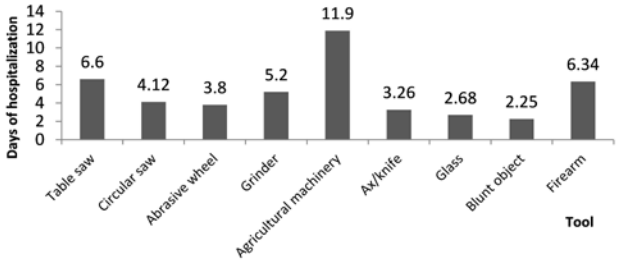

Fig. 5 – Length of hospitalization for every mechanism/tool of injury.

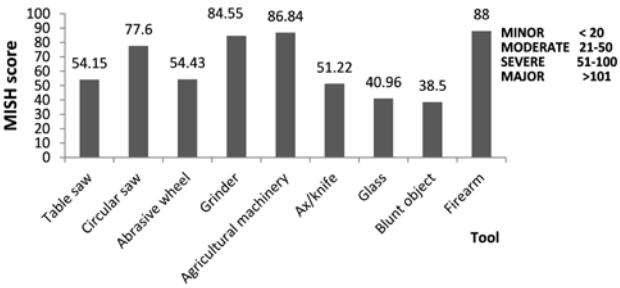

Fig. 6 – Modified Hand Injury Severity Score (MHISS) in correlation with mechanism/tool of injury.

Amputation of one or more fingers was seen in every mechanism/tool of the injury group but blunt, glass and firearm groups. Injuries with circular saw and agricultural machinery had the highest percentages of amputation risk (Figure 7).

All reconstructive techniques were used in the closure of defects after hand injury: direct suture (347.81%), skin graft (32.7%), skin flaps (8.2%), amputation (26.6%), amputation and skin graft (13.3%), amputation and skin flap (4.1%).

The average time from injury to arrival at the University Clinical Center of Vojvodina was 2.5 hours. The data was obtained from patients recalling the time of injury, so it has

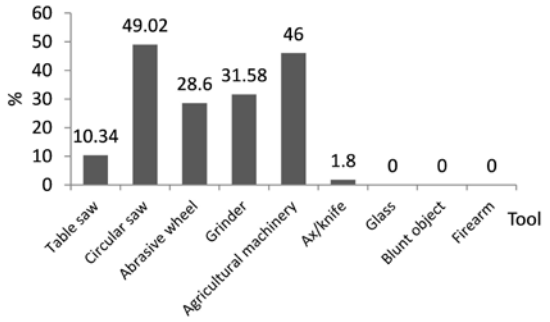

Fig. 7 – Presence of amputation of one or more digits in different mechanisms/tools of injury.

to be taken with caution. Most often, patients reported the following reasons for the delay of arrival at the University Clinical Center of Vojvodina: initial referral to a secondary level hospital, waiting for transportation, underestimating the need for surgical treatment, or being injured far away from the referral center. As reasons for the delay of surgical treatment after arrival to the ED, two group-related causes were identified: patient-related (consumption of alcohol, prior food intake, arrival after midnight, comorbidities, need for additional diagnostic procedures, associated injuries that required delay of surgical treatment), and hospital related (occupancy of OR or surgeon). The yearly distribution of cause-related delay by groups is shown in Figure 8.

A yearly decreasing trend in waiting time between arrival to the ED and operative treatment was observed (Figure 9).

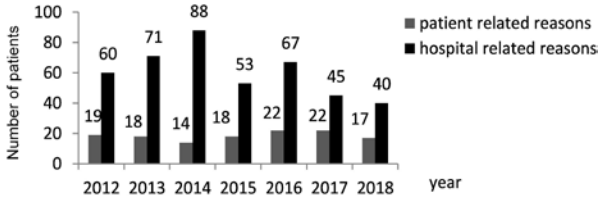

Fig. 8 – Reasons for the delay of operative treatment.

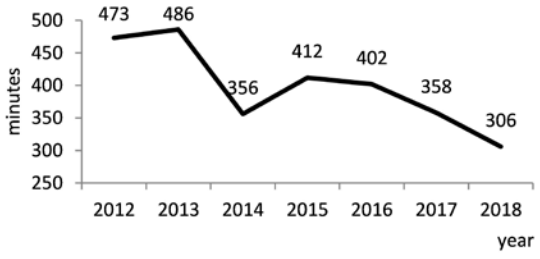

Fig. 9 – Yearly trend of waiting time between emergency department arrival and operative treatment.

In general cluster, most of the patients were injured during day shifts; 6–12 hrs (180; 32.49%), 12–18 hrs (184; 33.21%), 18–24 hrs (131; 23.65%), 24–06 hrs (59; 10.65%).

Special attention was paid to the reasons for patient-related operative treatment delay, such as alcohol abuse, as one of the preventable factors. It was present in 11% of the entire cluster, and 40% of patients who abused alcohol had arrived after midnight. Daily quartered distribution of patients who abused alcohol upon admission was as follows: 40.91% in 24–06 hrs time interval, 21.15% in 18–24 hrs, 3.68% in 12–18 hrs, and 2.74% in 6–12 hrs time interval.

The average elapsed time while waiting from arrival to operative intervention in 2018 was 5 hours. Factors that emerged as risk factors for longer waiting were the time of arrival, age of the patient, need for more than one specialist, occupancy of ORs, and need for additional diagnostic procedures.

Discussion

Hand injuries often present a multilevel impact on society in general. Costs of medical treatment, rehabilitation, absence from work, health insurance reimbursements, and costs of prequalification are just some of the problems that have to be taken into consideration.

Our study reveals that just 1.6% of all patients who suffered hand injuries and were referred to the ED required hospitalization. One must acknowledge that this does not mean that injuries managed under local or regional anesthesia in the outpatient department did not result in invalidity or produce considerable final costs. In our study, we focused on patients whose injuries required hospitalization. All of them, according to the MHISS score, were classified as severe (MHISS > 50) or moderate (MHISS 21–50), as represented in Figure 6. Most of the injured patients were men (70–92% depending on the calendar year examined), fully capable of working, and around 40 years old (43.20; SD ± 15.58). Larsen et al. [5] presented results similar to ours, where most of the injured were males, with females being dominant only in the group of assault victims older than 65. They also found that 1 out of every 55 Dutch and 1 out of every 28 Danish people presented to ED with hand injuries, thus confirming the importance of adequate management and good primary surgical treatment of these injuries. In our study, men were dominant in all age groups. In the group of patients older than 65, women presented just 9.2% of the entire cluster.

It is also interesting to analyze occupational hand injuries presented in different studies. Occupational acute hand injuries were responsible for 13.9% of all hand injuries in our sample of patients. The average age of those patients was 40.92 ± 15.03 years which is significantly higher than the data presented in a review article by Sorock et al. [6], where young workers under 24 years of age were at the highest risk of hand trauma. This significantly younger age of injured compared with other groups of patients with hand injuries could be attributed to a lack of experience in work or underestimation of the importance of safety measures. This was confirmed in a multicenter study on occupational hand injuries by Wu et al. [7] in Foshan, PR China. The study included 2,186 patients, with most injuries occurring due to occupational hazards. The patients were mostly young men that lacked safety training. This makes young men an especially vulnerable group that has to be addressed in security briefings and education plans made by occupational management. Our study showed no significant age difference between the

people injured at work, at home, or in other activities, but most of our patients with occupational hand injuries also confirmed not having any special safety training. One can safely assume that the working population in Serbia is exposed to more difficult working conditions than in the USA, meaning that risk factors should differ. Authors cannot overrate working conditions in Serbia, where older machinery, sometimes outdated technology, and the economic situation pushes people to work longer hours or more jobs simultaneously. When asked about circumstances leading to injury, it was interesting to see that patients mentioned the perceived reasons as the most important for injury occurring. Most of them, 37.67%, said they were in a hurry to finish the job or that they were working overtime (15.6%). In the Wu et al. [7] study, distraction was most often seen as patients' idea of the injury cause. Authors cannot claim that it was a lack of experience in our sample, as most of the injured were over 40 years old, but it looks like people in Vojvodina underestimate the importance of safety measures and standards which, in combination with outdated machinery, puts them at higher risk for accidents. Close studies of these patients and analysis of circumstances before the moment of injury could provide useful information for National Health Service and labor departments and consecutively lead to the creation of targeted strategies that would make a safer working environment.

Usually, in the region of Vojvodina, most severe injuries happened due to hand or finger conquassation, which occurred in the agricultural industry while working with heavy types of machinery such as corn snappers or harvesters (Figures 1 and 2). Those injuries are characterized by "T triad" as in excess Time until treatment, Thresh/wound contamination, and big Trauma and often require more operative procedures, have more complications, and longer hospitalization in general [8, 9]. In this study, patients injured by agricultural machinery had the longest hospitalization, an average of 11.9 days, which is significantly longer than the average of 4 days for all injury mechanisms in general.

As this survey reveals, men are often injured while working at home with circular saw and table saw as part of their do-it-yourself (DIY) activity. Women are also more likely to suffer an injury at home but usually suffer minor cuts, small burns, and lacerations that can be treated without hospital admission. Working during off hours is also a category presented as a place/circumstance of injury (15.7%). As seen in previous studies, illegal or off-license work often puts workers in a position to work without proper protection, in unsafe conditions, with prolonged working hours, and without adequate training and education for that particular job. All of these factors are known to facilitate the occurrence of injuries.

A wide palette of reconstructive procedures (skin graft, local flaps, direct sutures, amputations) is being done in order to treat hand injuries adequately. Most of the hospitalized patients had good skin coverage that did not require skin grafts or skin flaps in order to close the wound, but despite that had to be hospitalized as complex reconstructions of tendons, nerves, and bone fractures are usually done in general anesthesia.

The golden standard/window for wound closure is within 6 hrs from the moment of injury. This means that the best results and the lowest risk of infection can be expected if primary wound care is done in the above-mentioned time window. In practice, it is very difficult to arrange all the necessary stages of treatment in such a short period, especially if a large area of one medical center is the referral hospital for a vast area of the region. Many factors contribute to operative treatment delay. In our study, patients needed an average of 2.5 hours just to arrive at the ED. This data is uncertain as patients were recalling the time of injury and were sometimes unsure about it. The average waiting time in ED for operative treatment in these seven years was 6 hrs and 39 min, but this time is getting significantly shorter throughout the years, which suggests that changes made in organizational structure have been giving good results. Shorter time from admission to definite treatment and, thus, improved medical care was achieved by the better organization of the triage system, employment of more specialists in the ED, implementation of a new information system that covers all patient steps through ED service, and, for sure, by a continuous struggle to continuously educate doctors and nurses. In 2018, last year analyzed, the time to definite treatment was around 5 hrs which is considered very good compared with more developed countries. This is a common problem seen in all EDs worldwide. ED setting is specific and complex. Numerous attempts have been made to improve ED care services around the world [10–12]. Reviewing literature that addresses this issue, the authors came across many models that have been proposed in different ED settings: various systems of patient grouping (Emergency Severity Index Triage System – ESI, tree-level triage evaluation system, etc.), "fast track" models, senior doctor assessment at triage instead of nurse triage model, are only some of the possible solutions to a problem in which one may achieve better results within available resources [10, 13]. Ajami et al. [14] presented results that demonstrate that in recent years patient waiting time in the ED has increased in many countries, mostly due to the rising number of patient referrals to EDs. The same study found that waiting time for medical examination in EDs in England was increased to 4 hrs, and in Canada to 2 hrs. We have to keep in mind that this is just waiting time for medical examination with more elapsed time when adding time from arrival to ED to surgical intervention. Horwitz et al. [15] revealed that fewer than half of the hospital centers in their study, which included 364 non-federal US hospital EDs, admitted their ED patients within 6 hours. Besides a higher inflow of patients, there is also a problem of inexperienced interns, residents, and young specialists who have multi-tasks in several places, different wards, operation theaters, triage rooms, etc. Treating more than one patient at the same time is difficult and requires more experience. Lack of experience in the decision-making process can lead to requesting more investigations and tests in order to make a decision and prolonging the waiting time before operative treatment. The University Clinical Center of Vojvodina is the only tertiary health center and University Hospital in the whole province of Vojvodina. This means that, on a daily basis, 1.5 million people are ori-

ented to this Center in case of complex hand injuries, as most of the hospitals in the region do not have plastic/reconstructive surgeons available on call. Complex hand injuries sometimes require the teamwork of more surgeons like neurosurgeons, orthopedic and vascular surgeons, and others that have to be available at the same time for the same surgical procedure. The reasons for the late onset of surgical interventions are the following: time of arrival, severe comorbidities usually associated with an aging population, need for more than one specialist, consumption of alcohol or food before arrival to the hospital, occupancy of ORs or surgeons, need for additional diagnostic procedures and other associated injuries that required delay. In most cases (78.84%), occupancy of the OR or surgeon was the reason for intervention delay. In the previous years, a higher number of road traffic accidents, usage of more powerful machinery, industrial environment, easy access to alcohol, increasing violence on the street, and immense workload on trauma centers both locally and worldwide all led to prolonged waiting times. It is most important to shorten the time from injury to arrival in ED, as upon arrival, primary wound care is done, with wounds temporarily dressed in sterile conditions. While waiting for intervention, preoperative antibiotics, pain therapy, and, if needed, blood transfusion is administered. This means that patient is under constant medical supervision. As it was already underlined, loss of time before surgery is a big problem in cases such as injuries in agriculture, which are unfortunately often the most violent ones, as an injured patient is somewhere in the field, far from the nearest local ambulance, and usually alone. Those people take more time to reach the hospital and medical help than the people working near regional health centers or those at home. Besides direct costs of medical treatment and time of work absence, one has to keep in mind that permanent disability often requires prequalification or even early retirement, so these injuries may impose a significant burden on society, as presented in de Putter et al. [16] study. The economic impact of hand injuries is substantial, so prevention strategies should be created and targeted at the most expensive injuries in order to control and lower resource spending. Proper epidemiological analysis of injuries in ED should provide directions for training priorities for the medical crew.

The limitation of this study is certainly the inclusion of patients from a single center. Even though the University Clinical Center of Vojvodina is the largest hospital in the region and is the only tertiary level center in Vojvodina, hand injuries are also treated in local hospitals within 100 kilometers' reach. Problems that are dominant in those health centers could be different and, at the same time, interesting for evaluation. Another limitation is patient-related: false data recalling, such as time of injury or concealing the truth (usually concerning the place and circumstances of the injury, use of protective gloves, etc.). Occupational injuries are usually followed by insurance company compensations and employment problems, so injured employee tends to be under pressure, not to mention the circumstances of the injury, and thus give false information to medical staff.

Conclusion

Hand injuries present a complex problem that is sometimes underestimated by both patients and general practitioners, usually regarded as something unimportant and easily treatable. Need for highly specialized surgeons (plastic, orthopedic, vascular, or hand surgeons where available), sometimes special equipment (e.g., microscopes), multiple operations, prolonged rehabilitation, possible invalidity, and high costs of treatment are putting this medical problem at the pinnacle of our attention. A more comprehensive and detailed study could give us better insight into this problem and allow us to draw more relevant conclusions. One can argue that different medical care levels (primary/secondary/tertiary) have different dominant problems and thus require individual approaches and special logistic plans for health care improvement. Additionally, closer insight into the circumstances of occupational hand injuries can result in a better approach to safety management and further safety training for specific work-related risks.

REFERENCES

1. *Murphy GR, Gardiner MD, Glass GE, Kreis IA, Jain A, Hettiaratchy S*. Meta-analysis of antibiotics for simple hand injuries requiring surgery. Br J Surg 2016; 103(5): 487–92.
2. U.S. Department of Labor, Bureau of Labor Statistics. Survey of Occupational Injuries and Illnesses. 2018. Available from: https://www.bls.gov/iif/oshwc/osh/case/cd_r6_2018.htm [accessed on 2020 March 7].
3. The Republic of Serbia, Ministry of Labour, Employment, veteran and social affairs, The Administration for the Safety and Health at Work report for 2017. Available from: https://www.minrzs.gov.rs/sites/default/files/2018-11/izvestaj_o_radu_uprave_za_2017.pdf [accessed on 2020 March 7]. (Serbian)
4. *Ootes D, Lambers KT, Ring DC*. The Epidemiology of Upper Extremity Injuries Presenting to the Emergency Department in the United States. Hand (N Y) 2012; 7(1): 18–22.
5. *Larsen CF*, *Mulder S*, *Johansen AM*, *Stam C*. The epidemiology of hand injuries in The Netherlands and Denmark. Eur J Epidemiol 2004; 19(4): 323–7.
6. *Sorock GS, Lombardi DA, Courtney TK, Cotnam JP, Mittleman MA*. Epidemiology of occupational acute traumatic hand injuries: a literature review. Saf Sci 2001; 38(3): 241–56.
7. *Wu Z, Guo Y, Gao J, Zhou J, Li S, Wang Z*, et al. The epidemiology of acute occupational hand injuries treated in emergency departments in Foshan City, South China. Ulus Travma Acil Cerrahi Derg 2018; 24(4): 303–10.
8. *Nikolić J, Janjić Z*. Burn injuries in agriculture. Trakt i pog maš 2009; 14(4): 122–8.
9. *Nikolić J, Janjić Z*. Specifities of hand trauma in agriculture. Vojnosanit Pregl 2009; 66(10): 802–6. (Serbian)
10. *Ashour OM, Okudan Kremer GE*. Dynamic patient grouping and prioritization: a new approach to emergency department flow improvement. Health Care Manag Sci 2016; 19(2): 192–205.
11. *Ortíz-Barrios MA, Alfaro-Saíz JJ*. Methodological Approaches to Support Process Improvement in Emergency Departments: A Systematic Review. Int J Environ Res Public Health 2020; 17(8): 2664.

12. *Kaushal A, Zhao Y, Peng Q, Strome T, Weldon E, Zhang M,* et al. Evaluation of fast track strategies using agent-based simulation modeling to reduce waiting time in a hospital emergency department. Soc Econ Plann Sci 2015; 50: 18–31
13. *Abdulwahid MA*, *Booth A*, *Kuczawski M*, *Mason SM*. The impact of senior doctor assessment at triage on emergency department performance measures: systematic review and meta-analysis of comparative studies. Emerg Med J 2016; 33(7): 504–13.
14. *Ajami S, Ketabi S, Yarmohammadian MH, Bagherian H*. Wait Time in Emergency Department (ED) Process. Med Arh 2012; 66(1): 53–7.
15. *Horwitz LI, Green J, Bradley EH*. US emergency department performance on wait time and length of visit. Ann Emerg Med 2010; 55(2): 133–41.
16. *de Putter CE*, *Selles RW*, *Polinder S*, *Panneman MJ*, *Hovius SE*, *van Beeck EF*. Economic impact of hand and wrist injuries: healthcare costs and productivity costs in a population-based study. J Bone Joint Surg Am 2012; 94(9): e56.

Received on March 8, 2020
Revised on February 13, 2021
Accepted on March 29, 2021
Online First April 2021