BMJ Open

Nationwide population-based study of poisoning-induced out-of-hospital cardiac arrest in South Korea

Gihun Park, Chiwon Ahn, Jae Hwan Kim

ABSTRACT

Objective To evaluate the characteristics of poisoning-induced out-of-hospital cardiac arrest (pOHCA) and the factors influencing survival to discharge and good neurological outcomes using a nationwide, population-based database.

Design Nationwide, retrospective, population-based cohort study.

Setting and participants This study included adult patients who had experienced pOHCA and those who had not (non-pOHCA patients) in South Korea from January 2008 to December 2018.

Outcome measures The primary outcome was survival to discharge, and the secondary outcome was a good neurological outcome.

Methods The basic characteristics of pOHCA and non-pOHCA patients were analysed by descriptive analysis. Logistic regression analysis was conducted for related variables, including pOHCA.

Results A total of 173,190 patients were included, and 3,582 patients (2.1%) were in the pOHCA group. Some of the pOHCA patients were young (56.2±17.8 vs 69.0±15.5, p<0.001), a few of their cardiac arrests were witnessed (12.8% vs 45.1%, p<0.001), a few were resuscitated by bystanders (8.2% vs 14.8%, p<0.001) and they had low shockable rhythm rates (1.2% vs 8.8%, p<0.001). They showed significantly lower survival to discharge and poorer neurological outcomes than non-pOHCA patients (survival to discharge, 3.7% vs 6.2%, p<0.001; good neurological outcomes, 1.3% vs 3.2%, p<0.001). There were no significant differences between pOHCA and non-pOHCA patients in terms of the adjusted OR for survival to discharge (adjusted OR 0.608; 95% CI 0.86 to 1.27) and good neurological outcomes (adjusted OR 1.03; 95% CI 0.73 to 1.42).

Conclusion This study shows that apparent aetiology of OHCA caused by poison, did not influence survival to discharge and good neurological outcomes. Furthermore, pOHCA occurs in younger patients and has fewer witnesses and shockable rhythms. pOHCA did not influence survival to discharge and good neurological outcomes. Also, pesticides and gases were the most frequent substances causing pOHCA in South Korea.

INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) is a major public health issue. OHCAs include both cardiac and noncardiac cause arrests, and non-cardiac cause arrests are characterised by young age and a low incidence of ventricular arrhythmia. There are various causes of non-ventricular arrhythmias, but poisoning-induced OHCA (pOHCA) is a global public health issue, resulting in more than 1000 deaths every year. Claesson et al reported that 5.9% of all non-medical aetiological cardiac arrests in Sweden were pOHCA; Orkin et al reported the rate was 13.8% in Ontario, Canada and Kim et al showed that 6.7% of emergency medical services (EMS)-treated OHCAs in South Korea were due to poison exposure.

The generally known characteristics of pOHCA are similar to those of noncardiac cause OHCA, but pOHCA occur in younger people, have lower shockable rhythm rates and have fewer witnesses. Lower shockable rhythm rates and fewer witnesses are associated with lower OHCA survival rates. However, the pathophysiological mechanism of d-pOHCA is different from that of a cardiac cause arrest. Despite these differences, similar or better outcomes were observed for some cases of pOHCA.

Another reason for lower pOHCA survival rates could be differences in the poisoning agents causing the arrests. Opioid and...
cocaine poisoning account for 70% of pOHCA deaths in the USA. However, in some countries, this percentage is significantly lower. A previous study showed that the rate of pOHCA deaths caused by opioid and cocaine poisoning in South Korea was 1/18th that of the USA. In contrast, Kim et al reported a high mortality rate from gases and pesticides among EMS-treated OHCAs in South Korea.

In this study, we analysed the expanded population of pOHCA patients and compared them with the non-pOHCA population based on a nationwide, population-based database of 11 years in South Korea. In addition, we evaluated the factors affecting outcomes, including poison exposure.

**METHODS**

**Study design, setting and data source**

This study was a retrospective observational study that evaluated the characteristics of pOHCA patients and prognostic factors associated with survival to discharge and good neurological outcomes from January 2008 to December 2018 using the nationwide, population-based database Out-of-Hospital Cardiac Arrest Surveillance (OHCAS) (managed by the Korea Disease Control and Prevention Agency (https://www.kdca.go.kr/)). The database includes all acute cardiac arrest patients transferred to medical institutions via EMS, which is around 30,000 patients per year.

In South Korea, the government-based public EMS operates 24 hours a day, 365 days a year and is operated through 19 fire headquarters nationwide by the National Fire Agency. When an OHCA occurs, an ambulance is dispatched to where the arrest occurred in response to a phone call, and the patient is transferred to a hospital. Paramedics provide cardiopulmonary resuscitation (CPR) using an automatic external defibrillator before transport to the hospital. CPR can be stopped, or advanced airway techniques can be provided under the supervision of a physician, but poisons for advanced life support (ACLS) cannot be used. At handover to the hospital, any substances related to the poisoning found at the scene and any corresponding information are transmitted. Treatments for resuscitation at the hospital and after the return of spontaneous circulation (ROSC) are performed according to each hospital’s protocol.

OHCAS uses data based on patient information extracted from the EMS data registry and hospital medical records. KCDA medical record reviewers visit medical institutions to investigate arrest patients’ medical records in relation to treatments and outcomes and to check items according to the Utstein Style and the Resuscitation Outcomes Consortium Project. The database consists of individuals and settings, EMSs, care received in the emergency department, hospital procedures and the outcomes at discharge, including survival to discharge and neurological outcomes, using a customised survey form.

Study population and poisoning group pOHCA patients were defined as patients whose causes of cardiac arrest had been marked as poisoning in the database. The major poisoning agents were classified into 10 types in the database, and each item was recategorised into five groups using the method of classification described previously. Group 1 included non-opioid analgesics and antipyretics; antiepileptic, sedative–hypnotic, anti-Parkinsonism and psychotropic drugs; narcotics and hallucinogens; other...
drugs acting on the autonomic nervous system; and other unspecified drugs, medicaments and biological substances. Group 2 included other gases and vapours. Group 3 included pesticides. Group 4 included organic solvents and halogenated hydrocarbons and their vapours/alcohol. Group 5 included other unspecified chemicals and noxious substances. We excluded patients aged <18 years old, those with do-not-resuscitate orders, those who experienced traumatic cardiac arrests, those with invalid prehospital data and those with unknown final outcomes.

**Variables**

Several variables were collected, including age, gender, place of arrest (public, private or in the ambulance), region (metropolitan, urban or rural), whether the arrest was witnessed, whether bystander CPR was performed, whether rhythms were initially monitored in the prehospital interval (non-shockable vs shockable), time from arrest to hospital arrival and prehospital and in-hospital ROSC. A shockable rhythm was defined as an initial rhythm identified as pulseless ventricular tachycardia or ventricular fibrillation.

**Outcome measures**

The primary outcome of this study was survival to discharge, which was defined as the normal discharge of the patient or transfer to another medical facility for long-term treatment after acute treatment. The secondary outcome was a good neurological outcome. The neurological outcomes were categorised by the Cerebral Performance Category (CPC) score. Good neurological outcomes were defined as CPC scores of 1 and 2.

**Statistical analyses**

The data were analysed using Excel 2016 (Microsoft, Redmond, Washington, USA) and the R program (V.4.1.1, The R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics were applied to describe the baseline characteristics. For continuous variables, values are shown as means±SDs. Normally distributed variables were analysed using the Student’s t-test between groups. For categorical variables, data are expressed as frequencies and percentages. The χ² test or Fisher’s exact test was used to analyse categorical variables using contingency tables. In addition, the ORs for each group for each outcome were obtained and compared within the pOHCA group.

To identify outcome predictors, the covariates, including the binary variable of the cause of arrest (pOHCA or non-pOHCA), were evaluated by multivariate analysis. Logistic regression using the ‘enter’ method was independently performed. Age, gender, prehospital ROSC, witnessed or unwitnessed, bystander CPR, place of arrest, shockable rhythms and the cause of arrest were adjusted. In addition, ORs (95% CIs) were calculated for the outcomes by poison group. A p<0.05 was considered statistically significant.

**Patient and public involvement**

Neither patients nor the public were involved in the design, planning, conduct or reporting of this study.

---

**Table 1** Baseline characteristics of patients

| Variable                  | pOHCA (n=3582) | Non-pOHCA (n=169608) | P value |
|---------------------------|----------------|----------------------|---------|
| Gender Female             | 1270 (35.5%)   | 64 026 (37.7%)       | 0.005   |
| Male                      | 2312 (64.5%)   | 105 582 (62.3%)      |         |
| Age, years                | 58.2±17.8      | 69.0±15.5            | <0.001  |
| Prehospital ROSC No       | 3505 (97.9%)   | 162 824 (96.0%)      | <0.001  |
| Yes                       | 77 (2.1%)      | 6784 (4.0%)          |         |
| Witnesses No              | 3122 (87.2%)   | 93 094 (54.9%)       | <0.001  |
| Yes                       | 460 (12.8%)    | 76 514 (45.1%)       |         |
| Bystander CPR No          | 3287 (91.8%)   | 144 514 (85.2%)      | <0.001  |
| Yes                       | 295 (8.2%)     | 25 094 (14.8%)       |         |
| Place of arrest Public    | 481 (13.4%)    | 25 957 (15.3%)       | 0.008   |
| Private                   | 2920 (81.5%)   | 134 980 (79.6%)      |         |
| In-ambulance              | 181 (5.1%)     | 8671 (5.1%)          |         |
| Prehospital rhythms Non-shockable | 3539 (98.8%) | 154 656 (91.2%) | <0.001  |
| Shockable                 | 43 (1.2%)      | 14 952 (8.8%)        |         |
| Time (arrest to hospital) | 35.1±40.2      | 33.6±25.1            | 0.501   |
| Hospital region Metropolitan | 1132 (31.6%) | 70 956 (41.8%)     | <0.001  |
| Urban                     | 1905 (53.2%)   | 81 858 (48.3%)       |         |
| Rural                     | 545 (15.2%)    | 16 794 (9.9%)        |         |
| Arrest region Metropolitan | 1092 (30.5%)  | 69 374 (40.9%)       | <0.001  |
| Urban                     | 1797 (50.2%)   | 78 933 (46.5%)       |         |
| Rural                     | 693 (19.3%)    | 21 301 (12.6%)       |         |
| ROSC No                   | 2907 (81.2%)   | 127 649 (75.3%)      | <0.001  |
| Yes                       | 675 (18.8%)    | 41 959 (24.7%)       |         |
| Survival to discharge No  | 3448 (96.3%)   | 159 131 (93.8%)      | <0.001  |
| Yes                       | 134 (3.7%)     | 10 477 (6.2%)        |         |
| Good CPC (CPC 1 or 2) No  | 3522 (98.7%)   | 163 605 (96.8%)      | <0.001  |
| Yes                       | 47 (1.3%)      | 5399 (3.2%)          |         |

CPC, cerebral performance category; CPR, cardiopulmonary resuscitation; pOHCA, poisoning-induced out-of-hospital cardiac arrest; ROSC, return of spontaneous circulation.
RESULTS
Characteristics of the study subjects
We identified 293,852 patients who had experienced OHCAs between January 2008 and December 2018. We excluded patients aged <18 years (n=7114), those who had do-not-resuscitate orders (n=7150), those who had experienced traumatic OHCA (n=63,427), those with invalid prehospital data (n=28,126), and those whose survival outcome was unknown (n=14,845). There were 1020 patients with poisoning-induced OHCA among those included among those with invalid and missing outcomes. After exclusions, 173,190 patients were included in this study, of which 3582 were pOHCA patients (figure 1).

Between the pOHCA and non-pOHCA groups, there were significant differences in age, shockable rhythms, witnesses, bystander CPR and gender. pOHCA patients had significantly lower survival to discharge and poorer neurological outcomes than non-pOHCA patients (survival to discharge, 3.7% (pOHCA) vs 6.2% (non-pOHCA), p<0.001; good neurological outcomes, 1.3% (pOHCA) vs 3.2% (non-pOHCA), p<0.001). Details of the patient population are shown in table 1.

Table 2 shows the distribution of the 3582 pOHCA patients according to poisoning agent. Pesticides accounted for 44.7% of poisonings (1601/3582), followed by other gases and vapours (33.2%; 1188/3582). The survival rates were 2.8% and 2.5% for pesticides and gases, respectively, and the lowest survival rate was for poisoning by narcotics (no survivors out of eight patients).

Univariate and multivariate logistic regression analysis of prognostic factors associated with survival to discharge and good neurological outcomes
Univariate analysis showed that all included variables influenced survival to discharge. We then performed multivariate analysis including these variables. Among the variables included in the model, being male (OR 1.06, 95% CI 1.01 to 1.11, p<0.001), prehospital ROSC (OR 34.36, 95% CI 32.11 to 36.77, p<0.001), bystander CPR (OR 1.46, 95% CI 1.38 to 1.55, p<0.001) and shockable rhythms (OR 3.85, 95% CI 3.62 to 4.08, p<0.001) were significantly associated with better survival to discharge. Place of arrest (OR 0.99, 95% CI 0.95 to 1.04, p=0.832) and cause of arrest (OR 0.608, 95% CI 0.86 to 1.27) did not differ significantly between the two groups (table 3).

Good neurological outcomes were also associated with all the included variables in the univariate analysis. In multivariate analysis, being male (OR 1.16, 95% CI 1.06 to 1.27, p<0.001), prehospital ROSC (OR 47.86, 95% CI 44.19 to 51.85, p<0.001), witnessed arrest (OR 3.03, 95% CI, 2.76 to 3.33, p<0.001), bystander CPR (OR 1.59, 95% CI 1.47 to 1.73, p<0.001) and shockable rhythms (OR 5.93, 95% CI 5.46 to 6.44, p<0.001) were significantly associated with good neurological outcomes. Place of arrest (OR 1.01, 95% CI 0.94 to 1.08, p=0.820) and cause of arrest (OR 1.03, 95% CI 0.73 to 1.42) did not differ significantly between the two groups (table 3).

Univariate analysis of outcomes of pOHCA patients by poisoning agent group
Other gases and vapours (group 2) and pesticides (group 3) had significantly lower survival to discharge rates than the other groups (group 2: OR 0.57, 95% CI 0.38 to 0.86; group 3, OR 0.61, 95% CI 0.43 to 0.89) (figure 2A). In addition, other gases and vapours (group 2) and pesticides (group 3) had significantly poorer neurological outcomes than other groups (group 2: OR 0.35, 95% CI 0.16 to 0.78; group 3: OR 0.42, 95% CI 0.22 to 0.81) (figure 2B).
### Table 3

**Univariate and multivariate logistic regression analysis of outcomes**

| Factor                | Survival to discharge | Good neurological outcome |
|-----------------------|-----------------------|----------------------------|
|                       | P value               | Adjusted OR                |
|                       |                       | P value                    | Adjusted OR |
| **Survival to discharge** |                       |                            | Adjusted OR |<|<|<|
| Age, years            | 0.96 (0.96 to 0.96)   | 0.95 (0.95 to 0.95)        | 0.95 (0.95 to 0.95) |
| Gender, male          | 1.90 (1.72 to 1.89)   | 1.06 (1.01 to 1.11)        | 1.48 (1.36 to 1.61) |
| Prehospital ROSC      | 0.52 (0.50 to 0.53)   | 0.31 (0.28 to 0.33)        | 0.36 (0.33 to 0.39) |
| Wristless            | 3.09 (5.04 to 5.05)   | <0.001                     | <0.001       |
| CPR                  | 0.37 (0.25 to 0.45)   | 0.014                      | 0.47 (0.45 to 0.50) |
| Place of arrest       | 0.62 (0.50 to 0.70)   | <0.001                     | <0.001       |
| Shockable rhythms     | 1.92 (1.40 to 2.52)   | <0.001                     | 0.014        |
| Cause, pOHCAs         | 0.19 (0.08 to 0.52)   | <0.001                     | 0.034        |
| CPR CR (cardiopulmonary resuscitation) | 0.59 (0.42 to 0.83)   | 0.001                      | 0.47 (0.45 to 0.50) |
| Cause, pOHCAs         | 0.59 (0.08 to 0.52)   | <0.001                     | 0.034        |

**Factors included in the final logistic regression model for survival to discharge.**

Model of multivariate logistic regression analysis was backward stepwise and adjusted for the above factors.

**Factors included in the final logistic regression model for good neurological outcomes.**

**Factors included in the final logistic regression model for pOHCAs.**

Table 3: Univariate and multivariate logistic regression analysis of outcomes.

**Previous studies have mainly been conducted in the USA and Europe; therefore, it is meaningful to analyse EMS-treated pOHCAs using nationwide databases in Asia because underlying regional differences in drug abuse and availability are also likely to contribute to aetiology-specific pOHCAs incidence and survival.**

**DISCUSSION**

Previous studies have mainly been conducted in the USA and Europe; therefore, it is meaningful to analyse EMS-treated pOHCAs using nationwide databases in Asia because underlying regional differences in drug abuse and availability are also likely to contribute to aetiology-specific pOHCAs incidence and survival. Although Kim et al analysed a pOHCAs patient group using the South Korean nationwide database containing 4 years of data (2008–2013), this study, 11 years of data were used for comparative analysis with non-pOHCAs patients. In South Korea, the types of poisoning agents causing pOHCAs are different, and the frequency of opioids is relatively low (narcotics, eight cases) compared with those of the USA, where opioids make up a high proportion of poisoning agents. This is related to national regulations, such as those of the Narcotics Information Management System, which is not easily accessible by the public in South Korea. In contrast, the proportion of pesticides was relatively high, and along with gases, including carbon monoxide intoxication, these were causes of high mortality. pOHCAs caused by pesticides have been declining over the past 10 years, and pOHCAs caused by gases have been gradually increasing (online supplemental figure 1). The reason for the decrease in pesticides is presumed to be related to the national regulation of commercial access to highly toxic pesticides. Indeed, the direct purchase of highly hazardous pesticides was completely banned in 2012.

As a prehospital factor, witnesses, bystander CPR and prehospital ROSC were significant factors influencing survival to discharge and good neurological outcomes in this study. These factors may be influenced by prehospital care provided by EMS. The EMS system shows variability based on regional infrastructure, which may lead to differences in the outcomes of EMS-treated pOHCAs; when an OHCA occurs in the US, an average of 80% or more of patients receive advanced airway management (AAM), but in some parts of Asia, AAM implementation by EMS is less than 50%. Only 19.2% of patients received AAM in South Korea. The characteristics of pOHCAs can affect the outcome; unlike during cardiac cause arrest, ventricular arrhythmia is low, and rapid respiratory support is required. It can be assumed that pOHCAs is related to the damage induced by the poisons that cause hypoxia in apnoea and hypercapnia; therefore, rapid CPR is needed. Several previous studies have shown higher survival to discharge rates of pOHCAs compared with those of cardiac origin by advanced EMS teams. However, the Korean EMS system, which is not considered advanced, shows a relatively low rate of successful outcomes of pOHCAs compared with those of non-pOHCAs, as indicated by the results of this study.

Previous studies reported fewer witnesses of cardiac arrest in younger patients, and that they have a low proportion of shockable rhythms. Salcido et al reported that pOHCAs occurred in younger patients (41 years, range, 30–50 years) vs 67 years (range, 54–80 years). In addition, the rates of shockable rhythms in pOHCAs vs 82% and 23.3%, respectively, and 22.6% and 45.4%, respectively. Orkin et al showed that the younger
According to this classification, opioids were not classified as a poison group. Therefore, pOHCA group had fewer witnesses, less bystander CPR and fewer shockable rhythms than those of the non-pOHCA group. This is characterised by patients of younger age with fewer witnesses and shockable rhythms. In patients with OHCA, the proportion of invalid or missing outcome data was 14.7%, and the proportion for pOHCA specifically was 22.2%. These missing data invalid or missing outcome data was 14.7%, and the proportion for pOHCA specifically was 22.2%. These missing data may have affected the results; for example, it may have limited our interpretation of the outcomes. Finally, in retrospective observational studies, selection bias can occur and potential confounders, such as underlying disease, haemodynamic status and laboratory findings, can be included.

**CONCLUSION**

This nationwide, population-based study shows that pOHCA is characterised by patients of younger age with fewer witnesses and shockable rhythms. In patients with OHCA,
pOHCA was not a variable influencing survival to discharge and good neurological outcomes, but witnesses, shockable rhythms and bystander CPR were significantly associated with good neurological outcomes. In addition, pesticides and gases were the most frequent causative agents of pOHCA; compared with other substances, they resulted in lower survival to discharge rates and poorer neurological outcomes in South Korean pOHCA patients.

Contributors CA conceptualised the study, GP and CA managed data collection, CA and JHK conducted factor analysis and provided statistical technical input. GP and CA wrote the manuscript. All authors reviewed and contributed to the final version of the manuscript. CA is responsible for the overall content as the guarantor.

Funding This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) [2021R1G1A1091336].

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study was exempt from review by the institutional review board of Chung-Ang University Hospital because the study data were anonymous (2104-003-19361).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is distributed in accordance with the terms of the licence.

ORCID iD Chivon Ahn http://orcid.org/0000-0002-1813-1098

REFERENCES
1. Berdowski J, Berg RA, Tijssen JGP, et al. Global incidences of out-of-hospital cardiac arrest and survival rates: systematic review of 67 prospective studies. Resuscitation 2010;81:1479–87.
2. Writing Group Members, Mozaffarian D, Benjamin EJ, et al. Heart disease and stroke statistics-2016 update: a report from the American heart association. Circulation 2016;133:e38–60.
3. Kuisma M, Alaspää A. Out-of-hospital cardiac arrests of non-cardiac origin. Epidemiology and outcome. Eur Heart J 1997;18:1122–8.
4. Claesson A, Djurf T, Nordberg P, et al. Medical versus non medical etiology in out-of-hospital cardiac arrest-changes in outcome in relation to the revised Utstein template. Resuscitation 2017;110:48–55.
5. Engdahl J, Bång A, Karlson BW, et al. Characteristics and outcome among patients suffering from out of hospital cardiac arrest of non-cardiac aetiology. Resuscitation 2005;67:33–41.
6. Ro YS, Shin SD, Song KJ, et al. A comparison of outcomes of out-of-hospital cardiac arrest with non-cardiac etiology between emergency departments with low- and high-resuscitation case volume. Resuscitation 2012;83:855–61.
7. Alqahtani S, Nehme Z, Williams B, et al. The incidence and outcomes of out-of-hospital cardiac arrest precipitated by drug overdose: a systematic review and meta-analysis. Resuscitation 2019;134:10–18.
8. Koller AC, Salcido DD, Callaway CW, et al. Resuscitation characteristics and outcomes in suspected drug overdose-related out-of-hospital cardiac arrest. Resuscitation 2014;85:1375–9.
9. Paredes VL, Rea TD, Eisenberg MS, et al. Out-of-hospital care of critical drug overdoses involving cardiac arrest. Acad Emerg Med 2004;11:71–4.
10. Orkin AM, Zhan C, Buick JE, et al. Out-of-hospital cardiac arrest survival in drug-related versus cardiac causes in Ontario: a retrospective cohort study. PLoS One 2017;12:e0176441.
11. Kim M, Shin SD, Jeong S, et al. Poisoning-induced out-of-hospital cardiac arrest and outcomes according to poison agent. J Korean Med Sci 2017;32:2043–50.
12. Salcido DD, Torres C, Koller AC, et al. Regional incidence and outcome of out-of-hospital cardiac arrest associated with overdose. Resuscitation 2016;99:13–19.
13. Hess EP, Campbell RL, White RD. Epidemiology, trends, and outcome of out-of-hospital cardiac arrest of non-cardiac origin. Resuscitation 2007;72:200–6.
14. Elmer J, Lynch MJ, Kristian J, et al. Recreational drug overdose-related cardiac arrests: break on through to the other side. Resuscitation 2015;99:177–81.
15. International Narcotics Control Board. Narcotic drugs. New York, United Nations, 2018. https://www.incb.org/documents/Narcotic-Drugs/Technical-Publications/2017/Narcotic_drugs_technical_publication_2017.pdf.
16. National Fire Agency. Organization of the National fire agency. Available: https://www.nfa.go.kr/eng/agency/organization/organization/ [Accessed 2 Dec 2021].
17. Choi SW, Shin SD, Ro YS, et al. Effect of therapeutic hypothermia on the outcomes after out-of-hospital cardiac arrest according to initial ECG rhythm and witnessed status: a nationwide observational interaction analysis. Resuscitation 2016;102:51–9.
18. Jacobs I, Nadkarni V, Bahr J, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update and simplification of the Utstein templates for resuscitation registries. A statement for healthcare professionals from a task force of the International liaison Committee on resuscitation (American heart association, European resuscitation Council, Australian resuscitation Council, New Zealand resuscitation Council, heart and stroke Foundation of Canada, InterAmerican heart Foundation, resuscitation Council of southern Africa). Resuscitation 2004;63:233–49.
19. Daya MR, Schmicker RH, Zive DM, et al. Out-of-hospital cardiac arrest survival improving over time: results from the resuscitation outcomes Consortium (ROC). Resuscitation 2015;91:108–15.
20. Kim S, Kim E, Suh HS. Cost-effectiveness of an opioid abuse–prevention program using the narcotics information management system in South Korea. Value Health 2012;14:174–81.
21. Rosenstock Let al. Chronic central nervous system effects of acute organophosphate pesticide intoxication. The Lancet 1991;338:223–7.
22. Forget G. Pesticides and the third World. J Toxicol Environ Health 1991;32:11–31.
23. Lee H, Kang H, Ko BS, et al. Initial creatine kinase level as predictor for delayed neurophysiologic sequelae associated with acute carbon monoxide poisoning. Am J Emerg Med 2021;43:195–9.
24. Gunnell D, Knipe D, Chang S-S, et al. Prevention of suicide with regulations aimed at restricting access to highly hazardous pesticides: a systematic review of the International evidence. Lancet Glob Health 2017;5:e1026–37.
25. Cha ES, Chang S-S, Gunnell D, et al. Impact of parquet regulation on suicide in South Korea. Int J Epidemiol 2016;45:470–9.
26. McMullan J, Gerecht R, Bonomo J, et al. Airway management and out-of-hospital cardiac arrest outcome in the CARES registry. Resuscitation 2014;85:617–22.
27. Oh YS, Ahn KO, Shin SD, et al. Variability in the effects of prehospital advanced airway management on outcomes of patients with out-of-hospital cardiac arrest. Clin Exp Emerg Med 2020;7:95–106.
28. Horburger D, Kurckiyan I, Sterz F, et al. Cardiac arrest caused by acute intoxication-insight from a registry. Am J Emerg Med 2013;31:1442–7.
29. Ro YS, Shin SD, Song KJ, et al. A trend in epidemiology and outcomes of out-of-hospital cardiac arrest by urbanization level: a nationwide observational study from 2006 to 2010 in South Korea. Resuscitation 2013;84:547–57.
30. Baek H-S, Park S-S. The emergency medical services system of South Korea the present and future of emergency medical technicians. Medico-Legal Update 2019;19:688–92.