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## Review

# Establishing the Korean Out-of-Hospital cardiac arrest registry (KOHCAR)



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## Abstract

**Background:** The Korean out-of-hospital cardiac arrest registry (KOHCAR) serves as the basis for a chain of survival monitoring and quality improvement programs for out-of-hospital cardiac arrest (OHCA). This study describes the development history and current status of KOHCAR.

**Methods/design:** The KOHCAR, initiated in 2008, is a population-based OHCA registry that captures all emergency medical service (EMS)-assessed OHCA cases, regardless of etiology. The KOHCAR represents complete nationwide data and aligns with South Korea's comprehensive plan for cardiovascular disease, which has a legal basis. The KOHCAR is a collaboration between the National Fire Agency (NFA) and the Korea Disease Control and Prevention Agency (KDCA). The NFA identifies OHCA patients and provides prehospital information after integrating various EMS records, whereas the KDCA collects hospital information and clinical outcomes through a medical record review. Comprehensive Utstein variables, including patient and arrest characteristics, prehospital and hospital management, and survival outcomes, were collected.

**Discussion:** The KOHCAR has significantly contributed to improving OHCA survival rates in South Korea; however, the COVID-19 pandemic has posed a challenge. To address the post-pandemic survival rate decline, there is a need to enhance data utilization, expand data sources, and tailor communication with diverse stakeholders.

**Keywords:** Out-of-hospital cardiac arrest, Epidemiology, Outcome, Survival, Quality

## Introduction

Out-of-hospital cardiac arrest (OHCA) poses a significant health burden worldwide.<sup>1</sup> Thus, it is imperative to establish an effective system of care that integrates the community, emergency medical services (EMS), and hospitals to enhance survival outcomes.<sup>2,3</sup> Quality measurement plays a fundamental role in enhancing healthcare systems, and implementing an OHCA registry is an essential initial step for enhancing OHCA outcomes.<sup>4,5</sup> The survival of OHCA patients is primarily influenced by prehospital factors.<sup>6</sup> Thus, EMS responses to OHCA serve as a key metric of the quality of EMS care within the community.<sup>7,8</sup> In South Korea, a national OHCA registry, called the Korean OHCA Registry (KOHCAR), was established to comprehensively monitor the entire healthcare system, spanning the community, EMS, and hospital responses to OHCA. This registry also serves as a foundation for the development of evidence-based quality improvement strategies for OHCA patients, with a particular focus on the EMS

phase. The aim of this study was to share the experiences and processes of establishing a KOHCAR as a foundation for improving survival outcomes of OHCA in South Korea.

## Methods

### Study design

The KOHCAR was designed as a population-based cohort study. In South Korea, the Ministry of Health and Welfare incorporated OHCA into its comprehensive plan for cardiovascular diseases in 2006, initiating a pilot project for the OHCA registry in 2007. In 2008, a national OHCA registry, known as the KOHCAR, commenced its investigation of OHCA cases documented from 2006 onward. That same year, the National Fire Agency (NFA) and Korean Disease Control and Prevention Agency (KDCA) signed a memorandum of understanding to establish a stable foundation for the continuous investigation and development of quality metrics. In 2011, the KOHCAR was approved as a national statistical tool.

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## Setting

South Korea has 5.1 million people living in 100,210 km<sup>2</sup>. Its GDP per capita was 34983.7 in 2021. The country operates a fire-based public EMS system managed by the NFA, which consists of 18 provincial fire departments and a dispatch center.<sup>9</sup> The designated call number for EMS, fire, and rescue services is 119. In 2021, there were a total 3.2 million calls, resulting in 1.8 million transports. In 2021, a total of 13,133 EMS clinicians and 1,579 ambulances were operating nationwide. The level of service provided by EMS clinicians is equivalent to that of advanced emergency medical technicians. They are qualified to perform advanced airway management, intravenous line access, and epinephrine administration under online medical oversight. Dispatcher-assisted bystander CPR began in 2011,<sup>10</sup> with video instruction available from 2017.<sup>11</sup> Multiple dispatches for OHCA were introduced in 2015,<sup>12</sup> and by 2021, 79% of all OHCA patients receives this service. Multiple dispatches consist of multiple ambulances of the same service level, but 5% of multiple dispatches for OHCA involve a fire engine (pumbulance). Feedback CPR devices and first responder activation apps have been introduced in select cities, but not yet nationwide. Feedback CPR devices have been used and monitored in Seoul since 2015,<sup>13</sup> and by 2021, 95% of all cardiac arrest calls in the city were using them.<sup>13</sup> Text message alert systems for registered volunteers were implemented in Seoul in 2015 and Daegu in 2016.<sup>14</sup> An activation system via a government-developed app has been operating in Seoul since 2021. In that same year, there were 53,910 PADs installed nationwide (10.4 per 100,000 people). The National Emergency Medical Center maintains a public map on its website that contains information on AED availability. In South Korea, CPR has been conducted by EMS clinicians according to the CPR guidelines of the Korean Resuscitation Council since 2006. These guidelines align closely with those of the American Heart Association and European Resuscitation Council, and as of now, the 2020 Korean CPR guidelines are in use.<sup>15</sup> EMS clinicians transport OHCA patients to the nearest emergency department (ED). However, if prehospital return of spontaneous circulation (ROSC) is achieved, it's recommended to take those patients to a PCI-capable hospital. Only certified EMS clinicians can execute prehospital 12-lead ECGs, though they are infrequently performed. Currently, there are no government-designated cardiac arrest centers in South Korea.

## Ethical approval

The KOHCAR is a part of the survey and statistical programs for cardiocerebral diseases under the Act on the Prevention and Management of Cardiocerebrovascular Diseases. The specific protocols for the programs were approved by the Institutional Review Board of Seoul National University Hospital, and the requirement for informed consent was waived.

## Data source and quality control

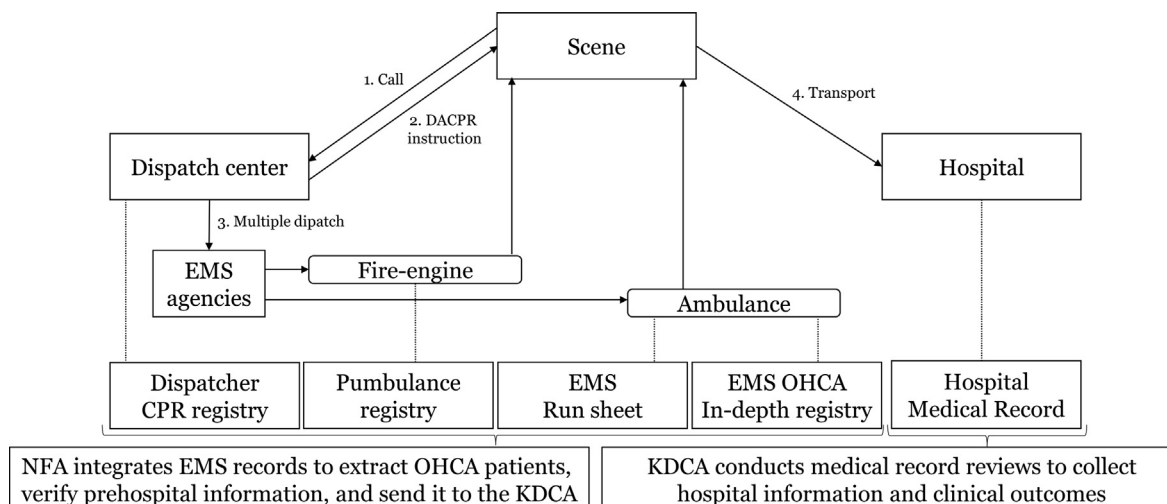
KOHCAR's data are produced in cooperation with the NFA and KDCA.<sup>16</sup> The NFA integrates EMS records to extract target OHCA patients, verify prehospital information, and send it to the KDCA, which conducts medical record reviews to verify hospital treatment and survival outcomes. EMS records, including the EMS run sheet, EMS OHCA in-depth registry, dispatcher CPR registry, and pumbulance registry, were merged into a single EMS-assessed OHCA database. The EMS run sheet contains ambulance dispatch information, general patient and management information, and the name of the hospital to which the patient was transported; the EMS OHCA

in-depth registry contains EMS clinician-verified Utstein variable information; the dispatcher OHCA registry contains dispatcher-assisted CPR-related information; and the pumbulance registry contains information about the first response when the fire engine is dispatched. All EMS records are electronically stored, and EMS clinicians can enter data using tablet devices in the field (Fig. 1). Data quality management of EMS records is performed in several steps. The NFA trains EMS clinicians to record EMS data using the data dictionary of EMS records through onboarding and periodic education programs. EMS records of each OHCA are primarily evaluated by the EMS team leader after management is completed. Medical oversight for each OHCA case is also performed by dedicated medical directors of each EMS agency every month. In addition, the EMS quality Committee of the NFA checks the internal validity of the collected information, including the number of cases by time and region, and the frequency of each variable by agency, and sends feedback to individual EMS agencies on problematic data.

The KDCA educates and trains hospital medical record reviewers (approximately 10 people) who are employed by the KDCA and work only on the medical record review program. All medical record reviewers are licensed as health information managers by the Ministry of Health and Welfare, trained on data dictionary and case review protocols, and dispatched to all hospitals to gather information on hospital care and outcomes (Fig. 1). Monthly data quality management meetings are held while medical record reviews are ongoing. The meetings include emergency physicians, EMS medical directors, epidemiologists, statistical experts, and KDCA representatives of the KOHCAR project. The data quality control meeting uses a statistical program to check the results of applying the quality control logic to the collected data, checks the data entry status of each medical record reviewer, and identifies any cases that have not been entered correctly. In addition, to spot outliers, the data is scrutinized for variations in frequency distribution by year, considering both medical record reviewers and hospitals. For information that needs to be verified, medical record reviewers return to the hospital or call the hospital representative to double-check the information and make the necessary corrections. In 2012, all OHCA patients were transported to 593 hospitals, and in 2021, all OHCA patients were transported to 433 hospitals. Since 2012, medical record reviews have been completed for more than 95% of all OHCA cases, and in 2021, more than 99% of all OHCA cases have completed medical record reviews.

## Population

All patients whose primary symptoms in the EMS run sheet were cardiac arrest or respiratory arrest, or for whom CPR was performed by EMS clinicians, were selected as eligible patients for KOHCAR. Since 2013, the EMS OHCA in-depth registry has been completed for more than 99% of patients whose primary symptoms are cardiac arrest or respiratory arrest, or for whom CPR has been performed by EMS clinicians. There were no exclusion criteria based on age, initial rhythm, or cause of OHCA, and all causes of OHCA, including trauma, were included at all ages, regardless of initial rhythm. In South Korea, EMS clinicians are not allowed to declare death in the field; therefore, all EMS-treated patients with OHCA are transported to hospitals and included in the KOHCAR. However, if there is no possibility of resuscitation in the field, such as in cases with rigor mortis, livor mortis, or decapitation, EMS clinicians withhold resuscitation through online medical control after confirming the cardiac rhythm and arranging for transport by private ambulance. These patients are not included in the KOHCAR. Therefore, among



**Fig. 1 – Number of out-of-hospital cardiac arrest patients and survival outcomes in recent 10 years (2012–2021).**

EMS-assessed OHCA cases, obviously dead patients who were transported by private ambulance were excluded from the KOHCAR. As the prehospital EMS system is exclusively operated by the NFA in all regions, the KOHCAR represents complete nationwide data collection rather than sampling.<sup>9</sup>

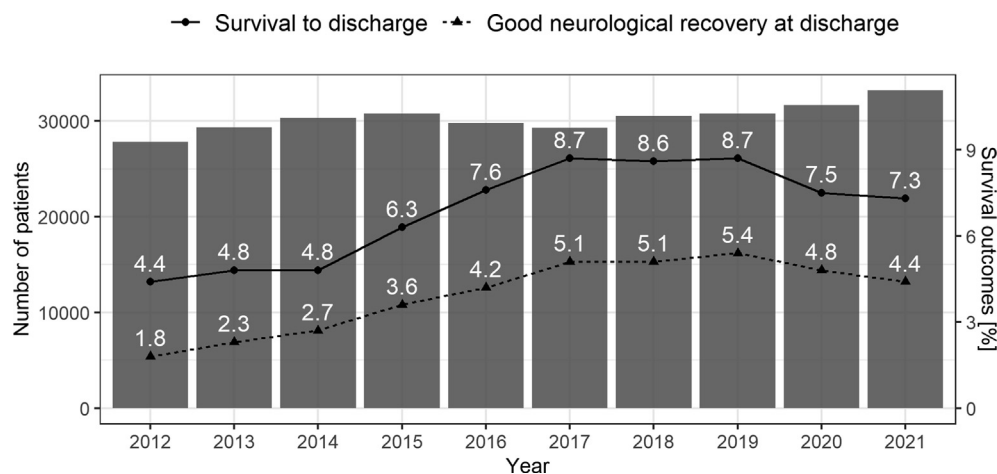
**Variables**

Most of the Utstein variables are collected in KOHCAR.<sup>5,17</sup> Patient’s characteristics (age, gender, comorbidities), arrest characteristics (witness status, arrest location, bystander CPR, bystander automated external defibrillator), EMS characteristics (first monitored rhythm, response time, on-scene time, transport time, prehospital management including defibrillation, advanced airway management, mechanical CPR, intravenous line placement, fluid administration and epinephrine administration), hospital characteristics (cardiac rhythm at ED arrival, hospital management including mechanical CPR, coronary angiography, percutaneous coronary intervention, coronary artery bypass graft, targeted temperature management,

extracorporeal membrane oxygenation, pacemaker insertion, internal cardioverter defibrillator insertion), survival outcomes (any ROSC at field, ROSC at ED arrival, survival to discharge, good neurological recovery at discharge) were collected. Neurological status at discharge was collected through the cerebral performance category.<sup>18</sup> Those who were hospitalized in the ED were checked for survival outcomes at discharge, and those who were transferred from the ED to another hospital were checked for survival outcomes at the secondary hospital. The causes of cardiac arrest were categorized based on medical record review. Since the implementation of the Act on the Prevention and Management of Cardio-Cerebrovascular Diseases in 2017, individual social security numbers for OHCA patients have been collected, allowing the KDCA to link KOHCAR to other national data.

**Reporting**

Since 2012, an annual symposium has been organized to discuss the state of OHCA and methods to enhance survival rates. Key



**Fig. 2 – Emergency medical service system and data sources of Korean out-of-hospital cardiac arrest registry. DACPR, dispatcher-assisted cardiopulmonary resuscitation; EMS, emergency medical service; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; OHCA, out-of-hospital cardiac arrest; NFA, national fire agency; KDCA, Korea disease control and prevention agency.**

**Table 1 – Survival outcomes according to reporting population in 2012 and 2021.**

Population	Total		Survival to discharge		Good neurological recovery	
	2012	2021	2012	2021	2012	2021
All EMS treated Arrests	26,531	33,041	1170 (4.4%)	2410 (7.3%)	488 (1.8%)	1462 (4.4%)
Shockable bystander witnessed*	1619	2134	352 (21.7%)	919 (43.1%)	224 (13.8%)	750 (35.1%)
Shockable bystander CPR*	1191	2411	268 (22.5%)	969 (40.2%)	179 (15.0%)	798 (33.1%)
Non-shockable witnessed*	7170	9652	229 (3.2%)	402 (4.2%)	54 (0.8%)	155 (1.6%)

EMS, emergency medical service; CPR, cardiopulmonary resuscitation.

\* EMS witness excluded.

statistics are available on the public national statistics portal or statistical compilations published annually by the KDCA and the NFA. Additionally, the KDCA offers researchers access to this data for download upon request.

### Status and recent trends

The number of OHCA events and key survival outcomes since 2012 are shown in Fig. 2, and the survival outcomes according to the reporting population are described in Table 1. The number of survivors per million population has doubled over a decade, from 23.2 (1,170/50,345,324) in 2012 to 46.9 (2,410/51,333,252) in 2021. In the last 10 years, the survival rate per million population was highest in 2019 at 51.1 (2,623/51,337,423).

## Discussion

KOHCAR has been pivotal in monitoring OHCA in South Korea and evaluating the effectiveness of OHCA quality improvement programs,<sup>10,12,13,16</sup> contributing to an increase in OHCA survival rates comparable to developed countries.<sup>1</sup> However, survival rates significantly declined during the COVID-19 pandemic, with no recovery to date (Fig. 2). While the COVID-19 pandemic has affected all elements of the chain of survival, bystander CPR rates in South Korea have remained stable. However, analysis suggests that EMS response plays a crucial role in the decreased survival rates.<sup>19</sup> The nationwide EMS project for OHCA (designated advanced life support team response with additional training, education, and medical oversight) was introduced in late 2019 to improve survival rates, which had stagnated since 2017, but it was not effectively implemented due to COVID-19 and could not reverse the decline in survival rates.<sup>20</sup> In addition, compared to developed nations during the pandemic, the layperson responder activation system and AED registry utilization were not fully implemented.<sup>21</sup> In the first half of 2022, the KDCA reported a 7.3% survival rate, mirroring 2021s statistics, and a 4.6% rate of good neurological recovery, which is a slight improvement from 2021, indicating a possible plateau. Therefore, continued efforts to improve survival rates are warranted.

### Future directions

To improve the OHCA survival rate, various changes are required within KOHCAR. First, it is essential to improve data utilization timeliness by optimizing data collection efficiency, accelerating data processing and completion, and increasing data reporting frequency. To this end, several changes have been made in KOHCAR. Up until 2020, OHCA data from the previous year were investigated in December of

that same year within KOHCAR. However, starting in 2021, data collection shifted to a semi-annual basis. Consequently, OHCA cases from the first half of the year were reviewed in the second half of the same year. In addition, quarterly (now semiannual) OHCA EMS quality improvement workshops initiated in 2021 addressed the decline following the COVID-19 onset. Second, external data connections can improve the accuracy of the registry data and expand the utilization of unused variables. Integration with the national health insurance system (the entire population is covered by the national health insurance system in South Korea), which began in 2022,<sup>22</sup> should be further developed and expanded to encompass diverse patient cohorts. Finally, engaging various organizations in OHCA responses and tailoring communication to stakeholders, such as vulnerable community population management organizations, school CPR training programs, workplace first responders, and medical director organizations, is also essential. Customized and timely materials should be disseminated to these groups.

## Conclusion

Since 2008, the KOHCAR, a population-based nationwide OHCA registry, has served as the foundation for monitoring the chain of survival and enhancing OHCA quality improvement efforts in South Korea. Owing to the robust data collection system established through the KDCA and NFA collaboration, KOHCAR has played a vital role in improving OHCA survival rates in South Korea. However, to address the decline in survival rates after the COVID-19 pandemic, efforts should be made to enhance data utilization timeliness, expand variables through data linkages, and ensure tailored and objective communication with the different stakeholders.

## Author contributions

Drs. JH Park and SD Shin had full access to all the data in the study and take responsibility for the integrity of the data as well as the accuracy of the data analysis.

Study concept and design: Drs. SD Shin, KJ Song, and JH Park.

Acquisition, analysis, and interpretation of data: Drs. JH Park, YS Ro, SD Shin, and Y Choi.

Drafting of the manuscript: Drs. SD Shin and JH Park.

Critical revision of the manuscript for important intellectual content: Drs. Y Choi, YS Ro, and KJ Song.

Statistical analysis: Drs. Y Choi, JH Park, and YS Ro.

Obtained funding: Dr. SD Shin

Administrative, technical, or material support: Drs. Y Choi, JH Park, and YS Ro.

Study supervision: Drs. SD Shin and KJ Song.

Manuscript approval: All authors.

## CRedit authorship contribution statement

**Jeong Ho Park:** Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft. **Yeongho Choi:** Methodology, Software, Writing – review & editing. **Young Sun Ro:** . **Kyoung Jun Song:** . **Sang Do Shin:** .

## Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: 'There are no conflicts of interest for all authors in this study. This study was supported by the National Fire Agency (NFA) and the Korea Disease Control and Prevention Agency (KDCA)'.<sup>1</sup>

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