Ph.D. Dissertation of Medicine

Clinical Effects of the Home Education and Resuscitation Outcome Study (HEROS) Program or a New Dispatcher-Assisted Basic Life Support Training Program in a Metropolitan City in Korea

새로운 형태의 전화도움 기본소생술 교육프로그램 HEROS (Home Education and Resuscitation Outcomes Study)의 임상적 효과 분석

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Abstract

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Objectives

This study aimed to determine the effect of a new dispatcher-assisted basic life support (DA-BLS) training program on the survival outcomes of patients with out-of-hospital cardiac arrest (OHCA).

Methods

Before-and-after intervention trials were conducted in Seoul.

Patients who had OHCA in a private setting from January 2014 to December 2017 were included in the study. The intervention group consisted of 3 districts; the other 22 districts were regarded as the control group. The primary outcome was survival up to hospital discharge. We calculated the difference-in-difference (DID) to evaluate changes in the survival outcomes of the two groups over the study period.

Results

A total of 10,127 patients with OHCA were included in the final analysis. Patients with OHCA in the intervention group were less likely to receive bystander cardiopulmonary resuscitation (57.8% vs. 61.1%, P = 0.02) and showed lower survival outcomes (5.7% vs. 6.4% for survival up to hospital discharge, P = 0.34, and 2.8% vs. 3.7% for good neurological recovery, P = 0.11); however, it was not statistically significant. Compared with that in 2014, good neurological recovery in 2017 was significantly improved in the intervention group (DID for good neurological recovery 3.2% [0.6 to 5.8]). There were no statistically significant differences in return of spontaneous circulation (ROSC) and survival up to hospital discharge between the two groups (DID for survival to discharge was 1.8% [−1.7 to 5.3] and DID for ROSC was −2.5% [−9.8 to 4.8]).

Conclusion

Bystander CPR and witnessed rates showed a decreasing trend, and overall outcomes were low during the study period. However, improvement in neurological recovery was observed in the three districts after implementing the new DA-BLS training program.

Keywords: Out-of-Hospital Cardiac Arrest; Dispatcher-Assisted Bystander Cardiopulmonary Resuscitation; and Survival

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Chapter 1. Introduction

Out-of-hospital cardiac arrest (OHCA) is one of the most important public health issues with a high incidence rate but poor survival outcome.[1-3] Bystander cardiopulmonary resuscitation (CPR), one of the key components in the chain of survival, has a great effect on the survival rates and neurological recovery of patients with OHCA.[4-6] However, bystander CPR rates vary across different regions and are quite low in some communities, which might be associated with inadequate bystander CPR performance on the scene.[7-9]

Most OHCAs occur at home and have worse outcomes than those occurring in public places.[10,11] Home bystanders may experience fear and panic when the victim is a family member and be unable to provide appropriate CPR.[12, 13] Moreover, most of them are older women, who are less likely to have the opportunity to receive CPR training.[14] To solve these problems, CPR education programs have been simplified and now emphasize identifying patients with cardiac arrest and providing chest compression-only CPR.[15, 16]

Dispatcher-assisted CPR (DA-CPR), identifying cardiac arrests through key questions and helping laypersons provide appropriate chest compressions improve bystander CPR rates and survival outcomes.[17-19] In Korea, implementation of the DA-CPR protocol began in 2011, and a recent study showed that DA-CPR was associated with improved neurological recovery, especially in private settings.[20, 21]

In collaboration with the Laerdal Medical Strategic Research team, we developed a 1-hour dispatcher-assisted basic life support (DA-BLS) training program called "Home Education and Resuscitation Outcome Study" (HEROS). Current BLS

programs do not fully reflect the characteristics of home bystanders and the concept of DA-CPR.[22] However, the HEROS training program emphasizes DA-CPR for untrained home bystanders, involving more hands-on practice to provide high-quality bystander CPR in real-life situations. Two simulation studies have demonstrated the efficacy of such a training program compared with a standard BLS program.[23, 24]

We hypothesized that the implementation of this new DA-BLS training program would result in an increase in the bystander CPR rate, followed by improved survival outcomes. This study aimed to determine the effect of a new DA-BLS training program on the survival outcomes of patients with OHCAs in private settings in a metropolitan city in Korea.

Chapter 2. Methods

2.1. Study design and setting

This before-and-after intervention study was conducted in Seoul. The study was registered on ClinicalTrials.gov: NCT02142387. Seoul is the capital city of the Republic of Korea, with a population of approximately 9.7 million people and an area of 605 km^2. In 2019, 4,424 OHCAs occurred in Seoul, and the bystander CPR rate was 38.4%.

The city has 116 "119 safety centers" (also known as ambulance stations; 119 is the universal telephone number for fire, disaster, and emergency medical services [EMS] in Korea) and 24 "fire stations" with "Seoul Emergency Operation Center," a certified single dispatch center operated by the "Seoul Metropolitan Fire & Disaster Headquarters" (also known as Seoul Metropolitan Fire Department). In 2019, there were 1,359 firefighter EMS providers (555 [40.8%] level 1 emergency medical technicians [EMTs], 167 [12.3%] registered nurses [RNs], 452 [33.3%] level 2 EMTs, and 185 [13.6%] non-EMT/non-RN ambulance drivers) and 151 firefighter EMS ambulances.

They were dispatched to 473,950 incidents in 2020. EMS ambulances are usually staffed by three personnel: one level 1 EMT (paramedic or advanced EMT in the USA) or RN, one level 2 EMT (EMT in the USA), and one non-EMT non-RN driver. Most qualified level 1 EMTs or RNs can provide CPR with an automated external defibrillator (AED), assess cardiac rhythms on site, perform advanced airway, and administer intravenous fluids. CPR cannot be stopped unless the patient

regains a pulse on site or during transport to the emergency department (ED). Therefore, EMS-treated patients are transported to the nearest hospital.

An ED is formally categorized into levels I, II, and III by the Ministry of Health and Welfare. The ED level is based on its resources, such as manpower, equipment, and capacity. There are 67 EDs in Seoul: 6 level I EDs, 24 level II EDs, 36 EDs level III, and 1 specialty center (burn center). Level I EDs should be staffed by emergency physicians by law. Although not legally required, most level II EDs are also staffed by emergency physicians.

The Seoul Metropolitan Fire & Disaster Headquarters started a DA-CPR program in 2010, which led to increased bystander CPR rates and survival outcomes.[20] There are two levels of dispatchers; primary call dispatchers are responsible for detecting OHCAs and handling calls to secondary call dispatchers. Most primary call dispatchers are firefighters, whereas secondary call dispatchers are either EMTs or RNs. When primary call dispatchers detect cardiac arrests using the two key questions (altered mental status and abnormal breathing), they transfer the call to a secondary call dispatcher who helps bystanders perform CPR until the ambulance arrives. All OHCA cases with dispatcher instructions are recorded in the electronic dispatcher CPR registry by the secondary call dispatchers. Dispatch medical directors, who are certified by the Ministry of Health and Welfare, are required to review approximately 10% of DA-CPR audio recordings and provide feedback to the dispatchers for quality assurance.[19]

There are 25 districts in Seoul and each one has a community health center that is responsible for providing BLS training for citizens and first responders (e.g. police officers, nursing teachers, and safety guards). In 2016, 324,574 laypersons were

trained by a rescue and first-aid education program including BLS.

Gangbuk, Nowon, and Jungnang districts belong to the Northeast Living Area of Seoul, with a population of approximately 3.3 million people and an area of 171 km^2. It serves as a bed town and is characterized by a concentration of small and medium-sized businesses.[25] The proportion of individuals aged > 65 years was higher in Gangbuk district (21.3%), Nowon district (17.2%), and Jungnang district (18.3%) than in Seoul (16.5%). The proportion of recipients of basic livelihood security was also higher in Gangbuk district (5.2%), Nowon district (4.4%), and Jungnang district (4.9%) than in Seoul (3.0%). The gross regional domestic product was low in Gangbuk district (0.8%), Nowon district (1.5%), and Jungnang district (1.1%) (Gangnam district [16.5%], Jung district [12.3%]).[26]

2.2. Data source

We used the Korean OHCA registry as our data source. It is a nationwide prospective clinical registry that was established in 2006 and has been supported by the Korea Centers for Disease Control and Prevention (CDC) since 2007. Data were collected from EMS and hospital medical records. EMS records include an EMS run sheet with information on ambulance operation, an EMS cardiac arrest registry based on Utstein-style data collection, and a dispatcher CPR registry with information on dispatcher instructions.[27] Hospital medical records were obtained by well-trained medical record reviewers who visited all hospitals that treated patients with OHCA and evaluated the medical records to extract clinical information including survival outcomes.

2.3. HEROS program

The HEROS program has been classified into three phases. Phase 1 was the initial stage of preparation for and introduction of the program. Districts participating in this pilot project in Seoul prepared to operate a health community education center that could provide CPR training and personnel who would conduct education program.

The research team prepared the educational materials and curriculum and was responsible for quality assurance. Laerdal Medical provided resources necessary for training, including mannequins. In collaboration with the Laerdal Medical, we developed a video, HEROS version 1.0, for the program. The HEROS program is being conducted in the Gangbuk, Nowon, and Jungnang districts since 2015 through the signing of a Memorandum of Understanding.

Phase 2 was the expansion stage for the program. The program was expanded to Gangdong district in 2016 and to Dobong, Seodaemun, and Seongdong districts in 2017. The video content used in the program has been upgraded to HEROS version 2.0. It was made with Korean actors without using foreign language dubbing and included additional sectors related to the use of an AED. Relevant institutions participating in the program regularly held workshops to share the current status of the training and research agenda. This study focused on phase 3 and evaluated whether the HEROS program contributed to improving survival outcomes in patients with OHCAs in private settings (Fig. 1).

2.4. Study population

The study population included patients with OHCA with presumed cardiac etiology that occurred in a private setting in Seoul. They were treated by EMS providers from January 2014 to December 2017. Patients aged < 19 years, those who did not receive CPR, and patients with OHCA initially witnessed by EMS providers were excluded from the study. Moreover, patients with unknown survival outcomes because of a lack of medical records were also excluded.

2.5. Interventions and control

The HEROS program is a 1-hour training course that includes a 30-min video-based self-instruction (VSI) training session, short role-play, and debriefing. The video consists of a bystander CPR simulation with dispatcher instructions using the trainee's own phone and practice session following demonstration by a simulated layperson. After watching the video clip, all trainees are divided into two groups and conduct a role-play for 15 min. During the role-play, one trainee acts as a layperson, and the other acts as a dispatcher with the same scenario used in the actual DA-CPR; then, they switch the roles. Finally, there is a 15-min debriefing session with several assignments. The HEROS program focuses on cooperation with a dispatcher, from recognition of cardiac arrest to performing DA-CPR, with hands-on practice so that laypersons can provide bystander CPR immediately in a real-life situation. Moreover, the HEROS program emphasizes practice for providing the correct address of the scene and switching to speakerphone mode, especially for the elderly population. Because dispatchers usually instruct CPR

using bystanders' mobile phone, it is important for bystanders to quickly switch to speakerphone mode and place the phone on the floor. However, most elderly individuals are not familiar with the use of a mobile phone and have difficulty switching to speakerphone mode.

Community health centers in Gangbuk, Nowon, and Jungnang districts have provided the HEROS program since 2015 and consisted the intervention group. These districts have been designated as pilot project areas for the HEROS program conducted in Seoul. The use of the HEROS program was recommended when CPR education was conducted at the health community education centers located in the pilot project districts. The number of CPR trainees was regularly reported to the research team and quality control was performed monthly.

The other 22 districts were regarded as the control group. The control group commonly used a one-hour training program that was developed by the Korea CDC and based on the American Heart Association BLS provider course (http://www.cdc.go.kr/board.es?mid=a20503050000&bid=0021&tag=&act=view&list_no=127655). The program consists of a 30-min VSI and a 30-min practice and debriefing session. It focuses on detailed techniques for performing high-quality chest compressions including the correct hand and body position of the bystanders. There is no role-play simulating the occurrence of cardiac arrest. Among the four years of study period, 2014 was the control, 2015 was the run-in period, and 2016 to 2017 was the intervention period.

2.6. Outcomes and measurements

The primary outcome was survival up to hospital discharge. The secondary outcome was the return of spontaneous circulation (ROSC), which was defined as any cases in which spontaneous circulation was achieved at least once until the patients were alive or died. The tertiary outcome was a good neurological recovery, which was defined as a cerebral performance category (CPC) score of 1–2: CPC 1, good cerebral performance; CPC 2, moderate cerebral performance; CPC 3, severe cerebral performance; CPC 4, coma or vegetative state; and CPC 5, brain death.

We collected data on arrest date, age, sex, location of arrest (public, private, or others), witnessed status, DA–CPR, bystander CPR and defibrillation, primary electrocardiogram on scene (shockable rhythm or not), EMS response time (the time from call to EMS arrival at the scene), scene time (time from EMS arrival at the scene to departure to the hospital), transport time (time from scene departure to hospital arrival), and ED level (level 1, 2, or 3).

2.7. Statistical analyses

Counts and proportions were calculated for the categorical variables, and median and interquartile ranges were calculated for the continuous variables. A χ^2 test for the categorical variables and a Wilcoxon rank–sum test or Kruskal–Wallis test for continuous variables were used to compare characteristics between the two groups. We showed the trend of survival outcomes for the intervention and control groups by year using the Cochran–Armitage test. Changes in the survival outcomes over the period between the two groups were assessed using difference–in–difference

(DID) analysis. DID is a statistical method that measures how different the trend change appears between the intervention and control groups before and after treatment to infer a causal effect. It was used as an analysis because it had the advantage of being able to see only the effect of treatment after removing the effect of change over time. The results of the DID method are expressed as adjusted estimates and 95% confidence interval (CI) (calculated from least-square means). All analyses were performed using SAS software version 9.4 (SAS Institute Inc., Cary, NC, USA).

2.8. Ethics statement

This study was approved by the Institutional Review Board of Seoul National University Hospital IRB (No. 1607-210-784). Informed consent was waived, and patient information was anonymized prior to analysis.

Chapter 3. Results

Of the 18,822 OHCAs in Seoul during the study period, 13,965 were EMS-treated OHCAs. After excluding patients who were attended by EMS providers and those with incomplete data on survival outcomes, 12,899 patients were obtained. A total of 10,127 patients with OHCA were included in the final analysis, limited to cases where the OHCA occurred in a private setting (Fig. 2).

OHCAs in the HEROS districts occurred more often in private settings (83.3% vs. 77.7%; P < 0.01), received less bystander CPR (56.7% vs. 60.8%; P < 0.01), and showed lower survival outcomes (8.1% vs. 10.5% for survival up to hospital discharge; 4.8% vs. 6.9% for good neurological recovery; all P-values < 0.01) during the entire study period (from 2014 to 2017) (Table S1).

Among the 10,127 included patients, 1,486 (14.7%) OHCAs occurred in the HEROS districts. OHCAs that occurred in the HEROS districts were less likely to receive bystander CPR (57.8% vs. 61.1%; P = 0.02) and be treated in a level 1 ED (P < 0.01). Conversely, EMS response and transport times were shorter in the HEROS districts (P < 0.01). Compared with the non-HEROS districts, patients with OHCA in the HEROS districts showed lower rate of survival up to discharge (5.7% vs. 6.4%; P = 0.34) and good neurological recovery (2.8% vs. 3.7%; P = 0.11) during the study period, but the differences were not statistically significant (Table 1).

Figure 3 shows the trends in the bystander CPR rate, witnessed rate, and survival outcomes by year. In the HEROS districts, the bystander CPR and witnessed rates

showed a decreased trend, but survival up to discharge and neurological recovery increased from 3.7% (2014) to 6.3% (2017) and from 1.4% (2014) to 4.6% (2017), respectively (P-value for trends = 0.07 for survival up to discharge, < 0.01 for good neurological recovery). In the non-HEROS districts, the bystander CPR and witnessed rates maintained at > 45% and 60%, respectively, and survival up to hospital discharge and good neurological recovery showed increasing trends (from 5.5% to 7.1% for survival up to discharge, P-value for trend = 0.02; and from 3.3% to 3.5% for good neurological recovery, P-value for trend = 0.61).

Table 2 shows the DID analysis for the survival outcomes of the two groups. Compared with the non-HEROS districts, a significant improvement was observed in the neurological recovery of patients with OHCA in HEROS districts from 2014 (control period) to 2017 (intervention period) (adjusted DID, 3.2% [95% CI, 0.6 to 5.8]).

Chapter 4. Discussion

This study evaluated the effects of a new DA-BLS training program on survival outcomes. Overall survival outcomes were low in the HEROS districts during the study period, but the improvement in neurological recovery was statistically significant compared with that in the non-HEROS districts after implementation of the new DA-BLS training program.

The overall survival rate and prognosis of OHCAs that occur in private settings are poor compared with those in public places.[10, 11] Most home bystanders are older women who cannot provide high-quality CPR due to emotional stress or poor access to BLS training courses.[12-14] This is consistent with our discovery of more OHCAs in private settings, low bystander CPR rates, and poorer survival outcomes in the HEROS districts (Table S1).

Bystander CPR is well known to improve the survival outcomes of OHCA and several interventions have been implemented to increase bystander CPR rates in communities.[5, 28, 29] Among them, many communities have provided DA-CPR protocols for helping bystanders recognize cardiac arrest and perform appropriate CPR until EMS providers arrive on the scene. However, whether DA-CPR can really improve survival outcomes remains controversial.[30, 31] In Korea, the DA-CPR protocol started in 2011 and expanded to the entire country. One study showed improved survival outcomes after implementing DA-CPR.[20] A recent study demonstrated that DA-CPR had beneficial effects on OHCAs, especially those that occurred in private settings.[21]

However, the present CPR education programs are mainly focused on the general

population, and more targeted training programs for home bystanders are needed.[22, 32] Because the standard BLS training program usually does not contain the concept and protocols of DA-CPR, the quality of DA-CPR performed by home bystanders might not be sufficient to affect patient outcomes. This can make it difficult for the callers to understand and follow the instructions given by the dispatchers, particularly for older individuals. If bystanders can provide CPR under the direction of well-trained dispatchers' instruction,[33] high-quality bystander CPR and good survival outcomes can be expected. This new DA-BLS training program was designed to meet these needs and has been implemented in the community, which could contribute to improved survival outcomes of OHCAs, especially those in private settings. The HEROS program was developed to enhance compliance with the DA-CPR protocol and provide high-quality bystander CPR with confidence. It is unique in that it is intended for middle-aged housewives and elderly individuals. The entire course is designed to help participants provide bystander CPR without panicking by providing hands-on practice using scenarios similar to the real DA-CPR protocol.

Previous simulation studies reported the efficacy of the HEROS training program in the improvement of CPR quality. Kim et al. conducted a randomized controlled trial and compared the quality of CPR performed by participants twice, immediately after training and at the 6-month follow-up. They reported that home bystanders trained under the HEROS program showed shorter no-flow time and fewer interruptions.[23] Park et al. conducted a prospective, clustered randomized open-label clinical trial at three district community CPR training centers that participated in the HEROS projects. In this study, the HEROS program showed higher quality of

CPR performance during the course and increased willingness to perform bystander CPR in real-life situations.[24]

Through this study, we tried to verify the effectiveness of the program by establishing the program in real communities beyond the previous simulation studies. However, the expected results could not be sufficiently derived from this study. As shown in Figure 3, good neurological recovery improved from 1.4% (2014) to 4.6% (2017), while the bystander CPR rate seemed to decrease from 61.8% (2014) to 53.3% (2017) as the witnessed rate decreased in HEROS districts. Although the number of CPR trainees in HEROS districts is gradually increasing (Table S2), the decrease in witnessed rate and bystander CPR rate in private settings might be due to the lack of actual training for the target population – home bystanders.

Although the target population for the HEROS program is home bystanders, such as middle-aged housewives and elderly individuals, it is difficult to provide CPR program only for them. As shown in Table S3, the number of trainees aged > 60 years is still low, from 7.6% to 15.4% in the HEROS districts. Since the opportunity for education of home bystanders is low compared to that of other groups, an additional strategy for providing CPR education to these populations is needed. It is necessary to benchmark the successful strategies in Nowon district. As shown by the BLS training status of Nowon district in Table S3, the education rate increased rapidly from 54.7% in the first half of 2016 to 92.2% in the second half of 2016. Moreover, all BLS training programs conducted at the health community education center used the HEROS program in the second half of 2017. Nowon district is currently expanding educational opportunities to not only trainees visiting the

education center but also senior citizens visiting senior citizen centers and apartment dwellers.

Moreover, there are several challenges in the implementation of the HEROS program. As it was implemented as a pilot project in Seoul, the education rate in the three districts gradually increased to > 50% (Table S3). However, the HEROS program was only used in community health centers, and other associations (fire departments, Red Cross, and non-governmental organizations) utilized other educational materials distributed by the Korea CDC or their own programs. In order for the HEROS program to be effectively applied in the local community, it is necessary to diversify away from the existing program operation strategy, which is provided only at the health community education center. We should expand the use of HEROS program by establishing a cooperative system with other associations that are already responsible for much of CPR training. Furthermore, the development of flexible educational contents according to factors of the target population, such as age, occupation, and special social circumstance, is needed. As one of these attempts, a modified non-face-to-face CPR training program, rather than offline training, is being conducted as a pilot project in line with the COVID-19 era.

The HEROS program started in three districts in 2015 and has been expanded to seven districts, but it is difficult to expand further. Furthermore, there is still a practical limitation, in which it is provided only as a pilot project. Since the purpose of this project is for public interest with no expectation of profit, full support from the local government is required to operate the project for a long period for the improvement of survival outcomes of patients with OHCAs. It is necessary to

establish a system to reward participating districts for the achievements in actively expanding and operating the HEROS program. The research team should be authorized to provide quality assurance to participating districts and financial support to manage the project. By solving these challenges, this new DA-BLS training program would be successfully implemented and expanded. We could expect to improve survival outcomes by intervening community factors, especially home bystanders in private settings.

Gangbuk, Nowon, and Jungnang districts, which comprised the intervention group in this study, have a higher proportion of residential area than other districts in Seoul, and the incidence rate of OHCAs in private settings is relatively high. This indicates that the proportion of home bystanders is high and opportunities for practical CPR education might be low. Moreover, due to the relatively low socioeconomic status, there are few opportunities for CPR education itself, which seems to be a problem in providing high-quality CPR in real-life situations.[34, 35] All these factors might be closely related to low witnessed and bystander CPR rates despite the implementation of the HEROS program. The response time of EMS is faster than that in other districts in Seoul, but level I ED, the highest level of emergency medical center, is insufficiently distributed that it is difficult to expect a higher level of care. Nevertheless, since improvement in good neurological recovery was observed after implementing the HEROS program in the local community, it can be said that the implementation of the HEROS program contributed to the improvement of cardiac arrest survival outcomes in the intervention group.

This study had several limitations. First, it was a before-and-after intervention

trial and not a controlled study, so there may be potential confounders that were unadjusted. Particularly, hospital care-related factors such as advanced cardiovascular life support were not adequately adjusted for the main analysis, despite the use of ED level as a confounding variable. Second, it was difficult to identify whether laypersons who had performed bystander CPR actually participated in the HEROS training program, which made it difficult to estimate the actual effect of this intervention. Third, we could not assess the quality of CPR by bystanders, EMS providers, and dispatchers, which resulted in unmeasured bias. Prehospital and hospital-related factors are currently under quality control by the Seoul Metropolitan Fire & Disaster Headquarters and National Emergency Medical Center, respectively, but community-related factors are difficult to accurately measure and quantify in reality. Little is known about these community-related factors, especially those that can measure the performance of bystander CPR and have opportunities to improve care.[36] Therefore, the Global Resuscitation Alliance (GRA) was proposed at a meeting on how to implement best practices in community resuscitation in Stavanger, Norway, in 2015.[37] The Chain of Survival in GRA reinforces the EMS system's ability to deliver early access, rapid dispatch, quick DA-CPR instructions, and high-quality CPR. Fourth, only three districts participating in phase 1 consisted of the intervention group, and districts participating in phase 2 consisted of the control group. Thus, interpretation of the result is needed with caution in estimating the actual effect of this intervention. Lastly, education using this new DA-BLS program is currently being conducted through a pilot project. However, it is being extended to seven districts in a metropolitan city in Korea in 2018.

Chapter 5. Conclusion

Bystander CPR and witnessed rates showed a decreasing trend, and overall outcomes were low during the study period. However, improvement in neurological recovery was observed after implementation of the new DA-BLS training program. Public health efforts are needed to expand this program, especially to reach home bystanders.

Table 1. Demographic findings of the study population through a new DA-BLS training program

	Total		HEROS districts		Non-HEROS districts		
	N	%	N	%	N	%	P-value
Total	10127		1486	14.7	8641	85.3	
Year							0.18
2014	2615		356	24.0	2259	26.1	
2015	2603		394	26.5	2209	25.6	
2016	2485		389	26.2	2096	24.3	
2017	2424		347	23.4	2077	24.0	
Sex							0.25
Male	6017	59.4	863	58.1	5154	59.6	
Age							0.95
19-40	356	3.5	51	3.4	305	3.5	
40-50	633	6.3	85	5.7	548	6.3	
50-60	1241	12.3	183	12.3	1058	12.2	
60-70	1648	16.3	245	16.5	1403	16.2	
70-80	3014	29.8	455	30.6	2559	29.6	
80-90	2549	25.2	364	24.5	2185	25.3	
> 90	686	6.8	103	6.9	583	6.7	
Median (IQR)	74 (62-82)		74 (62-82)		74 (62-82)		0.81
Witnessed by laypersons							0.78
	4674	46.2	681	45.8	3993	46.2	
DA-CPR							0.35
	4674	46.2	681	45.8	3993	46.2	
Bystander CPR							0.02
	6140	60.6	859	57.8	5281	61.1	
AED applied by bystanders							1.0
	186	1.8	27	1.8	159	1.8	
Defibrillation by bystanders							0.06
	23	0.2	3	0.2	20	0.2	
Electrocardiogram							0.38
Shockable	1267	12.5	187	12.6	1080	12.5	
Defibrillation at EMS							0.47
	1030	10.2	159	10.7	871	10.1	
EMS response time							< 0.01
Median (IQR)	6 (5–7)		5 (4–7)		6 (5–7)		
EMS scene time interval							0.14
Median (IQR)	11 (8–14)		11 (8–14)		11 (8–14)		
EMS transport time interval							< 0.01
Median (IQR)	6 (5–9)		5 (4–7)		6 (5–9)		
Level of ED							
Level 1	1098	10.8	12	0.8	1086	12.6	< 0.01
Level 2	7809	77.1	1276	85.9	6533	75.6	
Level 3	1220	12.0	198	13.3	1022	11.8	
Survival outcomes							
ROSC	3662	36.2	544	36.6	3118	36.1	0.7
Survival to discharge	636	6.3	85	5.7	551	6.4	0.34
Good neurological recovery	358	3.5	42	2.8	316	3.7	0.11

DA-BLS, dispatcher-assisted basic life support; HEROS, Home Education and Resuscitation Outcome Study; IQR, interquartile range; DA-CPR, dispatcher-

assisted cardiopulmonary resuscitation; AED, automated external defibrillator; EMS, emergency medical services; ED, emergency department; ROSC, return of spontaneous circulation

Table 2. Difference-in-difference analysis for survival outcomes between the HEROS and non-HEROS districts

	2014		2017		Difference	DID (95% CI)	
	N	%	N	%	Estimate (95% CI)	Unadjusted	Adjusted[a]
ROSC							
Total	893/2615	34.1	900/2424	37.1			
HEROS	128/356	36.0	123/347	35.4	−0.3 (−7.4 to 6.8)	−3.9 (−11.5 to 3.8)	−2.5 (−9.8 to 4.8)
Non-HEROS	765/2259	33.9	777/2077	37.4	3.6 (0.7 to 6.4)		
Survival to discharge							
Total	138/2615	5.3	169/2424	7.0			
HEROS	13/356	3.7	22/347	6.3	2.7 (−0.8 to 6.3)	1.2 (−2.6 to 5.0)	1.8 (−1.7 to 5.3)
Non-HEROS	125/2259	5.5	147/2077	7.1	1.6 (0.1 to 3.0)		
Good neurological recovery							
Total	80/2615	3.1	89/2424	3.7			
HEROS	5/356	1.4	16/347	4.6	3.2 (0.5 to 5.9)	3.0 (0.1 to 5.9)	3.2 (0.6 to 5.8)
Non-HEROS	75/2259	3.3	73/2077	3.5	0.2 (−0.9 to 1.3)		

HEROS, Home Education and Resuscitation Outcome Study; CI, confidence interval; DID, difference-in-difference; ROSC, return of spontaneous circulation

[a]Adjusted for age, sex, bystander CPR, primary ECG, response time interval, transport time interval, ED level

Table S1. Demographic findings of patients with OHCA in Seoul through new DA-BLS training program

	Total		HEROS districts		Non-HEROS districts		
	N	%	N	%	N	%	P-value
Total	12899		1784	13.8	11115	86.2	
Year							0.2
2014	3255		423	23.7	2832	25.5	
2015	3296		477	26.7	2819	25.4	
2016	3189		461	25.8	2728	24.5	
2017	3159		423	23.7	2736	24.6	
Sex							0.08
Male	8272	64.1	1111	62.3	7161	64.4	
Age							0.47
19-40	540	4.2	70	3.9	470	4.2	
40-50	963	7.5	119	6.7	844	7.6	
50-60	1922	14.9	255	14.3	1667	15.0	
60-70	2266	17.6	306	17.2	1960	17.6	
70-80	3653	28.3	535	30.0	3118	28.1	
80-90	2833	22.0	391	21.9	2442	22.0	
> 90	722	5.6	108	6.1	614	5.5	
Median (IQR)	73 (59-81)		73 (60-81)		72 (59-81)		0.16
Location of arrest							< 0.01
Public	2526	19.6	268	15.0	2258	20.3	
Private	10127	78.5	1486	83.3	8641	77.7	
Others	246	1.9	30	1.7	216	1.9	
Witnessed by laypersons							0.12
	6185	47.9	825	46.2	5360	48.2	
DA-CPR							0.42
	9557	74.1	1308	73.3	8249	74.2	
Bystander CPR							< 0.01
	7767	60.2	1012	56.7	6755	60.8	
AED applied by bystanders							0.4
	340	2.6	39	2.2	301	2.7	
Defibrillation by bystanders							< 0.01
	82	0.6	6	0.3	76	0.7	
Electrocardiogram							0.04
Shockable	2388	18.5	307	17.2	2081	18.7	
Defibrillation at EMS							0.28
	1339	10.4	198	11.1	1141	10.3	
EMS response time							
Median (IQR)	6 (5-7)		5 (4-7)		6 (5-7)		< 0.01
EMS scene time interval							
Median (IQR)	11 (8-14)		11 (8-13.5)		11 (8-14)		0.13
EMS transport time interval							
Median (IQR)	6 (4-8)		5 (4-7)		6 (5-9)		< 0.01
Level of ED							< 0.01
Level 1	1413	11.0	19	1.1	1394	12.5	
Level 2	10085	78.2	1530	85.8	8555	77.0	
Level 3	1401	10.9	235	13.2	1166	10.5	
Survival outcomes							
ROSC	5229	40.5	707	39.6	4522	40.7	0.4
Survival to discharge	1317	10.2	145	8.1	1172	10.5	< 0.01
Good neurological recovery	850	6.6	86	4.8	764	6.9	< 0.01

OHCA, out-of-hospital cardiac arrest; DA-BLS, dispatcher-assisted basic life support; HEROS, Home Education and Resuscitation Outcome Study; IQR, interquartile range; DA-CPR, dispatcher-assisted cardiopulmonary resuscitation; AED, automated external defibrillator; EMS, emergency medical services; ED, emergency department; ROSC, return of spontaneous circulation

Table S2. Proportion of CPR trainees to the resident population in the HEROS and non-HEROS districts

	Total[a], %	2015, %	2016, %	2017, %
HEROS districts	6.0 (236,142/3,947,717)	2.8 (36,814/1,331,267)	7.8 (102,235/1,317,593)	7.5 (97,093/1,298,857)
Non-HEROS districts	4.2 (1,122,433/26,678,057)	3.7 (333,234/8,965,871)	3.9 (343,392/8,886,464)	5.1 (445,807/8,825,722)

CPR, cardiopulmonary resuscitation; HEROS, Home Education and Resuscitation Outcome Study

[a]The number of CPR trainees was estimated as the sum of trained laypersons educated at the fire departments and community health centers, which accounted for most of the CPR education.

Table S3. BLS training status in the HEROS districts during the study period

			Period												
			2015 1H		2015 2H		2016 1H		2016 2H		2017 1H		2017 2H		
	Total	%	N	%	N	%	N	%	N	%	N	%	N	%	P-value
Total[a]	85391		13254		15918		14600		14733		13237		13649		
Gangbuk district															
Total	15242	17.8	1620	12.2	2771	17.4	3090	21.2	1865	12.7	2810	21.2	3086	22.6	
Sex															< 0.01
Male	5978	39.2	572	35.3	1203	43.4	1398	45.2	752	40.3	849	30.2	1204	39.0	
Age															< 0.01
< 19	3429	22.5	387	23.9	719	25.9	140	4.5	641	34.4	243	8.6	1299	42.1	
20-40	4710	30.9	449	27.7	916	33.1	1123	36.3	448	24.0	945	33.6	829	26.9	
40-60	5874	38.5	572	35.3	1024	37.0	1566	50.7	621	33.3	1351	48.1	740	24.0	
> 60	1160	7.6	147	9.1	112	4.0	259	8.4	155	8.3	271	9.6	216	7.0	
Missing	69	0.5	65	4.0	0	0.0	2	0.1	0	0.0	0	0.0	2	0.1	
Median (IQR)	37 (21-49)		37 (19 (50)		35 (18-47)		43 (33-51)		33 (14-49)		42 (30-52)		22 (14-43)		< 0.01
HEROS program															< 0.01
	7930	52.0	198	12.2	2309	83.3	1667	53.9	980	52.5	1549	55.1	1227	39.8[b)]	
Nowon district															
Total	63396	74.2	10504	79.3	11241	70.6	10642	72.9	11842	80.4	8880	67.1	10287	75.4	
Sex															< 0.01
Male	27248	43.0	5075	48.3	4654	41.4	4762	44.7	4905	41.4	3829	43.1	4023	39.1	
Age															< 0.01
< 19	26593	41.9	2392	22.8	5247	46.7	3281	30.8	7352	62.1	2753	31.0	5568	54.1	
20-40	10751	17.0	2220	21.1	1396	12.4	1971	18.5	1465	12.4	1988	22.4	1711	16.6	
40-60	16312	25.7	3374	32.1	2243	20.0	3594	33.8	2143	18.1	2688	30.3	2270	22.1	
> 60	9740	15.4	2518	24.0	2355	21.0	1796	16.9	882	7.4	1451	16.3	738	7.2	
Median (IQR)	25 (16-49)		41 (19-56)		19 (16-49)		40 (17-54)		17 (15-38)		36 (16-52)		17 (14-43)		< 0.01
HEROS program															< 0.01
	39442	62.2	451	4.3	3641	32.4	5821	54.7	10921	92.2	8321	93.7	10287	100.0	

			Period												
			2015 1H		2015 2H		2016 1H		2016 2H		2017 1H		2017 2H		
	Total	%	N	%	N	%	N	%	N	%	N	%	N	%	P-value
Jungnang district															< 0.01
Total	6753	7.9	1130	8.5	1906	12.0	868	5.9	1026	7.0	1547	11.7	276	2.0	
Sex															
Male	1726	25.6	225	19.9	662	34.7	162	18.7	259	25.2	375	24.2	43	15.6	
Age															< 0.01
< 19	577	8.5	109	9.6	150	7.9	68	7.8	63	6.1	155	10.0	32	11.6	
20-40	2210	32.7	354	31.3	608	31.9	284	32.7	314	30.6	557	36.0	93	33.7	
40-60	3305	48.9	560	49.6	940	49.3	406	46.8	507	49.4	757	48.9	135	48.9	
> 60	635	9.4	107	9.5	208	10.9	84	9.7	142	13.8	78	5.0	16	5.8	
Missing	26	0.4	0	0.0	0	0.0	26	3.0	0	0.0	0	0.0	0	0.0	
Median (IQR)	43 (32-52)		43 (32-52)		43 (35-52)		43 (30-52)		45 (34-54)		41 (30-49)		42 (28-52)		< 0.01
HEROS program															< 0.01
	4635	68.6	272	24.1	1655	86.8	868	100.0	904	88.1	828	53.5	108	39.1[c)]	

BLS, basic life support; HEROS, Home Education and Resuscitation Outcome Study; IQR, interquartile range

[a]Only for the trainees in the residential training center (excluding those conducted outside the center)

[b]Low turnout of HEROS program due to the increase in participants in another BLS training program targeting first responders

[c]Low turnout of HEROS program due to the reconstruction of the residential training center since October 2017

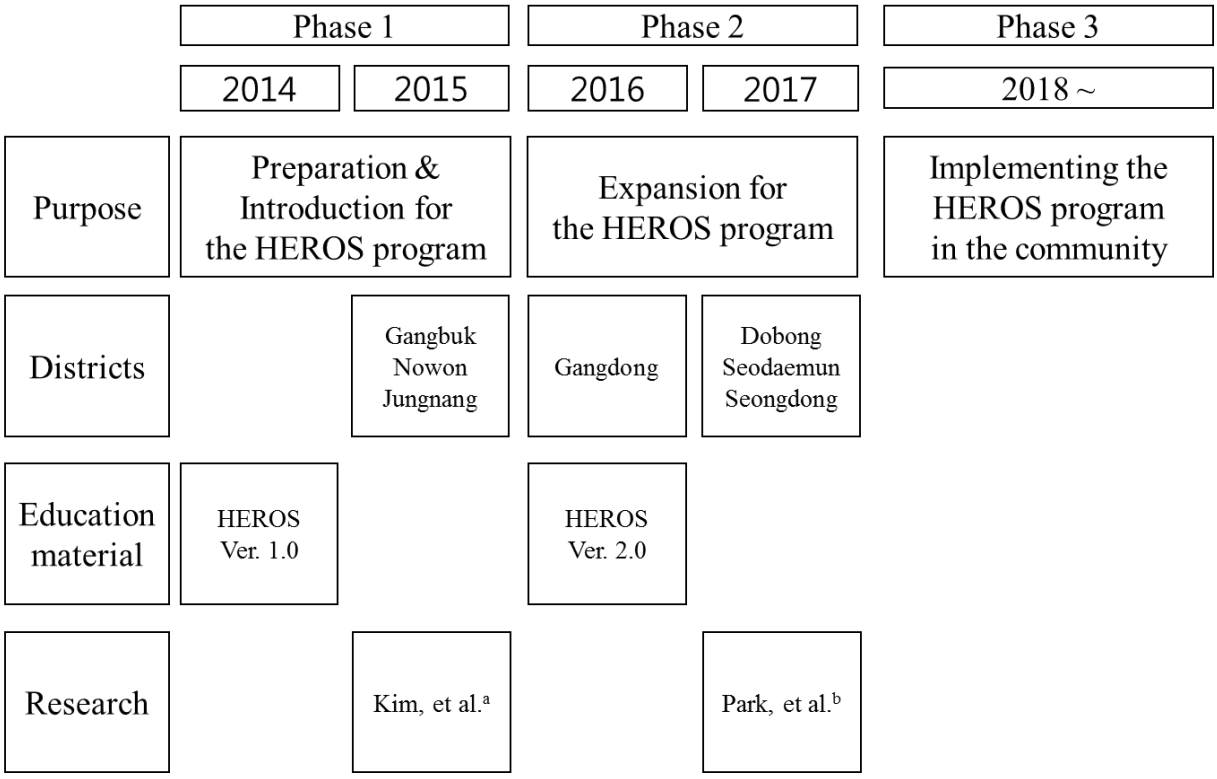

Figure 1. Implementation of the HEROS program by study period

HEROS, Home Education and Resuscitation Outcome Study

[a]Reference 23 is cited. The study was conducted in 2015 and published in 2018 (Kim, et al. Simulation in Healthcare, 2018).

[b]Reference 24 is cited. The study was conducted in 2017 and published in 2020 (Park et al. Simulation in Healthcare, 2020).

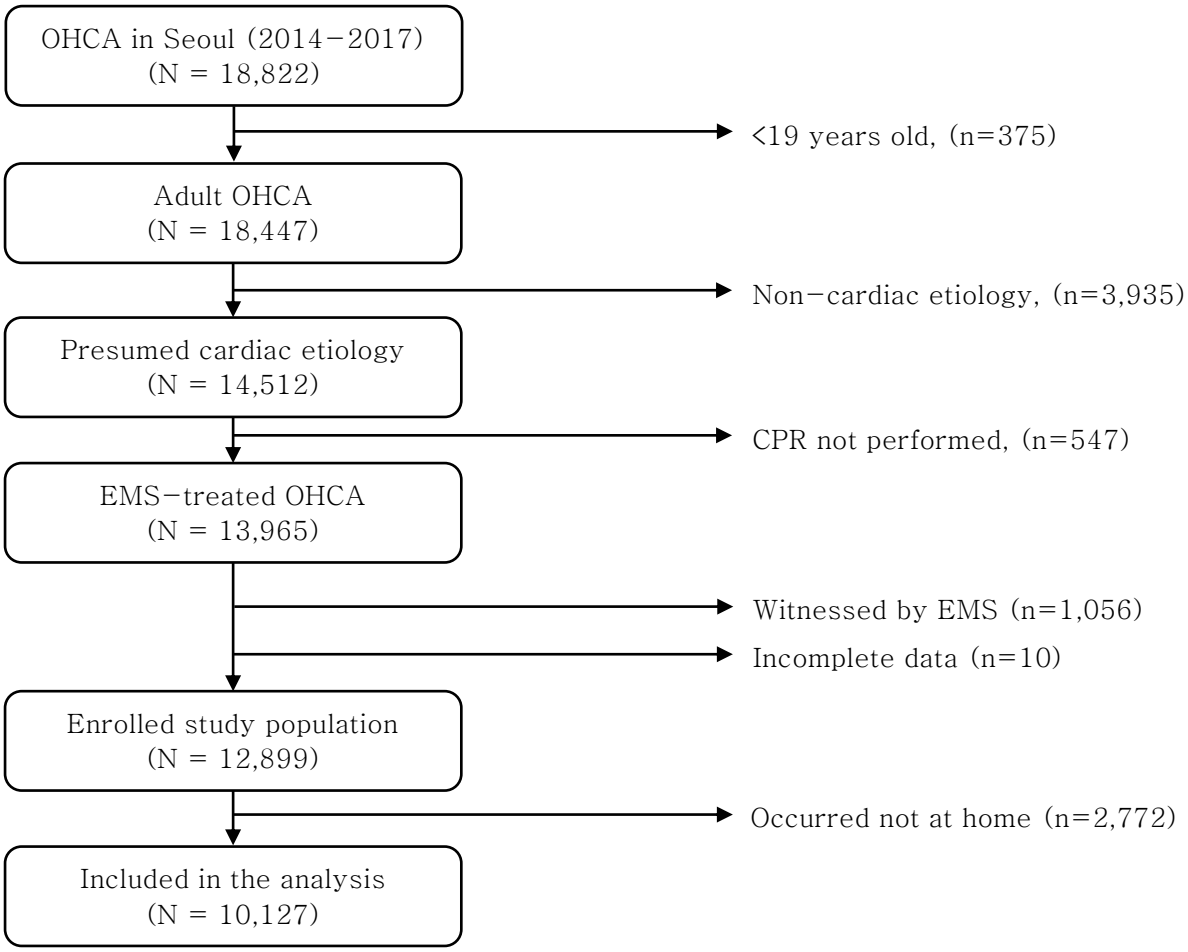

Figure 2. Study population

OHCA, out–of–hospital cardiac arrest; CPR, cardiopulmonary resuscitation; EMS, emergency medical service

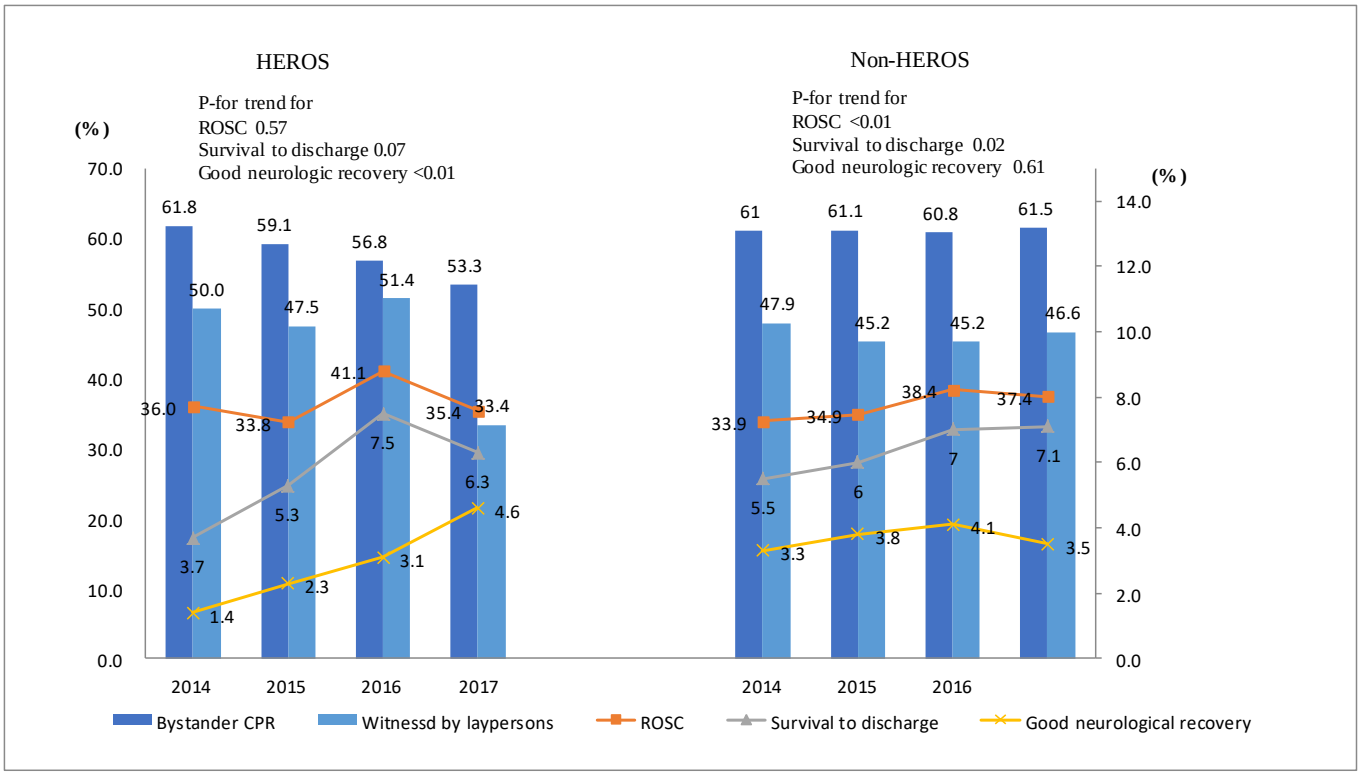

Figure 3. Trends of bystander CPR rate, witnessed rate, and survival outcomes in the HEROS and non-HEROS districts

HEROS, Home Education and Resuscitation Outcome Study; CPR, cardiopulmonary resuscitation; ROSC, return of spontaneous circulation.

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초록

새로운 형태의 전화도움 기본소생술 교육프로그램의 임상적 효과 분석

목적

일개 대도시에서 시범사업으로 진행하고 있는 새로운 방식의 전화도움 기본소생술 교육 프로그램이 가정에서 발생하는 병원 밖 심정지 환자의 생존결과에 미치는 영향을 분석하였다.

방법

본 연구는 서울에서 진행된 전후 중재 연구로 2014년 1월부터 2017년 12월까지 가정에서 발생한 병원 밖 심정지 환자를 대상으로 진행하였다. 서울시의 25개 지역구 중 새로운 방식의 전화도움 기본소생술 교육 프로그램을 도입한 3개 지역구를 중재군으로, 나머지 22개 지역구를 대조군으로 정의하였다. 1차 결과변수는 생존 퇴원율로 정의하였다. 이중차분법(Difference in difference, DID)를 이용하여 연구기간동안 두 군간의 생존결과의 변화를 분석하였다.

결과

총 10,127명의 병원 밖 심정지 환자가 분석에 이용되었다. 중재군에 속한 병원 밖 심정지 환자군에서 일반인 구조자에 의한 심폐소생술 시행률이 낮은 것으로 확인되었다 57.8% vs. 61.1%; P = 0.02). 또한, 중재군에서 낮은 생존결과를 보였으나 통계학적으로 유의한 차이를 보이지 않았다(생존 퇴원율 5.7% vs. 6.4%; P = 0.34, 좋은 신경학적 회복 2.8% vs. 3.7%; P = 0.11). 2014년과 비교하였을 때, 2017년도의 좋은 신경학적 회복은 중재군에서 의미 있게 향상된 결과를 확인하였다(좋은 신형학적 회복에서 이중차

분법 3.2% [0.6 to 5.8]). 하지만 자발순환 회복률과 생존 퇴원율의 경우, 두 군간에 통계학적으로 의미 있는 차이는 확인되지 않았다(자발순환 회복률에서 이중차분법 2.5% [−9.8 to −4.8], 생존 퇴원율에서 이중차분법 1.8% [−1.7 to −5.3]).

결론

연구기간동안 중재군에서 병원 밖 심정지의 목격률과 일반인 구조자에 의한 심폐소생 시행률은 상대적으로 낮았다. 낮은 생존결과를 보였으나 통계학적으로 유의한 차이는 없었다. 하지만, 새로운 방식의 전화도움 기본소생술 교육 프로그램을 도입한 후 중재군에서 신경학적 회복의 향상을 확인하였다.

주요어 : 병원 밖 심정지, 전화도움 심폐소생술, 생존율

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