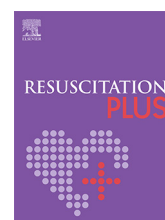


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Review

The development history, current state, challenges, and future directions of the BASIC-OHCA registry in China: A narrative review



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On behalf of the BASIC-OHCA Coordinators and Investigators

Abstract

Out-of-hospital cardiac arrest is a major public health problem worldwide due to its high burden and poor outcomes. Despite progress in treatment, patient outcomes remain unsatisfactory, particularly in low-resource settings. The establishment of a registry is the first step towards gaining a comprehensive understanding of prevailing local conditions and identifying potential opportunities for improving patient survival. Here, we provide a narrative review of the BASeline Investigation of Out-of-hospital Cardiac Arrest (BASIC-OHCA), the first national OHCA registry in China, to introduce its development history, current state, challenges and future directions. We aim to enhance cross-cultural understanding by providing insights from China, while also serving as a reference for the implementation of large-scale registries in low-resource settings.

Keywords: Out-of-hospital cardiac arrest, Registry, Cardiopulmonary resuscitation, Survival, Quality improvement, China

Introduction

Out-of-hospital cardiac arrest (OHCA) is a major cause of premature death and one of the most critical public health issues in the world due to its high burden and poor outcomes.^{1,2} Based on systematic reviews of clinical research evidence, the International Resuscitation Liaison Committee (ILCOR) published and regularly updated the international consensus on cardiopulmonary resuscitation (CPR), offering objective and comprehensive recommendations for the management of cardiac arrest worldwide.^{3,4} However, it is important to acknowledge that medical science does not directly equate to patient survival, with educational efficiency and local implementation serving as crucial intermediary factors.⁵ In 2015, the Global Resuscitation Alliance (GRA) proposed the Ten Steps to Improve Cardiac Arrest Survival, which serves as a fundamental framework bridging medical science with local implementation efforts, empowering communities to enhance the survival of OHCA patients.^{6,7} The establishment of a registry is the first step in these concrete initiatives by facilitating an adequate understanding of the current situation while identifying

areas for improvement and resource allocation optimization. Several excellent registry studies have successfully undertaken this important mission by driving improvements in OHCA patient outcomes.^{1,2} Nevertheless, it should be noted that these registries are almost all from well-developed countries or regions, and there is a lack of exploration in low-resource settings. In recent years, the challenges associated with providing cardiac arrest care in low-resource settings have gained recognition and been emphasized through ILCOR's comprehensive evaluation.⁸ In low- and middle-income countries (LMICs), small-scale OHCA data are available to provide some insights into the challenges faced in OHCA care, including non-standard data reporting, barriers to the utilization of emergency medical resources, and unsatisfactory outcome.^{8–13} But more systematic, comprehensive OHCA data reporting in accordance with the Utstein template is needed to be able to perform: accurate surveillance, impactful quality improvement activities and meaningful observational research.

The BASeline Investigation of Out-of-hospital Cardiac Arrest (BASIC-OHCA) study is the first national registry with large population size, well-designed protocol, and high-quality data to systemat-

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ically describe the incidence, process of care, and outcomes of OHCA in China.^{14,15} Through this narrative review, we aim to introduce this registry to international counterparts while sharing valuable understanding, experiences, and lessons learned from China that can contribute towards saving more lives globally.

Development history

Conception – project establishment

Over the past decades, several epidemiological studies of cardiac arrest have been conducted in China, providing valuable primary data and certain important insights into the burden, quality of care, and prognosis of OHCA.^{16–22} However, these studies were limited to specific cities or districts, resulting in a lack of national baseline data on OHCA patients. Furthermore, most of these studies were initiated by individual physicians or researchers with variations in inclusion criteria, variable definitions, data sources, and statistical analysis. Consequently, sharing and comparing this data becomes challenging which not only leads to inefficiency but also hinders effective allocation of healthcare resources, policy formulation, and quality improvement.

Emergency medicine teams in China have long been aware of the aforementioned challenges but have been unable to organize a nationwide investigation due to a lack of government support, funding, and a viable protocol. Drawing on extensive experience collaborating with numerous hospitals and emergency medical service (EMS) agencies nationwide, the emergency medicine team at Qilu Hospital, led by Professor Yuguo Chen and Professor Feng Xu, assembled a panel of experts in the field to conduct a systematic review of cardiac arrest registries both domestically and internationally. Subsequently, they developed a scientifically sound protocol that could be implemented nationwide. Collaborating with other experts, they diligently advocated for increased attention towards cardiac arrest within relevant authorities such as the Ministry of Science and Technology and the National Health Commission in China. In alignment with the government's proactive promotion of the "Healthy China" national strategy, their proposed protocol received official recognition from the Ministry of Science and Technology which provided financial support for comprehensive data investigations. This official acknowledgment served as significant motivation to undertake subsequent concrete actions.

Initiation- cooperation network building

The EMS in mainland China is a physician-based single-tiered public system managed by a top-down administrative system.²³ Pre-hospital emergency medical missions are mainly carried out by ambulances, each staffed by at least one doctor, one nurse and one driver. EMS systems can be classified into three types according to the relationship between ambulances (emergency station), dispatch center, and hospital: (1) Independent type refers to the EMS system which has its own independent dispatch center, and ambulances and personnel deployed at multiple EMS stations; (2) Command and dispatch type means that the EMS system has its own independent dispatch center, but the ambulances and staff belong to the hospitals which accept the command of the dispatch center; (3) Dependent type means that the dispatch center, ambulances, and EMS staff are provided by a general hospital.¹⁴

Due to China's vast territory and large population, the selection of participating monitoring sites aimed to ensure a more representative study sample that reflects the overall population characteristics. Simultaneously, feasibility considerations were taken into account to enhance the project's success. Geographically, there are seven regions in China (northeast, north, east, south, central, southwest, and northwest), which is an official regional classification that reflects economic, cultural, climatic, and resource allocation characteristics across the country. Participating sites were selected from all seven regions encompassing both urban and rural areas. Each region included no less than two urban sites and one rural site.^{14,15} A total of 31 monitoring sites were selected, including 24 urban and seven rural sites, which covered a population of 125.5 million.¹⁴

In the process of site selection and achievement of cooperation, the leaders of the emergency medicine team of Qilu Hospital proactively leveraged their academic reputation and influence in the field of emergency medicine to extend invitations to the directors of the target sites (EMS directors of provincial capitals and municipalities) and elucidated on the funding sources, significance, and data sharing protocols associated with the investigation. Since such large-scale clinical studies in the field of pre-hospital emergency care are rare in China, the directors of each site initially had concerns. Firstly, there was uncertainty surrounding data security as patient privacy could potentially be compromised. Secondly, this investigation entailed additional work beyond their daily clinical practice; considering that EMS staff already bear a heavy workload with limited manpower and high turnover rates, they were unsure about how much personnel should be allocated for participation without affecting routine clinical duties. Lastly, it would be embarrassing if unsatisfactory outcomes from one agency such as low survival rates or prolonged response times were made public.

Several solutions have been proposed to effectively address these concerns. Firstly, multiple measures are implemented to ensure data security. Each investigator is assigned an independent account and is restricted from accessing the data of other investigators. Unauthorized parties and outside entities cannot gain access to the data. Patient privacy information will be promptly desensitized upon completion of registration. A data confidentiality agreement must be signed to establish the responsibilities of both parties in case of a data breach. Secondly, efforts are made to minimize the workload for investigators, and scientifically and reasonably determine the variables to be collected. The relevant variables are developed based on the Utstein template and actual circumstances of China. EMS directors and experts in emergency, critical care, clinical research, and statistics were convened to discuss the necessity of each variable setting, which received unanimous endorsement from these experts. Moreover, priority should be given to completing clinical work before conducting data collection overtime if necessary. Thirdly, it is ensured that national or regional level reporting will take place while specific agency-level data will not be publicly disclosed.

The majority of the directors demonstrated a strong willingness to participate, taking into account the aforementioned solutions and recognizing the positive impact this investigation would have on work quality and patient outcomes. In addition, it is also attractive that participating in national projects can improve the research capabilities of investigators and the academic reputation of the institutions. In cases where the EMS of the provincial capital city did not express interest,



Fig. 1 – The electronic collaborative network platform of the BASIC-OHCA registry. BASIC-OHCA: BASeline Investigation of Out-of-hospital Cardiac Arrest; EMS: emergency medical service.

communication was established with the director of an EMS in a prefecture-level city within the same province to ascertain their willingness to participate. In some provinces, there are no cooperative urban sites. Rural sites in each of the seven geographic regions were recommended by the directors of the selected urban EMS sites due to their established cooperation and capable administrative execution of the rural site directors to facilitate the smooth progress of the investigation. Each region is led by a highly esteemed and influential director who serves as the regional leader.

To ensure the high-quality operation of the project, a Project Steering Committee, an Expert Advisory Committee, a Project Coordination Center, and Regional Coordination Groups were established.¹⁴ The Project Steering Committee is responsible for developing protocols, monitoring research progress, and resolving major issues. Its members consist of the registry chairman and regional leaders from the seven regions who were determined during the cooperation negotiation stage and national project application stage. This committee convenes formal meetings 1–2 times annually to discuss project operations, fund utilization, significant changes, and other matters while proposing corresponding solutions. In case of major matters arising unexpectedly, emergency meetings are promptly held for effective communication. The Expert Advisory Committee comprises esteemed professionals specializing in emergency medicine, pre-hospital care, critical care, cardiology, statistics, public health and other related fields. Their role is to offer expert guidance, ensure effective oversight, and facilitate collaborative efforts. The Project Coordination Center is responsible for the management of all project operations, including overall planning, implementation, monitoring, resource integration and deployment, database establishment and maintenance, data management and quality control, as well as communication and coordination. The center holds a weekly meeting to promote the progress of the project. Regional Coordination Groups are accountable for executing and managing the project within specific regions while providing support to the Project Coordination Center in effectively overseeing regional

implementation. These groups engage in daily communication with the participating sites in the region regarding relevant matters.

An electronic collaborative network platform has been developed, which can be easily operated on various terminals such as web pages and mobile applications. One of the key features of this platform is the electronic data capture (EDC), with which investigators can easily input data directly into the system, eliminating the need for paperwork and reducing human error. Furthermore, the platform incorporates follow-up reminders to prompt investigators to conduct timely follow-ups with patients or collect additional data as required by the study protocol. Quality control is an indispensable component within this platform. Advanced algorithms are employed to automatically detect any inconsistencies or errors in the collected data, while personnel responsible for quality control can manually propose queries, enabling researchers to promptly address and rectify potential issues that may arise. Throughout this entire process, a comprehensive audit trail is maintained, ensuring easy traceability of changes made. Moreover, the platform offers visual displays of overall progress and key indicators, facilitating project supervision by the coordination center (Fig. 1).

The investigation was approved by the ethics committee of the coordination center, Qilu Hospital of Shandong University (authorization number 2019012) with waiver of patient consent. All participating sites agreed on this ethics approval.

Implementation – data collection and management

As for the data collection method, a preliminary survey conducted by the project coordination center revealed that electronic medical record systems are prevalent; however, there are still some EMS agencies where handwritten paper medical records are utilized and stored in the medical records database either of stations or the dispatch center. Prospective data collection is crucial to ensure the accuracy and completeness of the target variables, as the extraction of structured data from electronic or handwritten paper medical records remains unattainable.

Since August 2019, OHCA patients assessed by EMS staff were consecutively enrolled by participating EMS agencies. EMS medical staff or dispatchers, as investigators, registered patients and reported data through the EDC within 24 hours of assessing patients. Information was obtained from interviewing family members or bystanders and reviewing medical records. For patients transferred to the hospital, investigators need to complete the collection of information in emergency department (ED) and hospitalization by consulting the emergency physicians. For patients who survived to discharge, followed up were taken on the patients or their families according to the prompts (30 days, 6 months, and 12 months) from the EDC system. If patient outcomes were not available, data from the national death registration system, outpatient data, and inpatient data of all hospitals covered by the EMS agencies were used to complete patient survival outcomes.

This registry prioritizes data quality management as one of its core tasks, ensuring comprehensive coverage of quality control throughout the entire project process and all participants.^{14,15} During the start-up phase, a unified training plan and core documents were formulated by the project coordination center, including study protocol, case report form (CRF), data dictionary, data management plan, etc. Special personnel were sent to all the participating sites for on-site training and guidance on data collection and query response. In the implementation stage, the data quality control was continuously performed using logical verification embedded in the EDC system, statistical verification, manual verification, etc. Additionally, quality control personnel visited participating sites for on-site assessments to ensure compliance with the protocol while solving problems and providing retraining as necessary. During the data analysis stage, the coordination center conducted an additional round of spot checks and accomplished the tasks of data cleaning and analysis. This process adhered to a two-person back-to-back workflow in order to minimize potential human errors.

Current State

BASIC-OHCA is a new member of the international OHCA registry family. Since August 2019, over 300,000 EMS-assessed OHCA cases and over 90,000 EMS-treated OHCA cases have been enrolled across China. According to the requirements of the Ministry of Science and Technology to support the project, the scientific data specified in the fundamental investigation task has been submitted to the National Population Health Data Center to facilitate data sharing. Since 2021, some participating sites have ceased collaboration while new sites have progressively joined. Some sites enroll EMS-treated patients, and some solely register patients treated by specific stations. Presently, there are still at least 25 monitoring sites continuing to actively contribute data.

The BASIC-OHCA registry has facilitated significant advancements not only in terms of data, but also across various dimensions aimed at enhancing CPR quality, with active involvement from leading researchers at the participating sites in the project.

Understanding the current situation

Currently, our primary focus is to comprehensively understand the nationwide situation and identify areas for improvement (Fig. 2). The incidence of EMS-assessed OHCA in China stands at 95.7/100,000 with an estimated annual case count exceeding 750,000. Only a mere 31.8% of EMS-assessed OHCA cases

received treatment from EMS staff. Among non-traumatic EMS-treated OHCA patients, survival to discharge was observed in only 1.2%, while favorable neurological outcomes were seen in just 0.8%.¹⁵ The results did not demonstrate significant improvement when compared to previous local data from the past 10 years,^{16,17,20–22} and they fall considerably below those observed in high-income countries (HICs).¹ There is room for improvement in several aspects of the chain of survival, including long EMS response time (12 minutes), low application rate of bystander CPR (20.3%), dispatcher-assisted CPR (DA-CPR) (11.5%) and automated external defibrillator (AED) (<0.1%).¹⁵ As Adam Mellett-Smith and Keith Couper commented, the data has identified key opportunities to improve OHCA outcomes in China by optimizing community response, which can facilitate the sharing of experience with other countries towards the beginning of their journey in improving outcomes from OHCA.²⁴

Establishing investigation standards

Based on the Utstein template and local conditions in China, the BASIC registry has developed a set of standards and technical specifications suitable for investigating cardiac arrest in Chinese individuals. This has been submitted as a national standard and reviewed and approved by the Standardization Administration of China. The successful publication of the standard will play a crucial role in promoting the standardization and sustainability of cardiac arrest investigations within the Chinese population.

Promoting the administrative, public welfare and technical activities

During the implementation of the investigation, many participating sites actively promoted national and local administrative activities related to cardiac arrest care through various forms, such as drafting the “Guidance for The Configuration of Automated External Defibrillator in Public Places (Trial)” released by the National Health Commission,²⁵ formulating the local standard “Specification for the Construction and Management of Automated External Defibrillator in Public Places”, and promoting local legislation like “Hunan Province On-site First Aid Regulation”. Furthermore, significant efforts were made to enhance CPR training for the public, including initiatives like the “Public First Aid Knowledge and Skills Training Course”, “1555” urban first aid volunteer service actions, and “First Aid Onsite-First Responders Action”.²⁶ Based on clinical practice, registry data, and local culture, advanced dispatch systems and video-instructed DA-CPR platforms were developed to help dispatchers provide standardized guidance on bystander CPR.^{27,28}

Challenges

Sustainability

The BASIC study marks the initiation of a nationwide registry-based investigation on cardiac arrest in China, which should be continued and expanded as a fundamental basis for achieving persistent quality improvement efforts. However, ensuring sustainability poses a significant challenge. Firstly, national projects are bound by predetermined execution periods. Once completed, it becomes difficult to maintain the previous level of data reporting at existing participating sites and attract new sites to join. The results and efforts from BASIC have generated increased recognition among EMS directors regarding the value and vision of this registry; however, participation has

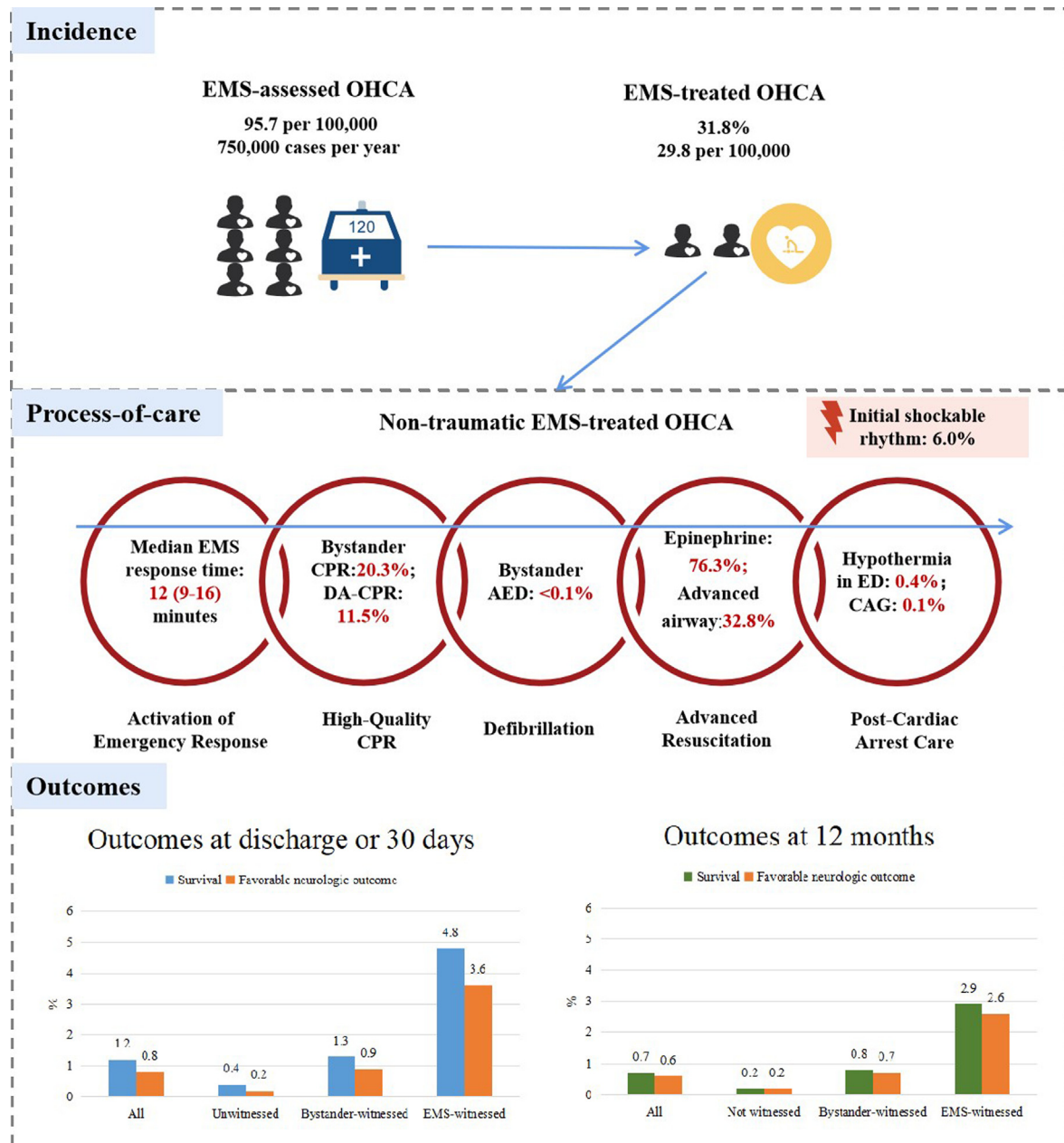


Fig. 2 – Incidence, process of care, and outcomes of OHCA in BASIC-OHCA registry. AED: automated external defibrillator; BASIC-OHCA: BASeline Investigation of Out-of-hospital Cardiac Arrest; CAG: coronary angiography; CPR: cardiopulmonary resuscitation; DA-CPR: dispatcher-assisted cardiopulmonary resuscitation; ED: emergency department; EMS: emergency medical service; OHCA: out-of-hospital cardiac arrest.

yet to reach its full potential. Although the monitoring network spans across seven geographical regions in China, it still covers less than 10% of the national population. More needs to be done to enhance awareness of the benefits associated with this registry and promote data sharing. Secondly, financial support presents a practical issue that cannot be overlooked. Adequate funding is necessary for maintaining normal operations across all aspects of registries, particularly in guaranteeing high-quality data reporting. In addition to financial support from the Ministry of Science and Technology in BASIC, implementation is ensured through multi-party backing from other non-commercial research projects whose corresponding research objectives can be achieved through BASIC data utilization.

Therefore, uninterrupted completion of successfully applied-for projects remains an ongoing task.

Data extractability in medical records

Owing to the constraints associated with extracting target variables from medical records, there is a necessity for manual data collection, thereby burdening EMS personnel with additional workload. Certain participating sites have recognized this concern and are presently undergoing information technology upgrades by integrating target variables into medical records, which facilitates EMS personnel in generating structured data during patient record documentation. Nevertheless, instances of such initiatives remain rare as most sites

continue to collect data manually. Furthermore, due to the frequent turnover and rotation of EMS personnel, ongoing training efforts along with strengthened quality control measures become imperative for the coordination center, which has devoted substantial resources towards ensuring the continuous enrollment of the target population as well as completeness and accuracy of data.

Obtaining care and outcome indicators during the ED and hospitalization for EMS-treated OHCA patients who are transferred to hospitals presents a big challenge. The lack of linkage between the EMS and hospital electronic systems prevents automatic matching of information. Additionally, accurate personal information of OHCA patients is often unavailable due to the emergency situation and the absence of family members. As a result, valuable time were spent in searching for relevant hospital information. Therefore, it is imperative to enhance both the degree of information technology and standardization in medical record documentation to improve extractability of variables.

Future directions

Providing sufficient knowledge

The primary objective of the BASIC registry is to collect and report national data on the epidemiology and treatment of cardiac arrest in China. Preliminary findings have already been published in a recent paper.¹⁵ Additional results will be presented focusing on the “chain of survival” and initiatives encompassing ten steps aimed at enhancing survival. This includes key factors related to care implementation in community settings, EMS, ED, and other relevant aspects. Furthermore, efforts will be made to examine spatio-temporal variations in occurrence and treatment patterns, develop a more rational strategic plan for the placement of AEDs, assess the impact of the pandemic, among other objectives. Researchers from participating sites are strongly encouraged to utilize registry data for analysis, while endeavors are being made to enhance data sharing among existing participants and attract new ones.

The development of this registry has brought to light the shortcomings in treatment at some participating sites, prompting them to take measures for quality improvement. We anticipate that years of continuous data collection and before-and-after comparisons will demonstrate changes in treatment and outcomes through a quantified statistical indicator.

Striving for more administrative and social support

Based on the fundamental investigation tasks and local efforts, it is hoped that enhanced administrative support can be obtained through diverse channels to facilitate the expansion of registry and quality improvement initiatives.

Providing well-structured annual reports containing results and perspectives on OHCA may be an effective way of reporting to administrative departments about the current situation, while facilitating evidence-based decision-making. These reports will enable administrators to identify areas within the medical system that require to be improved. For instance, if certain regions consistently demonstrate lower survival rates or longer response times compared to national averages, targeted interventions can be implemented to address these disparities. Moreover, annual reports will facilitate tracking progress over time by comparing data from previous years. This longitudinal analysis aids in identifying long-term trends or patterns that may necessitate attention or further investigation.

Another important measure is to promote the convenience and standardization of quality control indicator reporting. Relying on the existing quality control system in China, the National Health Commission, as the governing authority, mandates the reporting of key core indicators in medical treatment. Among these reported indicators, one is specifically related to cardiac arrest - the rate of return of spontaneous circulation (ROSC).²⁹ BASIC aims to standardize the collection of this indicator to enhance the convenience of indicator reporting and quality management. Additionally, it is highly recommended that more indicators related to cardiac arrest care be incorporated into national quality control system, as this would greatly facilitate administrators in overseeing medical quality and encourage medical institutions to prioritize cardiac arrest treatment and active participation in this registry.

The fostering of collaboration among a broader spectrum of institutions and organizations in China is imperative to jointly promote the profound development of OHCA registry. The collaboration with academic institutions and research organizations can facilitate further studies, publish research papers, present findings at conferences, and enhance awareness among policymakers and healthcare professionals regarding the significance of improving outcomes for OHCA. Collaborating with community groups and non-governmental organizations will enable us to collectively implement public education campaigns, deliver comprehensive first-aid skills training programs, and enhance public's capacity to identify OHCA and provide assistance. They may also provide valuable feedback on the effectiveness of current initiatives or suggest new approaches for further quality improvement.

Promoting medical information technology

The method of data extraction is a crucial factor that hinders the efficient development of registries. Currently, the collection of cardiac arrest data heavily relies on manual reporting, demanding significant efforts as well as financial support. With the rapid advancement in medical information technology and enhanced collaboration among experts from diverse fields, it is foreseeable that targeted cases can be identified from EMS systems and variables can be automatically reported.³⁰ Additionally, while it may prove challenging to achieve in the short term, we should explore the feasibility of connecting OHCA registries with other healthcare datasets.³¹ A potential option is to develop a secure cloud platform for the management of emergency and critical care information. This platform would collect data on the characteristics, treatment, and outcomes of OHCA patients from various datasets, including EMS dispatching and medical record systems, hospital information systems, medical insurance systems, death registration systems, and other relevant sources. Subsequently, the collected data would undergo classification, cleansing, extraction processes followed by extensive analysis to significantly enhance treatment efficiency and improve capabilities in data reporting.³²

Conclusion

The BASIC-OHCA registry represents the initial stride towards enhancing survival of OHCA patients in China, by establishing a nationwide data reporting network and implementing standardized data collection. Nevertheless, BASIC-OHCA still encounters numerous challenges pertaining to sustainability and data equity, as well as several missions and breakthroughs that necessitate future comple-

tion. A comprehensive understanding of these circumstances could contribute to the enhancement of care quality and outcomes for cardiac arrest in China, while also serving as a reference for large-scale registries in low-resource settings.

CRediT authorship contribution statement

Wen Zheng: Writing – original draft, Validation, Software, Methodology, Formal analysis, Conceptualization. **Jiaqi Zheng:** Writing – original draft, Validation, Software, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Chunyi Wang:** Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Chang Pan:** Validation, Software, Methodology, Data curation, Conceptualization. **Jianbo Zhang:** Validation, Software, Methodology, Investigation, Data curation, Conceptualization. **Rugang Liu:** Validation, Software, Methodology, Investigation, Data curation, Conceptualization. **Yuan Bian:** Validation, Software, Methodology, Investigation, Data curation, Conceptualization. **Jingjing Ma:** Validation, Software, Methodology, Investigation, Data curation, Conceptualization. **Kai Cheng:** Validation, Software, Methodology, Investigation, Data curation, Conceptualization. **Feng Xu:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition, Conceptualization. **Yuguo Chen:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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