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Clinical paper

A national effort to improve outcomes for in-hospital cardiac arrest in China: The BASeline Investigation of Cardiac Arrest (BASIC-IHCA)

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Abstract

Background: In-hospital cardiac arrest (IHCA) is a common clinical event with poor outcomes. Former IHCA registries in China were local, inconsisten
t in data reporting, and lacked attention to the process of care. Therefore, we designed and implemented the BASeline Investigation of In-hospital Cardiac Arrest (BASIC-IHCA), the first national IHCA registry in China.

Methods: BASIC-IHCA is a prospective, multicenter, observational study with a nationwide surveillance network covering urban and rural hospitals from seven geographic regions of China. IHCA patients were enrolled continuously, and data were collected from medical records by investigators at participating hospitals. Key variables referring to the updated Utstein Template included patient information, event variables, process of care, and outcomes. Follow-up was conducted by telephone interview to obtain details on long-term survival and neurological status.

Results: Thirty-two urban hospitals and eight rural hospitals from twenty-nine provinces in seven geographic regions of China participated in BASIC-IHCA. The starting time of enrollment ranged from July 1, 2019, to January 1, 2020. By December 31, 2020, 35,451 IHCAs were enrolled in all participating hospitals, of which 19,493 (55%) received CPR, with a predominance of males (65%) and a median age of 65 years.

Conclusion: BASIC-IHCA is the first national registry for IHCA in China. It will describe the epidemiology and outcomes of IHCA from a nationwide perspective, with a particular focus on details of the process of care for quality improvement. Meanwhile, it will help to facilitate the standardization of IHCA-related data reporting in China.

Keywords: In-hospital cardiac arrest, Resuscitation, Registry, Quality improvement

Introduction

In-hospital cardiac arrest (IHCA) is an acute event that can occur in all hospitalized patients and is often associated with significant mortality.[1] Several national registries of IHCA have been conducted worldwide, such as the American Heart Association's Get With The Guidelines-Resuscitation (GWTG-R) registry, the United Kingdom National Cardiac Arrest Audit (NCAA), the Swedish Register of Cardiopulmonary Resuscitation (SRCPR), and the Danish in-hospital cardiac arrest registry (DANARREST), reporting incidences of IHCA

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ranging from 1.7 to 17.16 per 1,000 admissions.[2–6] It has been demonstrated that survival and neurological outcomes of both adult and pediatric IHCAs at hospitals participating in a large national quality-improvement registry have improved significantly over time.[7,8]

China is a large country with a population of 1.4 billion,[9] with great geographic variation between regions and significant urban–rural disparities.[10] Previous local registries were unable to reflect the general situation of IHCA in China due to the shortage of coverage as well as differences in study objectives and data reporting. A Chinese regional study in 2014 reported the incidence of adult IHCA in Beijing as 17.5 per 1,000 admissions, and 9.1% of IHCA patients were discharged alive, which was much lower than the data from the GWTG-R (24.8%) and NCAA (18.4%) during the same period, indicating that there is much room for improvement in the quality of resuscitation in China.[3,11,12] However, previous work has rarely focused on the details of the process of care and thus cannot provide guidance for quality improvement.

To address these problems, the BASeline Investigation of In-hospital Cardiac Arrest (BASIC-IHCA) was designed and implemented with support from the Ministry of Science and Technology of the People's Republic of China. BASIC-IHCA referred to the Utstein Template for data collection and covered all seven geographic regions of China, aiming to describe the current situation and explore options for quality improvement. The specific objectives of BASIC-IHCA are (1) to establish a national, sustainable, standardized IHCA data reporting system; (2) to understand the current situation of IHCA epidemiology and management; and (3) to identify opportunities for improvement in IHCA care and provide measurable indicators and directions.

Methods

Study design

BASIC-IHCA is a prospective, multicenter, observational study that was designed to enrol patients who experienced IHCA in participating hospitals continuously. To ensure the scientific validity of the registry, an advisory committee of multidisciplinary experts was established, including specialists in emergency medicine, cardiovascular medicine, pediatric and adult critical care medicine, and statistics. A central coordinating centre was organized to maintain the operation of BASIC-IHCA and was responsible for conducting central data quality monitoring as well as holding regular registration quality control meetings.

Site selection

Geographically, there are seven regions in China (northeast, north, east, south, central, southwest, and northwest) containing several provinces respectively. Each province is further divided into several prefecture-level cities and dozens of counties (or county-level cities). According to the official view, prefecture-level cities (including provincial capitals) are defined as urban, and counties (or county-level cities) are defined as rural.[10] Economic development levels, clinical capacities, and dietary habits vary among geographic regions; differences also exist between urban and rural areas. Hospitals in China are officially classified into three levels: Grade III hospitals refer to medical centres or tertiary general hospitals with more than 500 beds, Grade II hospitals are generally regional hospitals with 100–500 beds, and Grade I hospitals are mostly community-based hospitals with less than 100 beds and do not have an emergency department.[13]

In BASIC-IHCA, Grade III hospitals in prefecture-level cities (mostly provincial capitals) of each province were selected as urban monitoring sites, and if the hospital was not interested in participation, a substitute at the same level was included. Considering the relative concentration of the medical resources in Beijing and Shanghai (as provincial administrative divisions), four hospitals in Beijing and two hospitals in Shanghai were selected. In addition, one to two county hospitals (generally the largest hospital, Grade II or III) were selected as rural monitoring sites in each of the seven regions. Thus, BASIC-IHCA enables the inclusion of both urban and rural participating hospitals in all seven geographical regions to capture a holistic view of IHCA in China.

CPR in Chinese hospitals

Currently, very few hospitals in China have established hospital-wide rapid response teams (RRTs), although they are considered to be associated with decreased incidence of IHCA and in-hospital mortality.[14,15] RRTs in Chinese hospitals are responsible for the entire hospital area other than the emergency department (ED) and intensive care unit (ICU), team members are generally intensive care physicians and nurses. Once a cardiac arrest occurs, the closest physician will activate resuscitation and call the RRT. The team will take over and continue to organise resuscitation on arrival.

Most hospitals in China do not have standard RRTs, and the organisation of resuscitation is divided into three scenarios depending on the location of the cardiac arrest: ED/ICU, general wards and public areas. First, resuscitation in the ED/ICU is activated and organised by the closest physician and performed by local medical staff on duty. Second, in general wards, resuscitation is also activated by the closest physician and is organised by the physician in charge or on duty subsequently. In Chinese hospitals, almost every department has one 'chief resident' or several 'chief residents', which are relatively senior physicians with extensive clinical experience and are responsible for in-hospital consultations, management of patients in the department (usually off-hours) and organization of resuscitation. Once a cardiac arrest occurs in general wards, the physician in charge of the patient may call 'chief resident(s)' from ED, ICU or Cardiology Department for assistance while performing resuscitation, but this is not mandatory. Third, in public areas, resuscitation is activated by the closest physician. At the same time, on-duty ED 'chief resident' is called. The ED 'chief resident' and his/her response team will take over the organization and performance of resuscitation subsequently. Patients will be quickly transferred to the ED for advanced care.

For patients achieving ROSC, physicians generally recommend transferring them to the ICU for further post-arrest treatment. However, whether to transfer or not is eventually determined by the patient's family and other objective factors, such as the availability of ICU beds. In the case of refusal to transfer, patients will continue to receive treatment in situ by local physicians. If resuscitation is performed for more than 30 minutes with no ROSC, the physician will make a recommendation to stop the efforts, but the decision is all made by the patient's family ultimately.

In Chinese hospitals, if the patient is in critical condition or with end-stage disease, the physicians will communicate with the family about whether to attempt CPR when cardiac arrest occurs. If the family members decide not to attempt resuscitation, they will sign

an informed consent regarding refusal to perform CPR, which is similar to the DNACPR order and is included as part of the medical records. It's rare for patients to sign the document themselves.

Patient enrolment

Cardiac arrest is defined as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation.[16] All victims (adult, pediatric, and neonatal) who sustain a cardiac arrest in any area of the hospital, regardless of whether chest compression or defibrillation is performed, are eligible for inclusion in the BASIC-IHCA study, which includes not only hospitalized patients but also emergency patients, outpatients, visitors, and staff in a hospital. The location of cardiac arrest can be the outpatient area, emergency department (ED), intensive care unit (ICU), general wards, operating room, and public non-clinical area. If a patient suffers multiple cardiac arrests in a single admission, the first episode is recorded. Cardiac arrests of the same person at different admissions should be included separately. Out-of-hospital cardiac arrests with treatment by EMS or other personnel are excluded. Participating hospitals began to enrol cardiac arrest patients successively from 1 July 2019, regardless of whether they received resuscitation. From 1 January 2021, all centres enrolled only resuscitated cardiac arrest patients.

For consecutive enrollment, when IHCA occurred, investigators at participating hospitals were notified by physicians in the corresponding department to collect data promptly. In addition, to ensure that no IHCA was missed, investigators were also trained to work with hospital network information departments to identify potential IHCAs by retrieving medical orders and billing information related to cardiac arrest from the Hospital Information System (HIS) through specific queries.

Data collection

A list of variables was determined based on the Utstein Template, covering the core elements such as hospital information, patient information, event variables, process of care, and event outcomes.

Annual admissions of all participating hospitals were collected to calculate the incidence. Patient information included age, sex, ethnic group, height, weight, medical history, and pre-existing conditions, such as coronary heart disease, myocardial infarction, congestive heart failure, sepsis, hepatic and renal insufficiency, malignancy, etc. Event variables consisted of location, time, witnessed or monitored, cause of arrest, and initial rhythm. The process of care, such as chest compression, defibrillation, ventilation, and use of medications, was recorded in detail. In addition, the use of other interventions such as extracorporeal membrane oxygenation (ECMO), targeted temperature management (TTM), and revascularization was also recorded.

Event outcomes included survival to discharge or 30-day survival, 6-month survival, 12-month survival and neurological outcomes at the corresponding time points. Any ROSC and sustained ROSC (lasting $\geq$ 20 min) were also recorded. A good neurological outcome was defined as cerebral performance category (CPC) score of 1 or 2 in adults ($\geq$18 years) and pediatric cerebral performance category (PCPC) score of 1–3 in paediatrics (<18 years)[17,18] (Table 1, find detailed descriptions in Supplement Table A1).

The survival and neurological status were assessed by trained investigators through telephone following a standardized script. The registry-specific electronic data capture (EDC) system could automatically remind investigators to follow up at the appropriate time and stored all call records for quality control. For patients who failed to be contacted, up to 2 additional attempts would be made at different dates and times. If remained unsuccessful, further matches would be made with all outpatient and inpatient data of the hospital, as well as the National Disease Surveillance System Death Cause Surveillance Network Report Database. In case all the above measures failed, the case was defined as lost to follow-up.

Data management

The focus of data management is to ensure the continuity, integrity, accuracy, and security of all collected data. To facilitate data collection, an electronic data capture (EDC) system was developed by the central coordinating centre, Qilu Hospital of Shandong University. Data were entered into the EDC system by trained investigators through a dedicated website or mobile application.

There were several audit features in BASIC-IHCA to ensure data integrity and accuracy. Specific input checks were performed when data were entered into the EDC system. If there were data formatting errors or values that were clearly out of reasonable range, then investigators would be alerted to review and correct the data. Second, data was reviewed by quality control officers at participating hospitals within seven days of case registration. If errors, incompleteness, or doubts about data were detected, investigators were required to complete the record, or make clarifications. Third, batch quality control of the data was performed by statisticians fortnightly through specific logic algorithms, such as time sequencing of relevant events, duplicate registrations, outliers in continuous data, etc. Fourth, a certain percentage of newly registered cases were re-examined online randomly by the central coordinating centre every week to evaluate the work quality of both investigators and quality control officers at participating hospitals to make targeted improvements or conduct retraining. Fifth, a team consisting of one to two central coordinators and several quality control officers was dispatched to each participating hospital every three to six months to conduct on-site inspections, with the tasks of verifying case omission, the completeness of original information, and the accuracy of registration.

Data de-identification was performed for security and ethical requirements, and we treated all data as protected information and stored it securely in an encrypted database. All trained staff were assigned with a unique account with appropriate EDC access based on their duties, and user authentication was achieved through a secure password.

Ethics approval

BASIC-IHCA was approved by the Central Ethics Committee at Qilu Hospital of Shandong University, and the requirement for written informed consent was waived. Six rural hospitals and six urban hospitals accepted the central ethics approval, whereas two rural hospitals and twenty-six urban hospitals obtained local approval from the internal ethics committee. The study was registered at https://www.clinicaltrials.gov (NCT03926325).

Statistical analysis

The annual incidence of IHCAs with resuscitation attempts was calculated based on total hospital admissions and presented as the number of arrests per 1,000 admissions. The epidemiological characteristics, process indicators, and outcomes were evaluated in IHCA patients who underwent resuscitation efforts. Continuous variables are summarized as the mean ± standard deviation or median

Table 1 – Core variables included in the BASIC-IHCA.

Hospital information
Number of hospital admissions per calendar year
Number of treated in-hospital cardiac arrests per calendar year
Patient information
Age
Sex
Ethnic group
Height
Weight
Personal history
Out-of-hospital cardiac arrest before this admission
Pre-existing conditions at time of event
Event variables
Location of event
Date of emergency department visit/admission
Aetiology
Event witnessed
Event monitored
Time of event
Initial rhythm
Process of care
Resuscitation attempted
Resuscitation team called
Time compressions started
Compression method(s) used
Time defibrillation first applied
Total number of defibrillation shocks
Airway interventions
Time of endotracheal intubation
Time epinephrine first injected
Total number of epinephrine injections
Other drugs given
Other interventions
Event outcomes
Any ROSC
Sustained ROSC
30-d survival or survival to discharge
Neurological outcome at 30 d after cardiac arrest or hospital discharge (CPC/PCPC)
Survival status (6 m, 12 m)
Neurological outcome at 6 m/12 m after cardiac arrest (CPC/PCPC)

Detailed descriptions of elements for the BASIC-IHCA are included in Supplement Table 1. ROSC: return of spontaneous circulation; CPC: Cerebral Performance Category; PCPC: Pediatric Cerebral Performance Category.

and interquartile range (IQR). Categorical variables are presented as percentages. Some continuous variables were transformed into dichotomous variables based on clinical cutoff values due to statistical needs. Multivariate logistic regression models were used to identify factors that predicted outcomes. A two-sided p-value of less than 0.05 was considered statistically significant. All statistical analyses were performed using R version 3.6.2 (Free Software Foundation, Boston, MA) and SAS version 9.4 (SAS Institute, Cary, NC, USA).

Results

A total of thirty-two urban hospitals and eight rural hospitals participated in the BASIC-IHCA in twenty-nine provincial administrative divisions of all seven geographic regions. There are three urban hospitals in Northeast China, eight in North China, eight in East China, three in South China, three in Central China, two in Southwest China, and five in Northwest China. Except for two rural hospitals in Eastern China, there is one rural hospital in each of the other six geographic regions. The distribution of the participating hospitals is shown in Fig. 1, and more detailed information of the hospitals is presented in Supplement Table A2.

The beginning time of enrollment ranged from July 1, 2019, to January 1, 2020, among all 40 participating hospitals. By December 31, 2020, a total of 35,451 IHCA cases were enrolled in the database, of which 19,493 (55%) received chest compression or defibrillation. The resuscitated population was predominantly male (65%), with a median age of 65 years. The number of cases reported per month is shown in Fig. 2, and the situation by region is shown in Fig. 3.

Discussion

BASIC-IHCA is the first national registry for IHCA in China, which includes both urban and rural hospitals in each of the seven geographic regions. All 40 participating hospitals currently in operation cover 29 of the 31 provinces in Mainland China. It will provide nationwide observational data and key information on the process of care, to create opportunities for improving the quality of care and evaluating the improvements.

To address the lack of standardization of variables and definitions in previous cardiac arrest registries, the International Liaison Committee on Resuscitation (ILCOR) developed and published the Utstein Resuscitation Registry Template to provide guidelines for the uniform reporting of IHCA events in 1997 and updated it in 2004 and 2019.[16,19,20] The variables in BASIC-IHCA are largely consistent with the core elements of the Utstein Template and have been disseminated across a nationwide registry network. We expect to accelerate the standardization of IHCA registries in China and align them with international recommendations.

In contrast to the updated in-hospital Utstein Template, which defined cardiac arrest as receiving CPR or defibrillation, patients without resuscitation were still enrolled in BASIC-IHCA. It was mainly based on two considerations: firstly, the real in-hospital situation of 'cardiac arrests' no matter with or without resuscitation in China remained unknown before BASIC-IHCA, so we need to collect data on both sides to get a comprehensive perspective; Secondly, due to differences in culture and medical systems, China is significantly distinct from Western countries in terms of the factors affecting resuscitation decisions and the signing of DNACPR orders, which we want to explore through the analysis of those who did not receive resuscitation. It is important to highlight that only personal information and event information was collected for patients without resuscitation, and they were not included in the calculation of incidence, as well as in the further description of the process of care and outcomes.

In China, it is difficult to identify IHCA directly from medical records because physicians often focus more on the aetiology when completing the diagnostic elements and often neglect the diagnosis of pathophysiological states, such as cardiac arrest. Although the International Classification of Diseases (ICD, 10th revision) is already used in almost all Grade II and Grade III hospitals in China, it is unreliable to check the list of cardiac arrests simply by searching CA-related codes (e.g., I46.0, I46.1, I46.9, I49.0). Therefore, we developed a novel strategy based on the information and features in the HIS. Specifically, in addition to searching ICD-10 codes, further

Fig. 1 – Geographic distribution of 40 participating hospitals in the BASIC-IHCA. BASIC-IHCA indicates the BASeline Investigation of In-hospital Cardiac Arrest.

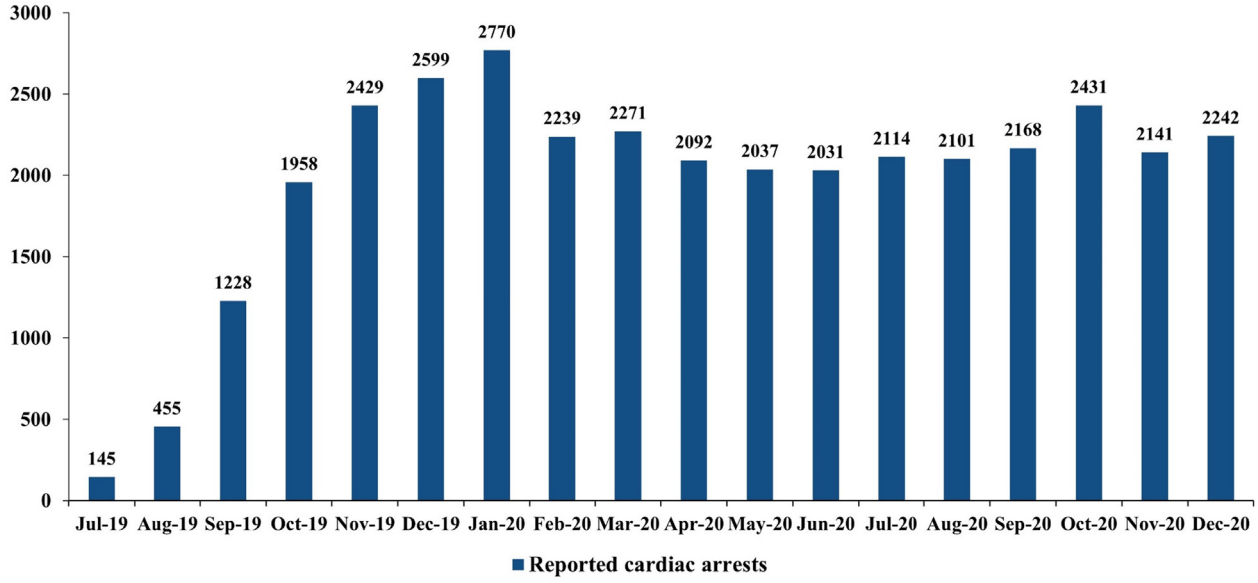

Fig. 2 – Number of reported cardiac arrests per month in the BASIC-IHCA (07/01/2019–12/31/2020). BASIC-IHCA indicates the BASeline Investigation of In-hospital Cardiac Arrest. Data derived from 40 participating hospitals of BASIC-IHCA.

comprehensive measures, such as retrieving cardiac arrest-related medical orders and charges, are used to capture potential cardiac arrest patients. It has been validated that these measures are effective in avoiding case omissions, allowing an accurate description of the incidence and the details of the process of care. This retrieval was validated on-site by the central coordinator.

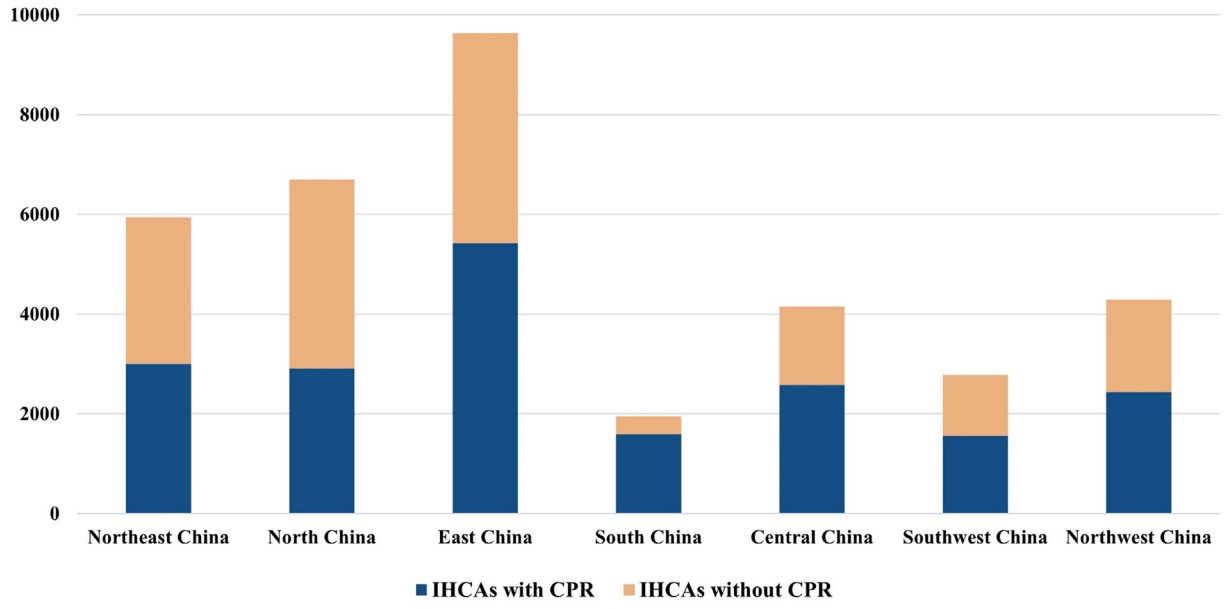

Fig. 3 – Number of reported cardiac arrests by region in the BASIC-IHCA (07/01/2019–12/31/2020). BASIC-IHCA indicates the BASeline Investigation of In-hospital Cardiac Arrest. Data derived from 40 participating hospitals of BASIC-IHCA.

Despite decades of improvements in resuscitation, survival rates for IHCA in China remain low.[11] We look forward to developing BASIC-IHCA as an ongoing monitoring platform for IHCA in China, allowing participating hospitals to evaluate their resuscitation performance and track long-term trends. It will also become a valuable resource for future research and will be shared with the government, health care providers, and research institutions to improve the levels of evidence for resuscitation guidelines and provide insights for future research in the field of resuscitation.

Limitations

The coverage of BASIC-IHCA is still low compared to other national registries. Due to the assessment of current resources and the need for continuous registration in the long term, BASIC-IHCA will maintain and continue to increase the number of participating hospitals, and commit to collaborating with other data platforms for automating data registration through models, such as structured electronic medical record information capture, to improve the representation and better explore the real situation of cardiac arrest in China.

Conclusion

BASIC-IHCA is the first nationwide registry for IHCA in China, which will systematically describe the current situation, promote understanding of the process of care, and provide opportunities to achieve quality improvements in Chinese cardiac arrest care. Meanwhile, it will accelerate the standardization of IHCA registration in China to align with the international recommendation. BASIC-IHCA is the first step in a series of IHCA resuscitation quality improvement programs and serves as the basis for future clinical trials in cardiac arrest management in China.

CRediT authorship contribution statement

Chunyi Wang: Conceptualization, Methodology, Software, Data curation, Validation, Investigation, Formal analysis, Writing – original draft. **Wen Zheng:** Conceptualization, Methodology, Software, Validation, Formal analysis, Writing – original draft. **Jiaqi Zheng:** Methodology, Software, Validation, Investigation, Formal analysis, Project administration, Writing – original draft. **Fei Shao:** Conceptualization, Methodology, Supervision. **Yimin Zhu:** Investigation, Resources, Data curation, Project administration. **Chaoqian Li:** Investigation, Resources, Data curation, Project administration. **Yu Ma:** Investigation, Resources, Data curation, Project administration. **Huiqiong Tan:** Investigation, Resources, Data curation, Project administration. **Shengtao Yan:** Investigation, Resources, Data curation, Project administration. **Xiaotong Han:** Investigation, Resources, Data curation, Project administration. **Chang Pan:** Conceptualization, Methodology, Software, Data curation, Validation. **Chuanbao Li:** Investigation, Resources, Data curation. **Yuan Bian:** Conceptualization, Methodology, Software, Investigation, Data curation, Validation. **Rugang Liu:** Conceptualization, Methodology, Software, Investigation, Data curation, Validation. **Kai Cheng:** Conceptualization, Methodology, Software, Investigation, Data curation, Validation. **Jianbo Zhang:** Conceptualization, Methodology, Software, Investigation, Data curation, Validation. **Jingjing Ma:** Conceptualization, Methodology, Software, Investigation, Data curation, Validation. **Yongsheng Zhang:** Software, Formal analysis, Visualization. **Haitao Zhang:** Conceptualization, Methodology. **Xuezhong Yu:** Conceptualization, Methodology. **Marcus Eng Hock Ong:** Methodology, Writing – review & editing. **Bryan McNally:** Methodology, Writing – review & editing. **Chuanzhu Lv:** Resources, Data curation, Supervision, Project administration. **Guoqiang Zhang:** Conceptualization, Methodology, Resources, Data curation, Supervision, Project administration. **Yuguo Chen:** Conceptualization, Resources, Writing – review & editing, Supervision, Project

administration, Funding acquisition. **Feng Xu:** Conceptualization, Resources, Writing – review & editing, Supervision, Project administration, Funding acquisition.

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Conflict of interest statement

All authors certify that they have no conflicts of interest related to the abovementioned manuscript.

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Appendix A. Supplementary material

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