# Quality indicators for post-resuscitation care after out-of-hospital cardiac arrest: A Joint statement from the Association for Acute CardioVascular Care (ACVC) of the European Society of Cardiology, the European Resuscitation Council (ERC), the European Society of Intensive Care Medicine (ESICM), and the European Society for Emergency Medicine (EUSEM)

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Running header

Quality of care in management of cardiac arrest survivors

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- Bernd W. Böttiger is treasurer of the European Resuscitation Council (ERC), Founder of the ERC Research NET, Chairman of the German Resuscitation Council (GRC), Member of the „Advanced Life Support (ALS) Task Force of the International Liaison Committee on Resuscitation (ILCOR), Member of the Executive Committee of the German Interdisciplinary Association for Intensive Care and Emergency Medicine (DIVI), Founder of the "Deutsche Stiftung Wiederbelebung", Federal Medical Advisor of the German Red Cross (DRK), Member of the Advisory Board of the "Deutsche Herzstiftung", Co-Editor of "Resuscitation", Editor of the Journal "Notfall + Rettungsmedizin", Co-Editor of the Brazilian Journal of Anesthesiology. He received fees for lectures from the following companies: Forum für medizinische Fortbildung (FomF), Baxalta Deutschland GmbH, ZOLL Medical Deutschland GmbH, C.R. Bard GmbH, GS Elektromedizinische Geräte G. Stemple GmbH, Novartis Pharma GmbH, Philips GmbH Market DACH, Bioscience Valuation BSV GmbH.

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**Abstract**

Quality of care (QoC) is a fundamental tenet of modern healthcare and has become an important assessment-tool for healthcare authorities, stakeholders and the public. However, QoC is difficult to measure and quantify because it is a multifactorial and multidimensional concept. Comparison of clinical institutions can be challenging when QoC is estimated solely based on clinical outcomes. Thus, measuring quality through quality indicators (QIs) can provide a foundation for quality assessment and has become widely used in this context. QIs for the evaluation of QoC in acute myocardial infarction are now well-established, but no such indicators exist for the process from resuscitation of cardiac arrest and post-resuscitation care in Europe. In this context, the Association of Acute Cardiovascular Care of the European Society Cardiology, the European Resuscitation Council, European Society of Intensive Care Medicine and the European Society for Emergency Medicine, have reflected on the measurement of QoC in cardiac arrest. A set of QIs have been proposed, with the scope to unify and evolve QoC for the management of cardiac arrest across Europe. We present here the list of QIs (6 primary QIs and 12 secondary Qis), with descriptions of the methodology used, scientific justification and motives for the choice for each measure with the aim that this set of QIs will enable assessment of the quality of post-out-of-hospital cardiac arrest management across Europe.

## Introduction

Evaluation of the quality of care (QoC) is an important tenet of modern healthcare.[1] Health authorities, the public, and patients rightly demand high quality healthcare. [1,2] However, measuring the QoC is challenging, as opinions regarding best practice may differ between institutions according to various factors. [3] Further, quality cannot be estimated exclusively based on clinical outcomes of patients, because baseline characteristics may confound inter- and intra-institutional comparisons. [4,5]

Patient outcomes can be improved through medical research; however, new medical interventions must be implemented at medical institutions to impact patient care and outcome. Thus, quality indicators (QIs) have been used in this context. [2,4,6] QIs are used in an 'if-then' format, meaning that 'if' a patient fulfils specific criteria, 'then' they should - or should not - be offered a given intervention. [5,7] The American College of Cardiology (ACC) and the American Heart Association (AHA) have published several documents on the optimal methodology for defining and reporting Qis. [8–10] The European Society of Cardiology (ESC) has published a four-step process for the development of the ESC Qis. [5] The ESC and the ACC/AHA have published QIs for treatment of myocardial infarction. [2,6,11] To our knowledge, no QIs for the acute and intensive post-cardiac arrest management have been proposed, however QIs for preventing cardiac arrest [12] and for identifying futile resuscitation attempts do exist.[13] Furthermore, The European Heart Rhythm Association have proposed QIs for ventricular arrythmias. In contrast to myocardial infarction, which is primarily treated within the field of cardiology, a multi-disciplinary/multi-professional approach is needed when managing cardiac arrest patients. Therefore, the ESC Association for Acute Cardiovascular Care (ACVC), the European Resuscitation Council (ERC), the European Society for Emergency Medicine (EUSEM) and the European Society of Intensive Care Medicine (ESICM) have formed a task force for QoC assessment for post-cardiac arrest care, aimed at creating QIs for the management of cardiac arrest across Europe. QoC is a difficult notion to define,[3] and the aim of this paper is to propose a definition for several specific QIs, for quality-assessment of post-cardiac arrest management in Europe.

## Objectives

The objective of the post-cardiac arrest management (post-CAM) task force was to define suitable QIs for the post-resuscitation care of patients after out-of-hospital cardiac arrest (OHCA) with the aim of improving the quality of care. The target population for this set of QIs is adult patients, who have regained return of spontaneous circulation (ROSC) and remain comatose after an OHCA of presumed cardiac cause or unknown cause. The QIs will aim to allow measurement and thereby reduce unwarranted variation within and between countries and centres, and to set a standard of care that will ultimately improve clinical outcome and quality of life for patients.

## Methods

### Membership of the post-CAM Working Group.

Under the supervision of the board of the ACVC, the post-CAM task force was created as a scientific collaboration with ERC, EUSEM and ESICM. The task force was formed and comprised of international experts selected for their expertise in patients resuscitated from cardiac arrest considering diversity (gender, physician, and non-physician), and geography. All members were invited to participate in the selection and definition of the QIs. The full list of the task force members with their respective area of expertise, is displayed in Table s1.

### Selection of domains and candidate QIs

This document has been commissioned by the Association for Acute Cardiovascular Care and the process of the ESC for the development of QIs [5] was used to guide the process including identification of key domains of care, construction of candidate QIs, the selection of a final set of QIs by obtaining expert opinions using the modified Delphi method [5].

Conducting literature reviews is needed to ensure that QIs are both clinically meaningful and evidence-based [5]. Initially, a scoping search was performed to identify existing QIs from the ESC or other organizations.

Furthermore, newly updated American and European guidelines [14,15] contributed to identifying clinically meaningful and evidence-based candidate QIs. Members of the post-CAM task force were involved in the newest guidelines and the Advanced Life Support section of the 2020 Consensus on Science and Treatment Recommendations (CoSTR) document.[16] These documents [16] are based on series of systematic reviews using search criteria to identify population, intervention, comparator, outcome, study design, and time frame (PICOST) [17]. The methodology used to identify the evidence was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The post-CAM task force updated the literature review (June 2021) to identify additional randomized clinical trials since the publication of the guidelines. Identical Medical Subject Headings, inclusion and exclusion criteria was used as the in the initial searches within the topics: Oxygen Dose After ROSC in Adults, Post-resuscitation Hemodynamic Support, Targeted Temperature Management, and Prognostication in Comatose Patients After Resuscitation From Cardiac Arrest. [17] This literature included published, peer-reviewed randomized controlled trials investigating treatment, management, and prognostication of out-of-hospital cardiac arrest. This was subsequently used as a background for the selection of domains and candidate QIs.

Based on consensus obtained through meetings in the task force, eight domains of care with clinical relevance were selected. The aim of the selected domains was to include measures of quality beyond simply patient-outcomes, but instead incorporating the full system that extends from prehospital resuscitation through in-hospital care to post-hospital rehabilitation and follow-up.

When reviewing the literature and international guidelines [14], care was taken to ensure that candidate QIs were directly associated with improving outcomes. Specifically, the task force considered:

• The applicability of the data to the target population for which the indicator is being developed.

• The strength of evidence supporting the indicator based on the assigned level of evidence in newest guidelines. In the ERC-ESICM-guidelines, treatment recommendation were given by the authors indicating the strength of the recommendation (recommends = strong, suggests = weak) and the certainty of the evidence [14].

• The degree to which adherence to the indicator is associated with clinically meaningful benefit (or harm).

• The clinical significance of the outcome based on its likelihood to be achieved by adherence to the indicator. [5]

A total of 39 candidate QIs were identified covering all eight domains (supplementary table 2). The 39 candidate QIs were derived primarily from the ERC-ESICM guidelines for post resuscitation care.[14] Subsequently, all candidate QIs were evaluated by the Post-CAM task force through a modified Delphi-process which has been evaluated and found suitable for this purpose [18,19] as proposed by the ESC methodology.[5] The modified Delphi technique involves conducting structured, anonymous surveys, with interposed meetings to reach consensus. The task force used an online survey circulated to the whole group and all questions was answered by 13/14 (92%) of members. Each candidate QI was graded on a scale of 1–5 with 5 being the best score. A score of at least 2.5 was needed to go through for the final set. When all QIs were selected, the task force once again voted whether QIs within the same domain should be regarded as primary or secondary. For each domain, one 'primary QI', as well as one or more 'secondary' QIs were selected. The primary QIs were selected for being an essential element and "need to have" within a given domain. The secondary QIs were considered as complementary measures that may be suitable for use in certain centres. Additionally, the task force held two online workshops, to which all members of all participating societies were invited. The purpose of the workshops was to evaluate the QIs in a broader audience resulting in numerous comments and opinions, which sparked further discussion in the task force resulting in further modification and selection of the QIs.

In the process of synthesizing candidate QIs, the numerator and denominator for each candidate QI were defined. The numerator of the QIs was defined as the group of patients fulfilling the QI. Patients within the target population formed the denominator. Potential exclusions of patients for assessment for each candidate QI are also specified in table 2. Using exclusions enables a fairer assessment, particularly when the QI is intended for public reporting or pay-for-performance. [20,21]

## Results: QIs for post-cardiac arrest management

Eight domains of care where quality should be assessed were defined. The selected domains are relevant to the clinical situation of cardiac arrest, namely: (1) centre organisation; (2) initial in-hospital examination after cardiac arrest; (3) intensive care treatment; (4) haemodynamic management during hospitalisation; (5) neurological prognostication; (6) patient discharge and follow-up; (7) outcomes and (8) composite QIs (CQIs).

Domain 1: Prehospital organisation and cardiac arrest centres.

Survival and recovery following OHCA depend on the different components of a system working together to secure the best outcome.[22] The system should encompass early recognition, high quality cardiopulmonary resuscitation (CPR), defibrillation of shockable rhythms, and high-quality post-ROSC in-hospital-care. The chain of survival encompasses these different links [23] and recognizes that most sudden cardiac arrests in adults are of cardiac cause. [23] After ROSC (and in some cases during cardiac arrest) pre-hospital transportation to a cardiac arrest centre [24] with advanced diagnostics and quick access to revascularization facilities available 24/7 have been shown to reduce time to reperfusion in ST-elevation myocardial infarction, which in turn is associated with lower mortality. [25]

*Network organisation with written protocols*

Organised systems of care are needed to determine the optimal pathways of care to reduce times to reperfusion, diagnosis, and intensive care management including safe transfer [26]. The main QI (table 1) for centre organisations was based on a single important point: written protocols for rapid and efficient triage and management. Although non-written teamwork can be used in practice, the post-CAM task force considers that only a centre with a written protocol signed by both the centre and the pre-hospital organisation should be viewed as participating in a network regarding QoC.

*Network organisation*

The secondary QI was based on three organisational points deemed to be the important in addition to being relatively easy to implement: 1) pre-hospital interpretation of post-ROSC ECG for diagnosis, 2) possibility for immediate transfer to a centre with catheterisation laboratory facilities, and 3) pre-hospital activation of the catheterisation laboratory-team. Organisation of care has an important impact on the times to reperfusion, [27] which can be improved by bringing the patient to the centre faster or bringing the treatment to the patient through advanced life support [17]. A well-organised system should provide appropriate treatment with the shortest delay [26,28]. Shorter delay has been shown to reduce mortality in acute coronary syndrome (ACS)-patients and is thus strongly recommended by the ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation [29]. A single phone number is recommended for lay people to call the ambulance dispatch centre. International Liaison Committee on Resuscitation (ILCOR) recommends that the dispatch centre is able to provide CPR guidance to bystanders over the phone. Ambulance crews should be directly connected to the dispatch centre and have the possibility for a direct admission to the percutaneous coronary intervention (PCI) facility centre where experienced cardiologists, intensivists and emergency physicians are on duty 24/7 [30]. This QI is identical with the recommendations for acute myocardial infarction [2].

<u>Domain 2: Initial in-hospital examination after cardiac arrest</u>

To triage the patient for transport, in addition to initiating the correct treatment, the cause of the arrest must be quickly determined. Prompt recognition of the cause of the arrest is a key factor in ensuring fast triage and optimal patient allocation. Invasive treatment with acute revascularization is fundamental for patients with acute myocardial infarction. This is especially the case in patients with a transmural myocardial infarction indicated by a prehospital ECG showing ST-elevation. In patients without STEMI, there is no benefit of routine early coronary angiography demonstrated in recent large trials [31–33], however, these trials excluded STEMI and those with haemodynamic and electrical instability. Since acute myocardial infarction is a frequent cause of OHCA, a

patient with ROSC should have STEMI excluded as a cause of the arrest, since the time to revascularisation in these patients has an impact on clinical outcomes [34,35].

*Timely angiography*

The use of revascularisation and its timely implementation have previously been used as indicators of quality [2,36]. Transporting the resuscitated patient from the prehospital setting to the cardiac catheterisation laboratory requires active participation by individuals from several disciplines along the management pathway and includes high-quality organisation of care within a network organisation as described in Domain 1. The primary QI is "timely angiography" of STEMI patients with "timely" being <90 minutes from ROSC to wire insertion in the patient.

*Timely echocardiography*

Another important tool for differential diagnosis is the transthoracic echocardiography, which is recommended by the 2021 ERC guidelines to be performed as soon as possible to detect underlying cardiac pathology and quantify the degree of myocardial dysfunction [14]. Serial echocardiography quantifies trends in myocardial dysfunction in addition to assessment of preload and potential mechanical complications [37,38]. Impaired cardiac function is frequent during the first 24-48 hours post-arrest, after which it often resolves if no underlying additional primary cardiac pathology is present [39]. Low cardiac output is likely not associated with poor outcome or prognosis in otherwise haemodynamic stable patients [40], but in cases of hemodynamic instability myocardial function and cardiac output are vital in guiding treatment. The secondary QI is "timely echocardiography". Timely is defined as: <2 hours from ROSC based on a consensus of the task force in addition to comments from participants in the workshops. Monitoring with echocardiography is commonly used in intensive care and its use to guide treatment in cardiac arrest patients is recommended by the ERC [14].

Domain 3: Intensive care

Resuscitated OHCA patients remaining comatose need intensive care for several reasons including inability to protect their airway, the need for mechanical ventilation, and to receive guideline-recommended temperature control. Furthermore, this patient group has a high risk of organ dysfunction secondary to the post-cardiac arrest syndrome [41]. Most intensive care guidelines in this area are based on expert consensus because there are few randomised controlled trials [42], however one intervention that has been studied extensively in the last two decades is temperature control.

*Temperature control.*

This primary QI is based on the number of patients remaining comatose after OHCA, who undergo temperature control defined as continuous monitoring of core temperature and actively preventing fever (defined as a temperature > 37.7 °C) for at least 72 h [43] or actively targeting mild hypothermia in a temperature range of 32-36°C [44].

*Tracheal intubation*

Another essential part of post-resuscitation care is tracheal intubation of comatose patients unable to protect their own airway. This secondary QI is based on tracheal intubation, and if the QI is fulfilled, tracheal intubation should occur before ICU-admission. A comatose post-cardiac arrest patient should preferably be intubated immediately after hospital admission or prehospital. Patients should be intubated before, during or following cardiac arrest depending on the specific circumstances [45] and local resources and organization. Most often, intubation occurs during CPR, but should alternatively be undertaken if the patient remains comatose after ROSC [46]. This will enable adequate post-resuscitation care including controlled oxygenation, protection from aspiration of stomach contents, control of seizures, and temperature control. [42]

*Early arterial blood gas sample*

A systematic review on oxygenation and ventilation targets after cardiac arrest, found seven RCTs [47]. Based on these trials, the ILCOR recommends the use of 100% inspired oxygen until the arterial oxygen saturation, or the partial pressure of arterial oxygen can be measured reliably in adults with ROSC after cardiac arrest in any setting (weak recommendation, very low-certainty evidence). A recent large trial found no benefit in targeting higher oxygen-targets and the focus should probably be on avoiding hypoxemia.[48] The recently published EXACT randomised clinical trial showed no benefit in targeting an oxygen saturation of 90% to 94% compared with 98% to 100% immediately after ROSC and there was a higher incidence of hypoxaemia in the group with the lower target.[49] Furthermore, in addition to risk of hypoxemia, post-ROSC patients are often haemodynamically unstable, and monitoring lactate may be needed. After ROSC, oxygenation can be monitored either with a pulse oximeter or preferably with an early arterial blood gas sample. Blood carbon dioxide values ($PaCO_2$) are sometimes above normal values because of hypoventilation and hemodynamic disturbances resulting in a mixed respiratory and metabolic acidosis. $PaCO_2$ can be adjusted in a mechanically ventilated patient through ventilation. Therefore, the QI of this domain relates to examination with arterial blood gas analysis within the first two hours after hospital-admission.

*Organ donation*

Comatose patients who have had a cardiac arrest and do not survive, can potentially become organ donors. In many healthcare systems, cardiac arrest patients form an increasing proportion of solid organ donors,[50] which is vital for modern health care where demand for solid organs exceeds supply. [51] If brain death occurs or a withdrawal of life sustaining therapy (WLST) decision is made, international guidelines for post-resuscitation care support organ donation. [42] Therefore, this QI related to the evaluation for organ donation of patients declared brain dead, and the QI is fulfilled when a such patient is evaluated for organ donation. The task force recognizes that cultural, religious and ethical practices regarding organ donation may vary between countries.

Domain 4: Haemodynamic management

A major clinical challenge in the management of post-OHCA patients is haemodynamic instability. As part of the post-cardiac arrest syndrome, post-resuscitation myocardial dysfunction and low cardiac output may occur in the majority of patients.[39] Further, vasodilation and vasoplegia due to systemic ischemia/reperfusion and inflammation further lowers blood pressure. [52–54] Myocardial dysfunction and vasoplegia peaks during the first 24-48 h after which hemodynamics improves in most cases. [55,56] Where cardiac output is likely not associated with poor outcome [40,57], hypotension has been associated with poor outcomes in most studies [58–60] and hypotension should be avoided through preload optimization, inotropes and vasopressors.[42]

*Mechanical circulatory support*

If conventional resuscitation with iv fluids, inotropes and vasopressors is insufficient to maintain tissue perfusion, the acute mechanical circulatory support (such as intra-aortic balloon pump, veno-arterial extracorporeal membrane oxygenation (VA-ECMO), IMPELLA, Abiomed USA) may be advised for selected patients.[61] Retrospective data suggest that 15% of patients developing cardiogenic shock after OHCA may require mechanical circulatory support.[62] Limited data support the use of mechanical circulatory support, and very few prospective trials have been undertaken in this patient population [42]. IMPELLA has been compared with IABP in a small pilot trial and this trial found no clinical difference in patients with myocardial infarction and cardiogenic shock [63]. Post-resuscitation care ERC Guidelines [42] include the recommendation for use of mechanical circulatory support stating that left-ventricular assist devices or VA-ECMO should be considered in haemodynamically unstable patients with acute coronary syndromes (ACS) and recurrent ventricular arrhythmias despite optimal therapy. [64] The primary QI of this domain relates to the evaluation for mechanical circulatory support in patients resuscitated after OHCA and develops persistent cardiogenic shock. The denominator includes all patients developing cardiogenic shock in-hospital after OHCA; however, the task force recognizes that a large proportion of patients may be deemed unfit for mechanical circulatory support. However,

to fulfil this QI a statement in the patient record, that the patient has been evaluated for mechanical circulatory support, must be given.

*Vasopressor therapy for hypotension*

Post OHCA-hypotension has been associated with poor outcome in several studies [58,65–69]. Three pilot-studies of higher mean arterial pressure (MAP)-targets did not show benefit on surrogate outcomes [70–72], but international guidelines still recommend vasopressor-treatment to avoid hypotension [14]. One large trial did not find benefit from targeting of a higher blood pressure target [73] and focus should likely be on avoiding hypoperfusion. ERC guidelines for 2021, define hypotension as a MAP<65 mmHg and suggest targeting a MAP higher than this to achieve adequate urine output (>0.5mL/kg/h) and normal or decreasing lactate [42]. This QI relates to the patients in whom treatment with vasopressors is used to correct hypotension according to the above definition of MAP<65 mmHg.

Domain 5: Neurological prognostication.

In patients with ROSC after OHCA, who are admitted to hospital comatose, the mortality is reported to be around 50% with wide variations and most deaths are from hypoxic-ischemic brain injury [74]. Active WLST is undertaken in patients diagnosed with severe irreversible brain injury, however it can be challenging to distinguish this patient-group from patients with a potential for late recovery [75]. Accurate prognostication is extremely important to avoid prolongation of suffering in a patient without potential for recovery and to avoid inappropriate WLST.

*Multimodal prognostication*

The primary QI in this domain is using multimodal prognostication to help clinicians to determine when a WLST decision may be indicated. The 2015 ERC-ESICM Guidelines on Post-Resuscitation Care proposed a model for the prediction of poor neurological outcome for comatose patients after cardiac arrest [42]. Retrospective studies have validated this model [76]. The prognostication model is based on a combination of tests including

results of clinical/neurological examination (absent or extensor motor response, absent pupillary and corneal reflexes, status myoclonus), electrophysiology (bilaterally absent N20 SSEP wave, unreactive burst-suppression or status epilepticus on EEG), biomarkers (high blood NSE values and trends), and imaging (signs of anoxic brain injury on CT or MRI). To fulfil this QI, patients remaining comatose for longer than 72 hours should receive multimodal prognostication including: clinical examination (absent or extensor motor response, absent pupillary and corneal reflexes, status myoclonus), biomarkers (elevated levels above cut-offs of NSE or other relevant biomarker), imaging (signs of diffuse anoxic brain injury on CT or MRI) and electrophysiology (EEG or SSEP). (Table 2)

*Head CT scan as part of neurological prognostication*

Head CT is advised to exclude potential intracranial hemorrhage as a cause of the arrest. Furthermore, some OHCA-patients may experience a fall or trauma related to a sudden arrest, thus traumatic brain injury should be diagnosed early. For neuroprognostication, the reduction of the grey matter/white matter ratio on brain CT within 72 h after ROSC is useful when combined with other prognosticators of poor neurologic outcome in comatose patients after OHCA (ERC-ESICM guidelines: weak recommendation, very-low-quality evidence). Measurement of the grey matter/white matter ratio), expressed in Hounsfield units is a method to assess the degree of cerebral oedema. This ratio is normally higher than 1, meaning that grey matter has the highest density. A lower ratio is associated with more severe brain injury [77]. This QI is fulfilled if comatose patients have had a head CT no later than 72 hours after admission.

*EEG as part of neurological prognostication*

Electroencephalography (EEG) is used widely to assess the extent of brain injury after OHCA [78]. EEG is also essential for diagnosing seizures and status epilepticus in comatose patients. The background activity, superimposed discharges, and reactivity are the primary indices of prognoses. The EEG is suppressed in many OHCA-patients, but in patients without severe brain injury, recordings return to normal within the first 24 hours

[79]. The EEG-background activity is often of low frequency initially [79]. An important source of bias in the OHCA-population is the use of sedative drugs, which affects background activity and has potential to induce discontinuous or burst-suppression background [80]. ERC-ESICM guidelines recommend performing an EEG in patients who are unconscious after the arrest. Furthermore, specific EEG-patterns including unequivocal seizures and absence of background reactivity should be used for prognostication when the patient is normothermic and after sedation has been cleared. EEG-results should be interpreted in the context of clinical examination. This QI is fulfilled if an EEG has been performed and interpreted within 72 hours (or when sedation has been tapered) after admission in comatose patients.

Domain 6: Patient discharge and Follow-up

OHCA survivors often have cognitive impairment. Most impairments are mild or moderate and many patients recover cognitively during the first three months after the cardiac arrest [58,81,82]. However, almost half of OHCA-survivors show signs of long-term cognitive impairments [81]. Emotional complications, such as anxiety, depression, and fatigue are also common [83]. The ERC 2021 guidelines recommend assessments of physical and non-physical impairments before discharge from the hospital to identify early rehabilitation needs and refer to rehabilitation [42]. Systematic follow-up for all cardiac arrest survivors is also encouraged within 3 months after hospital discharge, including screening for cognitive problems, screening for emotional problems and fatigue [42]. Risk-stratification for future cardiac arrest is not included in this document.

*Functional assessments of physical and non-physical impairments before discharge from the hospital*

Individualised rehabilitation plans can be necessary before discharge from the hospital in the patient group with moderate to severe functional and/or cognitive impairments. To catch these patients, assessments of physical and non-physical impairments should be performed before discharge from hospital. The task force recognizes that there are few high-quality studies to support the assessment for impairments. However, while urging researchers to investigate this area, the task force relies on the recommendations from ERC-ESICM and AHA on performing

functional assessments of physical and non-physical impairments including cognitive function to identify potential rehabilitation-needs [15,42]. To fulfil this QI, patients surviving to hospital discharge should have an assessment of physical and non-physical impairments stated in the patient record before discharge from hospital.

*Systematic follow-up and screening for cognitive problems after discharge.*

Cognitive impairments and emotional challenges are not always recognized by healthcare professionals. A structured follow-up could be organized, so these challenges are found early enabling appropriate care or rehabilitation. One clinical study showed that early intervention for cardiac arrest survivors had a positive impact on quality of life [84].

To fulfil this QI, a systematic follow-up of all OHCA-survivors should be implemented including screening for cognitive and emotional problems within three months after hospital discharge. Formal cognitive screening should be used since patients are not always aware of their cognitive impairments. The Montreal Cognitive Assessment (MoCA) tool takes approximately 10 minutes to complete and is easy to use. For emotional problems, short questionnaires, such as the Hospital Anxiety and Depression Scale (HADS), may be useful. If signs of cognitive or emotional impairment are present, referral to more extensive neuropsychological assessment can be considered.

Domain 7 (outcome quality indicators): Survival with good functional outcome

Improved clinical outcome for patients is the overall aim of medical treatment and of quality of care. However, the use of outcome measures as a QI is controversial since the outcomes of patients only partially depend on the quality of care. Also, reporting outcomes can have adverse consequences, such as restriction of admission for the most ill patients. Previous QIs from the ESC have used outcomes QIs and since outcome measures are easily interpretable and also possibly important for patients, the outcome QIs is an important part of the whole evaluation of a given institutions care.

This QI includes all patients admitted to hospital alive with spontaneous circulation. To fulfil this QI patients should be alive with a good functional outcome defined as "able to walk without assistance and attend own bodily needs" corresponding to a score of 3 or lower on the Modified Rankin Scale.

Domain 8. Composite QIs

A composite QI (CQI) is a combination of two or more QIs into a single QI to summarize multiple dimensions. This will make able a simple comparison between institutions. To contain the information in a single summary QI, the presentation of the CQI as a single number reduces the size of a set of indicators, allowing evaluation and categorisation of the centres, and it can be used to assess timely progress. The AHA/ACC Task Force on Performance Measures has published a statement for the creation and interpretation of CQIs in healthcare assessment. This QI could be perceived as having limited clinical usefulness but is mandatory to summarise the management of the patients and enables centre benchmarking or categorization.

The Task force has included two composite QIs. The first composite QI ("All or None" design) requires the fulfilment of QI 2.2, (echo within 4 hours), 3.1 (temperature control) and 6.2 (follow-up). These three QIs were chosen based on a consensus of the task force. A patient has fulfilled this QI if all three QIs have been fulfilled (all or nothing).

The second is based on the fulfilment of main QIs from the 7 domains ("Opportunity based" composite indicator). In assessing this QI, a patient receives 1 point for each main QI fulfilled, which equals a maximum of 7 points per patient; the value of this composite QI is the number of points achieved divided by 7. The best possible score is therefore 1. If a patient is not eligible to receive one or more of the 7 points, the total will be divided by the number of indicators applicable. This type of composite allows to consider more items in a single score.

## Discussion

Using a modified Delphi process through meetings, workshops and surveys of Qis, a task force of 13 experts in post-resuscitation care from ACVC, ERC, ESICM and EUSEM developed 8 domains and 18 QIs for post-OHCA care. All QIs were further discussed in two online workshops that included a broad audience of members of the four societies. The domains have a foundation in the ERC-ESICM guidelines for post-resuscitation care [42]. In this paper, the task force proposes primary QIs and secondary QIs. A total of 6 primary QIs are proposed, representing criteria considered to be of major importance, requiring preferential measurement. The secondary QIs are supplementary measures of quality.

The aim of the task force was to improve the quality of post-resuscitation care across Europe. The initiative was started by ACVC of the ESC. The multidisciplinary approach required to manage the OHCA-patient, was recognized and a scientific collaboration with ERC, EUSEM, and ESICM was organized. The task force consisted of experts from all four societies and can be seen in table s1. The QIs are based on existing scientific evidence and expert consensus and aim to improve post-resuscitation care of comatose, resuscitated out-of-hospital cardiac arrest patients, reduce variation within and between countries and centres based on adherence to the defined QI and ultimately, increase survival and improve neurological and quality of life outcomes of patients. Additionally, awareness Europe-wide could be improved within the areas covered by the QIs. This is the first collaborative initiative undertaken to set QIs for post-OHCA care. The QIs were developed according to the ESC guidelines for QIs [5]. While the QIs defined in this paper are in line with the ERC-ESICM guidelines, they are not simply a reflection of high-grade recommendations, but also incorporate measures that have a lower recommendation or even no recommendation at all. The reason, therefore, is that the task force incorporated considerations of importance, evidence base, specification, validity, reliability, feasibility, interpretability and actionability [5,20].

Compared with the ESC-QI for myocardial infarction, the task force identified fewer QIs reflecting, the fewer evidence-based treatments in comparison with myocardial infarction [2,4]. The current QIs are based on current

evidence, however, the field of post-OHCA care is rapidly developing [43]. Therefore, it should be emphasized that the development of QIs is a dynamic process and the QIs should be updated regularly to represent the newest evidence. For example, the recommendation of temperature control has undergone rapid changes in guidelines during the taskforces work [43].

Eight domains were selected to define one primary QI as well as secondary QIs for each domain. One domain is related to the organisation at the level of the centre, as opposed to individual-patient management. In particular, domain 1 emphasizes the importance of the system including both prehospital and in-hospital management in each centre, which has been highlighted in a recent position paper [24]. Domain 6 included the aspect of post-hospital management with a focus on identification of a need for specialized rehabilitation. In domains 2-5, the QIs selected by the task force represent different aspects of in-hospital management. The composite criterion proposed in this paper is computed using an 'all or none' composite QI, with a selected number of QIs. The other composite QI uses the 'opportunity-based' method, based on all the main QIs from all the domains [85].The QIs defined here by the task force are not intended for benchmarking, ranking or pay-for-performance, but simply contributing to improving quality of care through meaningful surveillance.

The list of selected QIs has several limitations. First, even though we used standardized methods including the Delphi process and anonymized scoring of each candidate QI, the QIs are selected based on a subjective valuation by the task force members. Alternative members may have resulted in different QIs. Furthermore, quality of care is much more than evidence-based interventions. For example, the care of relatives and families is an important aspect of care but is difficult to appreciate in QIs since very limited research has been done in this area.

## Conclusions

Through a modified Delphi process, 6 primary QIs and 12 secondary QIs have been constructed. Despite its limitations, this set of QIs will enable assessment of the quality of post-OHCA management in Europe and will help to identify the domains of care where improvements are most needed.

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| Domain 1 (Structural quality indicators): Prehospital organization and cardiac arrest centres | | | Assessment | GL class |
|---|---|---|---|---|
| 1 | The centre should be part of a network organisation with written protocols for rapid and efficient triage and management | **Primary** | **Numerator**: Centres participating in a network for management of OHCA patients with written protocols.<br><br>(centre level) | • Network organization: ESC STEMI GL class I, level B.<br><br>• Written protocol: ESC STEMI GL class I, level C.<br><br>• Single phone call: no recommendation. |
| 2 | The centre should be part of a network organization, with pre-hospital interpretation of ECG for 1) diagnosis, 2) decision for immediate transfer to a centre with catheterization laboratory facilities, and 3) pre-hospital activation of the catheterization laboratory | **Secondary** | **Numerator:** Centres with a system for pre-hospital ECG interpretation and transfer decisions.<br><br>(centre level) | •Network organization: ESC STEMI GL class I, level B.<br><br>• Prehospital interpretation of ECG: ESC STEMI GL class I, level B.<br><br>• Prehospital activation of the catheterization laboratory: ESC STEMI GL class IIa, level B. |
| **Domain 2: Initial in-hospital examination after cardiac arrest** | | | | |
| 1 | Timely angiography - Timely is defined as: <90 minutes from ROSC to wire is inserted in the patient | **Primary** | **Numerator:** Patients with ROSC after OHCA, with a prehospital ECG showing STEMI and undergo angiography within 90 minutes from ROSC<br><br>**Denominator**: Patients with ROSC after OHCA, with a prehospital ECG showing STEMI. | Strong recommendation, low-quality evidence |
| 2 | Timely echocardiography. Timely is defined as: <2 hours from ROSC | **Secondary** | **Numerator:** Patients with ROSC after OHCA admitted alive to the hospital, who undergo timely echocardiography.<br><br>**Denominator**: Patients with ROSC after OHCA admitted alive to the hospital. | Best practice recommendation |
| **Domain 3: Intensive care treatment** | | | | |
| 1 | Temperature control | **Primary** | **Numerator:** Patients with return of spontaneous circulation remaining comatose at hospital admission undergoing temperature control<br><br>**Denominator**: Patients remaining comatose at hospital admission where contraindications to temperature control have been excluded. | Best practice statement |
| 2 | Tracheal intubation and mechanical ventilation before admission to the ICU. | **secondary** | **Numerator:** Patients remaining comatose at hospital admission, who are tracheal | Best practice recommendation |

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| | | | intubated.<br><br>**Denominator**: Patients remaining comatose at hospital admission | |
| 3 | Examination with arterial blood gas analysis in the first hospital evaluation after ROSC within 2 hours | **secondary** | **Numerator:** Patients admitted to hospital after OHCA, who are examined with ABG during the first 2 hours<br><br>**Denominator**: Patients admitted to hospital after OHCA | Weak recommendation, very low-certainty evidence |
| 4 | Evaluation for organ donation of brain-dead patients | **secondary** | **Numerator**: Patients declared brain dead who are evaluated by the treating physician for organ donation<br><br>**Denominator**: Patients declared brain death. | Best practice statement |
| **Domain 4: Hemodynamic management.** | | | | |
| 1 | Mechanical circulatory support (such as intra-aortic balloon pump, left-ventricular assist device or arterio-venous extra corporal membrane oxygenation) for persisting cardiogenic shock from left ventricular failure. | **Primary** | **Numerator:** Patients with persistent cardiogenic shock from left ventricular failure patients, who are evaluated for mechanical circulatory support.<br><br>**Denominator**: Patients with persistent cardiogenic shock from left ventricular failure. | Not Reviewed in 2020 |
| 2 | Vasopressor therapy for hypotension. Hypotension is defined as either receiving vasopressors or a mean arterial blood pressure <65 mmHg or a systolic blood pressure <90 mmHg | **selected** | **Numerator:** Hypotensive patients in the ICU post-OHCA receiving continuous vasopressors therapy.<br><br>**Denominator**: Hypotensive patients in the ICU post-OHCA | Weak recommendation, low-certainty evidence |
| **Domain 5: Neurological prognostication.** | | | | |
| 1 | Multimodal prognostication | **Primary** | **Numerator:** Patients remaining comatose above 72 hours in who a multimodal prognostication is used.<br><br>**Denominator**: Patients remaining comatose above 72 hours | Strong recommendation, very low-certainty evidence |
| 2 | Head CT scan as part of neurological prognostication | **Selected** | **Numerator:** Patients remaining comatose without sedation above 72 hours who is examined by a CT of cerebrum | Very low-certainty evidence (Gray Matter–to–White Matter Ratio) |

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| | | | **Denominator**: Patients remaining comatose without sedation above 72 hours | |
| 3 | EEG as part of neurological prognostication | **selected** | **Numerator:** Patients remaining comatose above 72 hours who is examined with an EEG<br><br>**Denominator**: Patients remaining comatose above 72 hours | Weak recommendation, very low-certainty evidence (in case of myoclonic jerks) |
| **Domain 6: Patient discharge and Follow-up** | | | | |
| 1 | Functional assessments of physical and non-physical impairments before discharge from the hospital | **Primary** | **Numerator:** Patients surviving to hospital-discharge with an assessment of physical and non-physical impairments before discharge<br><br>**Denominator**: Patients surviving to hospital-discharge | Best practice statement |
| 2 | Systematic follow-up and screening for cognitive problems after discharge. | **selected** | **Numerator:** Patients alive after 3 months who are invited to a follow-up session including screening for cognitive problems.<br><br>**Denominator**: Patients alive after 3 months | Best practice statement |
| **Domain 7 (outcome quality indicators): Survival with good functional outcome** | | | | |
| 1 | Alive with a good functional outcome (able to walk without assistance and attend own bodily needs) 3 months after the arrest | **Primary** | **Numerator:** Patients alive after 3 months with a good neurological outcome<br><br>**Denominator**: number of patients admitted to hospital alive (alive being spontaneous circulation) | Best practice statement |
| **Domain 8. Composite QI** | | | | |
| 1 | Fulfillment of QI 2. (echo within 4 hours), 3.1 (temperature control) and 6.2 (follow-up) | **Primary** | **Numerator:** Patients surviving to discharge fulfilling QI 2c, 3c and 6a.<br><br>**Denominator**: Patients surviving to discharge | |
| 2 | Main QI of each domain. | | Assign 1 point for each main QI fulfilled = a maximal of 7 points per patient; the value of the composite is the number of points divided by 7. If a patient is not eligible to one or more of the 7 points, the total will be divided by the | |

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| | | | number of indicators applicable. This type of composite allows to consider more items in in a single score. | |

Explanatory text: The numerator is the value placed above the horizontal line in a fraction. It signifies the number of patients taken out of the whole. The numeric value below the horizontal line in a fraction is called the denominator. It represents the total number of patients. For each QI, the total number of eligible patients denotes the denominator, whereas the number of patients fulfilling the QI due to high quality of care denotes the numerator. A fraction close to 1 indicates high quality of care, whereas a fraction close to 0 indicates low quality of care.

**Table 2. Summary of the quality indicators (QIs): definition, target population and method of reporting.**

**1.1 The centre should be part of a network organization with written protocols for rapid and efficient triage and management including: A single emergency phone number for lay people and a direct way of communication between prehospital unit and centre.**

Domain: Centre organization.

Clinical rationale: to improve speed and efficiency of pre-hospital care, reperfusion for STEMI patients and eCPR for refractory cardiac arrest.

Target population: Centres managing OHCA-patients.

**1.2 The centre should be part of a network organization, with pre-hospital interpretation of ECG for 1) diagnosis, 2) decision for immediate transfer to a centre with catheterization laboratory facilities, and 3) pre-hospital activation of the catheterization laboratory.**

Domain: Centre organization.

Clinical rationale: to improve speed and efficiency of pre-hospital care, reperfusion for STEMI patients and eCPR for refractory cardiac arrest.

Target population: Centres managing OHCA-patients.

**2.1 Timely angiography - Timely is defined as: <90 minutes from ROSC to wire is inserted in the patient**

Domain: Initial examination of cause of cardiac arrest.

Target population: Adult OHCA-patients with STEMI before admission to hospital.

Measurement period: At the time of hospital discharge

Numerator: Patients with ROSC after OHCA, with a prehospital ECG showing STEMI and undergo angiography within 90 minutes from ROSC.

Denominator: Patients with ROSC after OHCA, with a prehospital ECG showing STEMI.

Exclusion: Patients with contraindications to angiography such as allergy, intolerance or renal failure, or who die within 90 minutes from ROSC. Patients with persistent cardiogenic shock or cardiac arrest and may require mechanical circulatory support prior to primary PCI

**2.2 Timely echocardiography. Timely is defined as: <2 hours from ROSC**

Domain: Initial examination of cause of cardiac arrest.

Target population: Patients with ROSC after OHCA admitted alive to the hospital.

Measurement period: At the time of hospital discharge.

Numerator: Patients with ROSC after OHCA admitted alive to the hospital, who undergo timely echocardiography (timely defined as before 2 hours after admission). The task force does not specify the kind of cardiac ultrasound used, but the examination should as a minimum include left ventricular ejection fraction, a measure of right ventricular function, pericardial effusion and valve disease.

Denominator: Patients with ROSC after OHCA admitted alive to the hospital.

Exclusion: none

**3.1 Temperature control**

Domain: 3. Intensive care

Target population: Adult OHCA-patients remaining comatose at admission to hospital.

Measurement period: At the time of hospital discharge

Numerator: Patients with ROSC after OHCA, remaining comatose (GCS<9) at hospital arrival who undergo temperature control.

Denominator: Patients with ROSC after OHCA, remaining comatose (GCS<9) at hospital arrival.

Exclusion: Patients with contraindications to temperature control, temperature on admission <30°C, pregnancy, intracranial bleeding.

**3.2 Tracheal intubation and mechanical ventilation before admission to the ICU.**

Domain: 3. Intensive care

Target population: Adult OHCA-patients remaining comatose at admission to ICU.

Measurement period: At the time of hospital discharge

Numerator: Patients with ROSC after OHCA, remaining comatose (GCS<9) at hospital arrival who undergo tracheal intubation.

Denominator: Patients with ROSC after OHCA, remaining comatose (GCS<9) at hospital arrival.

Exclusion: Patients with contraindications to intubation such as severe chronic obstructive pulmonary disorder (COPD).

**3.3 Examination with arterial blood gas analysis in the first hospital evaluation after ROSC.**

Domain: 3. Intensive care

Target population: Adult OHCA-patients remaining comatose at admission to ICU.

Measurement period: At the time of hospital discharge

Numerator: Patients with ROSC after OHCA, who are examined with ABG during the first hour after hospital arrival.

Denominator: Patients with ROSC after OHCA.

Exclusion: no exclusion

**3.4 Evaluation for organ donation of brain death patients.**

Domain: 3. Intensive care

Target population: Adult OHCA-patients who progress to brain death.

Measurement period: At the time of hospital discharge.

Numerator: Patients declared brain death who are evaluated for organ donation. Evaluated meaning a decision should be made whether a given patient qualifies for organ donation. This decision should be stated in the patient record.

Denominator: Patients declared brain death.

Exclusion: no exclusion

**4.1. Mechanical circulatory support (such as intra-aortic balloon pump, left-ventricular assist device or arterio-venous extra corporal membrane oxygenation) for persisting cardiogenic shock from left ventricular failure.**

Domain: 4. Intensive care

Target population: Adult OHCA-patients remaining comatose at admission to ICU, who are in persisting (where fluid resuscitation, inotropes, and vasoactive drugs is insufficient) cardiogenic shock.

Measurement period: At the time of hospital discharge

Numerator: Patients with persistent cardiogenic shock from left ventricular failure, who are evaluated for mechanical circulatory support. Evaluated meaning a decision should be made whether this patient qualifies for mechanical circulatory support. This decision should be stated in the patient record.

Denominator: Patients with persistent cardiogenic shock from left ventricular failure.

Exclusion: Patients with contraindications for mechanical support.

**4.2. Vasopressor therapy for hypotension.**

Domain: 4. Intensive care

Target population: Adult OHCA-patients remaining comatose at admission to ICU, who have hypotension (mean arterial blood pressure <65 mmHg) despite adequate filling pressures.

Measurement period: At the time of hospital discharge

Numerator: Hypotensive patients in the ICU post-OHCA receiving continuous vasopressors therapy.

Denominator: Hypotensive patients in the ICU post-OHCA

Exclusion: Patients with contraindications for vasopressor therapy.

**5.1. Multimodal neurological prognostication**

Domain: 5. Neurological prognostication

Target population: Adult OHCA-patients remaining comatose at 72 hours after hospital-admission.

Measurement period: At the time of hospital discharge

Numerator: Patients remaining comatose above 72 hours and with no sedatives in who a multimodal prognostication is used. Multimodal defined as: use of biomarkers (ie NSE), use of neurological imaging (signs of diffuse anoxic brain injury on CT or MRI), use of electrophysiology (unreactive burst-suppression or status epilepticus in EEG, bilaterally absent N20 SSEP wave) and use of neurological examination (absent or extensor motor response, absent pupillary and corneal reflexes, status myoclonus).

Denominator: Patients remaining comatose above 72 hours after stop sedatives.

Exclusion: Patients dying from non-neurological causes or receiving sedatives or neuromuscular blockade drugs.

**5.2. Head CT scan as part of neurological prognostication**

Domain: 5. Neurological prognostication

Target population: Adult OHCA-patients remaining comatose at 72 hours after hospital-admission.

Measurement period: At the time of hospital discharge

Numerator: Patients remaining comatose above 72 hours who have had a head CT performed prior to 72 hours after hospital-admission.

Denominator: Patients remaining comatose above 72 hours.

Exclusion: Patients dying from non-neurological causes.

**5.3. EEG as part of neurological prognostication**

Domain: 5. Neurological prognostication

Target population: Adult OHCA-patients remaining comatose at 72 hours after hospital-admission.

Measurement period: At the time of hospital discharge

Numerator: Patients remaining comatose above 72 hours who have had an EEG performed prior to 72 hours after hospital-admission.

Denominator: Patients remaining comatose above 72 hours after stop sedatives.

Exclusion: Patients dying from non-neurological causes or receiving sedatives or neuromuscular blockade drugs..

**6.1. Functional assessments of physical and non-physical impairments before discharge from the hospital**

Domain 6: Patient discharge and Follow-up

Target population: Adult OHCA-patients remaining comatose at 72 hours after hospital-admission.

Measurement period: At the time of hospital discharge

Numerator: Patients surviving to hospital-discharge with an assessment of physical and non-physical impairments before discharge.

Denominator: Patients surviving to hospital-discharge.

Exclusion: none

**6.2. Systematic follow-up and screening for cognitive problems after discharge.**

Domain 6: Patient discharge and Follow-up

Target population: Adult OHCA-patients remaining comatose at 72 hours after hospital-admission.

Measurement period: 3 months after hospital discharge

Numerator: Patients alive after 3 months who are invited to a follow-up session including screening for cognitive problems.

Denominator: Patients alive after 3 months.

Exclusion: Patients having impairments, where contact is unfeasible.

**7.1. Alive with a good functional outcome (able to walk without assistance and attend own bodily needs) 3 months after the arrest**

Domain 7 (outcome quality indicators): Survival and functional outcome

Target population: Adult OHCA-patients remaining comatose at hospital hospital-admission.

Measurement period: 3 months after hospital discharge

Numerator: Patients alive after 3 months with a good neurological outcome

Denominator: number of patients admitted to hospital alive (alive being spontaneous circulation).

Exclusion: none

**8.1. Main QI of each domain.**

Domain 8. Composite QI

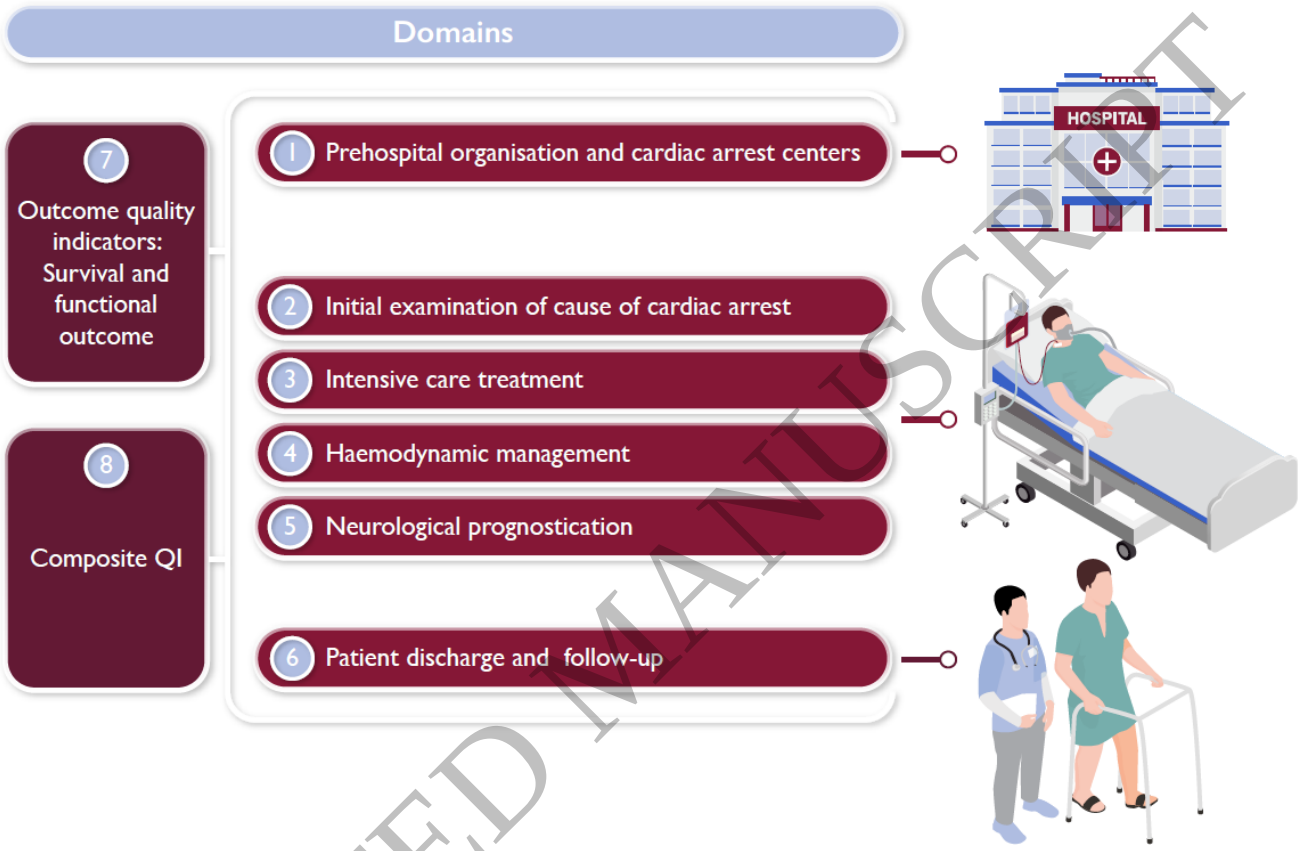
Target population: Adult OHCA-patients remaining comatose at hospital hospital-admission.

Measurement period: 3 months after hospital discharge

Assign 1 point for each main QI fulfilled = a maximal of 7 points per patient; the value of the composite is the number of points divided by 7. If a patient is not eligible to one or more of the 7 points, the total will be divided by the number of indicators applicable. This type of composite allows to consider more items in in a single score.

1 Figure 1: Graphic overview of the 8 domains

2

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**Quality indicators for post-resuscitation care after out-of-hospital cardiac arrest: A Joint statement from the Association for Acute CardioVascular Care (ACVC) of the European Society of Cardiology, the European Resuscitation Council (ERC), the European Society of Intensive Care Medicine (ESICM), and the European Society for Emergency Medicine (EUSEM)**


2

3 **Graphical Abstract**
4 **219x145 mm (.23 x DPI)**