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Code blue: methodology for a qualitative study of teamwork during simulated cardiac arrest

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Title: Code blue: methodology for a qualitative study of teamwork during simulated cardiac arrest

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Abstract

Introduction: In hospital cardiac arrest (IHCA) is a particularly vexing entity from the perspective of preparedness, as it is neither common nor truly rare. Survival from IHCA requires the coordinated efforts of multiple providers with different skill sets who may have little prior experience working together. Survival rates have remained low despite advances in therapy, suggesting that human factors may be at play.

Methods and analysis: This qualitative study uses a quasi-ethnographic data collection approach combining focus group interviews with providers involved in IHCA resuscitation as well as analysis of video recordings from in situ simulated cardiac arrest events. Using grounded theory-based analysis, we intend to understand the organizational, interpersonal, cognitive and behavioral dimensions of IHCA resuscitation, and to build a descriptive model of code team functioning.

Ethics and Dissemination: This ongoing study has been approved by the IRB at UC Davis Medical Center. Results will be disseminated in a subsequent manuscript.

Introduction

Despite advances in the science of cardiopulmonary resuscitation over the past several decades, the odds of neurologically intact survival from in-hospital cardiac arrest (IHCA) remain low. [1,2] When IHCA occurs, a patient's survival depends on both the immediate recognition of the event (as each minute delay from the time of cardiac arrest to the initiation of CPR corresponds to a 10% decrease in the likelihood of survival), as well as aggressive resuscitation in the form of CPR, mechanical ventilation, administration of cardioactive medications, and electrical defibrillation. [3,4] Successful resuscitation from IHCA requires the immediate and coordinated efforts of multiple providers, often with different types of training and levels of experience in dealing with IHCA. [5]

A major challenge to hospital preparedness for IHCA involves its frequency. IHCA is neither common nor truly rare, occurring roughly 200,000 times per year in the United States or an incidence of 4.5 cases per 1000 hospital admissions.[6] The infrequency of IHCA, coupled with the necessity for prompt and coordinated response, indicates a need for frequent and interdisciplinary training. Yet the American Heart Association's Basic Life Support (BLS) and Advanced Cardiac Life Support (ACLS) courses, which are the community standard for providers who participate in IHCA response in most U.S. hospitals, require training only every two years. [7] Additionally, these courses fail to recognize divisions in knowledge and expertise that become operationalized in the context of cardiac resuscitation. A respiratory therapist and pharmacist are likely to play very different roles in an actual cardiac arrest resuscitation, and yet ACLS treats both providers as essentially

the same with regards to their training and assessment needs. A number of studies have demonstrated that while close adherence to ACLS protocols can improve survival from in-hospital cardiac arrest, [8-10] the prescribed interval for cardiac arrest training leads to inadequate performance. [11-15]

Another overlooked yet fundamental aspect of the preparedness gap is a failure of hospitals to accurately apprehend the true nature of cardiac arrest teams. Hospitals aspire to the model of a "highly reliable team," one in which team members have a high degree of familiarity which each other and with their individual roles, and in which the leadership structure is mutually understood. [16,17] In truth, emergency response teams within hospitals "are defined by rapid formation, an abbreviated lifespan and often limited experience working together previously."[17] Further complicating matters, the traditional conceptualizations of cardiac arrest teamwork (e.g. the assumption of physician team leader who possesses both the clinical knowledge and communication skills to successfully conduct a resuscitation) often serve to reinforce dysfunctional hierarchies and tensions between integration (collaborative work that transcends job specification) and specialization (the distribution of work into distinct organizational categories by skill set or job specification). [18] Rachel Finn's study of teamwork among members of an operating room staff put it thusly: "Healthcare is characterized by an increasingly fragmented, specialized, professional division of labour. Each profession has a distinct role and socialized membership, with a historically developed and institutionalized set of hierarchical relations between them. This provides for fundamentally different professionals interests. As a consequence, the

tendency is towards conflict and contestation, to the detriment of professional integration." [18] This movement towards specialization undermines the interprofessional collaboration necessary for healthcare teams to achieve a high degree of reliability. [16] Not surprisingly, ad hoc cardiac arrest teams are associated with poor performance in terms of critical care processes such as CPR performance and timely defibrillation. [11,19,20]

There is evidence to suggest that high fidelity simulation is useful for evaluating clinical processes such as CPR performance as well as team interactions during simulated codes. [21,22] However, simulation has not previously been used as a means for studying the sociological processes at play within cardiac resuscitation. Previous efforts to study simulation as a training intervention have often been limited to the perspective of a single provider group. A recent study of simulation-based code training for physician team leaders found that it yielded no significant improvement in key processes of cardiac arrest care, such as time to initiation of CPR, time to administration of cardiac medication, and time to defibrillation. [23] Yet processes such as CPR initiation and defibrillator deployment rely on the actions of multiple providers, and they often unfold prior to the arrival of a physician leader. [24] The dynamic and unpredictable nature of cardiac arrest response creates a tension between interdependence and the need for autonomous action within a code team. Studies that focus entirely on interventions and assessment of physicians suffer from a critical limitation in understanding the diverse perspectives, roles, and needs of non-physician team members, who must (and typically do) act prior to the arrival of a "code leader." While the gap between

expected and actual performance for cardiac arrest teams has become increasingly clear, an approach that incorporates the perspectives of all team members and that addresses their specific needs is still lacking.

In order to understand the complex interactions inherent in cardiac arrest events within a hospital, the perspectives of each participant in a resuscitation team must be considered. Physicians, nurses, respiratory therapists and pharmacists each have their own knowledge sets, customs of communication, and views of themselves in relation to other providers within a healthcare system. In this way, each provider type can be construed as a distinct cultural group within a hospital. We believe these issues are best viewed from a sociological perspective, drawing from the tradition of ethnography and its roots in anthropological fieldwork as a fruitful and innovative methodological approach for our study. Such a qualitative approach allows us to examine not only the technical and procedural aspects of resuscitation but also the collective conceptions guiding each practitioner group behavior, discursive practices, and relational structures which underlie them.

To address these gaps in our understanding of cardiac arrest teams, we have selected an approach that emphasizes the diagnostic application of simulation as well as the discursive engagement of all practitioners within the team. The specific objectives of this project are as follows: 1) to describe practitioners' experiences of code blue events and their self-perceptions of knowledge and skills in cardiac arrest, 2) to describe practitioners' views of teamwork, with a focus on roles, communication, and coordination of cardiac arrest response, and 3) to identify organizational factors in order to improve cardiac arrest resuscitation training,

teamwork and patient care. This study is intended to address the emic perspective of cardiac arrest resuscitation teams and the organizational and educational approaches that would best support their functioning.

Methods:

This is a cross-sectional qualitative study of a large teaching hospital in California. Our methodological approach includes: 1) field observations of simulated "mock code" events conducted on units throughout the hospital (excluding ICUs, OR/PACU, ER), and 2) focus group interviews with the various provider groups that constitute our hospital's cardiac arrest response: nurses (both ICU and non-ICU), physicians, respiratory therapists and pharmacists.

Our fieldwork is carried out in a 619 bed academic medical center in Northern California with over 33,000 hospital admissions annually. Since August of 2012, a group of providers from the departments of Emergency Medicine, Anesthesia, Internal Medicine, and the Center for the Professional Practice of Nursing have conducted mock codes using in situ high fidelity simulation within the hospital. These events are held three times per month and in varying locations and times of day and night, and serve as the basis for our field observations of code team dynamics.

Data Collection:

Mock Codes

For each mock code event, the investigators bring a wireless, high fidelity human patient simulator (Laerdal Inc., Wappinger Falls, NY) to the designated nursing unit. A "primary nurse" is selected from the unit's staff, and receives a brief video orientation to the manikin. The nurse then reviews a patient chart describing the simulated patient's reason for admission to the hospital and clinical course. The scenario begins when the primary nurse goes to evaluate the patient and finds him unresponsive and without vital signs. Once the nurse recognizes that the simulated patient is in duress and calls for help, a "Code Blue Drill" announcement is made over the hospital's paging system. The mock code then proceeds as any other code would, with all members of the code team (ICU physician and nursing staff, pharmacists, respiratory therapists and anesthesiology housestaff) attending.

The scenarios are recorded from multiple perspectives throughout the room using pocket-sized "Flip Video" (Cisco Systems Inc., San Jose, California) digital recorders on adjustable tripods. One camera is placed directly above the patient's head to provide a view of chest compressions and airway maneuvers. Three additional cameras are placed around the room to capture views of all providers and equipment placed in the room. One or more investigators are also present during the event, and station themselves as unobtrusively as possible in the room. The investigators interact with the participants only after the scenario has been completed, as part of a structured debriefing that reviews recommended approaches to clinical skills such as CPR. This debriefing also addresses the importance of role identification for team members, and closed-loop communication to increase the accuracy of communication during codes.

We have selected the mock code events as the primary source of field data for this study. Given the unpredictability and infrequency of actual codes, as well as the imperfect nature of recall in emotionally charged situations, these events provide the clearest window into the unscripted interactions between providers during a code event. [25] Data has been collected from nine mock code events from different nursing units in the hospital, including both day and night shifts.

Focus Groups

We are conducting qualitative interviews with the provider groups involved in the hospital's Code Blue response: ICU and non-ICU nurses, physicians at different levels of training (residents, fellows and attendings) and from representative departments (medicine, emergency medicine, surgery and anesthesia), respiratory therapists, and pharmacists. All hospital staff members under these designations are invited to participate in the study regardless of having participated in a mock code event.

Interviews are conducted as focus groups and are limited to one provider-type per session. The interviews follow a semi-structured format. The interviews focus on four major themes: background and prior training in cardiac arrest; perceptions of teamwork, division of labor, and customs of communication in cardiac arrest events; quality and culture of training for cardiac arrest; and perceived areas in need of improvement. Interviews are audio recorded and transcribed verbatim by a professional service with a strict confidentiality policy in place.

We have selected focus group interviews as our other primary source of data collection because they allow us to draw upon providers' recollections of their

experiences, and provide a collaborative environment in which each provider group can develop a shared conception of their role within resuscitation teams and the greater hospital structure. We view the focus groups as not only complementary but synergistic with the mock codes. It is through comparison between these two methods that we believe we can understand providers' embodiment of their professional roles in cardiac arrest as well as their interpretation of those roles and their interaction.

Data Analysis:

Mock Code Videos

Video data from the mock codes are analyzed using a coding matrix created by the investigators. This tool was developed in an iterative fashion while reviewing videos of previous mock code events. The coding matrix divides the resuscitation into three distinct temporal and organizational phases: 1) recognition of the pulseless patient and initiation of the Code Blue response, which is typically performed by a single nurse, 2) team recruitment, in which personnel and resources within the unit respond to the crisis, and 3) team management, in which the formal Code Blue response (an interprofessional team composed of personnel from throughout the hospital) arrives at the scene and continues the resuscitation. The coding matrix is designed to address the key clinical processes involved in cardiac arrest resuscitation, as well as key statements and communication events that influence the resuscitation positively or negatively. We have selected this approach as we believe it is the most objective means available to us for examining the actual

behaviors of code team members in the midst of resuscitation. The videos also provide a substrate for comparison with statements made in the focus groups. This process of triangulation is essential for establishing the validity of interpretations made from qualitative data. [26,27]

Table 1: Coding matrix for mock code videos

	Phase 1: Recognition and initiation of Code	Phase 2: Team recruitment	Phase 3: Team management
CPR • Initiation • Patient positioning • Technique • Transitions			
Airway Management • Positioning • BVM technique • Airway adjunct • Ventilation rate			
Medications • IV access • Epinephrine or Vasopressin given • Repeat doses • Other meds			
Key Statements			
Responses to Key Statements			
Incorrect Statements			
Response to Incorrect Statements			

Two of the study investigators review and analyze the code videos in an iterative fashion. The investigators involved in coding meet on a regular basis to compare coding and resolve differences as needed. Following well-established data analysis procedures in qualitative methods, reliability is sought through ongoing discussions and revisions of the coding to remediate differences through a consensus-building process.

Focus Group Transcripts

Verbatim transcripts of focus group interviews are coded in the traditional qualitative fashion, which involves iterative coding of data to identify themes and patterns. This is a consensus building process where reliability is achieved through trustworthiness and data saturation. Study collaborators code data independently per established protocol and they proceed in qualitative tradition to compare coding results and discuss differences to resolve discrepancies.

This study follows a grounded theory approach in which the process of data collection and analysis occurs simultaneously. [27] The approach allows for the pursuit of emergent themes through early data analysis, as well as the discovery of basic social processes within the data that may shape subsequent data collection. Grounded theory is an inductive process by which abstract categories are constructed to explain and synthesize data. These categories are then integrated into a theoretical framework that describes the causes, conditions and consequences of the process being studied.

By applying this detailed analytic approach to video and transcript-data from the mock codes and focus groups, we plan to build an explanatory model of code blue teamwork that can be used to guide subsequent organizational and educational interventions intended to optimize performance.

Ethical Considerations

This project has been reviewed and approved by the Institutional Review Board of the University of California, Davis. Procedures have been developed to ensure data confidentiality and protection.

All focus group participants receive information on the design and goals of the study, and sign an informed consent for participation. All study records are kept confidential and secured to the fullest extent possible. Participant interview recordings, interviewer notes and interview transcripts are coded with a unique identifying number. All qualitative interviews are edited to remove information that could identify participants (e.g. names of persons or work location) before entering them into the qualitative data analysis program. Digital recordings of interviews are kept in a secured, password-protected database. Coded paper interview transcripts, coded screener interview questionnaires and coded paper interviewer's notes do not leave the principal investigator's research office where they are stored under lock and key. A list of subject names and unique identifiers are kept separate from the questionnaires and transcripts and are accessible to the principal investigator and research collaborators, all of whom have completed on-line training in the protection of human subjects. No images or identifying information about

participants are shared or published.

Results from this study will be disseminated via international and national peer-reviewed journals, separately and in papers summarizing the results. Key results will be shared at national and international conferences, and at local and regional meetings and symposia directed at practitioners, educators and researchers, as well as hospital administrators.

Discussion

This study draws upon qualitative methods that have been used in ethnographies of diverse workplace settings, and is intended to uncover the collective perceptions, group behavior, and organizational practices that underlie the IHCA response process. Qualitative studies are vanishingly rare in the world of cardiac arrest research. Given the inherently social and interpersonal nature of cardiac arrest resuscitation and its reliance on the coordinated efforts of people with distinct professional roles and training, we believe a qualitative approach can provide insights into the nature of these events that would otherwise be lost. This methodological approach is important in two distinct ways. On the one hand, rich descriptions of these processes provide the basis for needed explanatory or theoretical models of how cardiac resuscitation teamwork is accomplished. Equally important, this approach also allows for the development of set of hypotheses that can be formally tested in future quantitative or mixed-method research to verify the validity of theoretical models.

Our methodology is not, however, without limitations. We are relying on

simulation to recreate the conditions of IHCA, which may fail to evoke all of the emotional stress and interpersonal interactions than an actual IHCA would. Given the unpredictable and infrequent nature of IHCA, we feel this is a necessary concession. This is also a study being conducted at a single center, and as such the validity of our conclusions are limited by the experiences and perspectives of providers working in a single hospital.

The management of IHCA presents challenges in terms of training, hospital organization, and professional divisions of labor that have been often overlooked or else viewed as unchangeable. We believe this study will provide meaningful insights into each of these areas, and may provide additional lines of inquiry to inform future research.

Contributorship Statement:

Samuel Clarke is the principle author of the manuscript. He developed the study design and protocol and is overseeing data collection and analysis.

Ester Apesoa-Varano is co-investigator on the project. She helped to conceive the study design and has participated in the writing of the manuscript as well as the ongoing data analysis.

Joseph Barton is a co-investigator on this project. He has helped in the data collection and analysis.

Competing Interests:

The authors have no competing interests to disclose.

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Data sharing:

This is a protocol manuscript describing an ongoing study, and it contains no data. Results will be disseminated in a subsequent manuscript.

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Abstract

Introduction: In hospital cardiac arrest (IHCA) is a particularly vexing entity from the perspective of preparedness, as it is neither common nor truly rare. Survival from IHCA requires the coordinated efforts of multiple providers with different skill sets who may have little prior experience working together. Survival rates have remained low despite advances in therapy, suggesting that human factors may be at play.

Methods and analysis: This qualitative study uses a quasi-ethnographic data collection approach combining focus group interviews with providers involved in IHCA resuscitation as well as analysis of video recordings from in situ simulated cardiac arrest events. Using grounded theory-based analysis, we intend to understand the organizational, interpersonal, cognitive and behavioral dimensions of IHCA resuscitation, and to build a descriptive model of code team functioning.

Ethics and Dissemination: This ongoing study has been approved by the IRB at UC Davis Medical Center. Results will be disseminated in a subsequent manuscript.

Strengths and limitations of this study

- This study applies well-established qualitative methodology to a novel area of inquiry (team dynamics in cardiac arrest resuscitation) and with a unique means of qualitative data capture (*in situ* simulation).
- This study takes place at a single institution and is a study of simulated as opposed to actual cardiac arrest events, thus limiting its generalizability.

Introduction

Despite advances in the science of cardiopulmonary resuscitation over the past several decades, the odds of neurologically intact survival from in-hospital cardiac arrest (IHCA) remain low. [1,2] When IHCA occurs, a patient's survival depends on both the immediate recognition of the event (as each minute delay from the time of cardiac arrest to the initiation of CPR corresponds to a 10% decrease in the likelihood of survival), as well as aggressive resuscitation in the form of CPR, mechanical ventilation, administration of cardioactive medications, and electrical defibrillation. [3,4] Successful resuscitation from IHCA requires the immediate and coordinated efforts of multiple providers, often with different types of training and levels of experience in dealing with IHCA. [5]

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training leads to inadequate performance. [12-16] Additionally, these courses fail to recognize divisions in knowledge and expertise that become operationalized in the context of cardiac resuscitation. A respiratory therapist and pharmacist are likely to play very different roles in an actual cardiac arrest resuscitation, yet ACLS treats both providers as essentially the same with regards to their training and assessment needs.

Another overlooked yet fundamental aspect of the preparedness gap is a failure of hospitals to accurately apprehend the true nature of cardiac arrest teams. Hospitals aspire to the model of "high reliability teams" in which team members have a high degree of familiarity which each other and with their individual roles, and in which the leadership structure is mutually understood. [17,18] In truth, emergency response teams within hospitals "are defined by rapid formation, an abbreviated lifespan and often limited experience working together previously." [18] Further complicating matters, the traditional conceptualizations of cardiac arrest teamwork (e.g. the assumption of physician team leader who possesses both the clinical knowledge and communication skills to successfully conduct a resuscitation) often serve to reinforce dysfunctional hierarchies and tensions between integration (collaborative work that transcends job specification) and specialization (the distribution of work into distinct organizational categories by skill set or job specification). [19] Rachel Finn's study of teamwork among members of an operating room staff put it thusly: "Healthcare is characterized by an increasingly fragmented, specialized, professional division of labour. Each profession has a distinct role and socialized membership, with a historically

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There is evidence to suggest that high fidelity simulation is useful for evaluating clinical processes such as CPR performance as well as team interactions during simulated codes. [22,23] However, simulation has not previously been used as a means for studying the sociologic forces at play within cardiac resuscitation via qualitative methodology. Previous efforts to study simulation as a training intervention have often limited themselves to the perspective of a single provider group. A recent study of simulation-based code training for physician team leaders found that it yielded no significant improvement in key processes of cardiac arrest care: time to initiation of CPR, time to administration of cardiac medication, and time to defibrillation. [24] Yet processes such as CPR initiation and defibrillator deployment rely on the actions of multiple providers, and they often unfold prior to the arrival of a physician leader. [25] The dynamic and unpredictable nature of cardiac arrest response creates a tension between interdependence and the need for autonomous action within a diverse group of providers. Studies that focus entirely on interventions and assessment of physicians suffer from a critical limitation in

perspective, and fundamentally overlook the training needs and essential roles of providers who must act even prior to the arrival of a "team leader." While the gap between expected and actual performance for cardiac arrest teams has become increasingly clear, an approach that incorporates the perspectives of all team members and that addresses their specific needs is still lacking.

In order to understand the complex interactions inherent in cardiac arrest events within a hospital, the perspectives of each participant in a resuscitation team must be considered. Physicians, nurses, respiratory therapists and pharmacists each have their own knowledge sets, customs of communication, and views of themselves in relation to other providers within a healthcare system. In this way, each provider type can be construed as a distinct cultural group within a hospital. We believe these issues are best viewed from a sociological perspective, drawing from the tradition of ethnography and its roots in anthropological field study as a fruitful and innovative methodological approach for our study. Such a qualitative approach allows us to examine not only the technical and procedural aspects of resuscitation but also the mental models, discursive practices, and relational structures which underlie them.

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communication, and coordination of cardiac arrest response, and 3.) to identify organizational factors in order to improve cardiac arrest resuscitation training, teamwork and patient care. This study is intended to address the emic perspective of cardiac arrest resuscitation teams and the organizational and educational approaches that would best support their functioning.

Methods:

This is a cross-sectional qualitative study of a large teaching hospital in California. Our methodological approach includes: (1) field observations of simulated "Mock Code" events conducted on units throughout the hospital (excluding ICUs, OR/PACU, ER), and (2) focus group interviews with the various provider groups that constitute our hospital's cardiac arrest response: nurses (both ICU and non-ICU), physicians, respiratory therapists and pharmacists.

Our fieldwork is carried out in a 619 bed academic medical center in Northern California with over 33,000 hospital admissions annually. Since August of 2012, a group of providers from the departments of Emergency Medicine, Anesthesia, Internal Medicine, and the Center for the Professional Practice of Nursing have conducted "mock codes" using in situ high fidelity simulation within the hospital. These events are held three times per month and in varying locations and times of day and night, and will serve as the basis for our field observations of code team dynamics.

Data Collection:

Mock Codes

For each Mock Code event, the investigators bring a wireless, high fidelity human patient simulator (Laerdal Inc., Wappinger Falls, NY) to the designated nursing unit. A "primary nurse" is selected from the unit's staff, and receives a brief video orientation to the manikin. The nurse then reviews a patient chart describing the simulated patient's reason for admission to the hospital and clinical course. The scenario begins when the primary nurse goes to evaluate the patient and finds him unresponsive and without vital signs. Once the nurse recognizes that the simulated patient is in duress and calls for help, a "Code Blue Drill" announcement is made over the hospital's paging system. The Mock Code then proceeds as any other Code would, with all members of the Code Team (ICU physician and nursing staff, pharmacists, respiratory therapists and anesthesiology housestaff) attending.

The scenarios are recorded from multiple perspectives throughout the room using pocket-sized "Flip Video" digital recorders on adjustable tripods (Cisco Systems, San Francisco, California). One camera is placed directly above the patient's head to provide a view of chest compressions and airway maneuvers. Three additional cameras are placed around the room to capture views of all providers and equipment placed in the room. One or more investigators are also present during the event, and station themselves as unobtrusively as possible in the room. The investigators interact with the participants only after the scenario has been completed, as part of a structured debriefing that reviews recommended approaches to clinical skills such as CPR. This debriefing also addresses the

importance of role identification for team members, and closed-loop communication to increase the accuracy of communication during codes.

We have selected the mock code events as the primary source of field data for this study. Given the unpredictability and infrequency of actual codes, as well as the imperfect nature of recall in emotionally charged situations, these events provide the clearest window into the unscripted interactions between providers during a code event. [26] Data has been collected from approximately ten mock code events from different nursing units in the hospital, including both day and night shifts.

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We are conducting qualitative interviews with the provider groups involved in the hospital's Code Blue response: ICU and non-ICU nurses, physicians at different levels of training (residents, fellows and attendings) and from representative departments (medicine, emergency medicine, surgery and anesthesia), respiratory therapists, and pharmacists. All hospital staff members under these designations are invited to participate in the study regardless of having participated in a Mock Code event.

Interviews are conducted as focus groups and are limited to one provider-type per session. The interviews follow a semi-structured format. The interviews focus on four major themes: background and prior training in cardiac arrest; perceptions of teamwork, division of labor, and customs of communication in cardiac arrest events; quality and culture of training for cardiac arrest; and

perceived areas in need of improvement. Interviews are audio recorded and transcribed verbatim by a professional service with a strict confidentiality policy in place.

We have selected focus group interviews as our other primary source of data collection because they allow us to draw upon providers' recollections of their experiences, and provide a collaborative environment in which each provider group can develop a shared conception of their role within resuscitation teams and the greater hospital structure. We view the focus groups as not only complementary but synergistic with the mock codes. It is through comparison between these two methods that we believe we can access providers' embodiment of their professional roles in cardiac arrest as well as their interpretation of those roles and their interaction.

Data Analysis:

Mock Code Videos

Video data from the mock codes are analyzed using a coding matrix created by the investigators. This tool was conceived, developed and refined by reviewing ten videos of previous mock code events. Through an iterative process of individual and collaborative coding, we developed a coding matrix that divides the resuscitation into three distinct temporal and organizational phases: 1.) recognition of the pulseless patient and initiation of the Code Blue response, which is typically performed by a single nurse, 2.) team recruitment, in which personnel and resources within the unit respond to the crisis, and 3.) team management, in which

the formal Code Blue response (an interprofessional team composed personnel from throughout the hospital) arrives at the scene and continues the resuscitation. The coding matrix is designed to address the widely recognized key clinical processes involved in cardiac arrest resuscitation (performance of cardiopulmonary resuscitation, defibrillator deployment and operation, ventilator support and airway management, and administration of cardioactive medications) based on current conceptualizations of cardiac resuscitation described in the American Heart Association's Advanced Cardiac Life Support course and the balanced perfusion/oxygenation/ventilation model of Advanced Resuscitation Training. [8,27] Crisis Resource Management, a constellation of cognitive and communication techniques used to describe the activities of teams performing under time pressure and in high risk settings, served as the theoretical basis for the non-technical aspects (key statements and responses) of the matrix. [28] [29]

The tool is intended to be used for post hoc analysis of video recorded Mock Codes, owing to the technical difficulty of attempting to anticipate, capture and analyze actual codes in real time. We have selected this approach as we believe it is the most objective means available to us for examining the actual behaviors of code team members in the midst of resuscitation. The videos also provide a substrate for comparison with statements made in the focus groups. This process of triangulation is essential for establishing the validity of interpretations made from qualitative data. [30,31]

Table 1: Coding matrix for mock code videos

	Phase 1: Recognition and initiation of Code	Phase 2: Team recruitment	Phase 3: Team management
CPR • Initiation • Patient positioning • Technique • Transitions			
Airway Management • Positioning • BVM technique • Airway adjunct • Ventilation rate			
Medications • IV access • Epinephrine or Vasopressin given • Repeat doses • Other meds			
Key Statements			
Responses to Key Statements			
Incorrect Statements			
Response to Incorrect Statements			

The instrument is intended to provide structure to a narrative analysis of the Mock Code event. Two of the study investigators review and analyze the code videos in an iterative fashion (typically 3-4 viewings from multiple camera angles). Observations about each of the target activities, as well as the individual(s) performing them and a time stamp of when they occur, are recorded in each of the matrix cells. Staff categorization (e.g. RN, physician, respiratory therapist) is signified by scrub color in our hospital, which aids in the identification of roles

within the scenarios. After independent coding of two to three Mock Codes, two of the investigators meet to compare coding and resolve differences as needed. Following well-established data analysis procedures in qualitative methods, reliability is sought through ongoing discussions and revisions of the coding to remediate differences through a consensus-building process. The trustworthiness of the data is established via triangulation with focus group findings and detailed analysis across multiple Mock Code events in multiple settings (i.e. day and night shifts, telemetry and non-telemetry nursing units).

Focus Group Transcripts

Verbatim transcripts of focus group interviews are coded in the traditional qualitative fashion, which involves iterative coding of data to identify themes and patterns. This is a consensus building process where reliability is achieved through trustworthiness and data saturation. Study collaborators will code data independently per established protocol and they will proceed in qualitative tradition to compare coding results and discuss differences to resolve discrepancies.

This study will follow a grounded theory approach in which the process of data collection and analysis occurs simultaneously. [24] The approach allows for the pursuit of emergent themes through early data analysis, as well as the discovery of basic social processes within the data that may shape subsequent data collection. Grounded theory is an inductive process by which abstract categories are constructed to explain and synthesize data. These categories are then integrated

into a theoretical framework that describes the causes, conditions and consequences of the process being studied.

By applying this detailed analytic approach to video and transcript-data from the Mock Codes and focus groups, we plan to build an explanatory model of code blue teamwork that can be used to guide subsequent organizational and educational interventions intended to optimize performance.

Ethical Considerations

This project has been reviewed and approved by the Institutional Review Board of the University of California, Davis. Procedures have been developed to ensure data confidentiality and protection.

All focus group participants receive information on the design and goals of the study, and will sign an informed consent for participation. All study records are kept confidential and secured to the fullest extent possible. Participant interview recordings, interviewer notes and interview transcripts are coded with a unique identifying number. All qualitative interviews are edited to remove information that could identify participants (e.g. names of persons or work location) before entering them into the qualitative data analysis program. Digital recordings of interviews are kept in a secured, password-protected database. Coded paper interview transcripts, coded screener interview questionnaires and coded paper interviewer's notes do not leave the PI's research office where they are stored under lock and key. A list of subject names and unique identifiers are kept separate from the questionnaires and transcripts and are accessible to the PI and research collaborators, all of whom have

completed on-line training in the protection of human subjects. No images or identifying information about participants are shared or published.

Results from this study will be disseminated via international and national peer-reviewed journals, separately and in papers summarizing the results. Key results will be shared at national and international conferences, and at local and regional meetings and symposia directed at practitioners, educators and researchers, as well as hospital administrators.

Discussion

This study draws upon qualitative methods that have been used in ethnographies of diverse workplace settings, and is intended to uncover the professional ideologies, organizational practices, and labor divisions that underlie the IHCA response process. Qualitative studies are vanishingly rare in the world of cardiac arrest research. Given the inherently social and interpersonal nature of cardiac arrest resuscitation and its reliance on the coordinated efforts of people with distinct professional roles and training, we believe a qualitative approach can provide insights into the nature of these events that would otherwise be lost.

Our methodology is not, however, without limitations. We are relying on simulation to recreate the conditions of IHCA, which may fail to evoke all of the emotional stress and interpersonal interactions than an actual IHCA would. Given the unpredictable and infrequent nature of IHCA, we feel this is a necessary concession. This is also a study being conducted at a single center, and as such the validity of our conclusions are limited by the experiences and perspectives of

providers working in a single hospital.

The management of IHCA presents challenges in terms of training, hospital organization, and professional divisions of labor that have been often overlooked or else viewed as unchangeable. We believe this study will provide meaningful insights into each of these areas, and may provide additional lines of inquiry to inform future research.

Contributorship Statement

Samuel Clarke was the principle author of the manuscript. He developed the study design and protocol and is overseeing data collection and analysis.

Ester Apesoa-Varano is a research mentor to Dr. Clarke. She helped to conceive the study design and has participated in the writing of the manuscript as well as the ongoing data analysis.

Dr. Barton is a co-investigator on this project. He has helped in the data collection and analysis for this project.

In accordance with ICMJE authorship guidelines, all three authors contributed substantially to the drafting, revision, and final approval of this manuscript.

Competing Interests

The authors have no competing interests to report.

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Data Sharing Statement

This is a protocol manuscript describing an ongoing study, and it contains no data.

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Code blue: methodology for a qualitative study of teamwork during simulated cardiac arrest

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Title: Code blue: methodology for a qualitative study of teamwork during simulated cardiac arrest

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Abstract

Introduction: In hospital cardiac arrest (IHCA) is a particularly vexing entity from the perspective of preparedness, as it is neither common nor truly rare. Survival from IHCA requires the coordinated efforts of multiple providers with different skill sets who may have little prior experience working together. Survival rates have remained low despite advances in therapy, suggesting that human factors may be at play.

Methods and analysis: This qualitative study uses a quasi-ethnographic data collection approach combining focus group interviews with providers involved in IHCA resuscitation as well as analysis of video recordings from in situ simulated cardiac arrest events. Using grounded theory-based analysis, we intend to understand the organizational, interpersonal, cognitive and behavioral dimensions of IHCA resuscitation, and to build a descriptive model of code team functioning.

Ethics and Dissemination: This ongoing study has been approved by the IRB at UC Davis Medical Center. Results will be disseminated in a subsequent manuscript.

Strengths and limitations of this study

- This study applies well-established qualitative methodology to a novel area of inquiry (team dynamics in cardiac arrest resuscitation) and with a unique means of qualitative data capture (*in situ* simulation).
- This study takes place at a single institution and is a study of simulated as opposed to actual cardiac arrest events, thus limiting its generalizability.

Introduction

Despite advances in the science of cardiopulmonary resuscitation over the past several decades, the odds of neurologically intact survival from in-hospital cardiac arrest (IHCA) remain low. [1,2] When IHCA occurs, a patient's survival depends on both the immediate recognition of the event (as each minute delay from the time of cardiac arrest to the initiation of CPR corresponds to a 10% decrease in the likelihood of survival), as well as aggressive resuscitation in the form of CPR, mechanical ventilation, administration of cardioactive medications, and electrical defibrillation. [3,4] Successful resuscitation from IHCA requires the immediate and coordinated efforts of multiple providers, often with different types of training and levels of experience in dealing with IHCA. [5]

A major challenge to hospital preparedness for IHCA involves its frequency. IHCA is neither common nor truly rare, occurring roughly 200,000 times per year in the United States or an incidence of 4.5 cases per 1000 hospital admissions. [6] The infrequency of IHCA, coupled with the necessity for prompt and coordinated response, indicates a need for frequent and interdisciplinary training. Yet the American Heart Association's Basic Life Support (BLS) and Advanced Cardiac Life Support (ACLS) courses, which are the community standard for providers who participate in IHCA response in most U.S. hospitals, require training only every two years despite evidence to suggest that the knowledge and skills gained in these classes degrades in as little as 12 weeks. [7,8] A number of studies have demonstrated that while close adherence to ACLS protocols can improve survival from in-hospital cardiac arrest, [9-11]the prescribed interval for cardiac arrest

training leads to inadequate performance. [12-16] Additionally, these courses fail to recognize divisions in knowledge and expertise that become operationalized in the context of cardiac resuscitation. A respiratory therapist and pharmacist are likely to play very different roles in an actual cardiac arrest resuscitation, yet ACLS treats both providers as essentially the same with regards to their training and assessment needs.

Another overlooked yet fundamental aspect of the preparedness gap is a failure of hospitals to accurately apprehend the true nature of cardiac arrest teams. Hospitals aspire to the model of "high reliability teams" in which team members have a high degree of familiarity which each other and with their individual roles, and in which the leadership structure is mutually understood. [17,18] In truth, emergency response teams within hospitals "are defined by rapid formation, an abbreviated lifespan and often limited experience working together previously." [18] Further complicating matters, the traditional conceptualizations of cardiac arrest teamwork (e.g. the assumption of physician team leader who possesses both the clinical knowledge and communication skills to successfully conduct a resuscitation) often serve to reinforce dysfunctional hierarchies and tensions between integration (collaborative work that transcends job specification) and specialization (the distribution of work into distinct organizational categories by skill set or job specification). [19] Rachel Finn's study of teamwork among members of an operating room staff put it thusly: "Healthcare is characterized by an increasingly fragmented, specialized, professional division of labour. Each profession has a distinct role and socialized membership, with a historically

developed and institutionalized set of hierarchical relations between them. This provides for fundamentally different professionals interests. As a consequence, the tendency is towards conflict and contestation, to the detriment of professional integration." [19] This movement towards specialization serves to undermine the interprofessional collaboration necessary for healthcare teams to achieve a high degree of reliability. [17] Not surprisingly, ad hoc cardiac arrest teams are associated with poor performance in terms of critical care processes such as CPR performance and timely defibrillation. [12,20,21]

There is evidence to suggest that high fidelity simulation is useful for evaluating clinical processes such as CPR performance as well as team interactions during simulated codes. [22,23] However, simulation has not previously been used as a means for studying the sociologic forces at play within cardiac resuscitation via qualitative methodology. Previous efforts to study simulation as a training intervention have often limited themselves to the perspective of a single provider group. A recent study of simulation-based code training for physician team leaders found that it yielded no significant improvement in key processes of cardiac arrest care: time to initiation of CPR, time to administration of cardiac medication, and time to defibrillation. [24] Yet processes such as CPR initiation and defibrillator deployment rely on the actions of multiple providers, and they often unfold prior to the arrival of a physician leader. [25] The dynamic and unpredictable nature of cardiac arrest response creates a tension between interdependence and the need for autonomous action within a diverse group of providers. Studies that focus entirely on interventions and assessment of physicians suffer from a critical limitation in

perspective, and fundamentally overlook the training needs and essential roles of providers who must act even prior to the arrival of a "team leader." While the gap between expected and actual performance for cardiac arrest teams has become increasingly clear, an approach that incorporates the perspectives of all team members and that addresses their specific needs is still lacking.

In order to understand the complex interactions inherent in cardiac arrest events within a hospital, the perspectives of each participant in a resuscitation team must be considered. Physicians, nurses, respiratory therapists and pharmacists each have their own knowledge sets, customs of communication, and views of themselves in relation to other providers within a healthcare system. In this way, each provider type can be construed as a distinct cultural group within a hospital. We believe these issues are best viewed from a sociological perspective, drawing from the tradition of ethnography and its roots in anthropological field study as a fruitful and innovative methodological approach for our study. Such a qualitative approach allows us to examine not only the technical and procedural aspects of resuscitation but also the mental models, discursive practices, and relational structures which underlie them.

To address these gaps in our understanding of cardiac arrest teams, we have selected an approach that emphasizes the diagnostic application of simulation as well as the discursive engagement of all practitioners within the team. The specific objectives of this project are as follows: 1.) to describe practitioners' experiences of code blue events and their self-perceptions of knowledge and skills in cardiac arrest, 2.) to describe practitioners' views of teamwork, with a focus on roles,

communication, and coordination of cardiac arrest response, and 3.) to identify organizational factors in order to improve cardiac arrest resuscitation training, teamwork and patient care. This study is intended to address the emic perspective of cardiac arrest resuscitation teams and the organizational and educational approaches that would best support their functioning.

Methods:

This is a cross-sectional qualitative study of a large teaching hospital in California. Our methodological approach includes: (1) field observations of simulated "Mock Code" events conducted on units throughout the hospital (excluding ICUs, OR/PACU, ER), and (2) focus group interviews with the various provider groups that constitute our hospital's cardiac arrest response: nurses (both ICU and non-ICU), physicians, respiratory therapists and pharmacists.

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Data Collection:

Mock Codes

For each Mock Code event, the investigators bring a wireless, high fidelity human patient simulator (Laerdal Inc., Wappinger Falls, NY) to the designated nursing unit. A "primary nurse" is selected from the unit's staff, and receives a brief video orientation to the manikin. The nurse then reviews a patient chart describing the simulated patient's reason for admission to the hospital and clinical course. The scenario begins when the primary nurse goes to evaluate the patient and finds him unresponsive and without vital signs. Once the nurse recognizes that the simulated patient is in duress and calls for help, a "Code Blue Drill" announcement is made over the hospital's paging system. The Mock Code then proceeds as any other Code would, with all members of the Code Team (ICU physician and nursing staff, pharmacists, respiratory therapists and anesthesiology housestaff) attending.

The scenarios are recorded from multiple perspectives throughout the room using pocket-sized "Flip Video" digital recorders on adjustable tripods (Cisco Systems, San Francisco, California). One camera is placed directly above the patient's head to provide a view of chest compressions and airway maneuvers. Three additional cameras are placed around the room to capture views of all providers and equipment placed in the room. One or more investigators are also present during the event, and station themselves as unobtrusively as possible in the room. The investigators interact with the participants only after the scenario has been completed, as part of a structured debriefing that reviews recommended approaches to clinical skills such as CPR. This debriefing also addresses the

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We have selected the mock code events as the primary source of field data for this study. Given the unpredictability and infrequency of actual codes, as well as the imperfect nature of recall in emotionally charged situations, these events provide the clearest window into the unscripted interactions between providers during a code event. [26] Data has been collected from approximately ten mock code events from different nursing units in the hospital, including both day and night shifts.

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We are conducting qualitative interviews with the provider groups involved in the hospital's Code Blue response: ICU and non-ICU nurses, physicians at different levels of training (residents, fellows and attendings) and from representative departments (medicine, emergency medicine, surgery and anesthesia), respiratory therapists, and pharmacists. All hospital staff members under these designations are invited to participate in the study regardless of having participated in a Mock Code event.

Interviews are conducted as focus groups and are limited to one provider-type per session. The interviews follow a semi-structured format. The interviews focus on four major themes: background and prior training in cardiac arrest; perceptions of teamwork, division of labor, and customs of communication in cardiac arrest events; quality and culture of training for cardiac arrest; and

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The tool is intended to be used for post hoc analysis of video recorded Mock Codes, owing to the technical difficulty of attempting to anticipate, capture and analyze actual codes in real time. We have selected this approach as we believe it is the most objective means available to us for examining the actual behaviors of code team members in the midst of resuscitation. The videos also provide a substrate for comparison with statements made in the focus groups. This process of triangulation is essential for establishing the validity of interpretations made from qualitative data. [30,31]

Table 1: Coding matrix for mock code videos

	Phase 1: Recognition and initiation of Code	Phase 2: Team recruitment	Phase 3: Team management
CPR • Initiation • Patient positioning • Technique • Transitions			
Airway Management • Positioning • BVM technique • Airway adjunct • Ventilation rate			
Medications • IV access • Epinephrine or Vasopressin given • Repeat doses • Other meds			
Key Statements			
Responses to Key Statements			
Incorrect Statements			
Response to Incorrect Statements			

The instrument is intended to provide structure to a narrative analysis of the Mock Code event. Two of the study investigators review and analyze the code videos in an iterative fashion (typically 3-4 viewings from multiple camera angles). Observations about each of the target activities, as well as the individual(s) performing them and a time stamp of when they occur, are recorded in each of the matrix cells. Staff categorization (e.g. RN, physician, respiratory therapist) is signified by scrub color in our hospital, which aids in the identification of roles

within the scenarios. After independent coding of two to three Mock Codes, two of the investigators meet to compare coding and resolve differences as needed. Following well-established data analysis procedures in qualitative methods, reliability is sought through ongoing discussions and revisions of the coding to remediate differences through a consensus-building process. The trustworthiness of the data is established via triangulation with focus group findings and detailed analysis across multiple Mock Code events in multiple settings (i.e. day and night shifts, telemetry and non-telemetry nursing units).

Focus Group Transcripts

Verbatim transcripts of focus group interviews are coded in the traditional qualitative fashion, which involves iterative coding of data to identify themes and patterns. This is a consensus building process where reliability is achieved through trustworthiness and data saturation. Study collaborators will code data independently per established protocol and they will proceed in qualitative tradition to compare coding results and discuss differences to resolve discrepancies.

This study will follow a grounded theory approach in which the process of data collection and analysis occurs simultaneously. [24] The approach allows for the pursuit of emergent themes through early data analysis, as well as the discovery of basic social processes within the data that may shape subsequent data collection. Grounded theory is an inductive process by which abstract categories are constructed to explain and synthesize data. These categories are then integrated

into a theoretical framework that describes the causes, conditions and consequences of the process being studied.

By applying this detailed analytic approach to video and transcript-data from the Mock Codes and focus groups, we plan to build an explanatory model of code blue teamwork that can be used to guide subsequent organizational and educational interventions intended to optimize performance.

Ethical Considerations

This project has been reviewed and approved by the Institutional Review Board of the University of California, Davis. Procedures have been developed to ensure data confidentiality and protection.

All focus group participants receive information on the design and goals of the study, and will sign an informed consent for participation. All study records are kept confidential and secured to the fullest extent possible. Participant interview recordings, interviewer notes and interview transcripts are coded with a unique identifying number. All qualitative interviews are edited to remove information that could identify participants (e.g. names of persons or work location) before entering them into the qualitative data analysis program. Digital recordings of interviews are kept in a secured, password-protected database. Coded paper interview transcripts, coded screener interview questionnaires and coded paper interviewer's notes do not leave the PI's research office where they are stored under lock and key. A list of subject names and unique identifiers are kept separate from the questionnaires and transcripts and are accessible to the PI and research collaborators, all of whom have

completed on-line training in the protection of human subjects. No images or identifying information about participants are shared or published.

Results from this study will be disseminated via international and national peer-reviewed journals, separately and in papers summarizing the results. Key results will be shared at national and international conferences, and at local and regional meetings and symposia directed at practitioners, educators and researchers, as well as hospital administrators.

Discussion

This study draws upon qualitative methods that have been used in ethnographies of diverse workplace settings, and is intended to uncover the professional ideologies, organizational practices, and labor divisions that underlie the IHCA response process. Qualitative studies are vanishingly rare in the world of cardiac arrest research. Given the inherently social and interpersonal nature of cardiac arrest resuscitation and its reliance on the coordinated efforts of people with distinct professional roles and training, we believe a qualitative approach can provide insights into the nature of these events that would otherwise be lost.

Our methodology is not, however, without limitations. This is a study being conducted at a single center, and as such the validity of our conclusions are limited by the experiences and perspectives of providers working in a single hospital. Additionally, we are relying on simulation to recreate the conditions of IHCA, which may fail to evoke all of the emotional stress and interpersonal interactions than an actual IHCA would. While it would be ideal to directly observe team interactions

(either in person or via recording) for actual Code Blue events, their relative infrequency, unpredictability, and the medico-legal implications of critical patient care would make such a strategy impractical. Rather than simply relying on providers' recollections of their experiences in cardiac arrest resuscitations, we have sought to recreate the conditions of cardiac arrest resuscitation with as high a degree of fidelity as possible. The simulations are carried out in actual patient care spaces within the hospital and are responded to by all of the providers who would manage an actual Code Blue. The Codes are announced via overhead page, and responding staff have no prior warning of the event aside from the staff member playing the "primary nurse" (who is provided with a brief orientation immediately prior to the scenario). We believe that the unannounced nature of these simulations and their placement in realistic healthcare settings allows us to recreate the psychological as well as physical conditions of cardiac arrest response in the hospital setting.

The management of IHCA presents challenges in terms of training, hospital organization, and professional divisions of labor that have been often overlooked or else viewed as unchangeable. We believe this study will provide meaningful insights into each of these areas, and may provide additional lines of inquiry to inform future research.

Contributorship Statement

Samuel Clarke was the principle author of the manuscript. He developed the study design and protocol and is overseeing data collection and analysis.

Ester Apesoa-Varano is a research mentor to Dr. Clarke. She helped to conceive the study design and has participated in the writing of the manuscript as well as the ongoing data analysis.

Dr. Barton is a co-investigator on this project. He has helped in the data collection and analysis for this project.

In accordance with ICMJE authorship guidelines, all three authors contributed substantially to the drafting, revision, and final approval of this manuscript.

Competing Interests

The authors have no competing interests to report.

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Data Sharing Statement

This is a protocol manuscript describing an ongoing study, and it contains no data.

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