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A Complete Redesign of the Cardiopulmonary Resuscitation (CPR) and Automated External Defibrillator (AED) Learning Experience

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Working Paper #13-01

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Survival following sudden cardiac arrest in the community can be framed as a complex systems problem for which systems thinking and design methodologies may be applied. Focusing on the subsystem of the learning experience of cardiopulmonary resuscitation and use of an automated external defibrillator (CPR/AED), we used a systems approach to understand the current state of learning and a design methodology to identify improvements. A systems diagnosis identified six elements within the learning experience - need for training, opportunity for training, training class characteristics, perceived competence, anticipated event characteristics, and perceived readiness to act – each of which had positive and negative meanings and outcomes. As the elements are interactive and complex, the expected central property of learning – likelihood to act - may not be realized because of significant conflicts and obstructions. Design methodology identified 250 elements for an ideal CPR/AED learning experience which could be arranged as a containing system with eight interactive categories. Based on a system thinking and design methodology approach we suggested ten changes to improve the current state of the CPR/AED learning experience.

Keywords
cardiopulmonary resuscitation, automated external defibrillators, systems thinking, design, sudden cardiac arrest survival

Comments
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Abstract

Survival following sudden cardiac arrest in the community can be framed as a complex systems problem for which systems thinking and design methodology may be applied. Focusing on the cardiopulmonary resuscitation and automated external defibrillator (CPR/AED) learning experience, we used a systems approach to understand the current state of learning and a design methodology to suggest improvements. Systems diagnosis identified six elements within the learning experience that due to conflicts and obstructions explain why the expected central property of learning, likelihood to perform, may not be facilitated. Design methodology identified 250 elements for an ideal CPR/AED learning experience which could be described as a containing system with eight interactive categories and three sub-categories. Drawing from the ideal design, we suggest ten changes to improve the current CPR/AED learning experience.

A COMPLETE REDESIGN OF THE CARDIOPULMONARY RESUSCITATION (CPR) AND AUTOMATED EXTERNAL DEFIBRILLATOR (AED) LEARNING EXPERIENCE

The 2013 updated statistics on heart disease and stroke provided by the American Heart Association[1] indicate that an estimated 83.6 million Americans (>1 in 3) have 1 or more types of cardiovascular disease (CVD) and that each day an estimated 2150 Americans die. On an annual basis, approximately 635 000 Americans have a first hospitalized myocardial infarction or coronary heart disease death, 280 000 have a recurrent attack, and an additional 150 000 experience a silent first myocardial infarctions. This calculates to 1 coronary event approximately every 34 seconds, and 1 death every 90 seconds.

US and Canadian community EMS systems that collect incidence data report that 15-16% of cardiac arrests occur out-of-hospital (OOH) in public or occupational sites[2,3,4] and overall survival is poor.[5] While Seattle/King County reported a 57% survival rate,[6] perhaps the highest in the world and nearly three times Boston's rate of 21%,[7] Philadelphia reported 8.56%-10.9%,[8] New York City, Chicago and Los Angeles each report under 3%[9] and the US national average is a dismal 7.9%[10] a number that has not changed significantly in more than 30 years and which translates into the death of approximately 300,000 people annually.[1,2,11]

What is our method of inquiry for this intractable problem? With few exceptions, we think analytically a word that means to deconstruct into small parts and which holds the assumption that the (whole) problem is equal to the sum of its parts. SCA survival, therefore, can be understood by reduction into additive response elements, described primarily in terms of a time-related, "chain of survival" response paradigm[12,13] of early recognition and call for emergency medical services (EMS); early initiation of basic life support (BLS) cardiopulmonary resuscitation (CPR); early defibrillation via an automated external defibrillator (AED); early

advanced (cardiac) life support (ALS) primarily involving drug intervention protocols; and following the release of the *2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care*,[14] integrated post-cardiac arrest care.

What is our method of intervention to solve this problem? Also with few exceptions to improve SCA survival we adhere to scientific and research methodology which holds the assumption that if each part of this framed problem is considered independently and is optimized, i.e., if the error/variability of each predictive element approaches zero then the outcome will approach its maximum positive value. Thus, the Seattle/King County research community examined data between 1976 and 1991 then generated a linear equation[15]

> Survival Rate = 67% at collapse – 2.3% per minute to CPR – 1.1% per minute to defibrillation (AED) – 2.1% per minute to ALS.

They explained its meaning as follows:

> The regression constant, 67%, represents the probability of survival in the hypothetical situation in which all treatments are delivered immediately on collapse to patients with prehospital cardiac arrest…With delays in CPR, defibrillatory shock, and definitive care, the magnitude of the decline in survival rate per minute is the sum of the three coefficients (-2.2%, -1.1%, -2.1%), or -5.5%).

Analytic thinking (deconstruction) and scientific methodology (optimizing parts) have been applied to each element of the equation. For example, while many CPR courses are available within US communities, in 2005 to simplify access and optimize skill acquisition, the American Heart Association (AHA) began promoting video-based self-learning with the Family & Friends® CPR Anytime® kit, a product advertised [a] to "contain everything needed to learn basic CPR, AED skills and choking relief anywhere, from the comfort of your home to a large group setting … in just 20 minutes." In addition, in 2008, AHA reduced the four elements of patient assessment - responsiveness, airway, breathing, and circulation - to immediate

performance of Hands-Only™ CPR with the statement that a bystander who witnesses the sudden collapse of an adult should dial 911 then simply, "push hard and fast in the middle of the victim's chest." [a]

Regarding defibrillation, AED device weight, transport barriers, and operational procedures have been reduced then optimized by manufacturers who produce smaller, lightweight, simplified automated devices with easy-to-follow audio and visual prompt instructions[16,17,18] and automatic devices which operate without any user decision making after pads are placed on the chest of the patient. As well, the International Liaison Committee on Resuscitation (ILCOR) which represents principal resuscitation organizations worldwide including the American Heart Association, European Resuscitation Council and the Heart and Stroke Foundation of Canada has recommended that "AED use should not be restricted to trained personnel. Allowing the use of AEDs by persons without prior formal training can be beneficial and may be lifesaving."[19]

Despite spending billions of dollars through decades of focused research, promotion, marketing, and devoting enormous effort to simplify and optimize the additive elements of CPR and AED, the problem has not been solved. Excluding a small number of cities, the US national survival rate following OOH SCA since the 1970s has remained under 8%.

Alternative Epistemology

A report issued in 1999 by the Institute of Medicine[20] argued that the problems in health care are not about parts; rather, they involve systems and to improve outcomes the focus should be on design:

> … the majority of medical errors do not result from individual recklessness or the actions of a particular group--this is not a "bad apple" problem. More commonly, errors are caused by faulty systems, processes, and conditions that lead people to make mistakes or fail to prevent them … mistakes can best be prevented by (re)designing the health system at all levels to make it safer--to make it harder for people to do something wrong and easier for them to do it right.

The World Health Organization (WHO) makes a similar assessment. They argue that health care is a complex systems problem; yet, there is a common failure to appreciate the fundamental characteristics of their systemic nature, i.e., that they are "non-linear, unpredictable and resistant to change, with seemingly obvious solutions sometimes worsening a problem."[21] They noted that improvement within a system is less likely when focusing on individual parts:

> Given these complex relationships and characteristics of a health system, applying conventional approaches…will not take us far enough. These approaches are usually described as linear input-output-outcome impact chains…We need a radical shift in the intervention and evaluation approaches for health systems, along with an accompanying shift in mindset among designers, implementers, stewards and funders.

While we refer to a *health system* and *EMS system*, the meaning of *system* may not be fully understood or shared. A system is a whole consisting of a set of interconnected, interactive and interdependent parts. While there are several categories of systems each type has a central or essential property which is not present in any individual or group of its parts. Consider three examples. A mechanical system such as a clock has interconnected parts with the essential property of displaying and/or presenting time; no group of parts can do this. A biological cardiovascular system consists of interdependent organs and connecting tissues with the essential property of circulating and maintaining adequate nutrients and eliminating waste; none of the parts working alone or in a group can produce this complete outcome. A social-organizational system such as health care has been described by WHO[22] as consisting "of all organizations, people and actions

whose primary intent is to promote, restore, or maintain health." The central property of a health care system is to "improve health and health equity in ways that are responsive, financially fair, and makes the best or most efficient use of available resources." As with other kinds of systems, no part or parts working separately can produce this.

The effectiveness of a system is primarily based on the product of interactions of the parts; outcomes are based on how well they work together rather than how well they work individually. Furthermore, organizational systems, unlike mechanical and biological systems, contain people and groups who have their own interests and purposes. Attracting or adding the best people or groups of people does not necessarily lead to the best organizational systems unless they decide to collaborate and to work well together. And as organizational systems are tightly-linked, i.e., there is a high degree of connectivity, when trying to improve a single part or set of parts (a "sub-system") there can be unintended consequences such as decreasing or sub-optimizing the performance of the whole system.[22]

When SCA survival is framed as an organizational systems problem it suggests several concerns. One is that addressing this problem only with analytic thinking and linear methodologies "will not take us far enough." Worse, it can produce a Type 3 error[23] characterized by wasted effort seeking the right answers to the wrong problem an example of which is to model survival with a regression equation when the underlying assumptions for applying regression do not hold.[24] Another is that independent improvements or optimization of each part of a presumed chain sequence when the problem is systemic and the parts are interdependent can have the unintended and paradoxical effect of decreasing overall survival rate. A third is that trying to understand and improve a system by focusing on sequential response steps can miss elements and relationships not identified within the defined problem set.

Systems thinking and design methodologies have been part of organizational and management research and practice for more than 40 years.[25] While commonly taught in academic business education, these approaches are rarely discussed or included in graduate medical education.[26,27] Nevertheless, when systems thinking and design are applied to health systems, outcomes have been creative and positive.[28,29] One ongoing application is the redesign of the United Kingdom's National Health Service (NHS)[30] where its application is aimed at bringing about a "revolution" in health care.

That SCA survival is more complex than commonly portrayed - that it may not be fully understood as the sum of four or five parts; that a linear chain metaphor may be too simple - is beginning to receive attention.[31, 32] For example, when the SCA problem is examined in more detail, at least 50 "known or speculative" and additional "yet to be identified" factors not included in the chain can be acknowledged as influencing SCA survival.[33] In addition, in 2003, ILCOR described a cognitive framework using a hypothetical formula for survival (FfS) and in 2006 held a Formula for Survival Working Group symposium.[34] The FsS suggests that SCA resuscitation survival is the product of three interactive elements: science (ECC and CPR guideline quality) x education (efficiently provided to caregivers) x local implementation (the additive elements of the chain of survival).

Nevertheless, most reported improvement efforts continue to focus on part optimization assuming the SCA survival problem is about a chain of "bad apples." This thinking does not allow for deep understanding of the systemic nature of healthcare generally and SCA survival specifically nor does it consider how a methodology of redesign can be applied to eliminate opportunities for failures or errors to exist. We posit that if OOH SCA survival is framed as a systems problem, if

thinking systemically is the method of inquiry and if design is the method of intervention then improvement may result.[35]

That for at least 30 years, there has been little improvement in the rate of survival following OOH SCA; that fewer than 30% of people in OOH SCA receive bystander CPR; and that only approximately 4% have an AED applied before emergency medical services (EMS) arrival in the language of organizational systems thinking is called a wicked problem[36] or a mess.[37,38] A wicked problem is one that is ill defined (there is no clearly prescribed way forward), involves stakeholders with different perspectives, and has no optimal solution.[39] A mess

> is a system of constantly changing, highly interconnected problems, none of which is independent of the other problems that constitute the entire mess. As a result, no problem that is part of a mess can be defined and solved independently of the other problems. Accordingly, the ability to manage messes requires the ability to think and to manage systemically; this in turn requires that one understand systems thinking.[40]

Methodology

When OOH SCA survival is framed as a complex systems problem then overall improvement cannot be accomplished by improvement of any sub-system. Nevertheless, we report a pilot study in which changing the methods of inquiry and method intervention from analytic/research to systemic/design for the CPR/AED learning experience produced novel recommendations for improvement.

We report use of interactive planning methodology because of its sensitivity to complex organizational systems with multiple stakeholders.[41,42] The four steps are (1) formulate the design of the current state; (2) design the ideal state; (3) prioritize the gaps and resources required to move from the ideal to the current; (4) plan the implementation and controls for change. Strategically, changes are applied backward from what is ideally desired rather than forward from what currently exists.

Current State Design

Similar to a medical diagnosis, the current state formulation is a deductive, discovery and testing process involving collection of quantitative and qualitative data from interviews, operational, and historical sources. This includes identification and explanation of the elements and their interactions that are actual and likely contributors to the positive outcomes of the CPR/AED learning experience, as well as obstructions, conflicts and confusions that impede or impair the learning experience.

Individual interviews were conducted with a convenience sample of 44 adults (16 male; 28 female), with an age range of 18 years to 50 years, most of whom were college educated or had professional non-medical occupations. Half (22) had previous CPR/AED training. Open-ended questions were used to gather perceptions about the elements, relationships, structure, operation, and meanings of the anticipated (by those who were not trained) and actual (by those who were trained) CPR/AED learning experience.

The primary reason cited by those who attended a CPR/AED class was to meet a job requirement. The secondary reason was a perceived moral obligation that being trained was "the right thing to do" or a "responsibility" of a member of the community. The most common reason reported for not being trained was absence of a directive: it was not required either by policy or moral expectation. Some reported that they would learn in the future when they had children because as a parent they would feel a sense of personal responsibility. A second reason was degree of convenience: if training was not offered at their workplace they reported there was no opportunity to take a class. If a fee was associated with a taking a class it was cited as a barrier. However, those who needed to be trained for personal or professional reasons identified

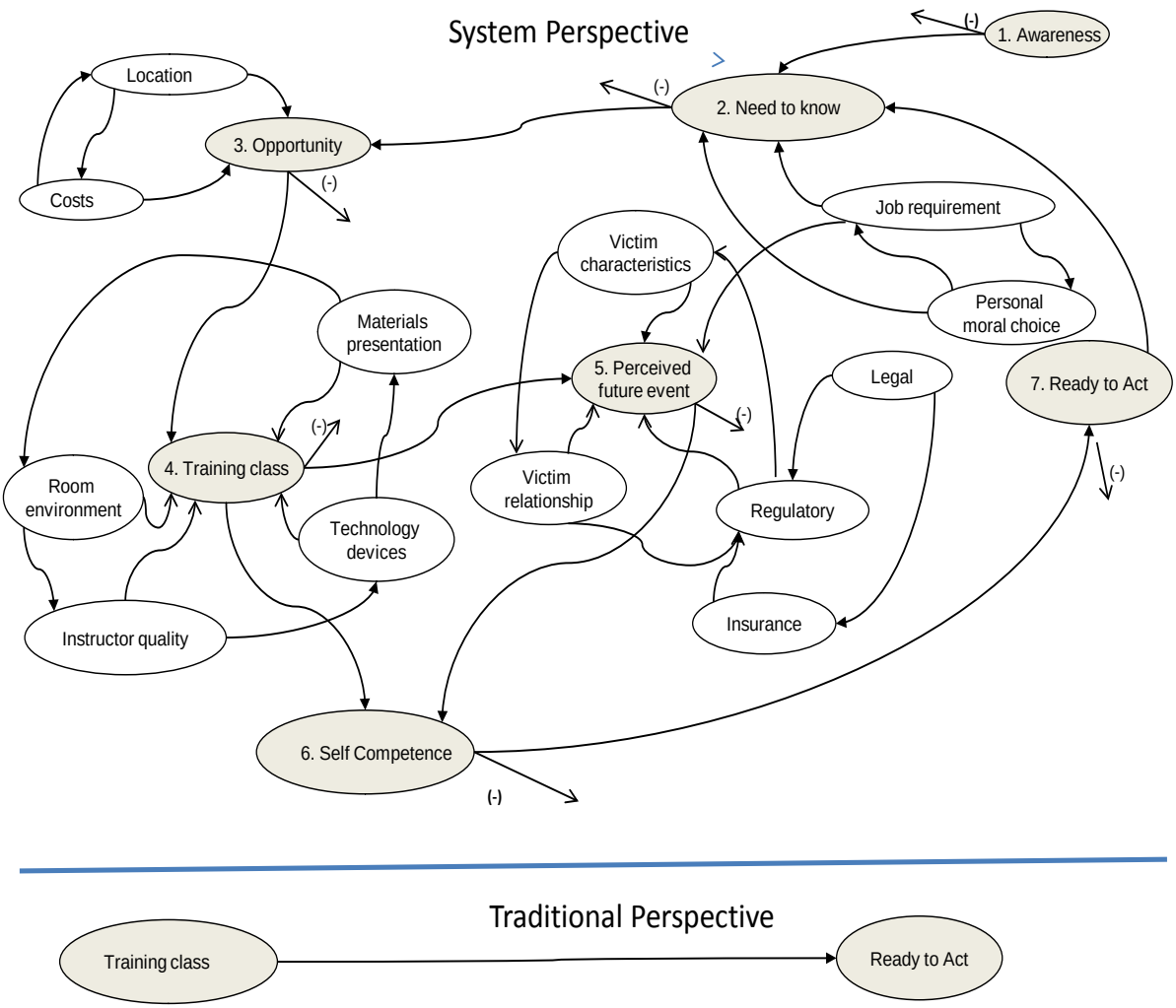
available classes elsewhere. A third reason to avoid training was that others were trained so it was not necessary for them.

Those who completed a class at their workplace reported it was easy to register and to participate. Those who were trained at a non-work location such as civic or religious organization reported they responded to an offer or searched for a class online. Finding a class, registration and fee payment were reported to be easy.

The CPR/AED class experience is influenced by the classroom environment, the interactions with and feedback from the instructor, training materials, the CPR manikin[43] which may be shared with others, and the AED or AED training device of which at least 15 different models are currently available.[44] Most of those who were trained reported surprise that becoming "CPR certified" was possible after such little training time and evaluation. Many who were required by their job to be CPR/AED reported that when their card expired, employers did not ask about or require retraining. Few who were trained for personal reasons expressed interest in taking or paying for a retraining class or indicated the class met their anticipated moral expectations. Most reported they would recommend CPR/AED training to one who had never taken a class, but not the specific class they had taken. The obstructions and conflicts in their experience included too many people, too small a room, lack of feedback and disinterested instructors, lack of realistic practice, and a general sense that the training was not engaging. Most reported after training they had a general sense of CPR; few said they felt prepared to act if they were presented with a situation in which CPR was needed. This feeling was intensified by those who had completed training several months in the past. Most reported that they would attempt CPR on a loved one but probably not on a stranger or in a public space.

The formulation of the current design (Figure 1) presents the complex system in comparison to the linear sequence that mere participation in a training class makes one ready to act. The formulation revealed seven elements each of which has positive, facilitating and negative, denoted with (-), conflicting characteristics. Awareness (1) that SCA is a threat to interests of oneself or others of importance prompts consideration of (2) whether one needs to know CPR/AED. This is influenced by external job requirements and internal moral obligations. One commonly reported learning conflict occurs when an employer does not require or enforce the training or retraining requirement and if there is no moral imperative. If the person seeks access or opportunity to complete a class (3), this is affected by location convenience and responsibility for cost. The overall training experience is also a product of three interactive elements: (4) characteristics of the training class x (5) perceived characteristics of the imagined future SCA event x (6) self-perception of competence to carry out the required performance. The class experience is influenced by the nature and use of the materials, room environment, instructor quality including how feedback is provided, and technology including equipment rehearsal. The perceived characteristics of the future SCA event are influenced by what has been experienced or what one imagines will be a victim's physical characteristics (will there be blood?), relationship (is the person a family member or friend?) and by regulatory considerations (will I be protected from liability at work or elsewhere?). These interact with self-competence which is also influenced by external obligations to be trained if in conflict with personal interests (fears) to avoid SCA or other emergency events. These experiences and perceptions contribute to overall readiness to act (7) which produces a positive (or negative) feedback loop to need to know (2) by retraining.

Figure 1. Current CPR/AED Learning Experience



The conflicting interactions and obstructions among the elements are in Table 2.

Table 2. Conflicts and Obstructions within the CPR/AED Learning Experience

Need to be Trained: Internal and External	Opportunity for Training and Class Training Characteristics	Anticipated Elements of an Emergency Event, Perceived Competency (ability and knowledge) and Perceived Readiness (motivation)
• lack of workplace sponsorship • poor follow-up by employers for retraining among those who impose CPR obligation • inadequate perception of social responsibility	• competitive revenue models among professional CPR agencies and AED manufacturers • inadequate training resources for instructors • financial cost to access training • time/distance cost to access training • poor engagement during training	• inadequate understanding of legal protections • inadequate self-confidence of ability • fear of public responding • fear of emergency characteristics

Ideal State Design

Designing the ideal state requires the specifications, elements and interactions that would eliminate the conflicts, obstructions and confusions within a CPR/AED learning experience. An ideal design would be one in which failing to learn would be unlikely to exist, i.e., the problem would be dissolved.

To promote a new mindset, ideal design methodology[45] begins with the statement that the current system – everything we currently do and the ways we currently do them – has been destroyed; it no longer exists. With this premise there is nothing to improve because there is no CPR class, no curriculum, no instructors or instruction system, no standardized programs or materials, but all the knowledge about these elements remain. There are AED technologies and we know the value of defibrillation, but no specific AED device exists. The task is to follow a

set of guidelines (Table 3) to identify specifications, elements and characteristics of an "ideal CPR/AED learning experience that you would want and use." In order to gather multiple perspectives, the methodology engages a broad community of stakeholders who participate in the learning experience not merely those who write or approve training curricula. This has been described as an example of turning learning right side up.[46]

Table 3. Guidelines for Collecting Ideal Elements

Describe the characteristics of the ideal CPR/AED learning experience for you. What elements or characteristics should be present?
Elements must be technologically feasible: they must exist or can be made to exist in the current environment. Elements must be operationally viable: they must be able to function in the current environment. • You are designing from "nothing." • There is nothing in place at present and so nothing to improve. • Focus on what you want – your ideal. • Do not focus on what is not needed. • If you disagree offer an alternative. • Hold one conversation at a time. • Stay focused on the task. • Encourage wild ideas. • Go for quantity. • Be visual. • Defer judgment. • Build on the ideas of others. • Do not worry about resources. • Do not worry about implementation.

Five design collection sessions were held which collected elements from approximately 100 people. Approximately 35 representatives from pre-hospital EMS systems, AED manufacturing, CPR professional societies, government health and regulatory agencies, CPR education and curriculum design, and CPR/AED research attended a conference[47] which included an ideal

design session. The other sessions included a dinner and design workshop attended by graduate students, faculty, staff and public safety officials from the University of Pennsylvania; attendees of a community CPR class conducted in Philadelphia by the American Red Cross; interviews with nonmedical and medical friends, colleagues, family members, coworkers and neighbors; and members of the project team. The sessions produced 250 elements that that were assigned to eight categories.

Organizational and personal values refer to government, media, industry and popular culture leaders and celebrities, educators, role models, and parents who should instill a sense of urgency and value in efforts and attitudes that promote CPR/AED learning, responding and SCA survival. CPR/AED competency should be recognized as a basic expectation of the services delivered by essential agencies. Being aware, prepared and competent to respond with CPR/AED competency should be part of organizational expectations, social learning, and family planning for all members. CPR/AED should be encouraged and supported as part of a healthy lifestyle.

Advocacy refers to multimedia public awareness campaigns that should promote and reinforce helping others as a basic responsibility of being a member of any community. Positive public figures such as sport and movie personalities and other cultural leaders and experts should spread the message of CPR/AED as responsible citizenry based on the constructionist principle[48]which argues that reality is a socially created state. Such figures should reframe what is "cool" and "right" giving more power to the engine of social and cultural change. Multimedia integration of the benefits of CPR/AED to the community should promote norms based on the Anticipatory Principle[51] which argues that by continuously showing a positive image of the future, people and groups will move toward it.

Access refers to opportunities of acquiring and requiring CPR competency and AED devices. Barriers and conflicts such as cost and availability should be eliminated whenever possible. Devices should be available on all public transportation and public safety vehicles. AEDs should be required, i.e., part of the building code for all public places similar to the requirement for fire extinguishers. Being competent to respond and use an AED should be an expectation of any job which has face-to-face interaction with the public.

Training and maintaining performance competency concerns providing the consistent and repeated message - that everyone should be competent because we all have personal responsibility and could have an opportunity to help save a life - should be embedded into the curriculum of all education. Using positive stories of response and survival, and distressing stories of the failure of responding such as of 1964 death of Kitty Genovese[49] should be used to enable understanding of societal norms and behaviors of responsible citizens. Multiple and simplified methods to acquire and maintain competency should be available.

Technology in the form of personal rescue technology (PRT) should be available for any person to carry in a smart phone or worn separately within a watch or necklace or pin, or which could be implanted as a microchip. PRT should provide guidance and reassurance to inform one if CPR/AED is needed. It should alert EMS of one's location and it should locate the closest AED. It should also communicate with EMS or another emergency agency as a *Cardiac* "*OnStar*™" when any AED is brought to the scene by providing a two-way channel with rescue professionals who can provide audio support and feedback during bystander rescue efforts until EMS arrives.

Examples of *social computing and networking* includes forums, blogs, and social media which should be harnessed to support and enhance community forces toward CPR/AED

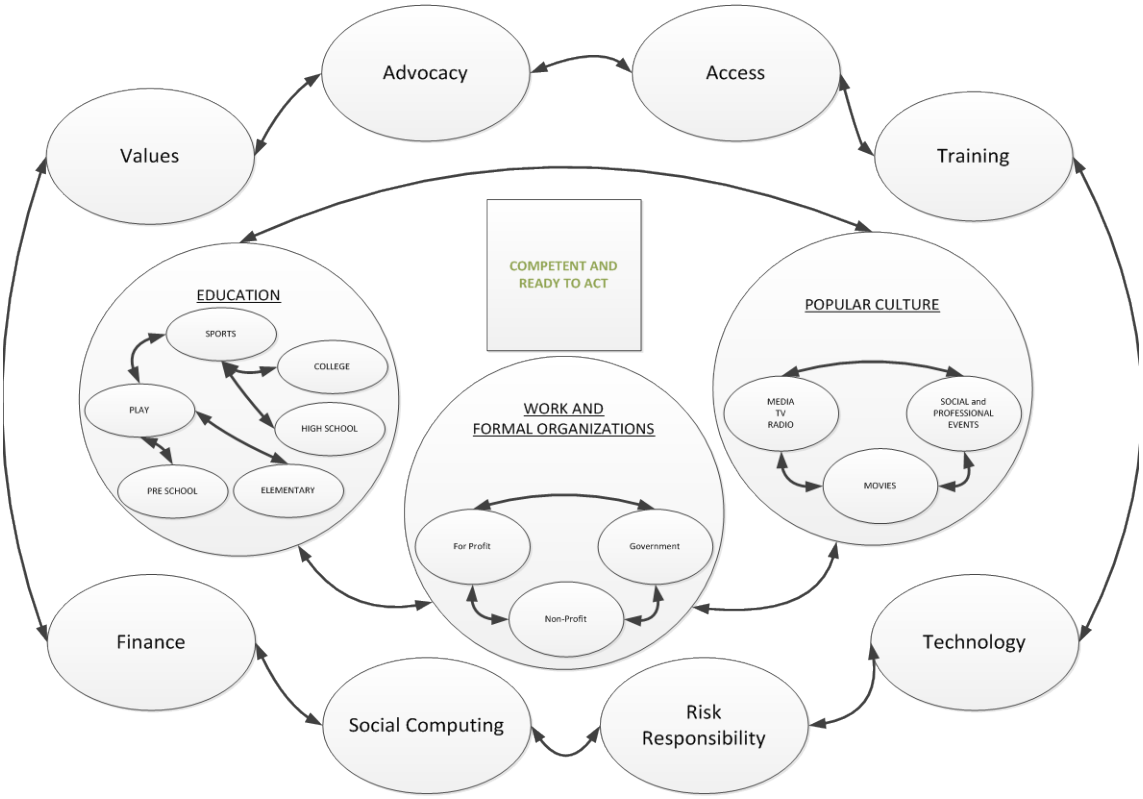
responding. Crowd-source competitions[50] and games should be connected to learning and use of CPR and an AED. Social sites such as *Facebook* and *LinkedIn* should have categories to describe or present one's competency to perform CPR and use an AED.

Health risk and responsibility refer to a system in which those who choose to engage in risky health behaviors that are negative and a burden to the health system should have these actions bundled with positive health behaviors. If one has the right to purchase tobacco products this should include the obligation of showing AED/CPR competency.

Financial resources should be allocated and directed to strengthen the containing culture of CPR/AED societal values. There should be distributed and organized CPR/AED networks that work with corporate, public, private, government, and nonprofit organizations. Regulated banks and financial institutions that hold or trade financial assets or provide loans to US citizens should provide funding for their physical locations that ensure CPR/AED competency for clients who visit. The National highway, aviation and marine transportation systems should have in place in all locations CPR/AED competency in order to ensure access of citizen lifesaving. Funds should be drawn in part from fines imposed on citizens and organizations that violate safe transportation policies.

When accepting the premise that the current system no longer exits and given the opportunity to suggest the design elements of an ideal CPR/AED learning experience, participants suggested that CPR/AED should *not* be a distinct skill acquired in a training class taught by instructors in a classroom setting. Instead (Figure 2), the CPR/AED learning experience should be supported, embedded and integrated into a broad containing system with three core structures: education, popular culture, and work and formal organizations.

Figure 2. Ideal CPR/AED Learning System



Discussion

Gaps, Resources, and Recommendations

The gap between the current and an ideal design is closed by selecting characteristics from the ideal and incorporating them into the current system. The following are recommendations that could be considered for immediate implementation. Resource planning which defines and determines the allocation of resources was not addressed in this pilot project. The implementation plan and the controls necessary for evaluation, monitoring and feedback were also not addressed.

1. State, city and local agencies should clearly describe and promote the protections of the Good Samaritan Law regarding CPR/AED responding. Statements should be available

and posted in all schools, workplaces and other venues explaining how personal litigation has been controlled, should not be considered a reasonable excuse for inaction, and encouraging responses. Brief and clear statements about how protection against disease can be quickly controlled or avoided when responding should be included.

2. Every CPR/AED course completion card should contain a statement indicating the protections provided by the Good Samaritan Law.
3. Proper response to SCA via CPR/AED should be combined with proper response to fire or other similar threats whenever facility rehearsal drills are held. SCA has a much higher risk/probability of death than from smoke/fire (1:7 vs 1:1,419)[51] and may be needed at the same time.
4. When group CPR/AED training and retraining classes are held, participants should demonstrate their performance in the presence of available bystanders who do not join the class. To demystify and build broader awareness that CPR/AED is a community expectation, it should be visible and modeled beyond the training room.
5. The educational system should integrate dialogue, knowledge, and competency about SCA, CPR and AEDs beginning in preschool, and progressing in complexity with grade levels. Preschool children from 2 years to 5 years should build the concept of helping others with appropriate stories and games. Elementary students should engage in role playing scenarios involving helping a person in distress including use of CPR/AED. Hands-only CPR should be taught in middle school. High school and college students should learn how to combine CPR with an AED, and competency should be a requirement for participation in all high school and college sports, and for graduation.

6. Opportunities should be available online where one can practice and be assessed with feedback for competency in CPR/AED use. Plug-on simulation devices and 3-D immersion training games that use virtual reality to respond to SCA with CPR and to use an AED should be available to anyone with internet access.
7. CPR/AED training and assessment should be without financial cost to any individual. Costs should be borne by the social, educational, professional, financial and insurance agencies which benefit financially from SCA survival in the community.
8. All smart phones should have a CPR application that at a minimum enables one to receive CPR instructions with compression timing, and which reminds one to ask a bystander to call 911 and to seek the closest AED. All smart phones should have an AED application that at a minimum enables one to receive AED instructions.
9. The right to provide SCA risk behaviors such as but not limited to tobacco industry manufacturers should be bundled with the obligation to support community SCA responding such as providing public service information, sponsorship of CPR/AED training and/or equipment, online education services, and other learning elements.
10. US national highway, aviation and marine transportation systems should have in place in all appropriate locations CPR/AED support systems. The access model common in airports could inform agencies how AEDs, CPR-trained people, and signage can be a core operational service obligation.

Summary

Using systems thinking for inquiry and design for methodology, we identified elements and interactions that facilitate and obstruct the CPR/AED learning experience. Although only a sub-

system, the current design argues that a similar approach may be applied to better understand to improve outcomes associated with SCA in the community. We identified an ideal design one important characteristic of which was that it did not include traditional modes of training as the primary mode of learning. Rather, by reframing the problem and expanding the forces of influence to include broad elements of education, social culture and the organizational workplace, it seems possible to increase the probability that when confronted with SCA almost anyone would appropriately respond.

Philosophers of science[52] remind us that when there is a predominantly accepted thesis or way of understanding something we should continue to study it in order to gain full understanding. The broad community of scientists, researchers, educators, practitioners, policy makers, and others should continue to apply analysis and the scientific method when trying to improve survival following SCA overall and when trying to improve the CPR/AED learning experience. But we should also present challenges – an antithesis - based on different assumptions which give rise to different ways of thinking and different methods of solving, in order to seek new outcomes. One example is the systems approach and use of design methodologies. When the accepted thesis and the challenging antithesis are considered together they can lead to synthesis, a fuller understanding of both positions and improved outcomes for this important problem.

Caveat

Future systems thinking and design methodology work should interview members from other stakeholder groups who are part of the CPR/AED learning system in order to expand and improve understanding of the current mess. There should be additional idealized design and interactive planning sessions in order to collect more elements that could improve an ideal design; one that

accounts for all current and anticipated conflicts and obstructions, and dissolves this subsystem problem within the larger problem of poor SCA survival. We should continue to seek improvements for the current design by selecting from the ideal design.

Notes

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[a] History of CPR, American Heart Association. Retrieved August 23, 2013 from: http://www.heart.org/HEARTORG/CPRAndECC/WhatisCPR/CPRFactsandStats/History-of-CPR_UCM_307549_Article.jsp

[b] Interview questions with other stakeholders follow different lines of inquiry because their interests differ from those of the direct learner/performer. For example, while some aspects of training activities overlap, CPR/AED instructors choose to participate or not for reasons that are different from those of participants. Indeed, each group of stakeholders in an organizational system has their own set of interests, purposes and obligations, yet all have impact on the CPR/AED learning experience of nonmedical learners. Interviews are necessary, therefore, with community Emergency Medical Service (EMS) providers such as fire, police and safety groups who respond to a 911 call and may take over responsibility of the patient upon arrival; representatives of professional societies such as the American Heart Association, American Red Cross and National Safety Council which govern and control the training curriculum for instructors and for bystanders, and which create and sell the training materials bundled with CPR/AED classes; CPR manikin and AED manufacturers who design and sell products to be used by the person being trained and by a bystander who witnesses SCA; representatives of groups which write and enforce CPR/AED legal and regulatory policies which drive

occupational requirements for training such as the Occupational Safety and Health Administration and Food and Drug Administration; organizations that have risk or other regulatory control policies that impact personal and/or employer-employee CPR/AED behaviors such as insurance companies and building facilities management; and local and regional administrative personnel who have professional or assigned responsibility or control over CPR/AED programs or activities in OOH public and private environments. The mess formulation elements for these groups were not collected for this project.

References

[1] Go AS, Dariush Mozaffarian, V, Roger L, et al. Heart Disease and Stroke Statistics—2013 Update. A Report From the American Heart Association. *Circulation.* 2013; 127: e6-e245.

[2] Becker L, Eisenberg M, Fahrenbruch C, Cobb L. Public locations of cardiac arrest: implications for public access defibrillation. *Circulation*. 1998; 97:2106-9.

[3] Weisfeldt ML, Everson-Stewart S, Sitlani C, et al., for Resuscitation Outcomes Consortium (ROC) Investigators. Ventricular tachyarrhythmias after cardiac arrest in public versus at home. *N Engl J Med.* 2011;364:313-21.

[4] Vadeboncoeur T, Bobrow BJ, Clark L, et al. The Save Hearts in Arizona Registry and Education (SHARE) program: who is performing CPR and where are they doing it? *Resuscitation*. 2007;75(1):68-75.

[5] Nichol G, Thomas E, Callaway CW, Hedges J, Powell JL, Aufderheide TP, Rea T, Lowe R, Brown T, Dreyer J, Davis D, Idris A, Stiell I; Resuscitation Outcomes Consortium Investigators.

Regional variation in out-of-hospital cardiac arrest incidence and outcome. *JAMA*. 2008;300:1423–1431.

[6] Public Health Seattle and King County Division of Emergency Medical Services 2013 Annual Report to the King County Council September 2013. Emergency Medical Services Division, Public Health – Seattle & King County, 401 5th Ave, Suite 1200, Seattle, WA 98104. Available at: http://www.kingcounty.gov/healthservices/health/ems.aspx

[7] Abrams HC, Moyer PH, Dyer KS. A model of survival from out-of-hospital cardiac arrest using the Boston EMS arrest registry. *Resuscitation*. 2011;82(8):999-1003.

[8] Wallace SK, Abella BS, Shofer FS, Leary M, Agarwal AK, Mechem CC, Gaieski DF, Becker LB, Neumar RW, Band RA. Effect of time of day on prehospital care and outcomes after out-of-hospital cardiac arrest. *Circulation*. 2013 Apr 16;127(15):1591-6.

[9] Eckstein M, Stratton SJ, Chan LS. Cardiac arrest resuscitation evaluation in Los Angeles: CARE-LA. *Ann Emerg Med*. 2005 May;45(5):504-9.

[10] Eisenberg MS, Copass MK, Hallstrom AP, et al. Treatment of out-of-hospital cardiac arrests with rapid defibrillation by emergency medical technicians. *NEnglJMed.* 1980;302:1379–1383.

[11] Whitcomb J, Blackman V. Cardiopulmonary Resuscitation: How Far Have We Come? *Dimensions of Critical Care Nursing.* 2007;26(1);16,12.

[12]Part 12: From science to survival – strengthening the chain of survival in every community: how to ensure effectiveness. *Circulation.* 2000;102:I-358.

[13]Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving survival from sudden cardiac arrest: the “chain of survival” concept. A statement for health professionals from the Advanced Cardiac

Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. *Circulation.* 1991;83 (5):1832-47.

[14] Field JM, Hazinski MF, Sayre MR, et al. Part 1: Executive Summary: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation.* 2010;122:S640-56.

[15] Larsen MP, Eisenberg MS, Cummins RO, Hallstrom AP. Predicting survival from out-of-hospital cardiac arrest: a graphic model. *Ann Emerg Med*. 1993;22:1652-8.

[16] Williamson LJ, Larsen PD, Tzeng YC, Galletly DC. Effect of automatic external defibrillator audio prompts on cardiopulmonary resuscitation performance. *Emerg Med J.* 2005;22:140-3.

[17] Yeung J, Meeks R, Edelson D, Gao F, Soar J, Perkin GD. The use of CPR feedback/prompt devices during training and CPR performance: A systematic review. *Resuscitation*. 2009;80(7);743-51.

[18] Mosesso Jr VN, Shapiro A, Stein K, Kurkett K, Wang H. Effects of AED device features on performance by untrained laypersons. *Resuscitation*. 2009;80(11):1285-9.

[19] Hazinski MF, Nolan JP, Billi, JP, et al. Part 1: Executive Summary, 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Circulation.* 2010;122:S250-75.

[20] Institute of Medicine, To Err is Human: Building a Safer Health System Brief Report. Retrieved August 23, 2013 from: http://www.iom.edu/~/media/Files/Report%20Files/1999/To-Err-is-Human/To%20Err%20is%20Human%201999%20%20report%20brief.pdf. Full report is

available in Kohn, LT, Corrigan JM, Donaldson MS. (eds.) *To err is human: building a safer health system*. Institute of Medicine (IoM), Committee on Quality of Health Care in America, National Academies Press, Vol. 627, 2000.

[21] World Health Organization. *Everybody's Business: Strengthening Health Systems to Improve Health Outcomes: WHO's Framework for Action*. Geneva:World Health Organization, 2007.

[22] Deming WE. *The New Economics for Industry, Government & Education*. Cambridge: Massachusetts Institute of Technology Center for Advanced Engineering Study, 1993.

[23] Kimball AW. Errors of the third kind in statistical consulting. *Journal of the American Statistical Association*. 1957;52(278): 133-142.

[24] Lyles M. Formulating strategic problems: empirical analysis and model development. *Strategic Management Journal*. 1981;2:61-75.

[25] Rittel H, Webber M. Dilemmas in a general theory of planning. *Policy Sciences*. 1973;4:155–169.

[26] Colbert CY, Ogden PE, Ownby AR, Bowe C. Systems-based practice in graduate medical education: systems thinking as the missing foundational construct. *Teach Learn Med*. 2011;23(2):179-85.

[27] West GB. The importance of quantitative systemic thinking in medicine. *The Lancet*. 2012; 379(9825):1551-1559.

[28] Golden, BR, Martin,RL. Aligning the stars: Using systems thinking to (re)design Canadian healthcare. *Healthcare Quarterly*. 2004;7(4):34-42.

[29] De Savigny D, Adam, T (Eds). *Systems thinking for health systems strengthening*. Alliance for Health Policy and Systems Research, World Health Organization, 2009

[30] Bevan H, Robert G, Bate P, Maher L, Wells J. Using a design approach to assist large-scale organizational change: 'Ten High Impact Changes' to improve the National Health Service in England. *The Journal of Applied Behavioral Science.* 2007;43:135-152.

[31] Field J. Death to Discharge - Surviving the System: Coronary Reperfusion for Out-of-Hospital Cardiac Arrest. *American Heart Association Science News*, July 15, 2013. Commentary on Peberdy MA, Donnino MW, Callaway CW, DiMaio JM, Geocadin RG, Ghaemmaghami CA, Jacobs AK, Kern KB, Levy JH, Link MS, Menon V, Ornato JP, Pinto DS, Sugarman J, Yannopoulos D, Ferguson TB Jr; on behalf of the American Heart Association Emergency Cardiovascular Care Committee and the Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation. Impact of percutaneous coronary intervention performance reporting on cardiac resuscitation centers: a scientific statement from the American Heart Association. *Circulation*. 2013, published online before print July 15, 2013. Retrieved August 23, 2013 from: http://my.americanheart.org/professional/ScienceNews/Science-News-Commentary-for-Exercise-Standards-6-10-13_UCM_452904_Article.jsp

[32] Bardy GH. A critic's assessment of our approach to cardiac arrest. *N Engl J Med.* 2011;364:374-37.

[33] Eisenberg MS. *Resuscitate! How Your Community Can Improve Survival from Sudden Cardiac Arrest.* Seattle: University of Washington Press, 2009.

[34] Søreide E, Morrison L, Hillman K, Monsieurs K, Sunde K, Zideman D, Eisenberg M, Sterz F, Nadkarni VM, Soar J, Nolan JP; Utstein Formula for Survival Collaborators. The formula for

survival in resuscitation. Resuscitation, 2013 Aug 3. pii: S0300-9572(13)00389-4. [Epub ahead of print]. http://www.ncbi.nlm.nih.gov/pubmed/23917078

[35]Starr LM. Rethinking SCA at work. *Occup Health Safety*. 2007;76(2):55-63.

[36] Conklin EJ. Wicked problems and social complexity. In, *Dialogue Mappings: Building Shared Understanding of Wicked Problems.* CogNexus Institute, 2010.

[37] Ackoff RL. The art and science of mess management. *Interfaces*. 1981;11(1):20–26.

[38] Starr LM, Braslow A. New thinking about SCA survival: Relying on the chain of survival model alone is not enough to improve SCA survival in your community. *Journal of Emergency Medical Services*, February 28, 2011. Retrieved August 23, 2013 from: *http://www.jems.com/article/patient-care/new-thinking-about-sca-surviva*.

[39] Conklin J. *Dialogue mapping : building shared understanding of wicked problems*. Chichester, England: Wiley, 2006.

[40] Mitroff II, Alpaslan CM, Mason RO. The Messy Business of Management. *MIT Sloan Management Review*, September 18, 2012. Retrieved August 23, 2013 from: http://sloanreview.mit.edu/article/the-messy-business-of-management/.

[41] Ackoff RL. *Re-creating the corporation: A design of organizations for the 21st century*. New York: Oxford University Press, 1999.

[42] Jackson MC. *Systems thinking: creative holism for managers*. John Wiley & Sons, Inc.: Chichester, UK, 2003.

[43] Chaning Bete Company, distributor of American Heart Association Training Products, CPR Prompt® Training And Practice Adult/Child Manikin 5-Pack (Blue). Retrieved August 23, 2013

from: http://shop.aha.channing-bete.com/onlinestore/item_ed.html?iid=177275&pr=434.95&pr1=&pr2=&dd=LF06100U_ed_1.html

[44] AED Brands, 3640 Kennesaw N. Industrial Pkwy, Suite A, Kennesaw, GA 30144. Retrieved August 23, 2013 from: http://www.aedbrands.com/defibrillator.

[45] Haftor DM. An Evaluation of R. L. Ackoff's Interactive Planning: A case-based approach. *Systemic Practice and Action Research*. 2011; 24(4):355-378.

[46] Ackoff RL, Greenberg D. *Turning learning right side up*. Upper Saddle River, NJ: Prentice Hall, 2008.

[47] Systems Approach for Improving SCA Survival Conference. University of Pennsylvania, April 29, 2011. Retrieved August 23, 2013 from: http://www.sca-aware.org/sca-news/penn-researchers-host-meeting-to-explore-systems-approach-for-improving-sca-survival

[48] Whitney D, Trosten-Bloom A. *The Power of Appreciative Inquiry*: *A Practical Guide to Positive Change*, San Francisco: Berrett-Koehler Publishers, 2003.

[49] Darley JM, Latané B. Bystander intervention in emergencies: diffusion of responsibility. *Journal of Personality and Social Psychology*. 1968;*8*(4);377-383.

[50] Merchant RM, Asch DA, Hershey JS, Griffis H, Hill S, Saynisch O, Leung A, Asch JM, Lozada K, Nadkarni L, Kilaru J, Branas CC, Starr LM, Shofer F, Nichol G, Becker LB. A Crowdsourcing innovation challenge to locate and map automated external defibrillators. *Circulation: Cardiovascular Quality and Outcomes*. 2013;6: 229-236.

[51] National Safety Council. What are the odds of dying from..? Injury Facts 2013 Edition. Retrieved August 23, 2013 from: http://www.nsc.org/news_resources/injury_and_death_statistics/Documents/Injury_Facts_43.pdf

[52] Churchman C W. *The Systems Approach*. New York: Dell Publishing, 1968.