American Red Cross

Scientific Advisory Council

ARC SAC SCIENTIFIC REVIEW
AED Placement

Questions to be addressed:

For people with sudden cardiac arrest, does placing AEDs in specified locations, compared to random AED locations, change outcome?

Introduction/Overview:

The 2010 consensus on science for CPR and Emergency Cardiovascular Care (ECC) agrees that Sudden Cardiac Arrest can be treated most effectively by a combination of CPR and Defibrillation. Therefore, it is very important that we place Automated External Defibrillators in strategic locations. This is in order that they will be used at the point where most cardiac arrests take place, especially in areas outside of medical facilities. In a world where there are finite resources to spend on medical equipment, the question of where to place medical equipment is a complex one.

Search Strategy and Literature Search Performed

The primary searches were performed using Pubmed; ONESEARCH@IU which searches across several biomedical databases [such as CINAHL, OVID, Cochrane]

Key Words Used

(AED OR "Automated External Defibrillator OR "public access defibrillation" OR "Defibrillators/statistics and numerical data"[Mesh] OR "Defibrillators/supply and distribution"[Mesh]) OR "Defibrillators/utilization"[Mesh]
AND
("Out-of-Hospital Cardiac Arrest"[Mesh] OR "Public Facilities"[Mesh] OR public access OR schools OR buildings OR sports OR exercise OR public buildings OR private homes OR apartments OR golf courses OR health clubs OR indoor tennis facilities OR indoor ice arenas OR bowling alleys OR non-medical facilities OR shopping malls OR sporting arenas OR casinos OR airplanes OR trains OR "Out-of-Hospital")

GOOGLE SCHOLAR:

- Public access defibrillator locations [as keywords]
- Where should AED'S be placed in nonmedical facilities [as a phrase]
- no unique journal articles found

Inclusion Criteria (time period, type of articles and journals, language, methodology)

Filters: Pub dates 2010/01/01-2016/12/31; English;
EBM/Clinical Reviews/Clinical Trials (customized filters: Systematic Reviews OR Controlled Clinical Trial[PT] OR Multicenter Study[PT] OR Randomized Controlled Trial[PT] OR Guideline[Publication Type] OR Practice Guideline[Publication Type] OR Review[Publication Type] OR Validation Studies[Publication Type]

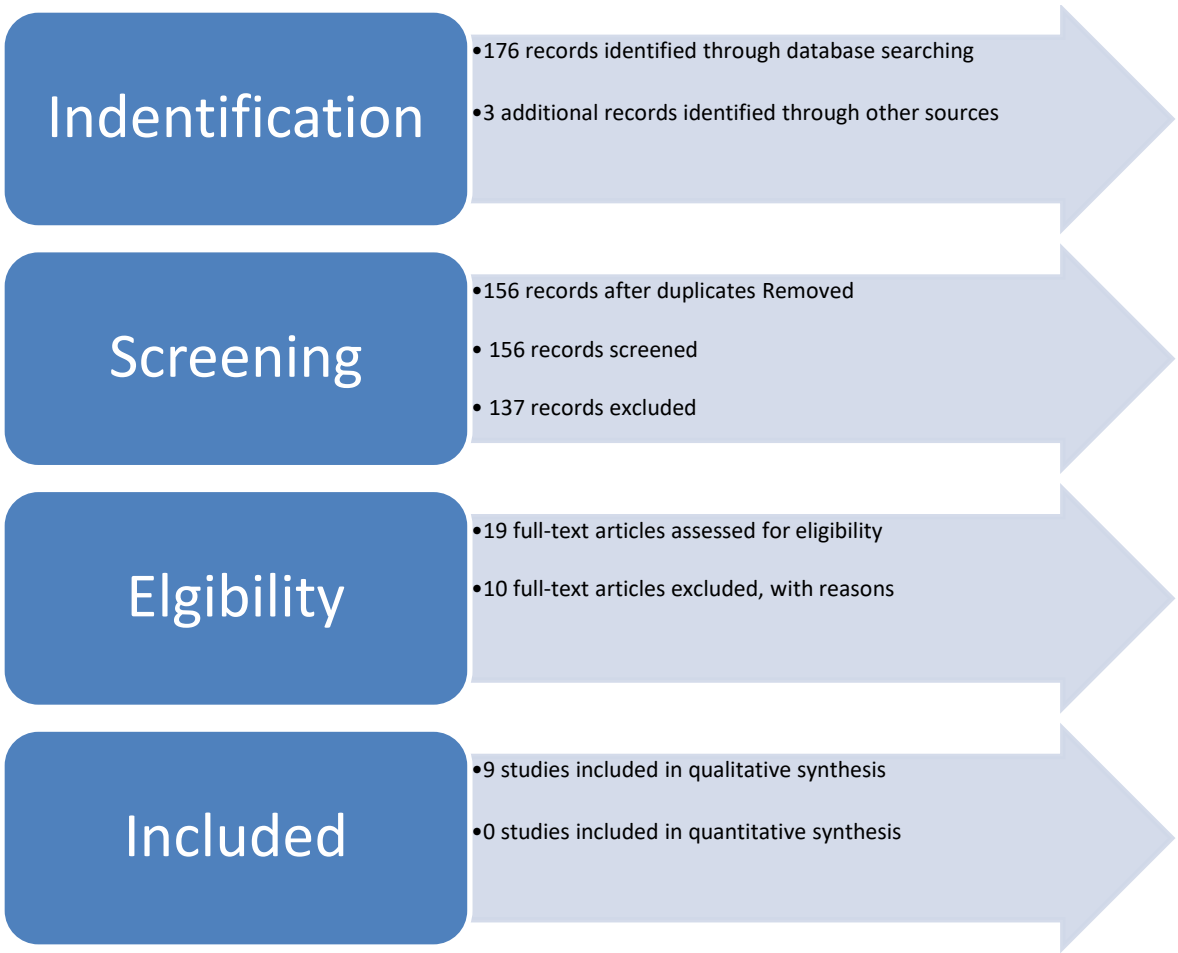
OR Clinical Trial[Publication Type] OR Randomized Controlled Trial[Publication Type] OR Consensus Development Conference[Publication Type] OR Meta-Analysis[Publication Type] OR Evaluation Studies[Publication Type]

Exclusion Criteria (only human studies, foreign language, etc…)
English, human studies only

Databases Searched and Additional Methods Used (references of articles, texts, contact with authors, etc...)

Pubmed; ONESEARCH@IU which searches across several biomedical databases [such as CINAHL, OVID, Cochrane]; GOOGLE Scholar; EBM REVIEWS (COCHRANE DSR, ACP JOURNAL CLUB, DARE), National Guideline Clearing House

Hits=176 duplicates removed=156 19 articles selected



Scientific Foundation:

Two studies showed only a weak correlation in accessibility of AEDs and the location of arrests. There are multiple thoughts on locations without scientific evidence to show where they should actually be placed.

We found that there is no convincing evidence in the literature that would tell us where to place AEDs. Some studies of limited quality suggest that community leaders should determine the locations with a high incidence of cardiac arrest in the local area and then place AEDs accordingly. Current and future technology may provide methods to improve survival.

Recommendations and Strength (using table below):

Standards: None

Guidelines: None

Options: Community leaders may consider determining the locations with a high incidence of cardiac arrest in the local area and develop methods to have AEDs available at these locations at the time of arrests.

Knowledge Gaps and Future Research:

- Limitations
  - Studies are mostly observational
  - No randomized controlled trials
  - Local/regional variation
- Knowledge Gaps
  - We still don't know where AEDs should be located.
  - What cost is society willing to bear for each life saved?
  - Is there a way to predict where AEDs should be located?
- Future Research
  - Large-scale location of arrest studies
  - Determining where arrests are likely to occur based on community characteristics
  - Use of unmanned aerial systems to deliver AEDs to emergencies

Implications for ARC Programs:

One of the most challenging issues with publically-accessible AEDs is that they may not be located near the location of an out-of-hospital cardiac arrest. A bystander may not know where the closest AED is located, which will prolong the interval from collapse to first shock. Since there is no good evidence that tells us where to place AEDs, for now, we should emphasize ways for bystanders to find AEDs. We recommend partnering with an existing service that provides AED-locating technologies, such as PulsePoint. The ARC should include PulsePoint information in classes, encourage students to sign up for PulsePoint, and include PulsePoint registration information with all AEDs sold by the Red Cross store.

We would also like to see a link to PulsePoint AED from the ARC First Aid app.

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Summary of Key Articles/Literature Found and Level of Evidence:

Author(s)/Full Citation	Summary of Article (provide a brief summary of what the article adds to this review)	Level of Evidence (Using table below)
Agerskov M, Nielsen AM, Hansen CM, Hansen MB, Lippert FK, Wissenberg M, Folke F, Rasmussen LS. Public Access Defibrillation: Great benefit and potential but infrequently used. Resuscitation. 2015 Nov; 96:53-8.	BACKGROUND: In Copenhagen, a volunteer-based Automated External Defibrillator (AED) network provides a unique opportunity to assess AED use. We aimed to determine the proportion of Out-of-Hospital Cardiac Arrest (OHCA) where an AED was applied before arrival of the ambulance, and the proportion of OHCA-cases where an accessible AED was located within 100 m. In addition, we assessed 30-day survival. METHODS: Using data from the Mobile Emergency Care Unit and the Danish Cardiac Arrest Registry, we identified 521 patients with OHCA between October 1, 2011 and September 31, 2013 in Copenhagen, Denmark. RESULTS: An AED was applied in 20 cases (3.8%, 95% CI [2.4 to 5.9]). Irrespective of AED accessibility, an AED was located within 100 m of a cardiac arrest in 23.4% (n=102, 95% CI [19.5 to 27.7]) of all OHCAs. However, at the time of OHCA, an AED was located within 100 m and accessible in only 15.1% (n=66, 95% CI [11.9 to 18.9]) of all cases. The 30-day survival for OHCA with an initial shockable rhythm was 64% for patients where an AED was applied prior to ambulance arrival and 47% for patients where an AED was not applied. CONCLUSIONS: We found that 3.8% of all OHCAs had an AED applied prior to ambulance arrival, but 15.1% of all OHCAs occurred within 100 m of an accessible AED. This	2B

	indicates the potential of utilizing AED networks by improving strategies for AED accessibility and referring bystanders of OHCA to existing AEDs.	
Nelson RD, Bozeman W, Collins G, Booe B, Baker T, Alson R. Mobile Versus Fixed Deployment of Automated External Defibrillators in Rural EMS. Prehosp Disaster Med. 2015 Apr;30(2):152-4.	INTRODUCTION: There is no consensus on where automated external defibrillators (AEDs) should be placed in rural communities to maximize impact on survival from cardiac arrest. In the community of Stokes County, North Carolina (USA) the Emergency Medical Services (EMS) system promotes cardiopulmonary resuscitation (CPR) public education and AED use with public access defibrillators (PADs) placed mainly in public schools, churches, and government buildings. HYPOTHESIS/PROBLEM: This study tested the utilization of AEDs assigned to first responders (FRs) in their private-owned-vehicle (POV) compared to AEDs in fixed locations. METHODS: The authors performed a prospective, observational study measuring utilization of AEDs carried by FRs in their POV compared to utilization of AEDs in fixed locations. Automated external defibrillator utilization is activation with pads placed on the patient and analysis of heart rhythm to determine if shock/no-shock is indicated. The Institutional Review Board of Wake Forest University Baptist Health System approved the study and written informed consent was waived. The study began on December 01, 2012 at midnight and ended on	2B

	December 01, 2013 at midnight. RESULTS: During the 12-month study period, 81 community AEDs were in place, 66 in fixed locations and 15 assigned to FRs in their POVs. No utilizations of the 66 fixed location AEDs were reported (0.0 utilizations/AED/year) while 19 utilizations occurred in the FR POV AED study group (1.27 utilizations/AED/year; P<.0001). Odds ratio of using a FR POV located AED was 172 times more likely than using a community fixed-location AED in this rural community. Discussion Placing AEDs in a rural community poses many challenges for optimal utilization in terms of cardiac arrest occurrences. Few studies exist to direct rural community efforts in placing AEDs where they can be most effective, and it has been postulated that placing them directly with FRs may be advantageous. CONCLUSIONS: In this rural community, the authors found that placing AED devices with FRs in their POVs resulted in a statistically significant increase in utilizations over AED fixed locations.	
Ohta S, Harikae K, Sekine K, Nemoto M. How, when, and where have rental automated external defibrillators been used in Japan? J Cardiol. 2014 Aug;64(2):117-20.	OBJECTIVE: Automated external defibrillators (AEDs) have been rented in various places in Japan. When rental AEDs are placed in locations where the probability of sudden cardiac arrest is high and permanent placement of AEDs is difficult, the possibility of improving survival rates might increase. In this preliminary study, we investigated how, when, and where rental AEDs have been used in Japan to clarify their characteristics when used in actual situations and to facilitate better usage in the future.	2B

	METHODS: We investigated the total number of AEDs rented, the duration of rental of each AED, the total number of AEDs rented monthly, the rental sites, the frequency and location of use, the number of defibrillations, and the time to defibrillation success for devices rented between January 2008 and December 2010 by a single company in Japan. RESULTS: The number of AEDs rented annually was 590 at 391 sites in 2008, 767 at 465 sites in 2009, and 847 at 477 sites in 2010. More AEDs were rented during the summer. The devices were actually used on 17 individuals, of whom 2 individuals (at a beach and a marathon) underwent defibrillation, and 1 individual (at a marathon) survived. CONCLUSION: Rental AEDs can play an important role in emergency cases occurring during seasonal and temporary outdoor events. The provision of rental AEDs in locations where permanent AEDs would be unfeasible may offer a useful strategy for efficiently improving survival rates in the future.	
Pulver A, Wei R, Mann C. Locating AED Enabled Medical Drones to Enhance Cardiac Arrest Response Times. Prehosp Emerg Care. 2016 May-Jun;20(3):378-89.	BACKGROUND: Out-of-hospital cardiac arrest (OOHCA) is prevalent in the United States. Each year between 180,000 and 400,000 people die due to cardiac arrest. The automated external defibrillator (AED) has greatly enhanced survival rates for OOHCA. However, one of the important components of successful cardiac arrest treatment is emergency medical services (EMS) response time (i.e., the time from	1-6E

	EMS "wheels rolling" until arrival at the OOHCA scene). Unmanned Aerial Vehicles (UAV) have regularly been used for remote sensing and aerial imagery collection, but there are new opportunities to use drones for medical emergencies. OBJECTIVE: The purpose of this study is to develop a geographic approach to the placement of a network of medical drones, equipped with an automated external defibrillator, designed to minimize travel time to victims of out-of-hospital cardiac arrest. Our goal was to have one drone on scene within one minute for at least 90% of demand for AED shock therapy, while minimizing implementation costs. METHODS: In our study, the current estimated travel times were evaluated in Salt Lake County using geographical information systems (GIS) and compared to the estimated travel times of a network of AED enabled medical drones. We employed a location model, the Maximum Coverage Location Problem (MCLP), to determine the best configuration of drones to increase service coverage within one minute. RESULTS: We found that, using traditional vehicles, only 4.3% of the demand can be reached (travel time) within one minute utilizing current EMS agency locations, while 96.4% of demand can be reached within five minutes using current EMS vehicles and facility locations. Analyses show that using existing EMS stations to launch drones resulted in 80.1% of cardiac arrest demand being reached within one minute Allowing new sites to launch drones resulted in 90.3%	

	of demand being reached within one minute. Finally, using existing EMS and new sites resulted in 90.3% of demand being reached while greatly reducing estimated overall costs. CONCLUSION: Although there are still many factors to consider, drone networks show potential to greatly reduce life-saving equipment travel times for victims of cardiac arrest.	
Lear A, Hoang MH, Zyzanski SJ. Preventing Sudden Cardiac Death: Automated External Defibrillators in Ohio High Schools. J Athl Train. 2015 Oct;50(10):1054-8. .	CONTEXT: Ohio passed legislation in 2004 for optional public funding of automated external defibrillators (AEDs) in all Ohio high schools. OBJECTIVE: To report occurrences of sudden cardiac arrest in which AEDs were used in Ohio high schools and to evaluate the adherence of Ohio high schools with AEDs to state law and published guidelines on AEDs and emergency action plans (EAPs) in schools.DESIGN: Cross-sectional survey.SETTING: Web-based survey. PATIENTS OR OTHER PARTICIPANTS: A total of 264 of 827 schools that were members of the Ohio High School Athletic Association. MAIN OUTCOME MEASURE(S): We surveyed schools on AED use, AED maintenance, and EAPs.RESULTS: Twenty-five episodes of AED deployment at 22 schools over an 11-year period were reported; 8 (32%) involved students and 17 (68%) involved adults. The reported survival rate was 60% (n = 15). Most events (n = 20, 80%) in both	2B

	students and adults occurred at or near athletic facilities. The annual use rate of AEDs was 0.7%. Fifty-three percent (n = 140) of schools reported having an EAP in place for episodes of cardiac arrest. Of the schools with EAPs, 57% (n = 80) reported having rehearsed them. CONCLUSIONS: Our data supported the placement of AEDs in high schools given the frequency of use for sudden cardiac arrest and the survival rate reported. They also suggested the need for increased awareness of recommendations for EAPs and the need to formulate and practice EAPs. School EAPs should emphasize planning for events in the vicinity of athletic facilities. DOI: 10.4085/1062-6050-50.8.01 PMCID: PMC4641543 PMID: 26381367 [PubMed - indexed for MEDLINE]	
Levy MJ, Seaman KG, Millin MG, Bissell RA, Jenkins JL. A poor association between out-of-hospital cardiac arrest location and public automated external defibrillator placement. Prehosp Disaster Med. 2013 Aug;28(4):342-7.	INTRODUCTION: Much attention has been given to the strategic placement of automated external defibrillators (AEDs). The purpose of this study was to examine the correlation of strategically placed AEDs and the actual location of cardiac arrests. METHODS: A retrospective review of data maintained by the Maryland Institute for Emergency Medical Services Systems (MIEMSS), specifically, the Maryland Cardiac	2B

	Arrest Database and the Maryland AED Registry, was conducted. Location types for AEDs were compared with the locations of out-of-hospital cardiac arrests in Howard County, Maryland. The respective locations were compared using scatter diagrams and r2 statistics. RESULTS: The r2 statistics for AED location compared with witnessed cardiac arrest and total cardiac arrests were 0.054 and 0.051 respectively, indicating a weak relationship between the two variables in each case. No AEDs were registered in the three most frequently occurring locations for cardiac arrests (private homes, skilled nursing facilities, assisted living facilities) and no cardiac arrests occurred at the locations where AEDs were most commonly placed (community pools, nongovernment public buildings, schools/educational facilities). CONCLUSION: A poor association exists between the location of cardiac arrests and the location of AEDs.	
Chan TC, Li H, Lebovic G, Tang SK, Chan JY, Cheng HC, Morrison LJ, Brooks SC. Identifying locations for public access defibrillators using mathematical optimization. Circulation. 2013 Apr 30;127(17):1801-9. .	BACKGROUND: Geospatial methods using mathematical optimization to identify clusters of cardiac arrests and prioritize public locations for defibrillator deployments have not been studied. Our objective was to develop such a method and test its performance against a population-guided approach. METHODS AND RESULTS: All public location cardiac arrests in Toronto, Ontario, Canada, from December 16, 2005, to July 15, 2010, and all automated external	2B

	defibrillator (AED) locations registered with Toronto Emergency Medical Services as of September 2009 were plotted geographically. Current AED coverage was quantified by determining the number of cardiac arrests occurring within 100 m of a registered AED. Clusters of cardiac arrests without a registered AED within 100 miles were identified. With the use of mathematical optimization techniques, cardiac arrest coverage improvements were computed and shown to be superior to results from a population-guided deployment method. There were 1310 eligible public location cardiac arrests and 1669 registered AEDs. Of the eligible cardiac arrests, 304 were within 100 m of at least 1 registered AED (23% coverage). The average distance from a cardiac arrest to the closest AED was 281 m. With AEDs deployed in the top 30 locations, an additional 112 historical cardiac arrests would be covered (32% total coverage), and the average distance to the closest AED would be 262 m. CONCLUSIONS: Geographic clusters of cardiac arrests can be easily identified and prioritized with the use of mathematical modeling. Optimized AED deployment can increase cardiac arrest coverage and decrease the distance to the closest AED. Mathematical modeling can augment public AED deployment programs.	

Sasaki M, Iwami T, Kitamura T, Nomoto S, Nishiyama C, Sakai T, Tanigawa K, Kajino K, Irisawa T, Nishiuchi T, Hayashida S, Hiraide A, Kawamura T. Incidence and outcome of out-of-hospital cardiac arrest with public-access defibrillation. A descriptive epidemiological study in a large urban community. Circ J. 2011;75(12):2821-6.	BACKGROUND: Detailed characteristics of those who experience an out-of-hospital cardiac arrest (OHCA) with public-access defibrillation (PAD) are unknown. METHODS AND RESULTS: A prospective, population-based observational study involving consecutive OHCA patients with emergency responder resuscitation attempts were conducted from July 1, 2004 through December 31, 2008 in Osaka City. We extracted data for OHCA patients shocked by a public-access automated external defibrillator (AED) and evaluated the patients' and rescuers' characteristics. The main outcome measure was neurologically favorable 1-month survival. During the study period, 10,375 OHCA patients were registered and of 908 patients suffering ventricular fibrillation arrest, 53 (6%) received public-access AED shocks by lay-rescuers, with the proportion increasing from 0% in 2004 to 11% in 2008 (P for trend<0.001). Railway stations (34%) were the places where PAD shocks were most frequently delivered, followed by nursing homes (11%), medical facilities (9%), and fitness facilities (7%). In 57% of cases, the subject received public-access AED shocks delivered by non-medical persons, including employees of railway companies (13%), school teachers (6%), employees of fitness facilities (6%), and security guards (6%). The proportion of neurologically favorable 1-month survival tended to increase from 0% in 2005 to 58% in 2008 (P for trend=0.081). CONCLUSIONS: Railway stations are the most common places where shocks by public-access AEDs were delivered in large urban communities of Japan, and among	2A

	lay-rescuers railway station workers use AEDs more frequently.	
Page RL, Husain S, White LY, Rea TD, Fahrenbruch C, Yin L, Kudenchuk PJ, Cobb LA, Eisenberg MS. Cardiac arrest at exercise facilities: implications for placement of automated external defibrillators. J Am Coll Cardiol. 2013 Dec 3;62(22):2102-9.	OBJECTIVES: This study sought to characterize the relative frequency, care, and survival of sudden cardiac arrest in traditional indoor exercise facilities, alternative indoor exercise sites, and other indoor sites. BACKGROUND: Little is known about the relative frequency of sudden cardiac arrest at traditional indoor exercise facilities versus other indoor locations where people engage in exercise or about the survival at these sites in comparison with other indoor locations. METHODS: We examined every public indoor sudden cardiac arrest in Seattle and King County from 1996 to 2008 and categorized each event as occurring at a traditional exercise center, an alternative exercise site, or a public indoor location not used for exercise. Arrests were further defined by the classification of the site, activity performed, demographics, characteristics of treatment, and survival. For some location types, annualized site incident rates of cardiac arrests were calculated. RESULTS: We analyzed 849 arrests, with 52 at traditional centers, 84 at alternative exercise sites, and 713 at sites not associated with exercise. The site incident rates of arrests at indoor tennis facilities, indoor ice arenas, and bowling alleys were higher than at traditional fitness centers. Survival to hospital discharge was greater at exercise sites (56% at traditional and 45% at alternative) than at other public indoor locations (34%; $p = 0.001$). CONCLUSIONS: We observed a higher rate of cardiac arrests at some alternative exercise facilities than at traditional exercise sites. Survival was higher at exercise sites than at nonexercise indoor sites. These data have important implications for automated external defibrillator placement.	2B

Level of Evidence	Definitions (See manuscript for full details)
Level 1a	**Experimental and Population based studies -** population based, randomized prospective studies or meta-analyses of multiple higher evidence studies with substantial effects
Level 1b	**Smaller Experimental and Epidemiological studies -** Large non-population based epidemiological studies or randomized prospective studies with smaller or less significant effects
Level 2a	**Prospective Observational Analytical** - Controlled, non-randomized, cohort studies
Level 2b	**Retrospective/Historical Observational Analytical** - non-randomized, cohort or case-control studies
Level 3a	**Large Descriptive studies** – Cross-section, Ecological, Case series, Case reports
Level 3b	**Small Descriptive studies** – Cross-section, Ecological, Case series, Case reports
Level 4	**Animal studies or mechanical model studies**
Level 5	**Peer-reviewed Articles** - state of the art articles, review articles, organizational statements or guidelines, editorials, or consensus statements
Level 6	**Non-peer reviewed published opinions -** such as textbook statements, official organizational publications, guidelines and policy statements which are not peer reviewed and consensus statements
Level 7	**Rational conjecture** (common sense); common practices accepted before evidence-based guidelines
Level 1-6E	**Extrapolations** from existing data collected for other purposes, theoretical analyses which is on-point with question being asked. Modifier E applied because extrapolated but ranked based on type of study.