Controlled Study of the Clinical Effectiveness of Automated Real-Time Feedback on CPR Process Conducted at a Subset of ROC Sites

Background A subset of emergency medical services (EMS) agencies that are participating in the Resuscitation Outcomes Consortium (ROC) are adopting new monitor/defibrillators that are capable of monitoring CPR process during attempted resuscitation of patients in cardiac arrest, as well as providing automated real-time feedback about this process to EMS providers so as to improve compliance with recommended guidelines for CPR. Monitoring of CPR process during attempted resuscitation is an important step towards reducing the potential for poorly-performed CPR to modify the effect of the study interventions upon outcome. Provision of real-time feedback could further reduce this potential as well as improve overall outcomes in agencies that adopt this technology.
Therefore, we propose a substudy of the ROC PRIMED Trial to evaluate the clinical effectiveness of providing emergency responders with automated real-time feedback on CPR process.
Setting EMS agencies that are participating in ROC and adopting or upgrading Philips monitor/defibrillators capable of monitoring and providing automated real-time feedback of CPR process to emergency responders (see Appendix).
Population Included will be all individuals who experience cardiac arrest outside the hospital, are evaluated by organized EMS personnel and receive attempts at external defibrillation (by lay responders or emergency personnel), or receive chest compressions by organized EMS personnel.
Design Cluster randomized controlled study with cross-over at some sites.
Intervention Laerdal Q-CPR™ technology incorporated into the Philips HeartStart MRx monitor/defibrillator. After initially collecting baseline data in each cluster for three to six months, the clusters will be randomized such that one-half will activate automated feedback and the other half will not activate feedback for a period of 12 months. The randomization will occur at each site once the ROC PRIMED Trial has been successfully implemented for a period of 3 to 6 months..
Outcomes All clinical outcomes that are already collected as part of the ROC Epistry study, including the primary outcome for this study of initial restoration of spontaneous circulation, the secondary outcomes of presence of spontaneous circulation at the time of arrival in the emergency room, survival to discharge, and CPR process (including CPR fraction, compression rate and ventilation rate.)
Analysis The primary outcome will be the proportion of patients experiencing ROSC at any time during resuscitation as measured over the twelve months post randomization of clusters to activation of automated feedback or no activation. Analysis will compare the rates of ROSC for clusters when using activated feedback to the rates for clusters when not using activated automated feedback. An Analysis of Covariance (ANCOVA) will use a general linear model with ROSC rates for each cluster as dependent variable and predictors indicating cluster treatment assignment and cluster baseline ROSC rate. Correlation among results for a cluster tested under both feedback strategies will be modeled using marginal models (generalized estimating equations).
Sample Size An estimated 388 OOHCA patients (194 per arm) will be treated by the participating agencies during the three month period of baseline observation (or 777 patients in six months*)*, and a total of 1554 OOHCA patients will be treated by one of the participating agencies during the twelve months post randomization. If there is an 20% incidence of prehospital ROSC without feedback, an intervention period of 12 months,

and clustering based on stations at all sites, there will be 89% power to detect an absolute improvement of 10% in incidence of ROSC due to automated feedback.
Anticipated Significance If survival to hospital discharge increased from 5% to 10% due to improvement in CPR process, then the premature deaths of 8,700 individuals would be prevented annually throughout North America.

Background and Significance

Scientific Background

Recent studies have demonstrated that cardiopulmonary resuscitation (CPR) is sometimes not performed according to evidence-based guidelines in either the out-of-hospital or in-hospital settings (Abella et al. 2005, Wik et al. 2005, Valenzuela 2005). The rate of chest compression is too slow, depth of chest compression is too shallow, and rate of ventilation is too high. While a variety of evolving technologies offer the ability to monitor CPR process either directly or indirectly through automated external defibrillators (AEDs), feedback to the providers can usually only be used for quality assurance through delayed, individualized review of the records (Hostler et al 2003, 2005, van Alem et al 2003).

Preliminary studies

Automated, real-time feedback has previously been shown to increase adherence to CPR guidelines by using a computerized manikin and software package in both brief and longer term training exposures. Three studies have used similar methods to examine the effect of feedback on CPR process variables. The first study used a cross-over design in which paramedic students performed one-rescuer CPR for three minutes on a manikin (Wik et al 2001). Subjects were randomly assigned to receive either feedback or no feedback. After a brief rest period, the subjects completed another three minutes of CPR under the opposite feedback condition. Students who did not receive feedback initially improved during the second session when feedback was provided. For students who received feedback initially, there was a carryover effect that resulted in CPR being performed without feedback at the same level as that observed during the first study period. In a large study of practicing EMT-Basics, paramedics, and prehospital nurses, feedback did not improve CPR performance but did attenuate the decay in CPR process variables over time (Hostler et al 2005). A third study of ward nurses found that subjects performed correct ventilations and achieved correct compression depth more often when provided feedback (Handley and Handley 2003).

While manikin studies indicate CPR feedback will improve CPR process variables or at least attenuate the decay associated with fatigue, there is limited evidence that such automated, real-time feedback would have impact on more clinically important outcomes such as incidence of ROSC. One small European study of feedback provided during resuscitation in the prehospital setting failed to identify a significant improvement in the rate of ROSC (Wik 2005).

The FDA has approved the use of the Laerdal Q-CPR™ technology as it is incorporated into the Philips HeartStart MRx monitor/defibrillator. This technology monitors parameters of CPR process including chest compressions and artificial ventilations by recording impedance and movements from an accelerometer placed between the patient's chest and the responder's hands during CPR. When the feedback component of Q-CPR™ technology is activated, an automated algorithm prompts corrective action when a deviation from the recommended standards in CPR performance is detected. The software utilizes voice and/or visual prompts to advise the emergency responders to modulate the rate or depth of chest compression and ventilations. In the activated state, EMS personnel can decrease the volume of the audible real-time feedback as desired during the resuscitation effort. Preliminary field experience with this feedback suggested that it was well-received by the majority of responders and bystanders who were exposed to it.(Personal Communication, P Steen, May 1, 2006)

ROC Situational Background

The Resuscitation Outcomes Consortium (ROC) consists of ten Regional Clinical Centers and a Data and Coordinating Center (DCC). The University of Washington Clinical Trial Center serves as the DCC. The Consortium was funded by the National Heart Lung Blood Institute and other government agencies to conduct a series of large randomized trials to evaluate the effectiveness of interventions for out-of-hospital cardiac arrest and life-threatening injury. Additional funding has been obtained from the American Heart Association to offset the cost of extending ROC activities to include a registry to define the true burden of cardiac arrest. Also, manufacturers of cardiac monitor/defibrillators have made in kind contributions to participating ROC EMS agencies of new or upgraded equipment capable of monitoring CPR process during attempted resuscitation of patients with out-of-hospital cardiac arrest.

The registry of the Resuscitation Outcomes Consortium (ROC), known as the ROC Epistry, includes the following data related to OOHCA: incidence of restoration of spontaneous circulation (ROSC) during prehospital resuscitation, the presence of spontaneous circulation upon arrival at the receiving emergency department, survival to hospital discharge, and CPR process. ROC is implementing the Prehospital Resuscitation using an IMpedance valve and Early vs Delayed analysis (ROC PRIMED) trial, to simultaneously test whether an active impedance threshold device (ITD) versus sham ITD and whether thirty seconds of compressions or three minutes of compressions before rhythm analysis and shock are effective in patients with OOHCA. All EMS agencies that participate in this trial will be expected to demonstrate an ability to adequately acquire and analyze CPR process data, identify and attempt to correct any observed deficiencies, and meet minimum performance standards before being eligible to enroll subjects in the trial. In addition, ongoing monitoring, review and remediation of CPR process will be used throughout the conduct of the trial.

New Technology

Phillips will provide or upgrade HeartStart MRx monitor/defibrillators with incorporated Q-CPR technology to those ROC emergency medical services (EMS) agencies willing to participate in a study of the effect the use of that device might have on clinical events. The participating agencies are listed in Appendix 1.

Clinical Equipoise

Data from manikin studies and preliminary reports from the field (Wik 2005) and in-hospital (Abella, 2005) demonstrate that automated real-time feedback increases adherence to CPR guidelines, supporting the FDA approval of Q-CPR technology. Thus, many EMS agencies will be adopting this technology on that basis. While there is considerable speculation that improving CPR process at the time of resuscitation will improve clinical outcomes, there are no published data about the effect of this single intervention on outcome from out-of-hospital cardiac arrest (OOHCA). Therefore, we propose a prospective examination of real-time feedback on the delivery of CPR during attempted resuscitation of OOHCA.

Methods

Hypotheses

This substudy will test the following hypotheses:

Automated, real-time feedback on CPR process variables will:

1) Increase rates of restoration of spontaneous circulation during prehospital resuscitation.

2) Increase rates of spontaneous circulation upon arrival at the receiving emergency room.
3) Increase rates of survival to hospital discharge.
4) Result in compression and ventilation variables being performed closer to the established AHA guidelines on emergency cardiovascular care and CPR.

Subject Population

The proposed substudy will involve the same subjects to be studied in the Epistry (some of whom will also be enrolled in the ROC PRIMED Trial). Inclusion/exclusion criteria will be similar to the Epistry in those agencies utilizing the HeartStart MRx monitor/defibrillators with incorporated Q-CPR technology. Specifically, included will be all individuals who experience cardiac arrest outside the hospital, are evaluated by organized EMS personnel and: a) receive attempts at external defibrillation (by lay responders or emergency personnel), or receive chest compressions by organized EMS personnel. The only additional exclusion criterion is use of a mechanical CPR device.

The subject population studied in the Epistry (and ROC PRIMED Trial) is the population for which the use of effective automated real-time feedback on CPR process would be indicated. As the intent is to accrue every eligible subject into the PRIMED Trial, there is truly no alternative to conducting the substudy in a subset of the same subjects.

Design

A prospective cluster randomized study of activated Q-CPR technology versus inactivated Q-CPR technology.

For the first three to six months of the study, participating EMS agencies will have defibrillators placed in service with automated, real-time feedback inactivated. This period of time is essential to ensure that there is no conflict with the successful implementation of the ROC PRIMED Trial. During this period, the baseline rate of ROSC (and secondary outcomes) will be collected. Once the ROC PRIMED Trial is deemed to be running successfully within a given EMS agency, e.g. after 3 to 6 months, randomization may proceed. At the end of this baseline period, EMS agencies will be randomized to one of two intervention groups, with randomization stratified within site by agency, station, or device, depending upon the site. Some clusters will cross-over to the opposite feedback strategy midway (6 months) through the intervention phase. The clusters initially randomized to use “activated feedback” will immediately activate the automated, real-time feedback. The “no feedback” clusters will continue with real-time automated feedback inactivated for an additional six months (if the agency will cross-over to the opposite strategy) or twelve months (if no cross-over will occur for that agency). Agencies using cross-over will switch to the opposite strategy 6 months after the initial randomization. These agencies will be balanced within site and will be equally likely to be using “activated feedback” or “no feedback” during the first 6 months of the intervention period. Data on the primary and secondary outcomes will then be gathered for a 12-month period for all participating agencies, although the start date will vary for each agency. Primary comparison of treatment effectiveness will be based on comparisons of the change in ROSC rates for clusters while using activated feedback relative to the changes observed in clusters while using no feedback. After the completion of subject enrollment it will be at the discretion of the individual medical directors to activate or deactivate the feedback.

Implementation

Agencies will receive in-service training on the HeartStart MRx monitor/defibrillators including use of Q-CPR technology when made available by Phillips. Agencies will provide training to their providers in a manner consistent with local policy and standards to include proper use of the monitor defibrillator, use of the accelerometer, use of feedback, and the study protocol. Agencies will have the option of combining this training with the ROC PRIMED training to limit training costs.

Although providers will have been exposed to the feedback features in the training process, the limited number of resuscitation calls answered by any individual provider should minimize this effect.

Providers will be asked to use the accelerometer throughout the study even though the feedback will not be activated for a period of time. Use of the accelerometer will allow for detailed CPR process data collection during this initial period.

Effectiveness Outcomes

The primary outcome would be the rate of ROSC during the prehospital resuscitation. Secondary outcomes would include the presence of spontaneous circulation upon arrival at the emergency department, survival to hospital discharge, and adherence to guidelines for CPR fraction, rate and depth of chest compression and rate of ventilation compression depth and complete release. The definitions of field ROSC, spontaneous circulation upon arrival at the emergency room, survival to hospital discharge and components of CPR process are consistent with the data to be collected routinely in the Epistry.

Limiting collection to variables already included in Epistry avoids any additional burden on data collection or data management procedures. There will be no need to gain additional consent from subjects for collection of longer follow-up data. The planned sample size for this pilot study will not likely have sufficient statistical power to detect effects of automated real-time feedback on the long-term outcomes.

Monitoring of Adverse Events

Monitoring of adverse events will proceed exactly as planned for the ROC PRIMED Trial. Adverse event data available on subjects not in the PRIMED Trial will be limited.

Monitoring of Compliance with AHA Guidelines on Emergency Cardiovascular Care and CPR

It is possible that simply improving the quality of CPR will not have a sufficiently large effect to change the rate of ROSC in the context of other interventions. Therefore, we will also compare CPR process variables in this subset of ROC subjects. Through the CPR process requirements of the Epistry, we will collect the following variables: CPR fraction, compression number, ventilation number, and compression rate. Variables that are optional for the Epistry but will be mandatory for this study include: compression depth, and proportion of compressions without complete release. The distribution of these variables will be collected during the control and intervention periods and compared to the recommendations contained in the AHA guidelines.

Statistical Plan

Primary and secondary outcomes will be analyzed by intention-to-treat in the primary comparison population. The primary outcome measure, restoration of spontaneous circulation at any time during pre-hospital resuscitation, will be analyzed as a binary outcome summarized within each period of

intervention for each randomization cluster. Since the secondary outcomes, will not be used to draw final conclusions, but just to corroborate the conclusions from the primary outcome and to provide further information on the relationship between all of these outcomes, there will be no adjustment for multiple comparisons. Exploratory analyses incorporating covariates will be based on generalized linear models for a binary outcome with random effects measuring randomization cluster and fixed effects measuring factors such as site (categorical), gender (categorical), witnessed (categorical), public location (categorical), rhythm (categorical), Analyze Later versus Analyze Early (categorical), age, and response time, as covariates (Hallstrom et al 1995, Herlitz et al 2005, Jacobs 2005). Presenting rhythm will not always be determined prior to implementation of the study ITD/sham device. Thus, this covariate will have four categories: VF/VT, PEA, asystole, and a fourth category consisting of those which the rhythm was not obtained prior to device implementation. The hypothesis of interest for the primary outcome is

H_0: The proportion of patients experiencing ROSC during resuscitation is equivalent for the activated feedback and control clusters.

$$\pi_{Feedback} = \pi_{Control}$$

H_1: The proportion of patients experiencing ROSC during resuscitation is greater for the clusters with activated feedback compared to control clusters.

$$\pi_{Feedback} > \pi_{Control}$$

The unit of analysis for the primary analysis will be randomization cluster. The primary analyses will evaluate the difference between rates of ROSC in the intervention period for clusters with activated feedback relative to results for clusters when randomized to no feedback. The ROSC rates for each cluster will be used as dependent variable in a general linear model using predictors indicating treatment group assignment and ROSC rates in the baseline period for the cluster. The Huber-White sandwich estimator will be used to adjust for correlation among measurements made on the same cluster. Secondary analyses for the primary outcome will use individual patient as the unit of analysis and model randomization cluster as a random effect along with covariates measuring other predictive factors.

The effect of feedback will also be examined separately within the following a priori subgroups:

- Analyze Early versus Analyze Late;
- ITD versus sham device;
- Initial rhythm prior to application of feedback (VF/VT vs. PEA vs. asystole vs. not obtained);

In each subgroup, the analyses will proceed exactly as defined for the primary and secondary endpoints in the entire sample. The study is not adequately powered to detect differences within individual subgroups, and thus the above analyses will be largely descriptive.

Sample Size

Sample size considerations for this pilot study were based primarily on the logistical constraints imposed by the participation restricted to specific agencies at four ROC sites. The Appendix lists for each participating agency the estimated number of EMS treated OOHCA cases per year. These estimates were derived from the actual number of cardiac cases reported in the ROC Epistry through October 16, 2006. The reported counts for each agency were then annualized to account for the variable timeliness of data reporting across agencies. ROC-wide, approximately 60% of cardiac Epistry cases actually receive CPR by the responding EMS agencies, and thus the annual rate of EMS treated OOHCA was estimated as 60% of the annualized rate of reported cardiac cases in

Epistry for each agency. It is thus estimated that approximately 1,554 cases of EMS treated OOHCA will be observed at the participating agencies during each 12 month period.

The statistical power of the proposed trial design to detect a beneficial effect due to automated real-time feedback was explored using simulation.

- Baseline incidence of ROSC at any time during resuscitation was assumed to be normally distributed across clusters, with mean 20% and a standard deviation of 3%. Hence, under this assumption, approximately 95% of clusters would tend to have *true* incidence of ROSC between 14% and 26%, though observed incidence rates would vary more substantially due to sampling variation. For instance, with 100 cases observed in each cluster, the above assumptions would suggest that 95% of clusters would have *observed* incidence of ROSC between 11% and 30%.
- Randomization of activation vs. no activation would be done using clusters corresponding to stations within agency. For purposes of simplifying the power computations, it was presumed that average accrual of cases would be equal for each station within an agency and for each device within each agency. (This scenario is an approximation to the actual plan for some agencies to randomize by device and some agencies to randomize by agency, but with cross-over.)
- In simulations of the clinical trial, the actual number of EMS treated OOHCA was assumed to be Poisson distributed with rate determined from the agency specific estimated annual rate as provided in The Appendix. Hence, simulations explicitly consider variation in sample size: A twelve month intervention period would have 1554 ± 39 evaluable OOHCA cases.
- Power computations were performed for treatment effects corresponding to absolute improvements in incidence of ROSC of 10% and 15% in each cluster.
- The conduct of the study will be monitored by an independent DSMB. A single formal interim analysis will be performed following accrual of approximately half the planned maximal sample size. At that analysis, the DSMB can recommend early termination of the study either for strong evidence of effectiveness of activation relative to no activation or for strong evidence of harm from activation relative to no activation. Because we are investigating the effectiveness of an FDA approved device, different recommendations would be made if feedback is merely neutral in its effect as opposed to actually harmful. It is thus clinically important to distinguish two-sided hypotheses. The DSMB's recommendation will be guided by a formal stopping rule using O'Brien-Fleming boundary relationships.

Under the above assumptions and using a two-sided level 0.05 test for detecting a difference in the incidence of ROSC, the planned 12 month intervention period would allow 89% statistical power to detect an improvement in incidence of ROSC from 20% to 30% and greater than 99% statistical power to detect an improvement from 20% to 35%,

Complicating Factors. When clustering is by station or device, there is some potential for individual EMS responders to "cross-over" between activated and inactivated feedback. That is, if a given EMS agency has EMTs or paramedics rotate among stations or devices, it is possible that within the randomized intervention period, a responder will treat some patients with activated devices and some patients with inactivated devices. If a primary role of the feedback is reinforcement/retraining, there may be carryover effects that could attenuate the difference between incidence of ROSC rates between the treatment arms. Such "carryover" of effect is only an issue when an EMS responder would use an inactivated device after using an activated device. The frequency with which such might occur can be estimated as follows:

- On average, an EMS responder is expected to treat two OOHCA per year, and we presume a Poisson distribution across responders.

- In the worst case of completely independent assignment of EMTs and paramedics to clusters for each treated OOHCA, we thus compute a 37% probability of a case treated with an inactivated device following treatment with an activated device.
- If we presume perfect "carryover" of treatment effect (i.e., a EMT or paramedic need only use activated feedback once to have lasting impact on all future treated cases), the treatment effect on such "cross-over" cases would be 0, while me might presume a treatment effect of 0.10 for cases without "cross-over" from activated to inactivated devices.
- If 25% of participating EMS agencies assign EMTs and paramedics in a manner that has independence of cluster assignment among successive cases, the attenuation of the treatment effect would be such that a true 10% absolute improvement in incidence of ROSC would lead to an attenuated effect of 9.1% absolute improvement.
- If clustering is by station at all sites, this attenuated treatment effect would decrease the statistical power to detect a true 10% absolute improvement in incidence of ROSC using a 12 month intervention period from 90% to 85%.

Potential Impact on ROC

Monitoring CPR process and assuring some measure of compliance with AHA BLS guidelines has been mandated by the ROC DSMB. Utilizing HeartStart MRx monitor/defibrillators with incorporated Q-CPR technology may facilitate this requirement by providing feedback on CPR performance while basic life support is being delivered. From an educational aspect, temporally shifting the quality assurance process from a retrospective exercise to real-time correction is likely superior.

A potential disadvantage exists if the feedback technology influences resuscitation through a similar mechanism as the ITD or if it alters the likelihood of adherence to the analyze early vs. analyze late arms of the ROC PRIMED Trial. It is plausible that providers will become confused with 3 levels of randomization. However, we plan to minimize the impact of this feedback study upon the providers by delaying the implementation of this substudy. It is likely that some EMS agencies participating in the ROC will incorporate this technology into their practice regardless of this substudy. We intend that this substudy will introduce the technology in a consistent and measurable fashion.

Impact on Emergency Response Personnel

The proposed substudy will have minimal impact on the emergency responders. EMS responders will have to be trained in the capabilities and use of the Philips device just as they would if no substudy was taking place. This training would include explanation of the automated recommendations and how the auditory feedback could be turned down when desired. The EMS responders would be told to ensure that the volume is turned up as they respond to a call, but then they may decrease the volume as they see fit, whether the device is activated or not. An EMS responder who used only the auditory feedback might not notice the inactivation of feedback in cases where CPR is performed consistently according to the programmed guidelines. EMS responders who use visual feedback would not have access to that feedback with inactivated devices.

Impact on Site Study Coordinators

There would be few additional requirements for data collection or data management, because the endpoint ascertainment, recording, and CPR process monitoring is consistent with the requirements already in place for Epistry. CPR process will be monitored for the entire episode rather than for than for first five minutes as is the case for other Epistry episodes. This should entail a small amount of additional effort because monitoring of CPR process is semi-automated by the analysis software

available from Philips Inc. The activated feedback may result in fewer corrective actions by site coordinators for poor CPR process by EMS providers.

Impact on ROC Clinical Trial Center

The CTC would have additional burden from the analysis of study data (both interim analyses and final analyses) and preparation of report for the substudy investigators and the DSMB. However, such activities are in keeping with the mission of the ROC in general, and the CTC in particular.

Impact on ROC PRIMED Trial

The proposed substudy does not have eligibility criteria beyond those needed for the PRIMED Trial or Epistry, there is no increased complexity in subject accrual. Additionally, the substudy requires only passive involvement of the EMS responder.

The ROC PRIMED trial requires monitoring and corrective action if CPR process variables fall below some threshold. Providing real time feedback for CPR at the time of resuscitation potentially represents the highest quality corrective action by providing input at the time the skill is performed. If high quality CPR has a higher than expected effect on OOHCA resuscitation it is possible that all arms of the ROC PRIMED Trial would perform better than sites not using real time feedback.

Anticipated Significance

Out-of-hospital cardiac arrest is a common, serious, debilitating and costly public health problem. Among participating ROC sites, there is a three-fold variation in survival after cardiac arrest. To the extent that some part of that variation in survival might be explained by variation in adherence to recommendations contained in the AHA guidelines, any intervention that provides greater quality control of CPR process might be expected to improve outcomes after cardiac arrest. As well, the efficiency of ongoing ROC interventional trials will be increased. Given the comparative ease of implementing real-time feedback by adopting new monitor/defibrillators, we anticipate that feedback would be widely implemented if this study demonstrated improved survival. If survival increased from 5% to 10%, then the premature deaths of 8,700 individuals would be prevented annually throughout North America

Appendix: Participating ROC Sites and Agencies

	Days of Data in Epistry	Number of Cardiac Cases in Epistry	Number of Devices	Number of Stations	Estimated Annual EMS Tx Cases per Site
OTTAWA					
Superior North Emergency Medical Services	94	15	10	3	35
Thunder Bay Fire and Rescue	99	13	9	8	29
Niagara Falls Fire and Rescue			22	6	29
PITTSBURGH					
City of Pittsburgh Fire	304	213	47	29	153
City of Pittsburgh	307	389	53	15	277
Mutual Aid	269	191	33	10	155
PORTLAND					
Tualatin Valley Fire and Rescue	117	112	36	22	479
MetroWest Ambulance	107	18	22	1	37
SEATTLE/KING COUNTY					
Northshore/Kenmore FD - KCFPD #16	270	25	8	2	20
Shoreline FD - KCFD #4	285	79	21	4	61
Redmond Fire Dept	273	29	20	7	23
North Highline FD KCFD #11	275	37	5	2	29
Mercer Is - FD	299	18	5	2	13
Maple Valley Fire and Life Safety KCFPD #43	291	22	6	7	17
City of Kirkland FD KCFD 41	282	31	14	7	24
South King Fire and Rescue	306	144	14	7	103
Bellevue FD	287	134	35	13	102
Bothell KCFD 17	215	25	8	3	25
Duvall FD - KCFPD 45	211	4	5	3	4
Fall City F.D. KCFPD #27	5	2	3	1	2
Woodinville F.D. KCFD #36	229	20	13	4	19
Tukwila F.D.	257	16	6	4	14
City of Snoqualmie Fire Division 17M17	242	3	2	1	3
South King Co Medic 1	293	218	2	1	163
City of Pacific Fire Department	153	3	1	1	4
Snoqualmie Pass # 51		1	3	1	1