Senior Project Proposal

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I. Title of the Project:

CPR Quality Metrics After Real-World Use of Zoll Defibrillators and Simulations

II. Contact Information:

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III. Statement of Purpose:

Every field—from sports to education, technology to agriculture—requires data analysis." Flagstaff Medical Center (FMC) is no different. Having recently acquired Zoll R series defibrillators and implementing the Resuscitation Quality Improvement (RQI) program, FMC is now tasked with the responsibility of using data analysis to evaluate whether this investment was worthwhile. In particular, with what CPR quality metrics is FMC currently struggling, and in what areas is it excelling? Additionally, are there some CPR factors that correlate more strongly with patient outcomes than others and should therefore be prioritized in training?

I expect to find the answers to these questions through the RQI program that provides data on healthcare worker skills during CPR simulations and from data stored over the past year in the defibrillators themselves. Hopefully, my research will ultimately help FMC save more people undergoing cardiac arrest by identifying flaws as well as strengths in our hospital's current methods.

My internship with FMC will teach me effective strategies for analyzing and interpreting various types of data sets. I aspire to obtain a PhD in psychology, so taking on a task that requires evaluating information will teach me research skills and help me explore if this field is what I really want to pursue in the long run.

IV. Background:

My junior year AP Statistics class was the first math class that I actively looked forward to. Every new concept we learned, from describing correlations between variables to finding z-scores on a table, felt significant. Word problems would excite me because I could picture real businesses asking similar questions. The first time we used a statistical method in my biology class astonished me: before that, I had never thought about how subjects could be so interdisciplinary.

The latest project in my Capstone Scientific Inquiry class has further enhanced my interest in data. Designing and implementing a survey that was distributed to the student body was as frustrating as it was satisfying because we had to repeatedly change the wording for focus and clarity. When I first stared at the spreadsheet that housed our data, I was immediately overwhelmed: how would we ever get results from this? My experiences in my statistics and computer science classes turned out to be incredibly useful, but even then, determining how to implement that knowledge efficiently using the available data required substantial research. With the internship at the hospital, I hope I can see how data analysis is conducted in a professional setting as well as make a difference in my community.

V. Prior Research:

For as long as people have died from cardiac arrest, there have been others searching for strategies and techniques to save them. Yet it was not until 1958 that modern cardiopulmonary resuscitation, or CPR, was implemented nationally in hospitals. Ever since then, an emphasis of the cardiology world has been to ensure that CPR performance is as effective as it can be. From the time between pauses to the depth of compression, researchers are constantly testing every factor that could affect resuscitation. Even so, the "...rate of successful resuscitation remains disappointing, and aggressive dissemination of the current CPR guidelines should be encouraged…"[1] Just as in all medicine—and in all science, really—there is no room for stagnation.

The American Heart Association (AHA) knows this well and periodically releases guidelines providing the most up-to-date and scientifically backed information and suggestions regarding CPR. For example, the AHA notes that chest compressions should be "...at least 2 inches…"[2] and "at a rate of 100 to 120/min."[2] In America, this technique is the gold standard for resuscitation and is used by all medical personnel. But then comes the problem of maintaining said standards. Technological improvements have helped greatly with this challenge. Feedback devices can provide real-time visual and auditory responses during CPR and store the data for further analysis. Due to their relatively new status, numerous studies on these device's effectiveness are conducted constantly.

The Zoll R-Series defibrillators that FMC uses have been the subject of some of these experiments. These Zoll defibrillators work just as other types of feedback defibrillators do, by providing an electrical charge to restore cardiac activity and storing data on CPR performance. One study found that without the devices, chest compressions "...were too shallow and too fast…"[3] Applied more broadly, even countries like Germany, which uses completely different brands of defibrillators, found similar results. After 292 resuscitations of various types using a variety of equipment, one study concluded that feedback devices could "raise the quality level"[4] of CPR. But this presents another question: how do we effectively train people on CPR, especially when using new technology that provides live comments on CPR performance?

Even fundamentals such as the type of mannequin should be considered when conducting resuscitation simulations. According to Shoemaker and colleagues[5], few mannequins "…can accurately represent its features". By 'features', they mean the measurements made by Zoll defibrillators. Meanwhile, incorporating feedback devices during training does seem to improve "...the accuracies of compression rate…"[6] and possibly "...CPR retention…"[7]

Determining what teaching methods to use during training is as important as the feedback devices themselves. Cheng et al[8] suggest that Just-in-time training, in which CPR is taught at sites where emergencies may happen, works quite well. Others, like Smart et al[9], wonder if creating competition could "encourage staff to practice." And finally, Sutton and colleagues[10] are convinced that "low-dose, high-frequency CPR training", such as the RQI training that FMC provides, is more effective than training that leaves long intervals between training sessions. All these ideas are supported by extensive research on the best ways to teach people these skills, but it is important to determine what will truly improve patient mortality rates. Many of these studies are evaluated via simulations that could differ from real life situations. At one point in his study, Lakomek et al[4] considered the "'Hawthorne effect'—behavioral change due to an awareness of being observed". For example, people might not perform as well when they are not being evaluated. However, without additional research into the best ways feedback devices can be used to teach medical personnel– not to pass a test, but to save a life—progress will be limited.

VI. Significance:

More than 50 years have gone by since the AHA first published its CPR guidelines, but "cardiac arrest remains a leading cause of mortality and morbidity…"[2] Furthermore, while the survival outcome of in-hospital cardiac arrests has drastically improved since the year 2000, around 75% of people who suffer them still die.[11] Because technologies like the live feedback defibrillators have aided in improved patient outcomes, it is important to garner as much knowledge as possible on the effects of these technologies.

Existing studies on feedback devices vary in numerous respects, including quality, size, and methodology. Each study has a different agenda and a different take on these feedback devices. Nevertheless, they have all contributed to a web of knowledge that has slowly but surely helped save people's lives. In fact, only 17% of the recommendations in the CPR guidelines come from expert knowledge. The remaining recommendations come from small-scale, sometimes amateur-level studies conducted all over the U.S.[2]

While I am by no means an expert, I know every bit of information counts. Flagstaff Medical Center (FMC) should understand the effects that its Zoll defibrillators are having on the lives of patients and whether the kinds of training and simulators their healthcare providers use are actually helping. Currently, there is a lack of research regarding the connection between patient outcomes and the feedback devices themselves. My study will investigate this connection. Every time a cardiac arrest patient enters FMC, they deserve to know that everything possible is being done, and has been done, to ensure their survival.

VII. Description:

My project will consist of performing analysis on already existing data from FMC on CPR metrics from the Zoll Defibrillators and the RQI training. I will then evaluate these numerical outcomes to see what kinds of patterns there are, so I can provide suggestions of my own. I will also take the results from my data analysis and graph them clearly into a research paper. This paper will be the final outcome, and it will also describe in detail my procedure as well as my conclusions.

VIII. Methodology:

Once I have access to the Zoll and RQI databases, I will first examine descriptive statistics such as central tendencies. Measuring the mean, median, and modes of individual metrics, such as average compression rate, will allow me to identify the general areas in which healthcare practitioners may be struggling. I will also calculate measures of spread, such as the standard deviation, to gain additional context about these analyses.

If I want to truly understand how these factors correlate with each other or with important outcomes like patient mortality, I must perform inferential statistics. I will consult with Mrs. Buckley, my internal advisor and former AP Statistics teacher, as well as digital resources on how to best do this. Factors such as sample size and distribution must be considered in order to properly analyze the date and determine what kinds of equations will be most effective.

My work using the Zoll and RQI databases will be mainly separate. The Zoll database, which contains ~100 cases, is already organized in an Excel sheet and is de-identified, meaning I can perform most of my calculations using the built-in tools provided by Microsoft. I also have access to the RQI database. Using the RQI database, I will study CPR metrics that are similar to the ones from Zoll, with the exception that these results are part of training simulations.

After I am satisfied that I have obtained as much information as possible from these databases, I will then assemble my findings into a research paper. These findings could be examined by the department in charge of quality outcomes at FMC so that the hospital can determine the next steps in relation to usage of these Zoll devices, RQI training, or both.

IX. Problems:

Because the collection of data from the Zoll R Series started only a few years ago, the sample size is quite small. There are around 100 total CPR cases, with only 60 providing patient outcomes, so I may sometimes have to use non-parametric tests, which yield less conclusive evidence than parametric tests. To make up for this, I plan on analyzing as many relationships between factors as I can.

While the add-on of the RQI data helps with the above problem by providing a new angle for examining CPR quality, it also holds problems of its own. I cannot compare the RQI data directly to the Zoll data because there is no way of telling which healthcare provider who completed a simulation performed what real-life CPR case. Still, by performing many different statistical tests (as with the Zoll data), I may be able to find distinguishable patterns that can lead to some important conclusions.

X. Budget:

I have no anticipation that this project will require any additional costs. FMC resides near my school, so transportation will not be an issue. There are plenty of free resources that can be provided by FMC, my internal advisor, and digitally through sources like google scholar. I can perform calculations using the built-in tools on the spreadsheet.

XI. References:

1. Cooper JA, Cooper JD, Cooper JM. Cardiopulmonary resuscitation: history, current practice, and future direction. Circulation. 2006;114(25):2839-2849. doi:10.1161/CIRCULATIONAHA.106.610907.

   This review explores the history of CPR as well as the potential paths it should take based on current practice and vital issues. According to the authors, the priority should be constantly updating CPR guidelines as more and more studies are conducted that show how to obtain better patient outcomes. As the history does not extend beyond the year 2006, there is little mention of defibrillators that provided feedback; however, it still provides a good perspective on the technological progress that has and has not been made.

2. Cheng A, Magid DJ, Auerbach M, et al. Part 6: Resuscitation Education Science: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2020;142(16):S551 - S579. doi:10.1161/CIR.0000000000000903.

3. Augusto JB, Santos MB, Faria D, et al. Real-time visual feedback device improves quality of chest compressions: a manikin study. Bull Emerg Trauma. 2020;8(3):135-141. doi:10.30476/beat.2020.83080.

This study examined how the Zoll R series defibrillators with real-time visual feedback affect the quality of CPR provided by healthcare professionals. After comparing the chest compression rate and depth between participants who had feedback to those who did not have feedback, the study’s authors concluded that visual feedback devices improve CPR performance. The experiment was only conducted on mannequins, so it is not certain if this would translate on real people the same way it did with simulations. Notably, healthcare professionals of all levels of experience were used, and there was no difference in overall improved performance.

4. Lakomek F, Lukas RP, Brinkrolf P, et al. Real-time feedback improves chest compression quality in out-of-hospital cardiac arrest: A prospective cohort study. PLoS ONE. 2020;15(2): e0229431. doi:10.1371/journal.pone.0229431.

This study evaluated the effect of a real-time feedback system on real CPR conducted by medical staff in out-of-hospitals settings. Pause lengths and frequency of compressions significantly improved, but the rate of chest compressions hitting the target depth did not increase. Notably, even the group that used CPR feedback sensors without any live suggestions performed better than the group who did not use any sort of special CPR devices. This potentially implies a psychological effect of improved performance due to the feeling of being observed.

5. Shoemaker JL, Duty OT, Martin KJ. Geis GL. Compatibility of ZOLL defibrillators in simulation-based training. Simulation Healthc. 2018;13(1):p 61-63. doi: 10.1097/SIH.0000000000000259.

Researchers from a medical institution evaluated what kind of simulators work best with the Zoll R series defibrillators. Using different kinds of commercial brand simulators, it was found that there were few simulators that the Zoll machines could accurately provide data of CPR display metrics, filtered rhythm, and idle time display. They were especially worried to find that they had no adequate pediatric simulations that functioned with the feedback devices. Since the researchers had to use the simulators available already, there may be a specific brand that works very well with Zoll, but this does demonstrate that providing training to medical practitioners might be more complex when Zoll feedback devices are used.

6. Kim KH, Kim CW, Oh JH. Effect of introducing a feedback device during adult and infant cardiopulmonary resuscitation training: a ‘before and after’ study. Hong Kong Journal of Emergency Medicine. 2020;27(2): 114-117. doi:10.1177/1024907918801488.

Researchers from Hong Kong used a SimPad PLUS feedback device during CPR training to see if it had a significant effect on performance or metrics. Medical students performing pediatric resuscitation after being taught with the feedback device scored higher on a CPR test than those who were taught without it. There was little effect on scoring with adult resuscitation, but the chest compression rate improved overall for those who learned using the SimPad. Unfortunately, the trainings and tests had long time intervals between them, so there may have been other factors that influenced results.

However, the study does support the idea that further research should be done on how feedback devices may affect specific CPR target areas.

7. Yeung J, Meeks R, Edelson D, et al. The use of CPR feedback/prompt devices during training and CPR performance: a systematic review. Resuscitation. 2009; 80(7):743-751. doi:10.1016/j.resuscitation.2009.04.012.

   Joyce Yeung, alongside others, performed a systematic review of numerous papers to see what effect feedback devices during training had on retention and performance. The results showed that people performed CPR better in real life and in simulated environments when they learned using feedback devices. The study did not evaluate patient outcomes, just quality metrics, but generally, if people reach CPR metrics, the patients most likely have an increased likelihood of survival. The way that feedback devices are used both in training sessions and in real life remains an important consideration, especially in terms of how it is incorporated alongside real-life instructors.

8. Cheng A, Brown LL, Duff JP, et al. Improving cardiopulmonary resuscitation with a CPR feedback device and refresher simulations (CPR CARES study): a randomized clinical trial. JAMA Pediatr. 2015;169(2):137–144. doi:10.1001/jamapediatrics.2014.2616.

9. Smart JR, Kranz K, Carmona F, Lindner TW, Newton A. Does real-time objective feedback and competition improve performance and quality in manikin CPR training–a prospective observational study from several European EMS. Scand J Trauma Resusc Emerg Med. 2015; 23(1): 1-11. doi:10.1186/s13049-015-0160-9.

   JR Smart and the rest of his team evaluated the CPR quality effect on emergency medical personnel that received training using a simulation with real-time feedback. They

also created a competitive environment by saying whoever improved the most would be the winner. It was ultimately concluded that having real-time feedback when learning improved performance and that the invented rivalries also motivated the participants. There are numerous issues with the study, notably that there were not enough control groups. It could very well be that the feedback devices did not affect performance; instead, it was just having the training at all. Similarly, participants were only surveyed on if they felt additionally motivated because of the competition, but there was no group that did not know about the competition to compare actual CPR metric results to. Still, the idea that CPR performance is not only affected by skill and practice but also by external pressures on medical personnel is an intriguing one.

10. Sutton RM, Niles D, Meaney PA, et al. Low-dose, high-frequency CPR training improves skill retention of in-hospital pediatric providers. Pediatrics. 2011;128(1):e145-e151. doi: 10.1542/peds.2010-2105.

    The researchers designed a study in which medical staff were given multiple micro training sessions in the span of 6 months to see if they retained CPR skills better. The staff performed better than expected using this technique, and interestingly, the group that was trained with real instructors performed better than the group who used feedback-devices in training. The idea of holding these “booster” sessions instead of the traditional methods, which often have a lower retention rate, could be worth looking into, as well as the difference in learning when faced with a real person compared to a machine. The possibility that feedback devices could be used as a crutch was briefly discussed, and while that could be fixed by having staff use the devices in real life as well, that may not always be possible.

11. Andersen LW, Holmberg MJ, Berg KM, Donnino MW, Granfeldt A. In-Hospital Cardiac Arrest: A Review. JAMA. 2019;321(12):1200-1210. doi: 10.1001/jama.2019.1696.