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QT Monitoring in the ICU: A Benchmark Project

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Executive Summary

In adult Intensive Care Unit (ICU) patients, does QT/QTc monitoring compared to no QT/QTc monitoring affect mortality or ventricular tachyarrhythmia rates during their ICU stay? Not monitoring changes in the QT interval can lead to poor outcomes since mortality rates are higher in patients with arrhythmias (Uvelin, Pejakovic, & Mijatovic, 2017). Approximately 300,000 sudden cardiac deaths occur in the United States each year with an estimated 15,000 because of a lethal ventricular tachyarrhythmia rhythm called Torsades de Pointes (TdP) that occurs when a QT interval is prolonged (Dave, Bessette, & Setnik, 2017). Some risk factors for developing prolonged QT intervals include medication administration, an older age, and electrolyte abnormalities.

This QT/QTc monitoring project entails creation of an electronic health record (EHR) flowsheet and Clinical Decision Support System (CDSS), replacing outdated bedside monitors in the ICU and Emergency Department (ED), educating all stakeholders, and go-live with the project. Total expected time for this project from approval to go-live is one year. Major project costs during this time will total approximately $200,000. Return on investment (ROI) would be a profit of at least $550,000 if one lawsuit was avoided. The outbreak of COVID-19 will increase ICU censuses and has a treatment regimen that has the possibility of prolonging QT intervals. QT/QTc monitoring has the ability to reduce incidences of unnoticed QT prolongation that could lead to ventricular tachyarrhythmias and death, saving many lives.

Rationale

Electrical activity of the heart can be recorded using an electrocardiogram (ECG) machine. The QT interval is the portion of the recording that indicates how well the ventricles depolarize and repolarize. Depolarization causes the muscle to contract while repolarization allows the muscle to relax. A prolonged QT interval would be indicative of a problem with the repolarization of the ventricles decreasing how effective the next contraction is. Since QT intervals need to be shorter with a faster heart rate due to the need for the ventricles to repolarize faster, a corrected QT (QTc) needs to calculated to ensure a more accurate number (Al-Khatib, LaPointe, Kramer, & Califf, 2003). A QT/QTc prolongation is defined as an interval greater than 500 milliseconds (ms) or an increase of greater than 60ms from baseline (Pham et al., 2016). Prolongation of the QT/QTc interval has been associated with ventricular arrhythmias such as torsades de pointes (TdP) (Hoogstraaten, Rijkenberg, & van der Voort, 2014).

Newer bedside ECG monitors can continuously measure, calculate, and detect when the QT/QTc is prolonged. These new monitors can even automatically send these ECG measurements and vital signs to EHRs to be validated and charted by the bedside nurse. However, not all EHRs are designed with a place to record ECG measurements, much less automatically download them from the bedside monitor.

Approximately 300,000 sudden cardiac deaths occur in the United States each year with an estimated 15,000 because of TdP (Dave et al., 2017). Medication administration is the most common cause of prolonged QT/QTc with ICU patients being the most affected (Etchegoyen, Keller, Mrad, Cheng, & DiGirolamo, 2017). Rates of QTc prolongation greater than 500ms are found to be from 2.6% to 24% (Sandau et al., 2017). Developing TdP as a result of these prolongations was found to be between 0% (Armahizer et al., 2013) to 3.8% (Hoogstraaten et al., 2014). An annual incidence rate of 0.1% was found for TdP or non-sustained ventricular tachycardia (nsVT) (Michels, Kochanek, & Pfister, 2016).

Literature Synthesis

Although published guidelines support the need for QT monitoring, many nurses are unaware of the need to monitor their high-risk patients for QT prolongation (Barrett, 2015). The American Heart Association (AHA) recommends QTc monitoring on patients with TdP risk factors such as "baseline QTc prolongation, who are being started on nonantiarrhythmic drugs with known, possible, or conditional risk for TdP" (Sandau et al., 2017). Other risk factors for acquired long QT syndrome (a-LQTS) include, but are not limited to, older age, low body mass index (BMI), electrolyte abnormalities, and the use of QTc-prolonging medications (Hoogstraaten et al., 2014). This would mainly apply to all ICU and Emergency Department (ED) nurses since they typically take care of critically ill patients on these medications with these risk factors.

It was found that between 35% (George et al., 2015) and 84% (Hoogstraaten et al., 2014) of patients were on medications that prolonged the QT interval. There are a vast number of medications that can prolong the QT interval (Farzam & Tivakaran, 2019) and an updated list can be found at crediblemeds.org. It is recommended that patients at risk for developing a-LQTS be identified and monitored, especially if they are receiving multiple medications that can prolong the QT interval (Beitland, Platou, & Sunde, 2014).

For these reasons, physicians also need to be aware of the dangers of prolonged QT intervals and the drug-to-drug interactions (DDIs) that can lead to a-LQTS. Being prescribed one QT prolonging medication is normally not a problem. Problems arise when multiple medications are prescribed which have drug-to-drug interactions (DDIs). DDIs are either pharmacodynamic (PD-DDI) or pharmacokinetic (PK-DDI) (Armahizer et al., 2013). PD-DDIs happen when two medications that prolong the QT interval are administered together, and PK-

DDIs occur when a metabolic inhibitor is administered with a QT prolonging medication (Fernandes et al., 2019). A clinical decision support system (CDSS) can effectively reduce the odds of QT prolongation occurring in hospitalized patients by reducing the frequency of these medications and interactions (Tisdale et al., 2014).

Classes of medications that can prolong the QT interval include, but are not limited to, antiarrhythmics (Uvelin et al., 2017), antibiotics, antimycotics, antidepressives, antipsychotics, and sedatives (Beitland et al., 2014). PD-DDIs involving ondansetron, metoclopramide, and amiodarone are of particular concern because they are most likely to prolong the QT interval (Fernandes et al., 2019). Another commonly prescribed medication of concern is diprivan. Diprivan has been suggested as the preferred sedative agent in the ICU for patients with a long QT interval (Avci et al., 2017). However, in another study, diprivan administration was found to cause a QT prolongation in a little over 4 out of 10 patients with the greatest risk in lower weight patients (Scalese, Herring, Rathbun, Skrepnek, & Ripley, 2016). If the patient's QT/QTc cannot be monitored, these medications should not be prescribed and a different medication used (Beitland et al., 2014).

All ICU-level patients should have a bedside monitor that is able to monitor the QT/QTc interval. This ability would give an audible alarm when the QTc was over 500ms, as this is considered "highly abnormal" (Pham, Banks, Narotsky, & Dorman, 2016, p. 439). The nurse could then take immediate action and notify the physician of a change in patient condition. Since patients can develop a prolonged QT/QTc anywhere between 15 minutes to 33.8 hours after admission (Hoogstraaten et al., 2014), ICU patients held in the ED should also be monitored. Flowsheets in the EHR also need to be modified so nurses can enter in ECG measurements. Enabling the nurse or physician to trend the QT/QTc measurements would allow them to notice if there has been an increase of greater than 60ms since this is another indicator of a-LQTS (Pham et al., 2016).

Minimum recommendations for QT/QTc monitoring would be an initial 12-lead ECG, another after 4 hours, and then daily regardless of continual bedside QT monitoring (Scalese et al., 2017). Further evaluation of these time intervals will need to be reevaluated annually to determine the optimal timing. Amending a current policy on vital signs by adding QT/QTc interval documentation every four hours will be suggested with every eight hours as the longest time span to go between reassessments (Sandau et al., 2017). The policy will also need to specify which lead to evaluate QTc and frequency of documentation (Sandau et al, 2017). Lead selection should be based on one with the longest T wave without any U waves (Sandau et al., 2017).

Stakeholders

Main stakeholders for implementing QT/QTc monitoring will be bedside nurses, nurse managers, nursing clinical coordinators, and physicians. The BioMedical (BioMed) department, Facility Management, and Information Technology (IT) departments will be secondary stakeholders. Nurses, physicians, and IT will need to be brought in early to gain feedback on new monitors, EHR build requirements, and EHR alerts. Doing these things will help manage stakeholder expectations and contribute to an environment for success (Alqaisi, 2018). Biomed and Facility Management will need to be brought in later to help install and manage the new monitors.

Planned Evaluation

Evaluation for this project will be divided into project management success, physician and nurse satisfaction, and patient outcome success. Project management success determination will occur at each meeting and three months after go-live. All project management goals will be given either a “met”, “on-going”, or “not met” determination. These goals include initial approval, inventory of outdated monitors, new monitor selection, capital expense request with replacement schedule, replacement of monitors, guideline/policy development, EHR flowsheet and BPA development, educational plan, go-live, and continued management and support.

Physician and nursing success will be determined by satisfaction of the new flowsheet and clinical decision support system (CDSS), respectively, and will be measured using the System Usability Scale (SUS) (Appendix A). “The principal value of the SUS is that it provides a single reference score for participants’ view of the usability of a product or service” (Martins, Rosa, Queirós, Silva, & Rocha, 2015). It is also a validated tool with consistent reliabilities over 0.90 (Lewis & Sauro, 2017). Nursing success will secondarily be measured by flowsheet usage as determined by monthly chart audits with a target score of 90%. This process will be discussed in more detail under the “Data Collection Methods” section.

Patient outcome success will be measured by a reduction in the percentage of in-hospital cardiac arrests with an initial rhythm of TdP. An audit of hospital code blue records for the year prior to go-live will be conducted by the project lead. On-going audits will continue monthly by the project lead or a designee. These numbers will be graphed and trended using Excel and distributed to the team and nursing units after each update. This will give stakeholders feedback as to how they are helping to improve patient outcomes and may improve intrinsic motivation (Greenhalgh et al., 2017).

Timetable/Flowchart

The first step to implement the recommendations would be to propose and get approval from the Executive Leadership of the hospital. Once approved, an inventory of all of the monitors in the ICU and ED will need to be conducted to determine which, if any, patient monitors have the needed functionality of assessing the QT/QTc interval. One week will be allocated for the proposal, approval, and inventory process. Next, three months will be given to decide which new monitor will replace the outdated ones since this will involve request for proposals and evaluations. Bedside nurses will be brought in to provide feedback as this will improve stakeholder buy-in. Once this is done, a capital expense request will need to be submitted to obtain the needed funds to purchase the new monitors. A buying schedule to replace the monitors that do not have the needed capabilities will need to be developed. Two weeks will be allotted to complete the capital expense request and buying schedule. Procurement of the monitors will most likely need to be spread out over a period of time, approximately nine months to two years should be sufficient. This will ensure that all monitors are replaced in a timely fashion while meeting budgetary requirements.

Guidelines/policies will need to be instituted in the critical care departments regarding ECG monitoring and patients at high risk for developing a-LQTS. Policies are important as they allow managers and nurses to know what is expected. They are normally developed to follow current evidence-based practice or regulatory standards (Dols et al., 2017). Since the new guidelines/policies will need to be approved by multiple committees, six months will be given to accomplish this task.

A flowsheet and CDSS will need to be developed within the EHR. Besides initial approval, this is the most essential phase of the project. Seven months will be allocated to complete these builds. Having access to all of this data would be meaningless without being able to track the QT/QTc interval trends, therefore the flowsheet will need to have this capability. Whether the QT interval is entered manually or is automatically sent from the monitor to the

EHR, the QTc interval can be automatically calculated in a preprogrammed data field. An alert will also need to be set up to notify the physician and nurse for any increase of the QTc interval over 500ms or greater than 60ms or more over baseline. Having a graph of the QTc interval will provide a quick a visual representation of how this interval has changed over time.

Informaticists will need to develop the CDSS with physician and pharmacist input. The CDSS will need an alert to notify the physicians and pharmacists whenever a possible combination of medications and/or lab results could adversely affect the patient. Physicians and pharmacists will need to determine which medications and medication combinations will need to have this notification. Involving the physicians in this process will help with provider acceptance of the notifications as they will be able to review and accept the supporting evidence to the recommendations, see they are relevant to their patients, and understand that the patient populations are similar (Seneviratne et al., 2019). These functions will allow modification of the treatment regimen to prevent adverse outcomes such as TdP or death.

An educational plan will also need to be developed and implemented. Education of the bedside nurses is of utmost importance as this will increase organizational competence and communication to the stakehholders, which are two main factors in project success (Radujković & Sjekavica, 2017; Butt, Naaranoja, & Savolainen, 2016). An educational power point on the importance of QT/QTc interval monitoring is already being developed by the Nursing Education and Professional Development (NEPD) department for critical care nurses and telemetry technicians due to the annual dysrhythmia exam being revised. Development began the last week of March 2020 and should be deployed in the Learning Management System (LMS) no later than the end of May 2020 after approval has been obtained from the LMS Governance Committee, of which the NEPD Directors are members. Appropriate QT/QTc education for physicians and pharmacists will need to be developed by the physician educator and pharmacy director, respectively. Education will also need to be developed for the new guideline/policy and will need to be completed before go-live of the new EHR flowsheet. The NEPD department will also need to develop training material, and then find and educate superusers on the new flowsheet before go-live. Finding unit superusers will start once approval is obtained for the project and should not be a problem as this activity will help nurses gain points towards their Clinical Advancement Program requirements. Two months should be enough time to train superusers to the new flowsheet and is the reason why the education to the new guideline/policy needs to be complete before the build is finished.

The last project management objective is go-live. Go-live will be scheduled for one year after initial approval for the project is granted. Unit support after go-live will continue for two weeks and IT Help Desk will continue indefinitely. The proposed timeline for this project is shown in Appendix B.

Data Collection Methods

Data will be collected from stakeholders (i.e. physicians and nurses), the EHR, and patient outcomes to determine project success. Physician and nurse satisfaction data will be obtained using the SUS. Ten physicians and two nurses from each inpatient unit and ED will be randomly selected to complete the initial survey with those same people completing all surveys afterwards. Clinical Informaticists will give out and grade the SUSs every three months until an average score of 80 is achieved. This will be indicative of project success and relates to an “A” rating (Lewis & Sauro, 2017). The SUS will also be analyzed using the Mann-Whitney-Wilcoxon test to determine statistical significance since it will be using ranked ordinal data.

Mann-Whitney-Wilcoxon tests have been shown to have sufficient power with low Type 1 errors rates with these analyses (Polit & Beck, 2017; de Winter & Dodou, 2010).

Monthly chart audits done by the Nursing Clinical Coordinators (NCCs) will gather data on flowchart usage. Ten random charts from their unit will be selected and analyzed. Percent usage will be tracked using Excel with the results displayed on each unit to help ensure flowchart use. Target percentage score for each unit will be 90%. If nurses are not following the new guidelines/policies, they will need to be held accountable by their managers.

Since patient outcome success will be measured by a reduction in the percentage of in-hospital cardiac arrests with an initial rhythm of polymorphic ventricular tachycardia/TdP, an audit of hospital code blue records for the year prior to go-live will be conducted. On-going monthly audits will be done so the numbers can be graphed and trended using Excel. These trends will then be distributed to all nursing units giving all stakeholders feedback.

Cost/Benefit

The largest cost for this project will be from the new monitors and employee time. Based on an old quote, replacing the monitors in the ED will cost approximately $80,000. Biomed will take about a month of work time to change out all of the monitors. With an average salary of $25 per hour, this will cost $4,000 (Indeed.com, 2020). Building the Epic flowsheet and practice alert will take two Nursing Informaticists roughly seven months. Median salary for a Nurse Informaticist is $85,000 per year, equating to an approximate cost of $99,000 (Payscale.com, 2020). One Nursing Educator will need to devote roughly one month of total work time to this project costing about $6,300 (ZipRecruiter.com, 2020). Giving one hour of total education time for each of the roughly 120 critical care nurses will cost around $4,200 (Nursejournal.org, 2020).

Adding up all of these main costs puts the total for this project around $200,000 from start to go-live.

Non-tangible benefits for this project include the possibility of saving one or more person's life. As stated previously, there are an estimated 15,000 deaths each year in the United States because of TdP (Dave et al., 2017). Preventing one of those deaths could have tangible benefits in saving hundreds of thousands of dollars if it avoids a lawsuit. Nursing leadership needs to listen to staff when they bring up a process or problem that is at high risk for causing harm (Cooper, 2016). Nursing leadership is not immune to legal responsibility because they are not actually delivering the care (Cooper, 2016). In this case, a patient's family can bring a tort of negligence against an employer under the Doctrine of Respondeat Superior for failing to prevent a situation that could be reasonably anticipated and prevented since not monitoring the QT/QTc could lead to factual causation (Cavico, Mujtaba, Samuel, & Muffler, 2016). Not including legal fees, one lawsuit alone could cost up to the maximum damage cap in Texas of $750,000 (Enjuris Editors, 2020).

Discussion

As of this semester, the main aspect of creating a new flowsheet in the EHR has not been started. However, there has been some progress made. Annual and new hire dysrhythmia testing for critical care nurses will now include scenario-based questions on QT prolongation. These nurses will be assigned educational material to help prepare for this test. Education is the first step to changing practice to make care safer for patients as it teaches the "Why" behind the importance of this change. Education is vital in supporting programs that improve patient outcomes (Gavine et al., 2016) because staff need to be able to learn how to use these new tools to achieve implementation aims (Rohrer Vitek et al., 2017). This education will be very timely as treatment for COVID-19 includes using hydroxychloroquine and azithromycin (American Heart Association [AHA], 2020). Guidance from the AHA, the American College of Cardiology (ACC), and the Heart Rhythm Society (HRS) regarding the use of this treatment regimen includes ECG/QT interval monitoring, correcting electrolyte abnormalities, and avoiding other QTc prolonging medications whenever possible (AHA, 2020).

Recommendations

Recommendations will be to implement QT/QTc monitoring, create an EHR flowsheet and CDSS, and change outdated beside monitors that do not have the capability to monitor QT intervals as soon as possible. Evidence suggests that “modest QTc prolongation in middle-aged and older adults may serve as an early marker for serious cardiovascular events and death” and that the QTc should be routinely assessed like other vital signs (Giudicessi, Noseworthy, & Ackerman, 2019). Therefore, QT/QTc interval monitoring should be added as a routine vital sign to be evaluated at the same time as pulse, respirations, etc. for any patient on ECG monitoring, or at the least every four hours when assessments are charted. EHR flowsheet and CDSS creation will take time but will allow healthcare workers the ability to track and trend QT/QTc intervals. This will help guide treatment to reduce unwanted patient outcomes such as QT prolongation. Changing monitors will also take time but will allow nurses to know immediately if the QT interval increases to over 500ms and to download directly into the EHR.

Conclusion

QT/QTc monitoring has the ability to reduce incidences of unnoticed QT/QTc prolongation that could lead to ventricular tachyarrhythmias and death. Medication administration is the most common cause of QT prolongation which disproportionally affects the more vulnerable ICU patients. Instituting this one change in practice has the potential to save 15,000 people, if done nationally, while reducing liability for nurses and hospitals.

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Appendix A: System Usability Scale

The System Usability Scale Standard Version		Strongly Disagree	1	2	3	4	5 Strongly Agree
1	I think that I would like to use this system frequently.		O	O	O	O	O
2	I found the system unnecessarily complex.		O	O	O	O	O
3	I thought the system was easy to use.		O	O	O	O	O
4	I think that I would need the support of a technical person to be able to use this system.		O	O	O	O	O
5	I found the various functions in this system were well integrated.		O	O	O	O	O
6	I thought there was too much inconsistency in this system.		O	O	O	O	O
7	I would imagine that most people would learn to use this system very quickly.		O	O	O	O	O
8	I found the system very awkward to use.		O	O	O	O	O
9	I felt very confident using the system.		O	O	O	O	O
10	I needed to learn a lot of things before I could get going with this system.		O	O	O	O	O

(Lewis & Sauro, 2018)

Appendix B: Timeline

Figure 1: Gantt Chart

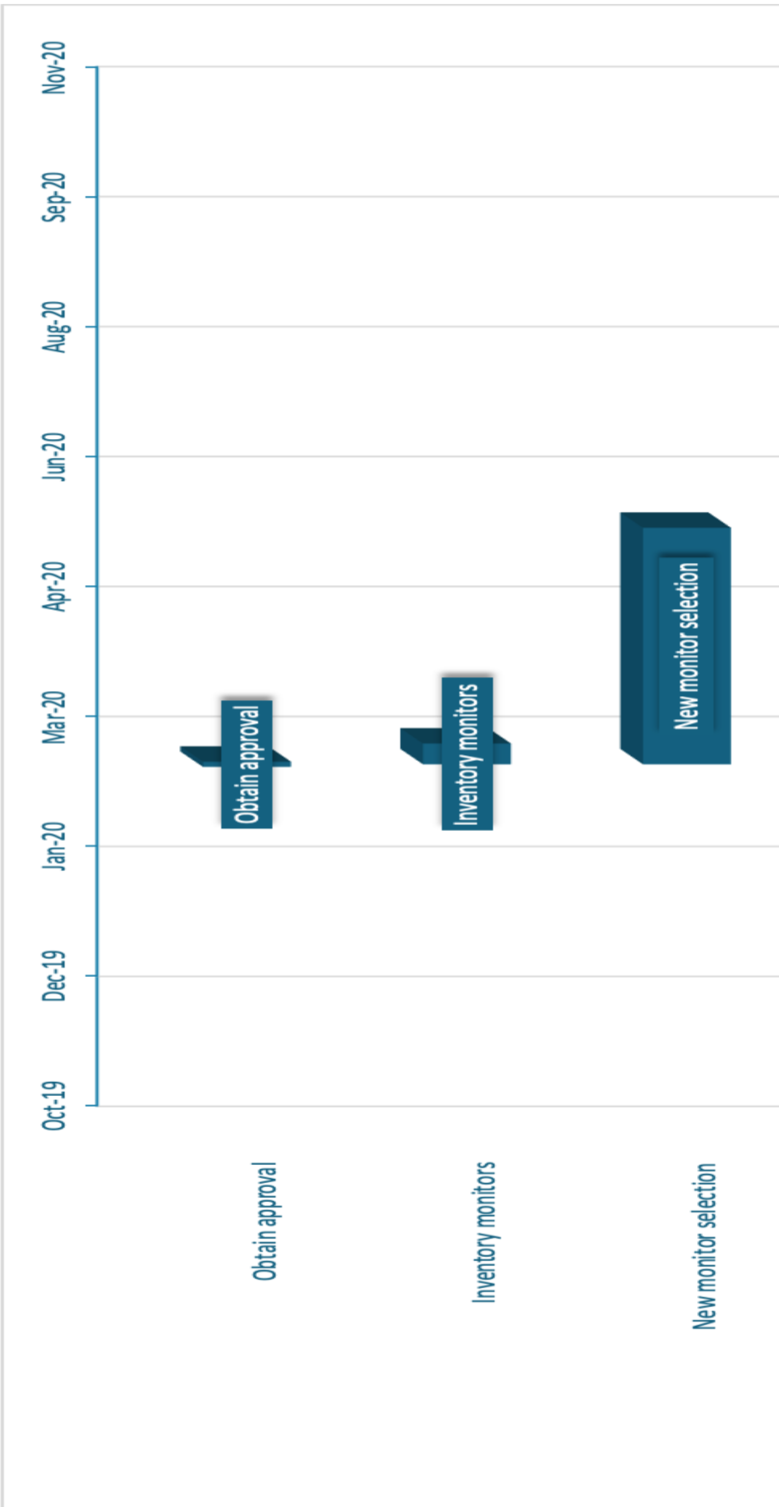

Figure 2: Gantt Chart (continued)

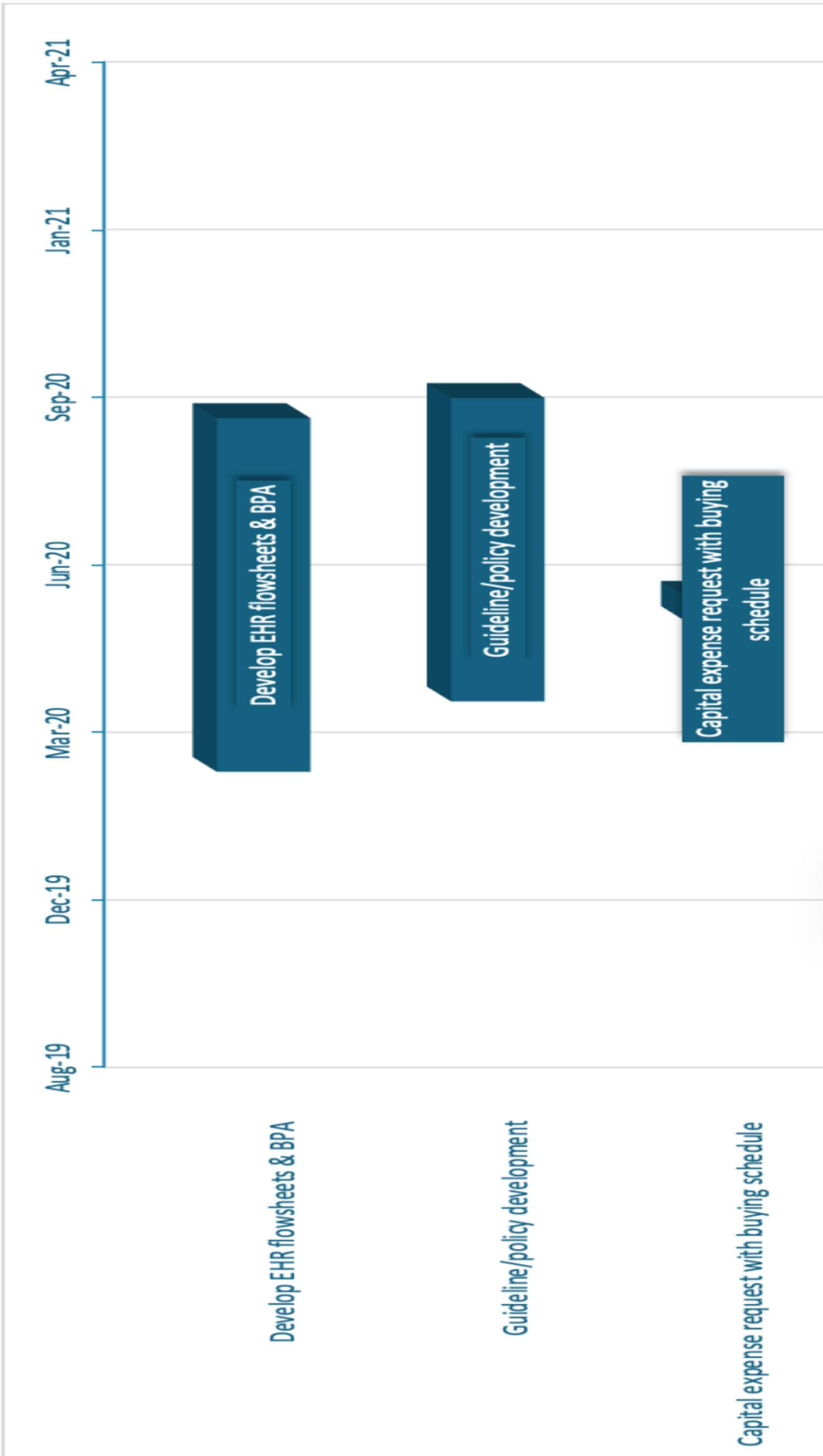

Figure 3: Gantt Chart (continued)

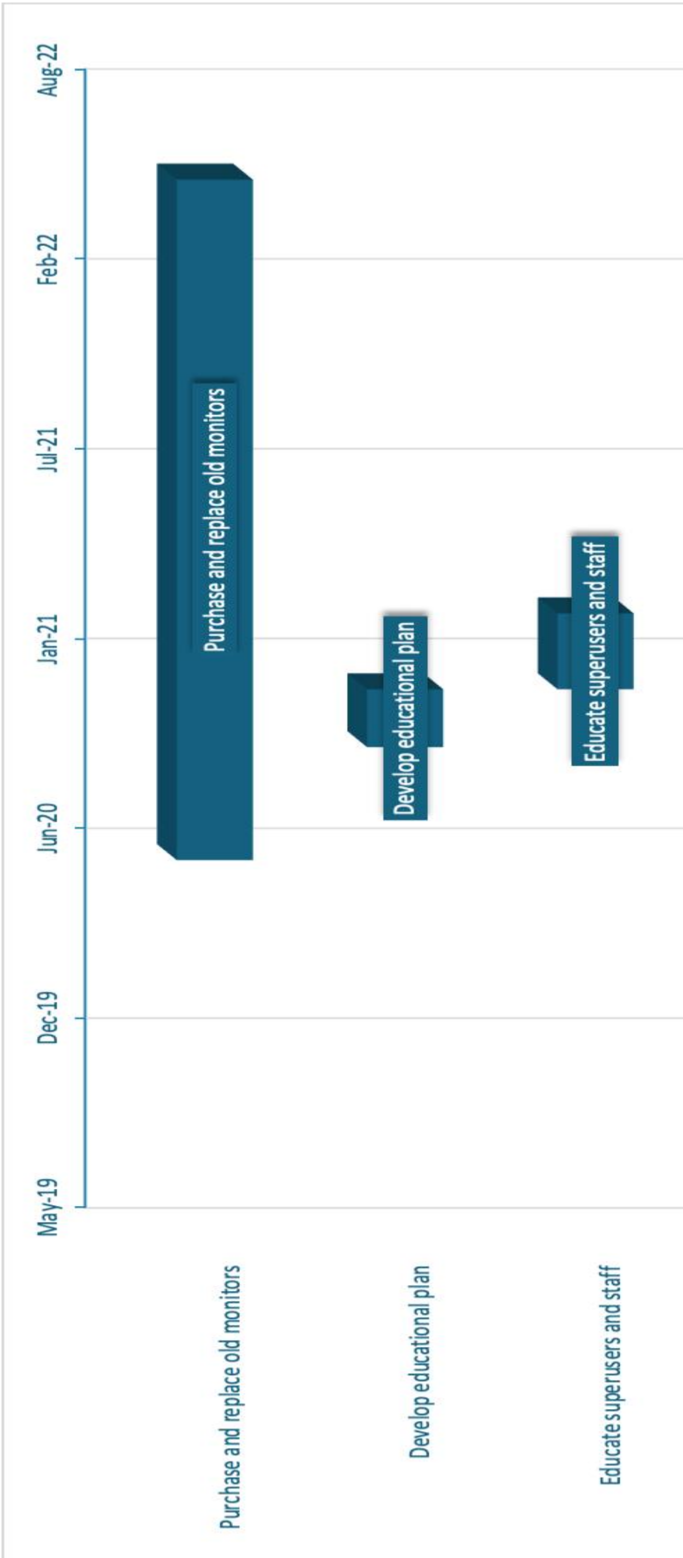

Figure 4: Gantt Chart (continued)