1-1-2018

Improving Adherence to the European Society of Cardiology’s 24-Hour to Coronary Angiogram Guideline

Rachel Malone
rachelmalone@rcsi.ie

Citation
Malone R. Improving Adherence to the European Society of Cardiology’s 24-Hour to Coronary Angiogram Guideline [MSc Dissertation]. Dublin: Royal College of Surgeons in Ireland; 2018.

This Dissertation is brought to you for free and open access by the Theses and Dissertations at e-publications@RCSI. It has been accepted for inclusion in Masters theses/dissertations - taught courses by an authorized administrator of e-publications@RCSI. For more information, please contact epubs@rcsi.ie.
Creative Commons Licence:

This work is licensed under a Creative Commons Attribution-Noncommercial-No Derivative Works 4.0 License.

This dissertation is available at e-publications@RCSI: https://epubs.rcsi.ie/mscttheses/135
Improving Adherence to the European Society of Cardiology’s 24-Hour to Coronary Angiogram Guideline

MSc Physician Associate Studies Year 2

Submitted in Part Fulfilment of the Degree of MSc in Physician Associate Studies, RCSI.

Student Name: Rachel Malone
Student ID: 16164946
Submission Date: 19th of September 2018
Word Count: 13198
Supervisor: Dr Pauline Joyce
Declaration Form

I declare that this dissertation, which I submit to RCSI for examination in consideration of the award of a higher degree MSc Physician Associate Studies, is my own personal effort. Where any of the content presented is the result of input or data from a related collaborative research programme this is duly acknowledged in the text such that it is possible to ascertain how much of the work is my own. I have not already obtained a degree in RCSI or elsewhere on the basis of this work. Furthermore, I took reasonable care to ensure that the work is original, and, to the best of my knowledge, does not breach copyright law, and has not been taken from other sources except where such work has been cited and acknowledged within the text.

Signed:

[Signature]

Date 19/09/2018
Table of Contents:

Declaration Form........................................................................................................ i

Acknowledgements ................................................................................................. vi

Abstract .................................................................................................................... vii

List of Abbreviations ............................................................................................... viii

Chapter 1.0: Introduction......................................................................................... 1

1.1 Introduction........................................................................................................ 2

1.2 Acute Coronary Syndrome and High-Sensitive Troponin Bloods............... 2

Table 1: Table describing how to classify a patient’s NSTEMI ........................... 3

1.3 Organisational Context ................................................................................... 4

Table 2: Staffing of the ED...................................................................................... 4

1.4 Rationale for the Quality Improvement Project........................................... 5

1.5 Aim and Objectives ....................................................................................... 6

1.5.1 Aim........................................................................................................... 6

1.5.2 Objectives: ............................................................................................... 7

1.6 The Role of the Physician Associate in the Organisation and the Project.... 7

1.7 Summary ......................................................................................................... 8

Chapter 2.0: Literature Review............................................................................. 9

2.1 Introduction....................................................................................................... 10

2.2 Search Strategy: ............................................................................................ 10

2.3 Review of Themes .......................................................................................... 11

2.3.1 Benefits of High-Sensitive Troponin Bloods Initiated in Triage .............. 11

2.3.2 Achieving Adherence to Evidence-Based Guidelines ............................. 13

2.3.3 High-Sensitive Troponin Bloods Protocols.............................................. 15
bloods orders................................................................................................................................................. 35

Figure 6: Bar chart of the number of troponin bloods taken by triage and the ED doctor and
post triage nurse assessment ............................................................................................................................ 35

3.4.3.2 Staff and Patient causes of Increased NSTEMI Management Times.............................................. 36

3.4.3.3 Environmental Causes of Increased NSTEMI Management Times................................................. 36

Figure 7: Stacked bar chart of the mean and median times of each stage of NSTEMI
management in the ED..................................................................................................................................... 37

3.4.3.4 Value Stream Mapping.......................................................................................................................... 37

Figure 8: VSM of the process flow of ED NSTEMI management with nurse assessment included
Figure 9: VSM of the process flow of NSTEMI management in the ED without nurse
assessment ........................................................................................................................................................ 40

Figure 10 VSM of the prioritised troponin bloods analysis pathway through the Biomedical
Laboratory .......................................................................................................................................................... 41

Figure 11: Scatter diagram of the wait times from taking troponin bloods to receiving results .......... 41

3.4.4 Improve .............................................................................................................................................. 42

Table 5: Overview of the utilisation of the DMAIC QIP model................................................................. 42

3.4.4.1 Driver Diagram: ................................................................................................................................. 42

Figure 12: Driver diagram (thicker arrows represent the most relevant information) ......................... 43

Figure 13: Example of the high-sensitive troponin bloods protocol proposed for use by this QIP
(also to be displayed on Q-pulse, the project site’s medical E guides, on the wall of the ED and
on the wallet card ........................................................................................................................................... 46

Figure 14: NSTEMI checklist for patient notes ........................................................................................... 48

3.5 Summary: ............................................................................................................................................. 49

Chapter 4.0: Evaluation ............................................................................................................................... 50

4.1 Introduction............................................................................................................................................ 51

4.2 Overview of the QIP: ................................................................................................................................. 51

4.3 Evaluation ............................................................................................................................................... 53

4.3.1 Aim of the Control Phase and DMAIC Model ......................................................................................... 53

iv
4.3.2 Monitoring and Review ................................................................. 53
4.3.3 Expected Results ...................................................................... 56
4.4 Dissemination Plan ..................................................................... 57
4.5 Summary: .................................................................................... 57

Chapter 5.0: Discussion and Conclusion ............................................ 59

5.1 Introduction ................................................................................. 60
5.2 Project Impact ............................................................................ 60
5.2.1 Stakeholders .......................................................................... 60
5.2.2 Practice .................................................................................. 61
5.3 Strengths of the Project ............................................................... 62
5.4 Limitations of the Project: ........................................................... 63
5.5 Recommendations : .................................................................... 63

Figure 15: Potential future ED NSTEMI process flow due to the possible implementation of the NICE and ESC recommended high-sensitive troponin bloods protocol................................................. 65

5.6 Learning about Quality Improvement ........................................... 65
5.7 Summary and Conclusion ............................................................ 66

References ....................................................................................... 69

Appendices ....................................................................................... 85

Appendix 1: Gantt Chart .................................................................. 85
Appendix 2: ED Healthcare Hierarchy Structure for NSTEMI Management ......................................................... 86
Appendix 3: Potential Future ED Healthcare Hierarchy Structure for NSTEMI Management ......................................................... 87
Appendix 4: Graphs Demonstrating Further Analysis Completed ......................................................... 88
Appendix 5: Staff Satisfaction Feedback Form: ................................... 91
Appendix 6: Patient Satisfaction Feedback Form .................................. 92
Acknowledgements

I owe an immense debt of gratitude to my MSc. dissertation supervisor, Dr Pauline Joyce, academic director of the MSc in physician associate studies at the Royal College of Surgeons in Ireland for her vital support and advice, which was very instrumental in steering the QIP in the right direction.

I am grateful to Professor Brendan McAdam, consultant cardiologist for granting the necessary permission to undertake the quality improvement project, for providing guidance on an appropriate quality improvement aspect to be addressed and for imparting valuable cardiology knowledge to me.

I would like to thank the cardiology team and in particular Noel Fitzpatrick, (cardiology registrar) for providing helpful advice on the management of patients with NSTEMIs.

I would like to thank my family particularly my parents Evelyn and Declan for continuous encouragement and support and my brother Ciaran for reading a draft version of the dissertation and providing helpful feedback.
**Abstract:**

Healthcare accessibility in Ireland is the worst in Europe. The project site (north Dublin teaching hospital), had over 700 Emergency Department (ED) Non-ST-Elevated Myocardial Infarctions (NSTEMIs) in 2017. These NSTEMI's were associated with increased times to Coronary Angiogram (CA), when compared to the European Society of Cardiology's (ESC) 24-hour to CA guideline. Increased time to CA is associated with increased mortality. Using Lean Six Sigma (LSS) tools within the DMAIC (Define, Measure, Analyse, Improve, and Control) Quality Improvement (QI) model, the root causes of increased times to CA times were identified. One cause found was the use of non-high-sensitive troponin bloods to aid diagnosis of an NSTEMI. Process flow timing was analysed using patient data and value stream mapping. Results demonstrated 35% compliance with the ESC's 24-hour to CA guideline for high-risk NSTEMIs. The project site is bringing high-sensitive troponin blood analysis into practice. Analysis of a driver diagram resulted in a proposal of a National Institute for Health and Care Excellence (NICE) and ESC high-sensitive troponin protocol for triage to aid adherence to the ESC's 24-hour to CA guideline. When compared to non-high-sensitive troponin bloods taken in triage, high sensitive troponin bloods taken in triage allows for earlier diagnosis of an NSTEMI. Many strategies are also proposed to aid achieving adherence to the high-sensitive troponin protocol e.g. displaying the protocol on the projects site's smart-phone application. Some expected outcomes include: decreased time to CA and decreased patient complications. Some proposed control methods include data re-measurement and patient surveys.
List of Abbreviations:

ACS: Acute Coronary Syndrome
Cinahl: Cumulative Index of Nursing and Allied Health Literature
DMAIC: Define, Measure, Analyse, Improve, and Control
EBSCOnhost: Research database platform
EMBASE: Excerpta Medica Database
ESC: European Society of Cardiology
GRACE: Global Registry of Acute Coronary Events
HIPE: Hospital Inpatient Enquiry System
KPI: Key Performance Indicators
MINAP: Myocardial Ischaemia National Audit Project
NSTEMI: Non-ST Elevation Myocardial Infarction
PIPE: Patient Information Profile Explorer
Q-Pulse: The project site’s computerised online protocol programme
RAT: Rapid Assessment and Treatment
SCOPUS: Elsevier abstract and citation database
STEMI: ST-Elevation Myocardial Infarction
TIMI: Thrombolysis In Myocardial Infarction (Risk Score)
Chapter 1.0: Introduction
1.1 Introduction

This chapter provides an introduction to the Quality Improvement Project (QIP) that was undertaken. Acute Coronary Syndrome (ACS) and high-sensitive troponin bloods are explained. Included also is the organisational context in which the project was conducted, the QIP’s rationale, and the aims and objectives of the QIP. Also outlined is a role description of the Physician Associate (PA) in the organisation and in the QIP.

1.2 Acute Coronary Syndrome and High-Sensitive Troponin Bloods

ACS is an umbrella term used to describe the different kinds of myocardial infarctions (heart attacks). An ST-Elevation Myocardial Infarction (STEMI), Non-ST Elevation Myocardial Infarction (NSTEMI), and unstable angina come under this classification. Troponin is a protein that increases in the blood if there is damage to the heart muscle cells (Lindert et al., 2015), thus a troponin blood test can help diagnose ACS. An NSTEMI is typically diagnosed by Chest Pain (CP), a raised troponin and an ECG that is initially normal or demonstrates T wave inversion/flattening, ST depression, transient ST elevation, or non-specific changes (Hamm et al., 2011).

This QIP focuses on improving adherence to the ESC’s (Roffi et al., 2016) 24-hour to Coronary Angiogram (CA) guideline. The ESC’s 24-hour to CA guideline only applies to patients with an NSTEMI who are high-risk. An NSTEMI can be classified as high-risk (i.e. an increased chance of negative patient outcomes due to a
blockage in an artery) by having one of the listed criteria in the high-risk category in Table 1. Non-high-sensitive troponin analysis assays can require blood to be taken three times from the patient (in triage, and at 6 hours and 12 hours post triage) (Thygessen et al 2010). This method is standardised and does not have process variability. That said, it also results in patients being admitted for multiple troponin blood tests. High-sensitive troponin bloods can allow for an earlier NSTEMI diagnosis when bloods are taken in triage using a high-sensitive troponin triage protocol. This protocol can thus increase adherence to the 24-hour to CA guideline (Boeddinghous et al, 2016). This is due to its ability to detect much lower levels of troponin in the blood (Roffi et al, 2016).

<table>
<thead>
<tr>
<th>Very-High Risk Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemodynamic instability or cardiogenic shock</td>
</tr>
<tr>
<td>Recurrent or ongoing chest pain refractory to medical treatment</td>
</tr>
<tr>
<td>Life-threatening arrhythmias or cardiac arrest</td>
</tr>
<tr>
<td>Mechanical complications of MI</td>
</tr>
<tr>
<td>Acute heart failure</td>
</tr>
<tr>
<td>Recurrent dynamic ST-T wave changes, particularly with intermittent ST elevation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High-Risk Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise or fall in cardiac troponin bloods compatible with an MI</td>
</tr>
<tr>
<td>Dynamic ST or T wave changes (symptomatic or silent)</td>
</tr>
<tr>
<td>GRACE Score &gt;140</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Intermediate-Risk Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes mellitus</td>
</tr>
<tr>
<td>Renal insufficiency (eGFR &lt; 60mL/min/1.73m²)</td>
</tr>
<tr>
<td>LVEF &lt; 40% or congestive heart failure</td>
</tr>
<tr>
<td>Early post-infarction angina</td>
</tr>
<tr>
<td>Prior PCI (Percutaneous Coronary Intervention)</td>
</tr>
<tr>
<td>Prior CABG (Coronary Artery Bypass Graft)</td>
</tr>
<tr>
<td>GRACE risk score &gt;109 and &lt;140</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Low-Risk Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any characteristics not mentioned above</td>
</tr>
</tbody>
</table>

Table 1: Table describing how to classify a patient’s NSTEMI
1.3 Organisational Context

The hospital where this QIP was carried out (referred to as the project site from here forward) is a public voluntary hospital located north of Dublin city centre. The project site’s catchment area is north Dublin, north county Dublin and Fingal (290,000 people). It is affiliated with a private hospital in Raheny (48 beds). The project site employs approximately 3,000 staff, has 820 beds and is one of the principal teaching hospitals affiliated to the Royal College of Surgeons in Ireland (RCSI). The Emergency Department (ED) provides service to 45,000 patients, 24-hours a day, 365 days a year. Table 2 outlines the ED’s staffing. The ED accommodates 56 patients along with a waiting room that seats 44 people.

<table>
<thead>
<tr>
<th>Staffing of the Emergency Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 ED Consultants</td>
</tr>
<tr>
<td>2 ED Registrars</td>
</tr>
<tr>
<td>2 Associate Specialist Registrars</td>
</tr>
<tr>
<td>3 Senior House Officers</td>
</tr>
<tr>
<td>1 Intern</td>
</tr>
<tr>
<td>5 ED Advanced Nurse Practitioners (ANP)</td>
</tr>
<tr>
<td>3 Cardiac ANPs</td>
</tr>
<tr>
<td>1 Rapid Access and Treatment Team</td>
</tr>
<tr>
<td>15 ED Nurses (including 1 triage nurse)</td>
</tr>
<tr>
<td>1 General Practitioner Liaison Nurse</td>
</tr>
<tr>
<td>4 ED Receptionists</td>
</tr>
<tr>
<td>2 Porters</td>
</tr>
<tr>
<td>1 Cleaner</td>
</tr>
</tbody>
</table>

Table 2: Staffing of the ED
1.4 Rationale for the Quality Improvement Project.

According to the Central Statistics Office (2018), heart disease due to ischaemia (lack of blood supply to the heart) accounted for 14% of deaths in Ireland in 2017. The ESC (Roffi et al., 2016) published a guideline for patients with a high-risk NSTEMIs. It recommends that these patients should have a CA within 24-hours. As a Physician Associate (PA) student on placement, the writer observed increased management times for high-risk patients with an NSTEMI and thus decreased adherence this ESC 24-hour to CA guideline. Health Information and Quality Authority's (HIQA, 2012) standard 1.2 explains that service users care should be based on their assessed needs. HIQA also advocate that service users are entitled to access care at the correct time. With regards to NSTEMI's, immediate invasive therapy is linked with decreased complications (Gorenek et al., 2015). It is also linked to decreased mortality (Sorajja et al., 2010) thus these patients are entitled to have a CA within 24-hours.

Ireland's population is rising. This is reflected in the project site's numbers, as they show an increase in hospital service demands from 2015-2016: ED presentations increased from 49,920 to 53,313. This increases overcrowding at the project site. Overcrowding leads to the escalation of treatment due to longer wait times. These longer wait times are associated with a worse patient prognosis (Milosevic et al., 2016). Ireland's elderly population (over 65) is also increasing (20% increase since 2011) (CSO, 2016). As advancing age is a risk factor for an MI (Eidgahi et al., 2018), this leads to more ED NSTEMI presentations. Ireland is ranked last for accessibility to healthcare in Europe (Bjornberg, 2017). It is possible for industrialised countries such as the United States to achieve 90% successful compliance with a 6 hour to
discharge rule and other countries with little to no resources to have short patient wait times (Horwitz et al, 2010, Bjornberg, 2017). Ireland should therefore, be able to achieve shorter overall wait times.

The HSE (2012-a) and the Royal College of Physicians in Ireland (RCPI) acknowledge the benefits of a CA within 24-hours for patients with a high-risk NSTEMI. They aim to reduce time to CA and negative patient outcomes via standardisation of care. ED staff play a central role in reducing times to treatment (McGrath et al 2018). Investigating how to better utilise the ED staff's time, could possibly lead to achieving the HSE/RCPI's aim e.g. standardisation. Quality improvement (QI) methods provide a standardised way to resolve a problematic issue, as they aim to improve quality of care in six domains e.g. care that is safe, efficient, effective, equitable, person-centred and timely (The Health Foundation, 2013). In summary, due to the evidenced-based rationales outlined above, the writer recognised that improvement in adherence to the ESC's 24-hour to CA guideline could be very beneficial.

### 1.5 Aim and Objectives

#### 1.5.1 Aim:

A Specific, Measurable, Achievable, Relevant and Time-bound (SMART) criteria was used to choose the following QIP aim:

To increase adherence to the ESC’s 24-hour to CA guideline by 10% within 1 year after high-sensitive troponin bloods analysis is brought into clinical practice in the QIP’s site.
1.5.2 Objectives:

The objectives of the QIP are to:

- Determine the factors causing decreased adherence to the ESC’s 24-hour to CA guideline by February 14th 2018,
- Identify possible improvement recommendations to help correct the factors causing decreased ED adherence to the ESC’s 24-hour to CA guideline by the 16th of May 2018,
- Establish strategies to aid increased staff implementation of one proposed recommendation for potential implementation by the 1st of July 2018

1.6 The Role of the Physician Associate in the Organisation and the Project

The writer of this QIP is a year two PA student on 3 weekly rotations in multiple different hospitals. It was the writer’s role as a student, in each hospital, to shadow medical teams. The writer’s role as part of the QIP involved submitting a project proposal, obtaining sign off to complete the QIP, conducting a literature review. The QIP also involved using the DMAIC model to find a possible improvement recommendation and also strategies to help ensure adherence to this recommendation. It is hoped through the completion of the above tasks with the help of a Gantt chart (Appendix 1) that the aims and objectives of the QIP will be achieved. Following communication with the Multi-Disciplinary Team (MDT) and QI staff, a specific QIP aim emerged; to increase adherence to the ESC’s 24-hour to CA guideline by 10% within 1 year after high-sensitive troponin bloods analysis is brought into clinical practice in the QIP’s site.
High-sensitive troponin bloods allow for early diagnosis of an NSTEMI when they are taken in triage, thus could lead to a reduction in the time to CA (Boedinghous et al., 2016). These bloods are therefore expected to increase the adherence to the ESC’s (Roffi et al., 2016) 24-hour to CA guideline. It was decided to propose the implementation of the NICE (2014-a) and ESC (Roffi et al., 2016) high-sensitive troponin bloods protocol (which includes high-sensitive troponin bloods being taken in triage). Strategies to help achieve adherence to this protocol are also proposed e.g. displaying the new protocol on a wall in the ED.

1.7 Summary

This chapter defined ACS and the relevance of the high-sensitive troponin to its management. The chapter also set out the QIP’s organisational context. The rationale as to why QI is necessary for the management of high-risk NSTEMIs in the project site was outlined, and the aims and objectives of the QIP were described. The role of the writer in the organisation and the QIP was also discussed. The next chapter discusses pertinent studies, official reports and internationally accepted guidelines relevant to the QIP. Also delineated are the implications that these studies, reports and guidelines had on the direction of the QIP.
Chapter 2.0: Literature Review
2.1 Introduction:

This chapter outlines the search strategy used to research for pertinent dissertation topics. It discusses studies, official reports and guidelines relevant to the QIP. The implications the literature review had on the development of the QIP is also discussed.

2.2 Search Strategy:

Google Scholar was used to find relevant studies for this QIPs literature review. A publication date of less than 5 years was used as an initial inclusion criterion. A large number of studies were published around 9 years ago as the high-sensitive troponin bloods analysis was first being considered to be brought into practice at this time. The inclusion criterion was therefore adjusted to a date of publication of less than 9 years.

EBSCO (online database platform) was searched through the RCSI database website. A keyword search was completed using terms such as “quality improvement”, and “high-sensitive troponin bloods”. Also undertaken, was a subject heading search. The keyword and subject heading search of the same word were combined using an “OR” search. The two combined “OR” searches were then combined again using an “AND” search The combined searches yielded focused results.

The same search strategy was applied in PubMed, and the Excerpta Medica Database (Embase). Scopus (database) was used to check for well-cited studies.
The literature review is comprised of 16 studies, 1 opinion piece, 1 randomised control trial and 1 position paper. The writer also used google to search for relevant reports from official organisations and official healthcare guidelines. Irish, European, American and other international studies are included in the literature review. The British Medical Journal and the European Heart Journal are examples of some of the journals incorporated into the literature review. The themes that emerged from reviewing the literature included: Benefits of high-sensitive troponin bloods initiated in triage, achieving adherence to evidence-based guidelines and high-sensitive troponin bloods protocols.

2.3 Review of Themes:

2.3.1 Benefits of High-Sensitive Troponin Bloods Initiated in Triage

Quality healthcare is safe, effective, efficient, timely, equitable and patient-centred (The Health Foundation, 2013). The Government of Ireland (2017) emphasise that Irish ED wait times are unacceptable. This may lead patients to access care privately. According to HIQA (2017), 77% of patients in the project site were waiting more than 6 hours for ED discharge to a ward, thus it is difficult to access timely care when it involves an ED admission. An improvement that could reduce the project site’s ED NSTEMI management times is thus imperative.

A study by Twerenbold et al, (2017) of 6 European countries demonstrated that 75% of NSTEMI diagnoses can be ruled out within 1 hour of presentation by taking high-sensitive troponin bloods. When high-sensitive troponin bloods are taken again at 3 hours post presentation the blood test can make a correct diagnosis approximately
100% of the time. This would allow for earlier prioritisation of patients with an NSTEMI (Giannitsis et al. 2010) and could possibly allow for earlier assessment by the cardiology team. This would be especially true if troponin bloods were taken in triage as it allows for the early identification of a rise in troponin in the blood (timely domain of QI). A prospective multi-centre study by Reichlin et al. (2009) compared the accuracy of non-high-sensitive troponin bloods assays and four sensitive or high-sensitive troponin bloods assays. The study demonstrates that non-high-sensitive troponin bloods take 12 hours post the patient's presentation time to reach the same diagnostic accuracy, as the more sensitive troponin bloods at 2 hours post the patient's presentation time. This study shows that taking high-sensitive troponin bloods could decrease waste time in diagnosing patients with an NSTEMI (efficiency QI domain). Waste time in NSTEMI management is the amount of time within NSTEMI management that is not used productively (HSE, 2012-b).

According to HIQA (2012), patients should receive care based on their assessed need. This care should commence in triage. NSTEMI’s require prompt assessment as complications e.g. life-threatening arrhythmias (Gorennek et al. 2015) and recurrent ischaemia (lack of blood supply to the heart) escalates with increased time to CA (Roffi et al. 2016). An Italian study by Lippi et al. (2017) established that non-high-sensitive troponin bloods have a 3.2 % chance of misclassifying (false positives and negatives) a patient on presentation. High-sensitive troponin bloods have a 0.5% chance of misclassification, along with a six-fold decrease in unsafe discharge. This demonstrates that high-sensitive troponin bloods could also improve safe diagnosis of an NSTEMI (safety QI domain).
It was established by Twerenbold et al, (2016) that high-sensitive troponin bloods are effective in making the correct NSTEMI diagnosis, without increasing ED CA orders. This allows for enhanced restricted resource use without impeding on quality of care i.e. do more with less (effectiveness QI domain). Early rule-out of NSTEMI diagnoses by taking high-sensitive troponin bloods is also linked to increased patient satisfaction (St John et al, 2018). This demonstrates that the high-sensitive troponin improves the patient-centred QI domain of healthcare. High-sensitive troponin bloods can detect smaller rises in troponin in the blood than non-high-sensitive troponin bloods (Giannitsis et al, 2010). This increases equitable care as smaller increases of troponin in the blood are more likely to be detected for patients having an NSTEMI who present very early. All of the above points demonstrate that the high-sensitive troponin could improve the project site’s NSTEMI care, in all the domains of QI.

2.3.2 Achieving Adherence to Evidence-Based Guidelines

Sustainable improvement can be achieved by applying evidence-based best practice procedures to healthcare practices (HSE, 2012-b), e.g. protocols for high-sensitivity troponin bloods are evidenced-based practice protocols which can identify patients at risk for adverse events (Cullen et al, 2013). HIQA (2012) deem that healthcare should mirror evidence that accomplishes best outcomes for service users, thus evidence-based practice should be implemented by staff.

The HSE (2016) highlight that quality health care is created by identifying opportunities to support patients in improving their health. Decreased adherence to
the 24-hour to CA guideline is a risk factor for life-threatening arrhythmias (Gornik et al., 2015). The impracticality of accessing information on evidence-based practice is a challenge staff face, thus any opportunities can be difficult to identify (Ballweg et al., 2013). Strategies to increase knowledge of evidence-based cardiology guidelines would therefore, be very relevant. Prior to this QIP's submission date, there were no QIP’s, audits (by the National Office of Clinical Audit), or research studies examining how to increase adherence to the ESC’s (Roffi et al., 2016) 24-hour to CA guideline, specifically aimed at the project site. It is consequently, essential that information is made available to the project site’s policymakers and QI Department staff involved in achieving quality care in each domain of QI.

The NICE (2014-a) and ESC (Roffi et al., 2016) recommend a protocol for use with high-sensitive troponin bloods. This protocol is meant as a guideline to demonstrate how high-sensitive troponin bloods could be used in clinical practice. If this guideline protocol was implemented, achieving an understanding of the guideline and compliance with the guideline would be necessary. Achieving an understanding of a high-sensitive troponin protocol before its implementation could help avoid unsafe patient discharge and incorrect early discharge of patients. Achieving an understanding of a guideline involves teamwork (Chou et al., 2011) thus engagement of frontline staff would be essential. The insight of frontline staff could disclose obstacles (HSE, 2016) that could be causing a lack of understanding (that would not be obvious to a person not working directly in the area). Education is also shown to be a cost-effective way of engaging staff by increasing awareness of a guideline (Kandler et al., 2016). Educating stakeholders regarding the benefits of new practices helps to attain good compliance with new procedures (Gray et al., 2016).
Implementation of new protocols is difficult. The Plan, Do, Study, Act (PDSA) cycle is a powerful tool which can solve specific QI problems (Reed & Card, 2016) e.g. if the evaluation of a newly implemented protocol showed decreased adherence to specific parts of the protocol. The HSE emphasises that the patient is paramount, thus, if the PDSA cycle was used to evaluate the implementation of any high-sensitive troponin bloods protocol the patient must be one of the main focuses of the PDSA cycle (Government of Ireland, 2017).

2.3.3 High-Sensitive Troponin Bloods Protocols

In 2017 almost 97,000 people attended Irish EDs (Connaghan, 2017), thus to achieve holistic NSTEMI patient assessment, a focused protocol for NSTEMI assessment is necessary. New protocols that focus on team decision-making, optimising resources and do not involve adding many extra streams to practices are successful (HSE, 2012-b). High-sensitive troponin bloods can improve an ED’s productivity when they are used with CP protocols (Than et al, 2014). Implementation of such protocols are also not associated with increased adverse patient events and they can increase patient satisfaction (Cullen et al. 2013, Hwang et al, 2015).

It is specifically recommended by the HSE (2012-b) that ACS is assessed using a Rapid Assessment and Treatment (RAT) protocol. RAT uses only one extra stream (the RAT team at peak hours), it optimises resources and involves shared communication. These protocols can also result in decreased time to pain treatment, time to first ECG, and a 70 minutes reduction in total ED time, thus they are very
useful in hospitals with high patient volumes (HSE-b, 2012). The ED of the project site has a RAT team, however, times to CA are still greater than 24-hours.

One trial by Jülicher et al. (2017) compares five different high-sensitive troponin bloods accelerated diagnostic guideline protocols. The findings included: increased diagnostic accuracy, improvements in overall ED NSTEMI management times, increased resource efficiency and lower costs when compared with a 6-hour non-high-sensitive troponin bloods protocol. Studies also discuss whether the use of a risk score is beneficial. One 2-hour accelerated diagnostic protocol uses the combination of the Thrombolysis In Myocardial Infarction (TIMI) risk-score, a non-ischemic ECG and high-sensitive troponin bloods. This protocol demonstrates that 40% of patients could be safely discharged without increasing adverse events (Cullen et al, 2013). A study by Boeddinghaus et al. (2016) in Switzerland shows that normal troponin bloods results, with no rise in troponin after 2 hours negates the need for the use of a risk score.

There is ample evidence supporting the use of a protocol-driven assessment for NSTEMIs although obvious differences in the protocols used in studies also exist, thus the NICE (2014-a) guidelines accept that one protocol will not fit every ED. The NICE guidelines (2014-a) outline guidance protocols for use with high-sensitive troponin bloods; they are not examples of best practice and hospitals are advised to use them with their own local policy. A guideline protocol they adapted from the National Health Service (NHS) suggests testing the level of troponin in the patient’s blood, completing the TIMI risk score and an ECG in triage, on patients presenting with cardiac CP. It is advised to then check for significant rise in troponin in the patient's blood 3 hours post triaging the patient (NICE, 2014-a). Another guideline
protocol published by both the British Medical Journal and NICE guidelines suggest completing an ECG and checking for a possibly abnormal troponin in the patient's blood in triage, and again up to 6 hours later (NICE, 2014-a).

The protocol of interest in this study is the only protocol recommended by both the NICE guidelines (NICE, 2014-a) the ESC guidelines (Roffi et al 2016). This guideline protocol uses the Global Registry of Acute Coronary Events (GRACE) risk score and advises to test for a possibly abnormal level of troponin in the patient's blood in triage and checking the troponin level again after 3 hours. The ESC also advocates the use of a 0-1 hour guideline protocol with a validated algorithm. This protocol considers discharging a patient after 1 hour (Roffi et al. 2016). This protocol was proven to be effective (Twerenbold et al in 2017). This 1-hour protocol however, is not recommended by the NICE guidelines (2014-a).

2.4 Implications of the Literature Review on the QIP:

Appraisal of the literature demonstrated the importance of increasing adherence to the ESC’s 24-hour to CA guideline in the project site. A decreased NSTEMI time from ED registration to CA is associated with a lower risk of adverse outcomes e.g. life-threatening arrhythmias (Gorenek et al. 2015). Increased time to invasive intervention is also a predictor of mortality (Sorajja et al, 2010). Boeddinghous et al, (2016) established that implementing a high-sensitive troponin protocol, with a high-sensitive troponin taken in triage can reduce a patient's time to CA (unlike if the non-high-sensitive troponin was taken in triage). This is because the high-sensitive troponin can diagnose an NSTEMI earlier (Roffi et al. 2016). Implementing such
protocols could therefore, increase adherence to the ESC’s 24-hour to CA guideline. The literature review revealed numerous practical benefits of taking high-sensitive troponin bloods to diagnose an NSTEMI.

2.5 Summary:

This chapter discussed the benefits of taking high-sensitive-troponin bloods, relevant protocols relating to high-sensitive troponin bloods and achieving adherence to internationally accepted guidelines relating to high-sensitive troponin bloods, with the aim to provide a rationale for this QIP. Also delineated was the implications that completing the literature review had on the direction of the QIP. The next chapter delineates the methodology used for the QIP.
Chapter 3.0: Methodology
3.1 Introduction:

This chapter describes different approaches to QI. The rationale for choosing the DMAIC (Define, Measure, Analyse, Improve, Control) model was chosen is also outlined. The chapter gives an explanation of how the DMAIC model was utilised in this QIP.

3.2 Approaches to Quality Improvement

QI has developed over the years as demonstrated by Ernest Coding. In 1914, he wrote about improving healthcare by evaluation of treatment results (Brand, 2009). Other QI methods developed later and demonstrated great success and have now been studied worldwide e.g. Taiichi Ohno’s Lean methods

3.2.1 Lean Six Sigma Methods

Lean Six Sigma (LSS) is a combination of Lean and Six Sigma methods. LSS methods use the Define Measure Analyse Improve and Control (DMAIC) QI model (Improta, et al, 2018). Lean methods focus on eliminating waste time as well as increasing the quality of care provided (Dahlgaard et al, 2011). Implementation of these methods in the ED can result in: better use of staff time, reduced ED wait times, reduced ED Length Of Stay (LOS), and fewer patients leaving the ED before being seen (NG et al, 2010). Six Sigma methods have been shown to reduce variability in healthcare processes (Pyzdek & Keller, 2014)
3.2.2 Queueing Theory

Variability in ED patient arrival times in a standard 24-hour period makes it challenging to match staffing to the number of patients in the ED. This causes increased wait times. Queueing theory can be used to balance capacity and demand (Rutherford et al, 2017). The theory has also been shown to lead to fast deterioration of performance in processes (HSE, 2012-b).

3.2.3 Lewin’s Change Management Model

Lewin’s change management model dates back to the 20th century. This model incorporates three stages. The first stage, called the unfreezing stage, entails clarifying exactly what problem exists, and it also aids others to see the need for an improvement. Stage two, called moving, incorporates creating a plan and encouraging its implementation. Refreezing, the 3rd stage, requires stabilisation of the improvement (Wallis & Chaboyer, 2012). The timing of Lewin’s Change Management model has been criticised i.e. healthcare evolves too rapidly, thus Lewin’s theory is too simplistic for today’s nonlinear and dynamic healthcare structures (Shirey, 2013).

3.2.4 Plan Do Study Act Model

The PDSA framework was founded from industry by Walter Shewhart and Edward Deming. This cycle was based on PDCA (Plan–Do–Check–Act), which established
after Deming's early Japanese teachings (Bisognano et al, 2014). PDSA cycles allow for the practice of an adapt, adopt or discard QI method (Reed & Card, 2016). The plan stage ascertains what is to be accomplished if a recommendation will be an improvement and how to achieve the improvement. The do stage involves implementing a recommendation. The check stage incorporates reflecting on the recommendation. The fourth stage (the act stage) incorporates implementing revisions according to feedback (Reed & Card, 2016). PDSA cycles have been shown to decrease admissions to the CP unit from the ED and also to aid sustained QI (Jade et al, 2015, McNamara et al, 2016). The underestimation of resources and the amount of time necessary to create success causes projects to fail (Reed & Card, 2016).

3.3 Rationale for Model Selected:

The model selected for this QIP was the DMAIC model (using LSS tools). This model was chosen as the design was deemed to be the most fitting for the QIP's objectives. One of the objectives of this QIP is to establish what factors are causing decreased adherence to the ESC's 24-hour to CA guideline. Factors such as triage assessment time could be examined during the measurement and analysis stages of the DMAIC model e.g. via the use of value stream mapping. The Improvement stage could allow for the potential implementation of improvement recommendations (Improta et al, 2017). The HSE emphasises the need for measurement of QI improvement recommendations which also reinforces the use of the DMAIC model as it has an evaluation stage (Marley et al, 2017).
The HSE (2016) highlight that models used for QI should be verified methods. The DMAIC model has been shown to reduce waste time in hospital processes (Improta et al. 2017) e.g. decreased times to doctor assessment for patients with ACS (including NSTEMIs) (Piggott et al. 2011). The application of Lean tools are demonstrated to be effective e.g. earlier diagnosis of patients with ACS (Piggott et al., 2011). Arafeh et al. (2018) demonstrated that Six Sigma tools e.g. the fishbone diagram can be used to determine the causes of increased wait times in medical processes’. The DMAIC model was also chosen as its flexible methodology can be applied to many diverse healthcare settings, thus it could have a higher likelihood to successfully improve the project site’s increased NSTEMI management times (Improta et al. 2017).

3.4 Model Application

3.4.1 Define Phase:

The first phase of the DMAIC model is called the Define phase. It incorporates three factors: a definition of the problem, an ideal target, and the QI tools used (Gejdos, 2015). Increased time to CA for a suspected NSTEMI is a risk factor for negative patient complications e.g. life-threatening arrhythmia's (Gorenek et al. 2015). Observations in the project site indicated that there was a problem of increased wait times in NSTEMI management from ED registration to CA. This problem was confirmed by the project sponsor. An ideal target was set; to increase adherence to
the ESC’s 24-hour to CA guideline by 10% within 1 year after high-sensitive troponin bloods analysis is brought into clinical practice in the QIP’s site.

3.4.1.1 Stakeholder Analysis:

The initial steps involved in a QIP involve forming a QIP team that has expertise in the problem area (Silver et al, 2016). A stakeholder analysis was thus completed at the start of a QIP. The stakeholder diagram (Figure 1) outlines the key stakeholders in the QIP. It helped analyse the potential impact that individual stakeholders could have on the success of the QIP (Makan et al, 2015). The stakeholders with high-power high-interest included the ED and cardiology consultants, the cardiology ANP’s, cardiology registrars, ED clinical nurse managers, ED nurses, ED junior doctors, medical doctors on call and Biomedical Laboratory staff. These members of staff possess valuable information that would be difficult to ascertain as an observer and they also play a major role in overall ED NSTEMI patient management. The laboratory staff in particular, are involved in analysing troponin bloods, therefore they are interested in any possible recommendations that could affect the number of troponin bloods they analyse.

The porters were allocated to a high-power-low-interest category as a high proportion of patients within the ED are deemed high priority to be on a ward with the specialised care they need, thus the porter is obliged to split their time equally. They are also involved in transporting urgent bloods down to the Biomedical Laboratory. Other stakeholders include the patients. They have low-power, but have
a high-interest in any improvement initiatives that could enhance the type of care they receive.

Figure 1: Stakeholder analysis

3.4.1.2 Process Flow Map:

Process flow mapping can be used to identify the structure of a process and is one of the best tools to help achieve a competent healthcare system (Lau, 2015). They can detect problems such as communication failures and unnecessary work (Lau, 2015). A process flow map can thus be used to identify areas in a process that need improvement (Colligan et al, 2010) and can direct the design of new process improvements (Lau, 2015)

A process flow map (Figure 2) of the ED’s NSTEMI management was devised. A healthcare hierarchy structure (Appendix 2) for the ED’s management an NSTEMI
was also created. It helped verify that the order of staff members in the process flow for ED NSTEMI management was correct. The process flow map starts with the patient's arrival at the ED and finishes at the ED's discharge of the patient to a ward. The process flow map thus identified the standard process flow for ED NSTEMI management e.g. it demonstrated that staff may not always check for a possibly abnormal troponin level in the patient's blood in triage. The process flow map also helped unveil previously unidentified variation in the ED's NSTEMI management which was causing a lack of standardisation e.g. patients did not always get assessed by a nurse post triage.

Figure 2: Process flow map of ED NSTEMI assessment
3.4.1.3 Fishbone Diagram:

The fishbone diagram (cause and effect diagram) was used to establish possible causes of increased overall ED NSTEMI management times (Figure 3) (Kudla & Brook, 2018). It identified a multitude of possible causes that could be addressed. The other causes of long NSTEMI management times that were outside of ED (e.g. CCU causes) were deemed too complex to address within the time constraints of the QIP. It was then decided to focus on making an improvement in ED NSTEMI management processes, with the hope that the result would be an improvement in the overall time to CA. Process flow maps and fishbone diagrams were thus not made to represent NSTEMI management outside of the ED. The problem is placed at the head of the main arrow and causative factors are placed under four headings coming out of the main arrow (Kudla & Brook, 2018).

![Fishbone Diagram](image-url)
The 5 whys can be used to clarify one cause of a problem. Once the fishbone diagram was created the 5 whys was therefore used for root cause analysis (Kudla & Brook, 2018). Root cause analysis has been shown to identify the most modifiable causes of patients being held in the ED for multiple troponin bloods to be taken (James et al 2014). The use of the 5 whys with root cause analysis has also been criticised. It is indicated that their combined use is too minimal to process a complex problem (Card, 2016). Root cause analysis and the 5 whys were therefore used as adjunct tools, alongside the use of other QI tools e.g. the process flow map. This was considered to be reasonable, as process flow maps are used for complex problems in healthcare management (Lau, 2015). The use of the 5 whys resulted in a continuum of reasons as to why troponin bloods are not being taken in triage. This is outlined next:

1. There is a low number of troponin bloods for suspected NSTEMI's taken in triage why?
2. Patients can be unsure of how long they have had CP for, thus staff are unsure as to whether it is too early to test the troponin level in a patient’s blood, why?
3. It is known that within the first few hours of CP onset / an NSTEMI occurring that troponin levels in the blood do not increase high enough to be detected why?
4. The troponin bloods analysis assay in practice in the project site is not sensitive enough to detect a small rise in troponin in the blood why?
5. It is not a high-sensitive troponin bloods analysis assay why? 

High sensitive troponin bloods testing will not come into 
practice in the project site until late 2018. 

Patients underestimate how long they have had CP for, thus it is still recommended 
for non-high sensitive troponin bloods to be taken in triage (Thygessen et al, 2010). 
That said, the 5 whys helped ascertain why taking high-sensitive troponin bloods in 
triage could be more beneficial at increasing adherence to the ESC's 24-hour to CA 
guideline. Triage is the earlier possibly stage in NSTEMI management that a 
possibly abnormal troponin result can be detected. When compared to high-
sensitive troponin bloods, non-high-sensitive troponin bloods cannot detect as many 
possibly abnormal troponin bloods results in triage (Nice, 2014-a). When a possibly 
abnormal troponin blood result is detected earlier in NSTEMI management, it can 
allow for an earlier diagnosis of a NSTEMI. It was therefore decided not to propose 
to increase the number of non-high-sensitive troponin bloods taken in triage. 

3.4.2 Measure: 

The second phase of the DMAIC model is the Measure phase. One aim of this 
phase is to measure baseline data as a starting point for improvement (Gejdos, 
2015). Although verbal confirmation was received confirming increased NSTEMI 
management times (in comparison to the ESC’s 24-hour to CA guideline) (Roffi et al, 
2016), it was deemed necessary to obtain confirmatory written measurements. 
Additionally, even though the process flow diagram established that in general 
troponin bloods may not be taken in triage, it was essential to collect data to
establish an exact value of how many troponins were not being taken in triage. It was also essential to collect data from every stage of NSTEMI management from ED registration to CA to aid accurate QIP evaluation. Accurate evaluation of any unintended consequences of an improvement recommendation would involve having baseline measurements of every stage of NSTEMI management (McQuillan et al 2016).

A random sample of (n=155) NSTEMI's was obtained and 30 parameters were measured from January to December 2017 (Table 3). The parameters for each patient were collected manually from the ED Organiser Programme, Mc Kessan cardiology software system, the project site’s Hospital Inpatient Enquiry System (HIPE) and patient notes.

<table>
<thead>
<tr>
<th></th>
<th>Table of Data Parameters Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Patient Age</td>
</tr>
<tr>
<td>2.</td>
<td>Patient Gender</td>
</tr>
<tr>
<td>3.</td>
<td>The Date and Time the Patient Registered at Reception</td>
</tr>
<tr>
<td>4.</td>
<td>Date and Time of when Triage Finished</td>
</tr>
<tr>
<td>5.</td>
<td>Triage Start Time</td>
</tr>
<tr>
<td>6.</td>
<td>Presenting Complaint</td>
</tr>
<tr>
<td>7.</td>
<td>Working Diagnosis</td>
</tr>
<tr>
<td>8.</td>
<td>Manchester Triage Category</td>
</tr>
<tr>
<td>9.</td>
<td>Date and Time of Retriage</td>
</tr>
<tr>
<td>10.</td>
<td>Retriage Manchester Triage Category</td>
</tr>
<tr>
<td>11.</td>
<td>Major/Minor Category</td>
</tr>
<tr>
<td>12.</td>
<td>Date and Time of Nurse Assessment</td>
</tr>
<tr>
<td>13.</td>
<td>Date and Time of ED Doctor Assessment</td>
</tr>
<tr>
<td>14.</td>
<td>Date and Time of Post ED Assessment Written Review</td>
</tr>
<tr>
<td>15.</td>
<td>Date and Time of Bed Request</td>
</tr>
<tr>
<td>16.</td>
<td>Date and Time of Discharge</td>
</tr>
<tr>
<td>17.</td>
<td>Discharge Consultant Speciality</td>
</tr>
<tr>
<td>18.</td>
<td>Discharge Ward</td>
</tr>
<tr>
<td>19.</td>
<td>Co-Morbidities</td>
</tr>
<tr>
<td>20.</td>
<td>Date and Time of First Troponin Order</td>
</tr>
<tr>
<td>21.</td>
<td>Date and Time of First Troponin Order Results</td>
</tr>
<tr>
<td>22.</td>
<td>The Results of the First Troponin</td>
</tr>
<tr>
<td>23.</td>
<td>Order Date and Time of Total Number of Results</td>
</tr>
<tr>
<td>24.</td>
<td>Collection Date and Time of Total Number of Troponins</td>
</tr>
<tr>
<td>25.</td>
<td>Received Date and Time of Total Number of Troponins</td>
</tr>
<tr>
<td>26.</td>
<td>Results Date and Time of Total Number of Troponins</td>
</tr>
<tr>
<td>27.</td>
<td>Verified Date and Time of Total Number of Troponins</td>
</tr>
<tr>
<td>28.</td>
<td>Results of Total Number of Troponins</td>
</tr>
<tr>
<td>29.</td>
<td>Date and Time of Coronary Angiography</td>
</tr>
<tr>
<td>30.</td>
<td>Treatment</td>
</tr>
</tbody>
</table>

Table 3: Titles of data parameters collected
Table 4 shows the results of the parameters collected. It displays the range, mean and median times associated with the pathway of a patient through the ED with an NSTEMI (the patients were not always assessed by a nurse post triage due to ED understaffing). Measurement of patient’s pathway times with and without nurse assessment was deemed necessary as nurse assessment represented an area for possible improvement. Table 4 also documents relevant data relating to taking troponin bloods and receiving results. Additionally, the range, mean and median times from registration to CA for patients with a high-risk NSTEMI is documented in table 4. The percentage of high-risk NSTEMIs and the percentage of all other NSTEMIs waiting greater than 24-hours for CA is also outlined.
Table 4: Summary of recorded data results for NSTEMI management (most relevant data points are highlighted)

Figure 4 shows that patients with an NSTEMI (all categories of NSTEMIs included) have wait times of up to 384 hours (16 days) in the project site for their CA. 65% of high-risk NSTEMI patients (abnormal level of troponin in their blood) waited greater than 24-hours for their CA (mean wait time 47 hours 2 minutes). This high percentage demonstrates that the high-risk category of NSTEMIs is a worthwhile category of NSTEMIs to investigate. As the time from ED registration to CA for patients with a high-risk NSTEMI displayed such a wide range (40 minutes -116 hours 44 minutes), the writer analysed the data further. The results of this showed
no statistical significance. (Appendix 4)

The Percentage of Patients who Received their Coronary Angiogram within 24, 48, 72 and 96 hours

![Graph showing the percentage of patients obtaining a CA within 24 hours, 48 hours, 72 hours, and 96 hours (every category of NSTEMI included)](image)

Figure 4: Graph showing the percentage of patients obtaining a CA within 24 hours, 48 hours, 72 hours, and 96 hours (every category of NSTEMI included)

### 3.4.2.1 Anomalies in the Data:

Extreme-outlier time measurements that were very high or low were omitted. There were few of these measurements and so it was assumed that alternative non-measured factors could have altered these results. Median values were measured to counter-act the effects of other less extreme outliers.

### 3.4.3 Analyse

The third phase of the DMAIC model is the Analyse phase. The aim of this phase is to identify one cause that is most suitable to address (Gejdos, 2015). It was deemed
necessary to use data analysis and ED VSMs, to establish the single most viable cause to address.

### 3.4.3.1 Diagnostic Causes of Increased NSTEMI Management Times

The project site uses a non-high-sensitive troponin bloods analysis assay that involves checking the level of troponin in a patient’s blood on presentation to the ED, and then again 6 hours later. The first troponin blood level taken for assessment of a suspected NSTEMI with this analysis assay, should be taken in triage (Thygessen et al., 2010). Post triage assessment, NSTEMI patients can wait a median time of 1 hour 3 minutes to see an ED doctor (in the project site). The histogram in Figure 5 shows the median time from ED registration to the first time troponin bloods are ordered is 1 hour 31 minutes indicating troponin bloods are not usually taken until the end of the ED doctor’s assessment.

Overlapping of where first troponin bloods are taken in the project site’s ED, was noted when the ED’s process flow map (page 26) for NSTEMI management was created e.g. troponin bloods could be taken in triage, the ED nurse or the ED doctor. The analysed data in Figure 6 shows that 63% of troponin bloods were taken by the ED doctor and 37% were taken by nurse assessment staff and 1% were taken in triage staff. This further demonstrated that troponin bloods are not being taken in triage (where they should be taken) (Thygessen et al., 2010). This lack of standardisation could be a cause of increased wait times as staff have to recheck as to whether patients have had their bloods taken.
Figure 5: Histogram of the time difference (hours) between ED registration and first troponin bloods orders.

Figure 6: Bar chart of the number of troponin bloods taken by the triage nurse, ED doctor, and post triage nurse assessment.

Finally, staff cannot compare new and old ECG’s quickly in the project site (needed for NSTEMI assessment). The ECG machines cannot store ECG’s, confidentiality regulations prevents staff saving ECGs to USB keys and obtaining old ECG’s from
storage is slow. The ECG machines could be set up to send ECGs directly to hospital computer programmes that already store patient information. This recommendation would involve QIP lead with knowledge in information technology systems.

3.4.3.2 Staff and Patient Causes of Increased NSTEMI Management Times

Primary causes of increased ED wait times for NSTEMI assessment e.g. the time from triage to nurse assessment are contributory to the overall increased ED NSTEMI management times. These can be attributed to numerous factors e.g. ED bed availability. It is difficult to improve these individual wait times without taking account of every type of patient seen in the ED. An Irish study demonstrated that ED ANP’s can decrease ED wait times, however, it was deemed more suitable to improve processes without additional resources (Coyne et al, 2016). Patient co-morbidities are a patient related cause of increased wait times (Erne et al, 2017). Co-morbidities were individualised to each patient in this QIP, thus it was difficult to isolate one causative co-morbidity. It would be necessary to consider a larger time-frame and use multivariable analysis. Patient complications are another cause of increased wait times to CA (Redfors et al, 2016). Patient complications would need similar analysis to patient co-morbidities.

3.4.3.3 Environmental Causes of Increased NSTEMI Management Times

The overcrowding and shortage of beds in the ED is aggravated by bottlenecks of patients awaiting discharge. The bar chart (Figure 7) shows that the time to ED
discharge encompasses nearly 50% NSTEMI ED management time. This increased individual wait time is dependent on how quickly patients are discharged from wards and the number of non-ED hospital beds available (especially CCU beds). A full capacity protocol where patients are discharged to inpatient hallways when the ED has full capacity is effective (Di Somma et al. 2015). This is not an ideal recommendation as it transfers hospital overcrowding to a different location. Another recommendation is transferring patients to an observational unit (Shin et al. 2013). This involves the introduction of many different types of new staff, thus it would be difficult to ascertain if this would be cost-effective in the project site specifically.

![Figure 7: Stacked bar chart of the mean and median times of each stage of NSTEMI management in the ED](image)

<table>
<thead>
<tr>
<th>Timing of the Main ED Management Steps for a NSTEMI (Hrs and Minutes) (from ED Registration to ED Discharge) (n=104)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
</tr>
<tr>
<td>A: 1 Minute</td>
</tr>
<tr>
<td>B: 22 Minutes</td>
</tr>
<tr>
<td>C: 3 Hours 2 Minutes</td>
</tr>
<tr>
<td>D: 1 Hour 33 Minutes</td>
</tr>
<tr>
<td>E: 4 Hours 27 Minutes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: 2 Minutes</td>
</tr>
<tr>
<td>B: 1 Hour 3 Minutes</td>
</tr>
<tr>
<td>C: 3 Hours 34 Minutes</td>
</tr>
<tr>
<td>D: 2 Hours 58 Minutes</td>
</tr>
<tr>
<td>E: 6 Hours 2 Minutes</td>
</tr>
</tbody>
</table>

A: Time difference between ED registration and triage finish time  
B: Time difference between triage finish time and ED doctor assessment  
C: Time difference between ED doctor assessment and cardiac ANP/cardiac registrar / medical doctor written review time  
D: Time difference between cardiac ANP/cardiac registrar / ED doctor written review time to bed request  
E: Time difference between bed request to discharge  

Figure 7: Stacked bar chart of the mean and median times of each stage of NSTEMI management in the ED

### 3.4.3.4 Value Stream Mapping

Value stream mapping is a Lean management analysis tool that attempts to improve systems through visualisation and quantification (Jeong et al, 2016). VSMs can
quantify the amount of non-value added time in a process (Cerfolio et al. 2016). They thus can be used to reduce ED waiting times (Bal et al., 2017). Mapping the patient’s journeys is therefore vital to this QIP as it could ascertain any non-value added time in ED NSTEMI management. The writer used value stream mapping to combine the NSTEMI process flow map and the collected data times.

Firstly, VSMs of the management of ED NSTEMIs were created (Figure 8, and 9). VSMs are shown with and without nurse assessment separately because analysis of both the VSMs, showed that patients had a lower total LOS in the ED when they did not have nurse assessment (minimum range values used). The mean times of the individual steps in NSTEMI management in the ED with and without nurse assessment were also added together. This also verified that the patient LOS in the ED was lower when patients did not have nurse assessment. These mean values are shown in table 4 (page 32). This demonstrated that although reducing the time to ED nurse assessment would be difficult, without taking into account every kind of patient in the ED, it may be feasible to omit nurse assessment altogether. It was decided at this stage of the QIP not to propose to omit post triage nurse assessment altogether as an improvement recommendation. This was because post triage nurse assessment did not occur regularly thus, this improvement recommendation would require more validation.

It was noted during observation in the Biomedical Laboratory that high-sensitive troponin bloods analysis is coming into practice in the project site. It was therefore taken into consideration that increasing the percentage of high-sensitive troponin bloods taken in triage could be a feasible QI recommendation to make. When the VSM’s were analysed, it was noted that the stage of the ED’s NSTEMI management
which had the lowest efficiency was when the patient was waiting for ED discharge to a ward. The stage with the highest efficiency was the time from ED registration to triage finish time. It was therefore deemed that, the addition of taking all high-sensitive troponin bloods in triage for suspected NSTEMIs, could be feasible as it is the location associated with the lowest wait times (i.e. instead of the ED doctor and the ED nurse taking troponin bloods) (max time from ED registration to triage finish time was 2 hours 41 minutes).

Figure 8: VSM of the process flow of ED NSTEMI management with nurse assessment included
Figure 9: VSM of the process flow of ED NSTEMI management without nurse assessment

Troponin bloods are prioritised in the project site’s Biomedical Laboratory. A third VSM was created of the prioritised troponin bloods analysis pathway in the Biomedical Laboratory (Figure 10). Figure 11 shows the distribution of times from ordering a troponin blood test to receiving results. It demonstrates that it takes a median time of 1 hour 43 minutes after requesting a troponin blood test, to receive results (ED doctor’s orders included only). As the VSM of the troponin bloods analysis pathway shows that this pathway takes 47 minutes; this indicates that the other 57 minutes is related to the ED’s management of troponin bloods. A time of
less than 60 minutes was deemed an acceptable troponin bloods analysis time (Moran et al, 2014). As the troponin bloods analysis pathway in the Biomedical Laboratory took 47 minutes, this indicated that this pathway is not a cause of increased ED NSTEMI management times.

<table>
<thead>
<tr>
<th>Value Stream Mapping of the the Prioritised Troponin Bloods Process Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Laboratory troponin blood analysis time: 47 minutes (&lt; 60 minutes is deemed acceptable)</td>
</tr>
</tbody>
</table>

Figure 10 VSM of the prioritised troponin bloods analysis pathway through the Biomedical Laboratory

Figure 11: Scatter diagram of the wait times from ordering troponin bloods to receiving results
3.4.4 Improve:

The Improve phase is the fourth phase of the DMAIC model. The aim of this phase can be to identify creative recommendations to help manage the problem that was chosen to be addressed (Gejdos, 2015). An overview of how the DMAIC model tools were utilised in this QIP to identify the proposed recommendations is shown in Table 5.

<table>
<thead>
<tr>
<th>Define</th>
<th>Measure</th>
<th>Analyse</th>
<th>Improve</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process flow mapping</td>
<td>Data collection plan</td>
<td>Data analysis - Bar charts, histograms, scatter diagrams, comparison of groups graphs</td>
<td>To be standard operating process Flow maps</td>
<td>Visual process controls</td>
</tr>
<tr>
<td>Stakeholder analysis</td>
<td>Data collection</td>
<td>Value stream mapping</td>
<td>Brainstorming</td>
<td>PDCA cycles</td>
</tr>
<tr>
<td>Fishbone diagram</td>
<td>Cumulative frequency graph</td>
<td>Process efficiency analysis</td>
<td>Driver diagram</td>
<td>Celebration of success</td>
</tr>
<tr>
<td>5 whys</td>
<td>Baseline KPIs noted</td>
<td>Waste identification</td>
<td>Benchmarking</td>
<td>S 5’s</td>
</tr>
<tr>
<td>Management engagement</td>
<td>Queueing theory analysis</td>
<td></td>
<td>Local reviews</td>
<td>Management reviews</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mistake proofing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A Kaizen event</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Comparison with expected outcomes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Likert scales</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Balancing measures</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Re-measurement of KPIs</td>
</tr>
</tbody>
</table>

Table 5: Overview of the utilisation of the DMAIC QIP model.

3.4.4.1 Driver Diagram:

A driver diagram can be used to identify the main drivers that impact on the aim of the QIP. In a driver diagram, drivers are factors that negatively impact on achieving the aim of a QIP. It can also help to identify recommendations to reduce the effects
of these drivers (Siriwardena & Gillam, 2013). The primary drivers which influenced ED NSTEMI management times were chosen during brainstorming (a QI tool) for causes of increased ED NSTEMI management times for the fishbone diagram.

The driver diagram thus enabled the comparison of focussed and viable improvement recommendations and therefore allowed for the identification of the most suitable improvement recommendation to propose (shown in the box with a thick outline in Figure 12). It also aided the identification of various strategies to aid the smooth implementation of the proposed recommendation (shown in the box with a thin outline in Figure 12).

Figure 12: Driver diagram (thicker arrows represent the most relevant information)
The proposed recommendation is to increase the adherence to the ESC’s (Roffi et al, 2016) 24-hour to CA guideline made possible by the introduction of a NICE (2014-a) and ESC (Roffi et al, 2016) recommended high-sensitive troponin bloods protocol (when high-sensitive troponin bloods are brought into practice in the project site). This protocol involves checking the level of troponin in the patient’s blood in triage. When the writer analysed the project site’s data from 2017 it identified that only 1% of troponin bloods were being taken in triage, thus the recommendation incorporates increasing the number of troponin bloods taken in triage. The use of the driver diagram has been shown to successfully reduce preventable serious safety events (Meuthing et al, 2012). Increased time to CA is a risk factor for life-threatening arrhythmias (Gorenek et al, 2015). It was thus anticipated that the proposed recommendation from the use of the driver diagram would be a safe recommendation.

The driver diagram aided numerous recommendations to be examined. The reason why the high-sensitive troponin protocol recommendation was chosen to increase adherence to the ESC’s (Roffi et al, 2016) guideline is discussed next. The troponin bloods analysis assay used in the project site is non-high-sensitive. If a patient presents to the ED with a suspected NSTEMI, the ED’s protocol for this troponin bloods analysis assay is to check the level of troponin in the patient’s blood in triage, 6 hours post triage assessment, and if clinical suspicion is high at 12 hours post triage assessment (as this troponin bloods analysis assay is not sensitive enough to detect small rises in troponin in the blood, which could indicate an NSTEMI) (Thygessen et al, 2010). Staff in some cases thus have to wait a long length of time to take further troponin bloods, and wait again for these results to become available
The high-sensitive troponin analysis assay allows for a NSTEMI diagnosis to be made 3 hours post triage assessment in nearly 100% of patients (Twerenbold et al, 2017). It also can detect more possibly abnormal troponin results earlier in the process flow for NSTEMI management, when compared to non-high-sensitive troponin bloods (as it can detect lower amounts of troponin in the patient’s blood). This allows for an earlier diagnosis of an NSTEMI (Giannitsis et al. 2010). Diagnosing an NSTEMI earlier is expected to lead to increased adherence to the ESC’s (Roffi et al, 2016) 24-hour to CA guideline by decreasing time to CA (Boedinghous et al, 2016).

Many different protocols were considered before choosing a specific high-sensitive troponin protocol as a recommendation to officially put on the driver diagram. A specific 0-3 hour high-sensitive troponin bloods protocol (which includes checking the level of troponin in the patient’s blood in triage) is recommended by the NICE (2014-a) and the ESC (Roffi et al, 2016) guidelines (see page 17 of the literature review for more details on this protocol). This is the only protocol recommended by both NICE (2014-a) and the ESC (Roffi et al, 2016). It was concluded that this protocol would be the best recommendation to propose for implementation (figure 13).
Retezar et al., (2011) demonstrated that ED times to treatment can be decreased by 16% for patients presenting with CP when assessment orders (e.g. bloods orders) are initiated within triage. Cullen et al. (2015) established that times to CA can be reduced by 12% with by taking high-sensitive troponin bloods. Baugh et al. (2016) established that compliance with ED troponin bloods recommendations can be increased by 44% in 4 months. The aim that was decided at the start of the QIP; to increase adherence to the ESC’s 24-hour to CA guideline by 10% within 1 year after high-sensitive troponin bloods analysis is brought into clinical practice in the QIP’s site was therefore thought to be achievable.
The driver diagram aided investigation of what strategies to suggest for implementation to smoothly bring the proposed high-sensitive troponin protocol into practice and also aid the most adherence to the protocol. The strategies are described next. In advance of the new protocol’s introduction, displaying the implementation date of the new protocol would help communicate relevant information to ED staff. It is also necessary to make sure the protocol is readily accessible for staff to read before the date for possible implementation. There is no information on the project site’s smart-phone application for protocols (the project site’s medical E-guides), Q Pulse (the project site’s online protocol programme for a desk computer) or on the walls of the ED about high-sensitive troponin bloods NSTEMI protocols. The QIP plan thus also involves putting the new and easy to follow step-by-step protocol in these places with information on contact and availability hours of cardiac specialists (in case staff need extra advice). Putting the guideline on a wallet-sized card that could be given to new staff members is also proposed.

The driver diagram aided the proposal of other strategies to increase adherence to the new protocol. A proposed strategy to remind staff to check the level of troponin in the patient’s blood in triage firstly involves creating a purpose designed troponin bloods tray with the high-sensitive troponin bloods protocol adhered to the tray. Secondly, this proposed strategy includes not allowing this tray to be kept anywhere but triage. This would act as a reminder to staff to take troponin bloods in triage. A high-sensitive troponin bloods protocol checklist is another suggested strategy for implementation to increase adherence to the proposed protocol to be brought into practice. This would be put in the patient’s notes in triage (the place where staff start
organising patient notes into one file). This would aid staff navigation of the protocol steps (Figure 14).

**NSTE MI High Sensitive Troponin Bloods Checklist to be Completed at the Different stages of ED Suspected NSTEMI Management**

![NSTE MI High Sensitive Troponin Bloods Checklist](image)

- Discharge/Stress testing
  - Pain-free, GRACE ≤140, differential diagnoses excluded
  - Pain-stay
  - hs-cTn level in the blood: no change

For 0 hour hs-cTn blood result ≤ULN
- Completed in Triage
  - Pain-stay
  - Pain-free, GRACE ≤140, differential diagnoses excluded

For 0 hour hs-cTn blood result >ULN
- Completed in Triage
  - Retest hs-cTn level in the blood: 3hr
  - A change (% value > ULN)
  - Highly abnormal hs-cTn blood result—clinical interpretation
  - hs-cTn blood result: no change

- Work-up differential diagnoses
- Invasive management

*hs-cTn* = High Sensitivity Cardiac Troponin (blood test)

ULN = Upper Limit of Normal, 99th percentile of healthy controls

% is dependent on assay

Highly abnormal hs-cTn blood level defines values beyond 5-fold the upper limit of normal

GRACE = Global Registry of Acute Coronary Events score

**Contact Information of Cardiac Specialists**

1. Cardiac ANPs hospital phone numbers [[number]](phone)
2. Cardiac centre department (out of hours) — [[number]](phone)

---

**Please tick the applicable box:**

- Troponin bloods completed in triage

- Troponin bloods re-checked after 3 hours if troponin bloods were negative and the patient had chest pain for < 6 hours or if the 0 hour troponin bloods were positive

*Completed* | *N/A*
---

Figure 14: NSTEMI checklist for patient notes

Benchmarking can be used to show organisations their performance in comparison to other similar organisations in the same area (Agarwal *et al*, 2016). It is proposed that benchmarking could be utilised to encourage staff to reach the same standards as other hospitals. The writer did not have access to information from other hospitals. Alternatively, relevant published studies could be used e.g. a multi-centre...
clinical trial demonstrated that taking high-sensitive troponin bloods resulted in a median 72-minute reduction in time to ED discharge (Twerenbold et al. 2016). This trial was a multi-centre trial therefore, the 72-minute reduction in time to discharge could be more likely to be generally applicable. Education initiatives (such as PowerPoint presentations) are recommended by the NICE (2014-a) guidelines. A survey completed in the UK and Ireland also specifies that good communication between the Biomedical Laboratory and ED staff is necessary to ensure staff are taking high-sensitive troponin bloods according to correct protocol (McKeeman & Auld 2015). The last adherence strategy proposed is therefore, the use of PowerPoint presentations lead by the Biomedical Department.

These adherence strategies could be implemented by an RCSI trained ED PA. An RCSI trained PA would be well positioned to implement these strategies, as QI education is part of their MSc programme. QI training is associated with improved QI skills (Kindratt et al. 2017). The part of the ED healthcare hierarchy structure that an ED PA would be allocated to can be seen in Appendix 3. All of the above methods would act as an effective care bundle. These actions should also increase reliability and mitigate against waste and error (The Health Foundation, 2013).

3.5 Summary:

This chapter outlined different approaches to QI. Additionally, the rationale why the LSS tools with the DMAIC approach was chosen for this QIP was addressed. How the various QI tools were utilised to establish the proposed recommendation was outlined. The next chapter explains how the QIP should be evaluated. Control methods for the QIP to be sustainable are also outlined.
Chapter 4.0: Evaluation
4.1 Introduction:

This chapter will provide an overview of the QIP and will explain the aim of the control phase of the DMAIC model. It appraises the best possible QI tools for evaluating the QIP. The expected short and long-term QIP outcomes and the dissemination plan for the QIP are explained.

4.2 Overview of the QIP:

Reduced time to CA reduces patient complications (Gornek et al, 2015). The ESC (Roffi et al, 2016) guidelines recommend that patients with a high-risk NSTEMI should have a CA within 24-hours. The DMAIC framework and LSS tools were utilised to examine the individual time steps for managing a patient with an NSTEMI (from ED registration to CA) in the project site.

The stakeholder analysis was used to identify the staff who have a high-interest in the QIP and have enough power, to aid possible implementation of the QIP plan. This tool thus identified the staff that would be most beneficial to engage with on a regular basis. Establishing the ED’s process flow for NSTEMI management, identified that troponin bloods may not be taken in triage all of the time. It showed that these bloods were also being taken by the ED doctor and the ED nurse. A fishbone diagram was employed to establish the possible causes of the overall increased ED NSTEMI management times. It was then decided to focus on ways to improve ED NSTEMI management processes, with the hope that the outcome would be an improvement in the overall time to CA. Process flows and fishbone diagrams
were thus not made to represent NSTEMI management outside of the ED. The use of the 5 whys identified that troponin bloods may not be taken in triage, because the troponin bloods analysis assay used in the project site is non-high sensitive. The 5 whys also helped ascertain that taking high-sensitive troponin bloods in triage would be more beneficial than taking non-high-sensitive troponin bloods. The manually collected data provided evidence that troponin bloods were not being taken in triage.

The process flow map and the manually collected data were combined to create a VSMs of the ED’s management of a NSTEMI (with and without nurse assessment). The VSMs established that there were increased wait times at every part of the ED NSTEMI process flow. It emerged during observation in the Biomedical Laboratory that high-sensitive troponin bloods analysis is being brought into practice. The point of highest efficiency in the VSMs was the time from ED registration to triage finish time. It was therefore deemed that, the addition of taking all high-sensitive troponin bloods in triage for suspected NSTEMIs could be feasible as it is the location associated with the lowest wait times (i.e. instead of the ED doctor and nurse assessment taking troponin bloods).

The driver diagram enabled the comparison of identified possible improvement recommendations that could be proposed to increase adherence to the ESC’s (Roffi et al, 2016) 24-hour to CA guideline. After analysis of the driver diagram, it was deemed that the most feasible recommendation to propose was the introduction of the NICE (2014-a) and ESC (Roffi et al, 2016) recommended ED NSTEMI management protocol (which includes increasing the number of high-sensitive troponin bloods taken in triage). The high-sensitive troponin allows for earlier detection of a possibly abnormal troponin result i.e. in triage. It also can reduced the
time to taking a second troponin by three hours. The driver diagram also allowed for the identification of various strategies to help smoothly integrate the new protocol for potential implementation into ED NSTEMI practices e.g. education and benchmarking

4.3 Evaluation

4.3.1 Aim of the Control Phase and DMAIC Model:

The goal of the control phase (the fifth phase of the DMAIC model) is to identify QI methodologies to monitor and sustain the QIP’s objectives. It endeavours to ensure the aims and objectives are realised (Gejdos, 2015).

4.3.2 Monitoring and Review:

This section suggests how to evaluate the QIP plan. The effectiveness of healthcare should be systematically evaluated (HIQA, 2012). Firstly, the team lead could develop a local review team to monitor any objectives met or gains obtained due to the QIP plan. The writer measured KPIs e.g. the time to when first troponin bloods were taken during the measurement stage of the QIP. Re-measurement of these KPIs (after the potential implementation of the QIP’s recommendation) would allow for the identification of whether the QIP’s objectives were achieved (Leeder, 2016) e.g. KPIs could be used as protocol effectivity markers. Re-measurement of the overall times to CA could deduce whether the QIP was effective overall. KPI re-measurement could be done more rapidly and accurately by recording prospective real-time data. This would involve an ED staff member manually recording NSTEMI
management process times in real-time. This would be effective because requesting and obtaining notes is a lengthy process and times of assessment are not always written in charts. The NICE (2014-b) guidelines offer direction on how to quantify the success of high-sensitive troponin bloods practices. The guidelines suggest data collection of clinical outcomes of NSTEMIs presentations. The QIP plan thus involves a collection of patient outcome KPIs. Balancing measures e.g. time to ED discharge should also be measured, to identify unanticipated consequences due to the implementation of the new protocol (McQuillan et al, 2016). Once the local review is completed, an MDT management review could commence. This involves a QI MDT, who make adjustments to eradicate unintended consequences. These reviews are necessary as there is a large mixture of staff disciplines and skill levels involved in NSTEMI ED management, which could result in unpredicted problems. A PDCA (Plan, Do, Check, Act) cycle could then be executed to allow for the implementation of adjustments recommended by the management review team (McQuillan et al, 2016).

Likert scale questionnaires could be used to assess staff and patient satisfaction, after the possible implementation of the NICE (2014-a) and ESC’s (Roffi et al, 2016) high-sensitive troponin protocol. Likert scales are an established method that provides beneficial psychometric analysis for a study and can be used for qualitative variables e.g. patient satisfaction (Beaulieu et al, 2011). The use of Likert scale questionnaires would allow for information to be collected from a large geographical area. Examples of possible Likert scales that could be used to evaluate staff and patient satisfaction are outlined in Appendix 5 and 6.
5S Methodology could be used to evaluate the QIP. It is an improvement methodology that creates and maintains an organised, clean, high-performance workplace with less variability. It incorporates: sorting, straightening, scrubbing, standardising and sustaining work practices (Rutman et al. 2015). Sorting involves removing what is unneeded e.g. removing information about taking bloods with the old troponin bloods analysis assay. Straightening (making sure everything is in the right place) involves making sure the new troponin equipment for taking bloods is readily accessible. The Scrubbing stage would involve keeping the ED environment clean when switching to the new protocol. Standardisation and Sustaining will help ensure the new triage protocol is always being implemented in the intended uniform fashion (Rutman et al. 2015). Application of 5S quality improvement methodology can improve the quality of healthcare services (Kanamori et al., 2015).

Visual controls could be used to make real-time performance feedback easily accessible to employees. This would involve putting graphical results of any improved individual ED wait times, due to the implementation of the new protocol on an ED wall. It should compare a similar period of time from when the data was originally collected. A visual timeline celebrating achievements and displaying the next target and the ideal target endpoint can encourage sustainable QI (Ingabire et al., 2015).

These evaluation methods could help inspire a culture of holistic patient centred QI. For any QIP to flourish involves an environment with good clinical governance. The QIP’s team lead needs to have frontline accountability and influential leadership skills to achieve good clinical governance (Veenstra et al, 2017). Attaining governance and standardisation will be more possible if there is an influential team
lead running the QIP's evaluation (Veenstra et al, 2017). Finally, these methods could foster an environment which aids improved outcomes quicker and thus encourages increased adherence to the ESC’s (Roffi et al, 2016) 24-hour to CA guideline.

4.3.3 Expected Results

Expected results if the new high-sensitive troponin bloods protocol is adhered to, would be, a decrease in the time to CA (Boeddinghous et al, 2016) and thus an increase in adherence to the ESC’s 24-hour to CA guideline. This is due to the fact that high-sensitive troponin bloods can diagnose an NSTEMI quicker than non-high-sensitive troponin bloods (when troponin bloods are taken in triage). A decreased time to CA is linked to a decreased total hospital LOS (Koganti et al, 2016). Correct high-sensitive troponin bloods implementation practices can result in a 12% reduction in time to CA (Cullen et al, 2015). This would indicate that mean time to CA in this project’s site could decrease to 41 hours and 24 minutes (5 hour 38 minute reduction). No increase in hospital costs is expected as taking high-sensitive troponin bloods in triage has been shown to be cost-effective (Jülicher et al, 2017).

Extra QI benefits are described next. A decrease in patient complications and an earlier diagnosis (St. John et al, 2018) could be predicted outcomes if the high-sensitive troponin bloods protocol is implemented. An improved sensitivity for detecting short-term patient outcomes could be anticipated if the high-sensitive troponin bloods protocol is adhered to correctly (Carlton et al. 2018). A more
satisfying ED work environment for staff could be predicted in the long-term to occur due to a decrease in ED overcrowding (St. John et al, 2018).

4.4 Dissemination Plan

This QI plan was discussed with the stakeholders. To disseminate findings and the knowledge learnt from the QI investigation of the project site’s ED NSTEMI management, will require future PowerPoint presentations to MDT stakeholders. A Kaizen event is a five-day workshop that focuses on Lean-driven processes to make improvements specific to an organisation (Dickson et al, 2009). A Kaizen event should be held at a later stage, to check for improvements that need to be made to the QI plan due to the time-lapse between the formulation of the initial QIP plan and when high-sensitive troponin bloods analysis being brought into practice. This should allow for further feedback to the QIP team leader and improvement of the QIP plan. It is hoped that the conclusions of the QIP and the positive implications of QI in general, could be disseminated to a much wider range and number of healthcare staff members. This would involve information leaflets (handed out to staff in the project site) and presentations at medical and surgical grand rounds. To achieve a wider dissemination. The writer will submit the QIP plan to cardiology/ED journals and conferences.

4.5 Summary:

In the evaluation chapter techniques to evaluate the QIP were discussed. The expected short-term and long-term outcomes of the QIP were explained. An outline
of how the QIP plan could be disseminated was also delineated. The next chapter provides a final discussion and conclusion for the QIP.
Chapter 5.0: Discussion and Conclusion
5.1 Introduction:

This chapter will discuss the potential impact of this QIP, as possible implementation is not feasible until taking high-sensitive troponin bloods comes into clinical practice. The chapter will critically assess the QIP’s impact on stakeholders and on work practices. The strengths and limitations of the QIP are described. Future recommendations for the QIP are proposed. What the writer learned about QI through making the QIP is also described.

5.2 Project Impact:

5.2.1 Stakeholders

This QI concentrates on achieving outstanding patient-centred care, thus patients are the main focus of this QIP. High-power high-interest stakeholders reported that time was wasted by checking with a patient or on the computer to see if the level of troponin in the patient’s blood was already checked. Good communication is imperative to alleviate the fears of a patient. Re-asking a patient as to whether they had bloods taken, is indicative to them of disorganisation in the workplace. The new standardised protocol for high-sensitive troponin bloods (along with implementing the recommended strategies to increase the use of this new protocol) should provide more consistent practice.

Crucial impacts due to the introduction of the high-sensitive-troponin protocol include: earlier NSTEMI diagnosis, earlier access to NSTEMI specialist
assessment, and an improved patient experience, earlier access to a CA (St. John et al, 2018). The use high-sensitive troponin bloods within a high-sensitive troponin bloods protocol are also associated with a decreased patient LOS and an improved patient quality of life due to decreased adverse outcomes for patients (St. John et al, 2018).

The positive enhancement the project has on the workload of staff, (especially high-power staff stakeholders) will have an impact on the long-term QIP plan’s achievements. The stakeholder’s workload that this QIP will mainly impact, are the triage nurses. This works in the favour of the new high-sensitive troponin bloods protocol, as triage assessment was associated with lowest individual wait times. A quantitative study using a lean design has also indicated that the combination of a guideline driven triage, with taking high-sensitive troponin bloods can result in decreased triage wait-times (Chan et al. 2014).

5.2.2 Practice:

Advertisement of the new protocol in the ED e.g. on the project site’s smart-phone protocol application provides information to new staff. This could impact on the overall smooth running of NSTEMI management. The increase in the speed in overall ED NSTEMI management could make additional time for staff to see other types of patients, thus possibly improving the productivity of the ED and holistic quality care spent with patients (St. John et al, 2018). Also, taking high-sensitive troponin bloods is not associated with an increase in the use of hospital resources.
(Eggers et al 2016). Finally, a protocol including taking troponin bloods in triage has also been proven to be cost-effective (Jülicher et al, 2017).

### 5.3 Strengths of the Project

The main strength of this QIP is that it succeeded in achieving its objectives. It identified a recommendation that could increase adherence to the ESC's (Roffi et al 2016) 24-hour to CA guideline for patients with a high-risk NSTEMI. Another strength of this QIP includes that high-sensitive troponin bloods are not associated with increased use of resources (Eggers et al 2016) and skills. High-sensitive troponin bloods protocols have also been proven to be cost-effective (Jülicher et al, 2017). These strengths increase the likelihood that the QIP would be a well-received initiative by the project site’s management.

The high-sensitive troponin bloods protocol recommended in this QIP is recommended by the NICE (2014-a) and ESC (Roffi et al 2016) guidelines. The use of the well-known DMAIC model is a proven successful method of QI Improta et al. (2017). Another strength of this QIP is thus that it is well supported by the best available evidence from studies and international guidelines. The detailed amount of data that was collected provided another strength. Re-measurement of this data permitted accurate analysis of all of the project site's steps for NSTEMI management (if the QIP is implemented).
5.4 Limitations of the Project:

The QIP was limited by the occasional lack of documentation in the patient notes, of dates and times that patients were assessed by different staff members. Nevertheless, the results shown in this QIP, are still considered to be an accurate account of the timing of NSTEMI management in the project site. The amount of troponin bloods that get mechanically stuck in the shoot system is not documented by the project site. When bloods arrive in the laboratory is also not documented. The times that ED troponin bloods were ordered to when the troponin bloods are registered in the laboratory did not represent an increased wait time. Finally, the team leader of this QIP was not allocated to the project site for all her placements, thus this limited the amount of time that could be spent engaging with the stakeholders.

5.5 Recommendations:

Firstly, an investigation of the practices within nurse assessment to attempt to improve the increased time from nurse assessment to ED doctor assessment is recommended by this QIP. The causes of this would be multifaceted. Improving the time from a ward bed request to ED discharge is also multifactorial. Starting with an analysis of factors such as: ward bed availability, ED staffing, and bed management protocols via the use of a driver diagram would be beneficial.
Secondly, the NSTEMI management process flow being used in the project site, involves troponin bloods being taken by three staff types in the ED. Figure 15 demonstrates a new NSTEMI standard operating process flow (a, to be, process flow) that could yield benefits if the NICE (2014-a) and ESC (Roffi et al, 2016) high-sensitive troponin bloods protocol was implemented. It is the same as the process flow being used in the project site except high-sensitive troponin bloods are taken in triage. This structured approach (with troponin bloods taken only in triage as per the NICE and ESC guidelines) could decrease variation and waste time the ED’s process flow for NSTEMI management. It is thus also recommended by this QIP to implement this process flow.
5.6 Learning about Quality Improvement

The writer was delighted to have been given the opportunity to learn about QI. Through studying QI lectures notes, recommended reading, official reports and studies, the writer developed QI skills e.g. how to utilise the DMAIC QI model and QI tools within a QIP. The writer learnt how to use Queueing theory, KPIs, LSS tools,
the fishbone diagram, the driver diagram, the 5 whys, a stakeholder analysis, and VSM’s. Within the DMAIC model, LSS methods were found to be very effective at narrowing down the causes of a very complex increased overall ED NSTEMI management process. The writer learned that value stream mapping, the fishbone diagram and driver diagram were the most helpful QI tools, for investigating the long wait times within the ED NSTEMI management process. Researching the QIP tools that were used also provided the writer with the opportunity to learn about other QI tools that could be used in the future e.g. force field analysis.

Completing this QIP demonstrated to the writer that implementing QIP methods is a consistently developing process in itself and involves patience and determination for success. The individually increased wait times in the different stages of total NSTEMI management from ED registration to CA in the project site has many causes. Deciphering which cause was the best to attempt to improve required more thought, time and improvements in the QIP direction than initially expected. The writer also learnt about the differences between research and QI e.g. QI is aimed at a specific population e.g. a particular hospital, whereas research is intended for use with a more generalised population (Foster, 2013).

5.7 Summary and Conclusion

In 2017 the project site’s ED had over 700 NSTEMIs. The project site’s registration to CA times for NSTEMIs are increased when compared to the ESC’s (Roffi et al, 2016) 24-hour to CA guideline. This increased time is a known risk factor for adverse events (Gornek et al, 2015). The aim of this QIP is to increase adherence to the
ESC’s 24-hour to CA guideline by 10% within 1 year after high-sensitive troponin bloods analysis is brought into clinical practice in the QIP’s site. Adherence will hopefully be achieved by the introduction of the NICE (2014-a) and ESC (Roffi et al, 2016) high-sensitive troponin bloods protocol (with troponin bloods taken in triage). (Roffi et al, 2016). High-sensitive troponin bloods taken in triage can allow for earlier diagnosis of an NSTEMI (Boeddinghous et al, 2016). This is because they can detect a possibly abnormal troponin blood result earlier and they reduce the time to taking a second troponin blood test by 3 hours.

This QIP demonstrates the use of the DMAIC model and LSS tools to find a potential recommendation to increase the project sites’ adherence to the ESC’s 24-hour to CA guideline. The stakeholder analysis was used to identify the staff who have a high-interest in the QIP and have enough power to aid possible introduction of the QIP plan. Creating the ED process flow map for NSTEMI management, identified that troponin bloods may not be taken in triage all of the time. A fishbone diagram was employed to establish the possible causes of the overall increased ED NSTEMI management times. It was then decided to focus on making an improvement in ED NSTEMI management processes, with the hope that the outcome would be an improvement in the overall time to CA. Fishbone diagrams and process flow maps of NSTEMI management outside of the ED were thus not created. The use of the 5 whys identified that the reason why troponin bloods may not be taken in triage, could be because the troponin bloods analysis assay in use is non-high sensitive. The 5 whys also helped ascertain that taking non-high-sensitive troponins in triage, would be less beneficial than taking high-sensitive troponin bloods in triage. The manually collected data provided evidence that troponin bloods
were not being taken in triage. It emerged during observations in the Biomedical Department that the high-sensitive troponin bloods analysis is being brought into practice. The process flow map and the manually collected data for NSTEMI management were combined. This created ED VSMs for NSTEMI management (with and without nurse assessment). These VSMs showed that the point of highest efficiency in the VSM was triage. It was therefore deemed that, the addition of taking all high-sensitive troponin bloods for suspected NSTEMIs in triage could be feasible as it is the location associated with the lowest wait times (instead of them being taken by the ED doctor and the ED nurse).

The driver diagram enabled the comparison of identified possible improvement recommendations to increase adherence to the ESC’s 24-hour to CA guideline. After analysis of the driver diagram, the recommendation deemed most feasible to propose was the implementation of the NICE (2014-a) and ESC (Roffi et al, 2016) recommended ED NSTEMI management protocol (which includes taking a high-sensitive troponin in triage). The driver diagram also allowed for the identification of various strategies for the smooth integration of the new protocol for potential implementation into ED NSTEMI practices e.g. education and displays of when the protocol is coming into practice. This QIP plan also incorporates methods to evaluate the QIP plan e.g. recollection of data and Likert scale questionnaires. It is expected that these changes could produce a decreased time from ED registration to CA (Boeddinghous et al, 2016). Also anticipated, is an improvement in the overall quality of NSTEMI care, due to decreased adverse patient outcomes (Gornek et al, 2015). No increase in hospital costs is expected (Jülicher et al, 2017).
References:


midwife specialists or advanced nurse practitioners, in Ireland. *Biomed Central*. 16(151)


coronary syndrome and negative troponin results on admission. Clinical Chemistry. 56(4), 642–650.


Than, M., Aldous, D., Lord, S., Goodacre, S., Frampton, C., Troughton, R., George P., Florkowski, C., Ardagh, M., Smyth, D., Jardine, D., Peacock, W., Young,


European Society of Cardiology 0 / 1-Hour Algorithm for rule-out and rule-in of acute myocardial infarction. *European Heart Journal*. 38(1).


Appendices:
Appendix 1: Gantt Chart

<table>
<thead>
<tr>
<th>Task Description</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meet with Consultant Cardiologist to discuss QIP ideas</td>
<td>September, 2017</td>
<td>October, 2017</td>
</tr>
<tr>
<td>Identify Consultant Cardiologist Sponsor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concept Analysis Research Feasibility of the idea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Submit Project Proposal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning Phase - Meet with MDT to discuss how to implement QIP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sponsorship Approval</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete Stakeholder Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Order Patient Notes from Medical Records</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete Flow Diagram and Process Flow map</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systematically Review Available Literature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gather Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QIP Tabled Day (16/03/18)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write Literature Review</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QIP Tabled Day (23/03/18)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present at to Quality Improvement Staff (27/03/18)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QIP Tabled Day (29/04/18)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analyze Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construct Driver Diagram</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write Introduction of QIP Write-Up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write The Define, Measure, Analyze Phases of the QIP Write-Up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write The Improve Phase of the QIP Write-Up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write Evaluation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write Discussion and conclusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QIP Tabled Day (24/05/18)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Reading of Draft QIP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Submit Draft QIP (3/6/18)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Reading and Final Adjustments to the QIP Write-Up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Submit Final QIP (19/10/18)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reducing the wait time in the Emergency department for Patients with an NSTEMI
Appendix 2: ED Healthcare Hierarchy Structure for NSTEMI Management

ED Healthcare Hierarchy Structure for NSTEMI Management

- Medical consultant
  - Cardiology registrar
    - Medical registrar
      - Cardiology ANP
        - Medical SHO
          - Medical intern
            - ED intern
              - ED consultant
            - ED SHO
          - ED intern
          - ED nurse
        - Medical SHO
      - ED registrar
    - Medical registrar
  - ED consultant
Appendix 3: Potential Future ED Healthcare Hierarchy Structure for NSTEMI Management

Potential Future ED Healthcare Hierarchy Structure for NSTEMI Management

A diagram showing the hierarchy structure, with roles such as Medical consultant, ED consultant, ED registrar, Cardiology registrar, Medical registrar, Cardiology ANP, Medical SHO, ED SHO, ED intern, and ED nurse. The diagram indicates the part of the medical hierarchy structure the ED PA would fit into, if an ED PA was hired.

The part of the medical hierarchy structure the ED PA would fit into, if an ED PA was hired.
Appendix 4: Graphs Demonstrating Further Analysis Completed

Time to Coronary Angiogram for Patients with an NSTEMI who are Less than and Greater than 50 Years of Age

Group 1: Less than or equal to 50 yrs old. Median = 50.0 hrs
Range = 16 - 389 hrs
N = 13

Group 2: Greater than 50 yrs old. Median = 51.5 hrs
Range = 1 - 385 hrs
N = 75

Time to CA (hrs) for patients with an NSTEMI who are less than or greater than 50 years of age

Comparison of Time (hrs) to Coronary Angiogram for Male and Female Patients with a NSTEMI

Males
N = 54
Median = 45.5 (hrs)
Range: 1 - 389 (hrs)

Females
N = 34
Median = 52.5 (hrs)
Range: 3 - 243 (hrs)

Comparison of time (hrs.) to a CA for male and female patients with an NSTEMI
Comparison of the time to CA (hrs.) for patients admitted and not admitted under a cardiology consultant.

- **Cardiology Consultant**
  - Group: N= 71
  - Median: 48.2 hrs
  - Range = 1-389 hrs

- **Non-Cardiology Consultant**
  - Group: N= 17
  - Median: 66 hrs
  - Range = 6-243 hrs

The Percentage of Each Proposed Follow-Up Management Type for Patients with a NSTEMI

- FD: For Discussion
- MM: Medical Management
- NE: Not Entered
- NT: No Treatment
- PCI: Percutaneous Coronary Angiogram

The percentage of each proposed follow-up management type for patients with NSTEMI
Bar chart displaying the profile of negative and positive troponin bloods

Histogram of the distribution of the times from ED registration to ED discharge to a Ward for patients with an NSTEMI.
Appendix 5: Staff Satisfaction Feedback Form:

In an attempt to reduce NSTEMI management time, a new NSTEMI protocol has been introduced.

Please answer the following questions to help demonstrate how the new protocol has affected your work. The Questionnaire takes approximately 1 minute. Please circle the most applicable answer. Thank you.

1. How satisfied were you with the amount of time you could spend with a patient having an NSTEMI?

   Very unsatisfied   Mildly unsatisfied   Satisfied   Very satisfied

2. How satisfied were you with the accessibility of information on NSTEMI management?

   Very unsatisfied   Mildly unsatisfied   Satisfied   Very satisfied

3. How satisfied were you with the available information?

   Very unsatisfied   Mildly unsatisfied   Satisfied   Very satisfied

4. How satisfied were you with the use of the new NSTEMI protocol?

   Very unsatisfied   Mildly unsatisfied   Satisfied   Very satisfied

Please outline any ideas you have to improve the new NSTEMI protocol
Appendix 6: Patient Satisfaction Feedback Form

In an attempt to reduce the increased the wait time associated with a specific type of heart attack called an NSTEMI, a new NSTEMI protocol has been introduced.

Please answer the following questions to help demonstrate how the new protocol has affected you care. The Questionnaire takes approximately 1 minute. Please circle the most applicable answer. Thank you.

1. How satisfied were you with your overall care while in the Emergency Department?

   Very unsatisfied    Mildly unsatisfied    Satisfied    Very satisfied

2. How satisfied were you with the length of time you spent in the Emergency Department?

   Very unsatisfied    Mildly unsatisfied    Satisfied    Very satisfied

3. How satisfied were you when you communicated your fears and worries to an Emergency Department staff member?

   Very unsatisfied    Mildly unsatisfied    Satisfied    Very satisfied

4. How satisfied were you with the amount of time Emergency Department staff members spent with you?

   Very unsatisfied    Mildly unsatisfied    Satisfied    Very satisfied

Please outline how we could make your experience in the Emergency Department better

_________________________________________________________________________________