Summary of Comments on Practical Work Report

Student Name................................... Markers Initials______________

	Ranking			
Structure of the Report (compliance issue) All instruction about format have been followed, and all the prescribed sections are present	5	4	3	2 OR 1
Quality of the Report Grammar and spelling are good. The language is fluent, and flows well, no proof reading errors.	5	4	3 OR 2	1
Presentation of the Report The report is well focussed, balanced, interesting and contains an appropriate amount of detail. Illustrations are useful.	5	4 OR 3	2	1
Scope of Report Well-chosen and relevant to a Practical Work Report	3	2	1	0
TOTAL VALUE OF MARKS	8	7	-	-

$\boxed{15}$

OVERALL Grade for this Report

Total Marks greater than 14	A
Total Marks greater than 10	B
Total marks greater than 6	C
You are required to resubmit this report.	D It is recommended that you contact the Student Learning Unit for advice on the writing of this report

THE UNIVERSITY OF AUCKLAND
FACULTY OF ENGINEERING

CERTIFICATE OF PRACTICAL WORK

Student Family Name		First Name	
Student ID Number		Specialisation	BIOMEDICAL
Part Completed			IV
Full Company Name	UNIVERSITY OF AUCKLAND, DEPARTMENT OF ANAESTHESIOLOGY		
Company Physical Address	LEVEL 12, AUCKLAND SUPPORT BUILDING AUCKLAND CITY HOSPITAL, 2 PARK ROAD,		
Company Postal Address	2 PARK ROAD, GRAFTON, AUCKLAND		
Company Website Address	www.fmhs.auckland.ac.nz/en/som/about/our-departments/anaesthesiology.		
Company Phone Number	+64 9 923 9300	Company Fax Number	+64 9 923 9300
Supervisor Name and Designation	Senior Lecturer	Supervisor e mail address	
Period Worked	From 01/07/2015		To 7/12/2016

Nature of Work (To be classified showing the hours for each classification)	Hours General	Hours Sub Prof
Data extraction	40	
Review of existing work / Literature	20	
Algorithm / script writing of code	120	
~~St~~ Stastical Analysis of results with report.	20	
Total Hours Worked	200	

Report of Engineer in Charge

Signature		Date	07 Dec 2016
Student Progress	Excellent work - will result in one or more papers	Student Diligence	Excellent work ethic.
Student Attendance	Worked well independently.	Remarks	Great to work with; highly recommend.

FOR OFFICE USE

Name of Marker			
Reports Approved	General Hours		Sub Professional Hours
Hours Credited	General Hours		Sub Professional Hours
Grade	Signature		Date

UNIVERSITY OF AUCKLAND

Practical Work Report

Author:

UoA ID

Department
Department of Engineering Science

Company
Faculty of Medical and Health Sciences

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
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Work completed between
1 July 2015 to 7 December 2016

December 7, 2016

Abstract

The author worked as a research assistant for senior lecturer and the Faculty of Medical and Health Sciences. The author and investigated whether incidences of clinically significant hypotension could be predicted. This work involved writing code to extract data from anesthetic records, create scripts and functions in the programme 'R' to define various events in the surgery, and perform a statistical analysis to investigate the problem.

The author completed 200 hours of work from the 1st of July 2015 to the 7th of December 2016.

Many skills and lessons were learnt while working with the FMHS including: maintaining coding 'best practices', working and collaborating as part of a team, and creative problem solving.

The author enjoyed working with , learning many lessons and skills which will be useful in the future.

Acknowledgements

I would like to thank for providing me with this opportunity to work as a research assistant. The lessons and skills I have developed will remain with me for many years to come.

Contents

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Chapter 1

Introduction

1.1 Faculty of Medical and Health Sciences Overview

The Faculty of Medical and Health Sciences (FMHS) belongs to the University of Auckland. The mission statement of the FMHS is to improve the health and well-being of local, national, and global communities through excellence in teaching, research, and service [1].

FMHS offer many opportunities for students to partake in research with faculty members at the forefront of their fields. These opportunities allow students to experience authentic case studies, consider a career in research, and potentially partake in the publication in an article for an academic journal.

The author worked closely with , who researches with the Department of Anaesthesiology, within the FMHS.

1.2 Research Investigation and Aims

Hypotension[1] induced by general anesthesia during a surgery is an undesirable event which can lead adverse outcomes for patients. Typically, hypotension commonly occurs shortly after induction[2] and before onset of surgery. This time-span is liable to inaccuracies in entered data due to anesthetist error[2].

The aim of this research was to investigate predictors of the incidence of clinically significant hypotension during surgeries. As the anesthetist entered data could be prone to inconsistencies, the entered time of induction could not be used. Therefore this investigation sought to initially calculate the time of induction using physiological parameters measured during a surgery.

Once this was accomplished a variety of statistical analysis were performed on 80,000 computerized anesthetic records to investigate predictors of hypotension.

[1]Low blood pressure

[2]Administration of anesthetic agent.

Chapter 2

Organisational Structure

2.1 Department Structure

The department of anesthesiology is part of the Faculty of Medical and Health Sciences (FMHS). The structure in department of anesthesiology is as follows:

- Head of Department
- Professors
- Associate Professors
- Senior Lecturers
- Research and Professional Teaching Fellows
- Professional Staff

The author worked closely with senior lecturer

2.2 Health and Safety

Prior to work, the author was tasked with reading the University of Auckland Health and Safety Policy. In addition the author learned relevant health and safety procedures including: course of action in the event of a fire drill, identifying locations of fire extinguishers, and how to respond to other hazardous events.

2.3 Location

The FMHS is located in 85 Park Road, Auckland. See Figure 2.1 for a map of the location.

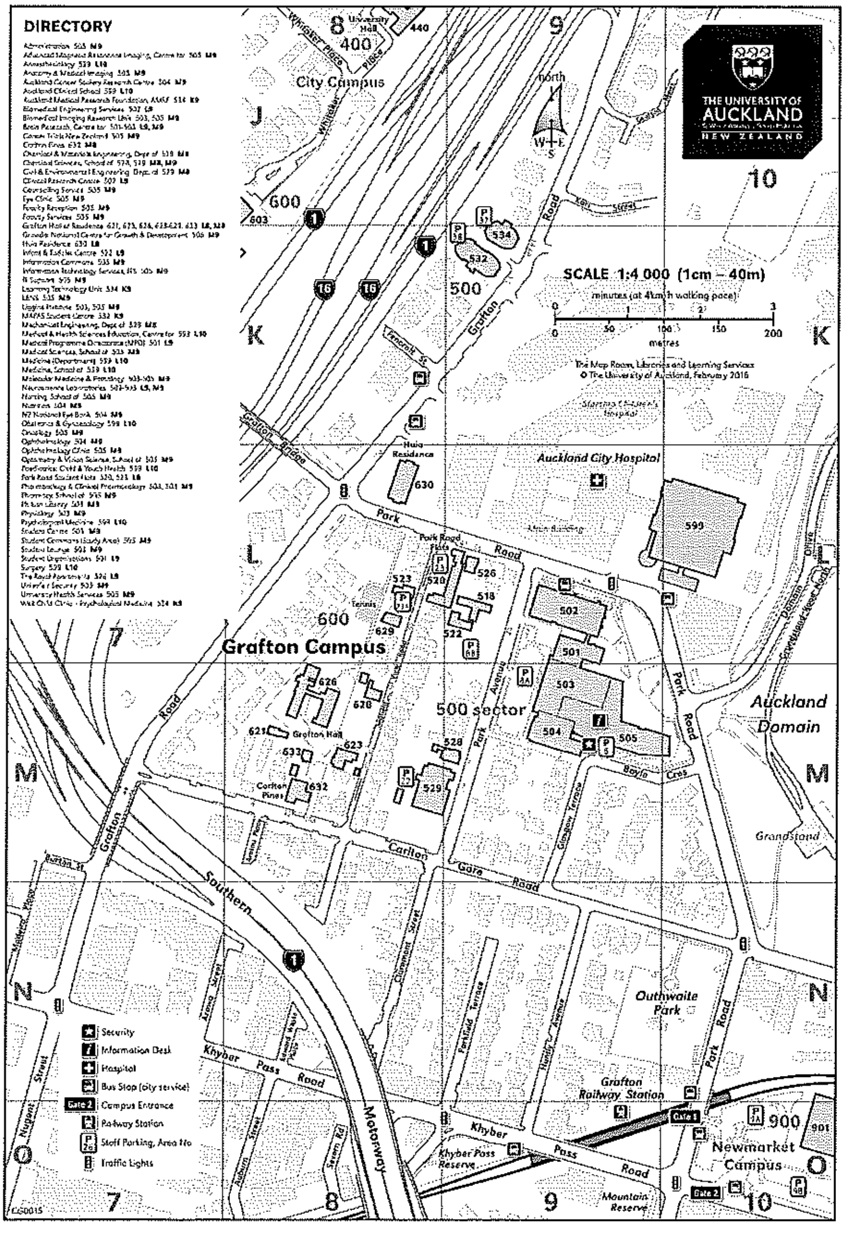

FIGURE 2.1: Locatioon of the Faculty of Medical and Health Sciences

Chapter 3

Work Undertaken

The author worked as a research assistant for exactly 200 hours with the FMHS. The work completed by the author focused mainly on extracting data from anesthetic records and then creating algorithms with the programme R to investigate the problem. The work completed by the author with the FMHS qualifies as general in nature.

3.1 Data Extraction and Reviewing of Existing Work

The initial aim was to calculate the time of induction using physiological parameters. Anesthetic records from surgeries are stored as XML files. These files contain data regarding what events occurred during the surgery, what drugs were administered, the dose and time of administration, and measurement of physiological parameters such as: blood pressures, heart rates, and the volume of CO_2 and anesthetic agent exhaled.

```
<drug>
  <drname SNOMED="387423006">Propofol</drname>
  <drtime>883</drtime>
  <drdose>
    <drvalue>150</drvalue>
    <drunit>mg</drunit>
  </drdose>
  <drroute>IV</drroute>
</drug>
<drug>
  <drname SNOMED="387470007">Cephazolin</drname>
  <drtime>883</drtime>
  <drdose>
    <drvalue>1000</drvalue>
    <drunit>mg</drunit>
  </drdose>
  <drroute>IV</drroute>
</drug>
```

FIGURE 3.1: Part of XML file containing data on drug, time, and dose of administration.

The programming language 'R' was used to store and manipulate the relevant data. There was some existing code that had been used to extract this data prior to this being tasked to the author. The author initially reviewed the code and was tasked with understanding what data was important to extract and where the data would be later used. This step was crucial; it was the author's second time using R and reviewing the existing work allowed the author to rapidly become acquainted with the basics of the coding language.

The next step was to extract the relevant data and store it in a data frame for fast and easy manipulation. Furthermore, the author was tasked with ensuring the routine was able to extract data quickly and efficiently; this speed was important as this routine would later be run on 80,000 anesthetic records, consuming a large amount of time.

Data is stored in groups in an XML file referred to as 'nodes'. In the case of anesthetic records the nodes were called: "Drugs", "Events", and "Data" (referring to physiological parameters). There is a vast quantity of data within these records; not all useful to this investigation. Therefore only some of the data in these nodes was extracted.

A number of drugs are administered over the course of a surgery. In this instance data relevant to anesthetic agents (such as Propofol) were recorded. Similarly, only some physiological measurements were required (blood pressures, and exhaled volume of anesthetic agent and CO_2). An part of the routine used to extract the data for anesthetic agents is shown below in figure 3.2.

```
### DRUGS: Following lines get the Name, Time, Dose, Units of the drugs used
temp_drugs = sapply(getNodeSet(x,"//drname"), xmlValue)
temp_drugt = sapply(getNodeSet(x,"//drtime"), xmlValue)
temp_drugd = sapply(getNodeSet(x,"//drvalue"), xmlValue)
temp_drugd = paste(temp_drugd, sapply(getNodeSet(x,"//drunit"), xmlValue))

#places the above data into a small dataframe for ease of access
if(length(temp_drugs)>0 & length(temp_drugs) == length(temp_drugt) & length(temp_drugt) == length(temp_drugd)){
  temp_drugs = data.frame(drug=temp_drugs, time=temp_drugt, dose = temp_drugd)
}else{
  temp_error = paste(temp_error, "noDrugs ")
  temp_drugs = data.frame(drug=NA, time=NA, dose = NA)
}

### FIRST INDUCTION DRUG ADMINISTRATION
#Get only the induction agents
IndAgt = temp_drugs[which(grepl("Etomidate|Thiop|Propofol", temp_drugs$drug)),]
```

FIGURE 3.2: Part of code to identify only the relevant anesthetic agent data within the XML file.

3.2 Induction Algorithm Creation

Once all the relevant data was to be extracted, the investigation could be conducted. The initial aim was to create a routine that can calculate the time of induction based on physiological parameters.

To begin with, it was necessary to outline the parameters and their values for which induction would be defined as. The end tidal CO_2 and end tidal anesthetic agent[1] were chosen. These parameters were chosen as the CO_2 implies that the Laryngeal Mask Airway has been inserted and the patient is breathing through the apparatus; the anesthetic agent implies that there as been intravenous administration of induction drug and the patient has

[1]Concentration of CO_2/anesthetic agent at the end of the breath.

begun to breathe out the agent (and is therefore under general anesthesia). In addition, to ensure the code was more resilient to erronous data; the algorithm was to check the values of the parameters for one minute and a half following the intial time point when threshold is reached. If those parameters were also over the threshold, the initial time point was recorded.

The efficiency of the code was again important for the aforementioned reasons. Many iterations were made, and the speed of execution (for 20 test cases) was measured for each. Figure 3.3 depicts the code which calculated the time of induction the fastest. For a more complete comparison, the threshold concentrations of CO_2 and anesthetic agent were varied and the time of induction calculated for each.

```
#Case number one
#Sets the dataframe into a data.table
setDT(Phys)
# Subsets the cases which meet the threshold (tr)
Phys[, tr:=etagt>0.5 & etco2 > 2.5]
# Run is the grouping variable that identifies how many values are above the threshold from each data point.
Phys[, run := rleid(tr)]
# Here we find the indices where the run was long enough - in this case we have chosen 9 as we have 10s intervals
# In a case where interpolation is reduced to 1s or we want to have a longer period - increase N.
ind <- Phys[,.N, run][N>=9]
# Now we find the first time for each run that was longer than 9 points.
newdata=Phys[ind, on="run", mult="first"]
# Subset the data to find only the cases which the threshold were met (tr = TRUE)
tmpnew=newdata[which(newdata$tr==TRUE)]
# Extract the first time point from this data and this will be our ALGTIME for this heuristic.
algTime1=tmpnew$time[1]
```

FIGURE 3.3: Sample of code for calculating the time of induction from extracted data.

3.3 Computation of Blood Pressures and Hypotension

The next step was to compare the blood pressures during the surgery to identify if and when hypotension occurred.

The time course of the entire surgery was divided into four categories:

- From five minutes before algorithm calculated induction to the time of calculate
- From calculated induction to five minutes afterwards
- From five minutes after calculated induction to ten minutes after calculated induction
- From ten minutes after calculated induction to 15 minutes after calculated induction

The blood pressures were taken from the data frame and separated according into the categories. Once this was completed the categories were analysed to identify if hypotension occurred using the criteria set by Reich et al[2]. The cases and times of hypotension were then recorded in a .csv file for comparison and analysis.

The last step before statistical analysis was to gather all data important to the statistical analysis. This data included: cases; anesthetic agent used;

blood pressures during the intervals; whether hypotension occurred; the sex, age, weight, and height of the patient; and whether any critical events took place. These variables were stored in one large file ready for statistical analysis.

3.4 Statistical Analysis

A generalised linear model (GLM) was used to predict the likelihood of hypotension occurring with respect to a given variable and whether this variable had a statistically significant influence on the occurrence of hypotension.

A number of variables were tested (such as sex, age, weight of the patient; the type of surgery; and the anesthetic agent used). A sample of code used to calculate the GLM for one variable is shown in figure 3.4.

```
##IF ART OR NBP MEASURED
g = glm(both$HYPOT ~ both$measure, family="binomial"); summary(g); exp(g$coefficients); exp(confint(g));
plot_odds(g)
```

FIGURE 3.4: Sample of code for performing a statistical analysis.

Once this was completed, a series of meetings took place with the supervisor to interpret the findings and describe them in an appropriate manner. A summary report of the findings was drafted and was given to Dr. Cumin for formal writing of the investigation.

Chapter 4

Learning Experience

4.1 Maintaining Coding Practices

The work undertaken by the author primarily consisted of coding with the programme R. This was completely new for the author, having only previously learned VBA, MATLAB, and C++. Coding in R was learned from scratch. Normally, this would be difficult in the limited time frame. However, the author was able to learn from the existing work created prior to this investigation.

The code was carefully commented, used sensible variable names, and was mostly efficient code. These are basics of coding which are emphasized and taught from the first year at university. This was extremely helpful, ensuring the author was able to quickly understand what the code was attempting to achieve at every line. The author replicated this in the undertaken work: code was tested to be as efficient as possible, removing redundant lines; variables were named appropriately so could follow the code at a glance; and regular commenting was utilised to ensure and reader understood the code.

The author has striven to perform these basic coding practices having recognised their importance, both in previous employment and during this investigation. These basics were invaluable, not only for sharing with but also for debugging. The author completely understood the importance of these and will undoubtedly use coding best practices when undertaking future work.

4.2 Skills Developed

Throughout the author's time as a student studying engineering, creative thinking was encouraged to solve problems. This was a core skill that was emphasized but one the author found difficult to apply given the scope of some courses. The work undertaken allowed the author to apply creative problem solving to coding skills. Creativity is a concept that is commonly associated with the arts alone. The author learned that creativity is as much problem solving and working outside the confines of a strict regiment as it is simply 'creating something new'. Initially the author was tasked with a problem. There was no 'correct' way to solve this problem. This allowed the author to test a variety of solutions, implementing functions in the code, and create a novel solution. The author was able to build on the style of problem solving taught by the university and will continue to apply this skill in the future.

The author developed perseverance and tenacity in solving a problem. Working with a new coding language was extremely difficult. The author encountered a large number of errors: from simple syntax errors, to incorrectly used functions. Several hours were spent simply debugging code to find errors. The author strove to solve the problem regardless of the error. The author found that persevering to complete the code to get a meaningful result was worth the strain and prior difficulties. The author will undoubtedly use this skill in the future, for undertaking any projects or tasks.

4.3 Lessons Learned

4.3.1 Thorough Testing

Prior to meetings with , the author rigorously tested the code and documentation to ensure optimal efficiency and to avoid any mistakes. It was critical to the investigation that once a function or script was writing it was tested appropriately with test cases. This provided any opportunity to ascertain whether the implemented code was efficient and bug free. This is a lesson that has been emphasized in previous work experience and also university work. The author appreciates the necessity to test code and will take care in testing or proofreading work undertaken in the future, prior to submission.

4.3.2 Collaboration and Team Work

The author found prior work experience to be completing tasks mostly independently. During the Part IV project, the student worked individually, without a team member. The author and worked together, as a team solving the problem. This was very beneficial to both parties as it allowed generation of more solutions and further ideas to investigate than would be possible if the author worked independently. Furthermore, regular meetings ensured that the author was on task and was working towards an appropriate solution and that was well informed of the process and what was being achieved. The author found that working as a team increased productivity and efficiency of solving the problem at hand. The author recognises that working as a team member is an important skill for the working as a professional; the work undertaken allowed the author to practice and improve these skills.

4.3.3 Working in Research

The work undertaken by this author was the first employment directly with a professional researcher. The author enjoyed their time working as a research assistant. Working as a researcher is challenging but rewarding. It can be slow, tedious, and require funding. However, discovering something new, creating knowledge, and the ability to investigate and solve a real world problem are aspects of research that the author found very stimulating. Furthermore, the formal statistical analysis performed in this investigation was the first performed by the author. It was fantastic experience that the author both excelled at and enjoyed. It has inspired the author to consider applying for postgraduate opportunities, both at the University of Auckland and abroad.

4.4 Final Remarks

Over the course of this work experience (and previous employment) the author identified that a healthy work life balance was important. The author was encouraged to work between 40 and 45 hours a week, with flexible work hours. This ensured the author was not overworked and was able to engage in a range of leisure activities. This flexibility combined with inspiring and interesting work made it a pleasure to work with and the FMHS.

Chapter 5

Conclusions

The author worked as a research assistant with senior lecturer and the Faculty of Medical and Health Sciences from the 1st of July 2015 to the 7th of December 2016 completing 200 hours of general practical work experience. The work undertaken contained tasks applicable to the Bachelor of Engineering (Hons). The learning experiences, skills developed, and tasks have been detailed in this report.

The author performed several tasks while investigating the problem defined by Firstly, existing work was reviewed to understand the overall investigation. The author used the programme 'R' to write scripts to extract useful data from anesthetic records. The author then created a number of routines to calculate when induction occurred during a surgery. Following this, the blood pressures during the surgery were queried to analyse whether hypotension occurred. A formal statistical analysis was then conducted to identify predictors of hypotension during surgery.

The author learned many values during the period of employment: thorough testing of code, working in a team, maintaining coding best practices, and also skills such as problem solving in creative ways and perseverance to accomplish a task. These are important values that the author will utilize in future employment.

The author found a healthy work environment increased efficiency and motivation to work; the healthy work environment created by made working with him a pleasure.

The author has learned many lessons from employment with the FMHS; these lessons will assuredly be useful in the course of future employment.

structure of report good - more description of work done could improve it (details of modelling process, issues encountered during coding, &c.) - but otherwise generally good - reflective content quite good. edited well throughout, with only minor errors.

Chapter 6

Glossary of Terms

- FMHS: Faculty of Medical and Health Sciences
- Anesthetic Agent: An intravenously applied drug that induces anesthetic affect
- Induction: The point at which a patient undergoing surgery is under general anesthesia
- Blood Pressure: The pressure blood in the circulatory system
- Hypotension: Abnormally low blood pressure
- GLM: Generalised linear model; used in statisitcal analysis to find predictors of one data set with respect to another

Bibliography

[1] F. of Medical and H. Sciences, *Vision and plans*, University of Auckland, 2016. [Online]. Available: `https://www.fmhs.auckland.ac.nz/en/faculty/about/our-faculty/vision-and-plans.html`, [Accessed: Dec. 02 2016].

[2] D. L. Reich, S. Hossain, M. Krol, B. Baez, P. Patel, A. Bernstein, and C. A. Bodian, "Predictors of hypotension after induction of general anesthesia", *Anesthesia & Analgesia*, vol. 101, no. 3, pp. 622–628, 2005.