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Understanding the Determinants of Blood Use in Orthopaedics:
A Review of the Literature and a Theory Based Exploration of the Factors Influencing the Decision to Transfuse

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UNDERSTANDING THE DETERMINANTS OF BLOOD USE IN ORTHOPAEDICS: A REVIEW OF THE LITERATURE AND A THEORY BASED EXPLORATION OF THE FACTORS INFLUENCING THE DECISION TO TRANSFUSE.

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1963325

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Abstract

Inappropriate transfusions overexpose patients to the risk of transfusions. The objective of this thesis was to better understand the determinants of *watching and waiting instead of transfusing red blood cells* among orthopaedic surgeons using 1) a systematic review of interventions to reduce inappropriate transfusions; 2) interviews with orthopaedic surgeons; and 3) a theory based predictive survey of transfusion intentions and behaviour. The results of the systematic review suggest that the literature is insufficient to determine the effectiveness of interventions designed to reduce inappropriate blood transfusions. The interviews with surgeons identified six theories potentially relevant to our behaviour. The analysis of the survey identified the Theory of Planned Behaviour as the best predictor of intention to transfuse, accounting for 37% variation. These findings can be used to support the development of a theory based knowledge translation intervention to improve appropriate use of blood transfusions by Canadian orthopaedic surgeons.

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CHAPTER ONE - Introduction

Blood Transfusions

The precise date of the first transfusion is not known [1] (McCullough, 1998), but transfusion attempts have been reported as early as the 15th century. Modern accounts of successful human to human transfusions began with James Blundell in the 1800's. Notably, he cautioned that transfusion should only be used in emergencies [2]. Blood transfusions were extremely risky before the identification of the ABO blood group system and the ability to perform compatibility testing greatly increased the effectiveness of transfusion treatments [3]. Later, the identification of Rhesus (RH) factor in the 1940's [4] further improved transfusion safety and established transfusion as a routine life saving therapy. Currently yearly collection exceeds 75 million units of blood worldwide [5].

In Canada, 915,858 units of blood were collected between April 2008 and March 2009 [6]. Whole blood is collected from donors and then separated into three main components: red blood cells (RBC) , platelets and plasma [7]. The goal of red cell transfusion is to improve the transport of oxygen to the tissues; platelets are transfused to help control bleeding; and plasma contains proteins to help with coagulation [6].

Transfusion Risks

Blood transfusions can increase patient survival [8], but blood transfusions also can cause adverse events and have been associated with increased in-hospital mortality [9], although causality is still not established for increased in-hospital morbidity. There is a lack of quality evidence supporting the benefits of blood transfusions, but there are demonstrated risks associated with the procedure [10]. According to Health Canada statistics, "about 0.5% to 3% of all transfusions result in some adverse events, although the majority of them are minor

reactions with no significant consequences"[11]. Severe reactions occur in 43.2/100,000 patients in Canada[12].

The risk of transfusion can be classified into two types: those related to the blood products and those related to the processing and administration of the blood products.

Adverse events related to the blood products include infectious and non-infectious reactions. The non-infectious reactions related to transfused products include non-febrile hemolytic reactions, allergic reactions, hemolytic transfusion reactions (due to ABO or other blood group incompatibility), *Transfusion Associated Circulatory Overload*, *Transfusion Related Acute Lung Injury*, *Transfusion-Associated Graft-versus-Host disease* and *Post Transfusion Purpura* [13]. Transfusion transmitted infections include viral infections such as Human Immunodeficiency Virus (HIV), Hepatitis C Virus, Hepatitis B Virus, West Nile virus and Human T-Cell lymphoma/leukemiavirus; parasite infections such as Malaria; bacterial infections such as Staphylococcus and Bacillus species and the transmission of prions such as variant Creutzfeld-Jacob disease (vCJD) [10].

The severity and frequency of adverse transfusion events depends on the type of reaction. Less severe reactions include allergic and febrile non-hemolytic transfusion reactions. *Transfusion Associated Circulatory Overload*, *Transfusion Related Acute Lung Injury*, mis-transfusion, *Transfusion-Associated Graft-versus-Host disease* and *Post Transfusion Purpura* reactions are more serious. The most serious adverse health events related to the processing and administration of the blood products are due to *Incorrect Blood Component Transfused* [10], including both events where the wrong person and/or the wrong blood is

transfused. Transfusing an incorrect blood component can lead to hemolytic reactions including hypotension, renal failure and disseminated intravascular coagulation, which, in some cases, may be fatal [10].

According to the British *Severe Hazards of Transfusion (SHOT) Committee* [10] *Transfusion Related Acute Lung Injury* and bacterial contamination are significant causes of death and morbidity. However, eight years of transfusion data from the UK highlighted that ABO incompatibility has the highest risk of mortality and morbidity [10]. Canadian data from 2004-5 indicated that there were 11 deaths associated with transfusion (representing 1.7% of reported Adverse Transfusion Events), 78 major health consequences (11.9%), 455 minor health consequences (71.1%), and 100 Adverse Transfusion Events that the severity is unknown (15.3%) [13].

In Canada, Adverse Transfusion Events are monitored by the Public Health Agency of Canada[14]. The *Transfusion Transmitted Injury Surveillance System* monitors transfusion outcomes across Canada. In 2005, the three most common adverse outcomes (for all blood products) were *Transfusion Associated Circulatory Overload* (13.5 per 100,000 units transfused), severe allergic reaction (5.5 per 100,000 units transfused) and *Transfusion Related Acute Lung Injury* (2.5 per 100,000 units transfused) [13].

The incidence of adverse transfusion events across all blood components was 1:3,270 in 2005 [13]. The incidence of adverse transfusion events in red cell transfusion was notably higher: 1:2,731 with a total of 226 reported events associated with red cell transfusion.

Since red blood cells are the most often transfused components (in 2005, 57.2% of blood units transfused were red cells) [13], the risks are compounded in this product. Overall, red cell transfusions were implicated in 67.5% of adverse transfusion events [13]. Kleinman *et al.* [12], estimated that the risk of potentially severe reactions is 43.2 per 100,000 red cell units transfused [95%CI 38.7-48.1]. The risk of specific transfusion transmitted infections is considerably lower, for example the risk of HIV transmission is 1 per 4,000,000 RBC units, and Hepatitis C is 1 per 3,000,000 RBC units; the risk of Hepatitis B infection is 1.6 per 100,000 RBC [12].

If blood is not required, therefore the intended patient and other patients should not be exposed to the risks associated with transfusions.

Transfusion Costs

In Canada, blood is donated by volunteers but the cost of a transfusion is not insignificant. Amin *et al.* [15] outline the different costs associated with transfusion of a blood product. First, there is the cost to collect, produce and distribute the blood products, which include labour, equipment, supplies and overhead. Second, the cost of a transfusion also includes the donor time spent donating each unit of blood. Third, there are the costs incurred by the hospital transfusion service for donor testing, compatibility testing, and handling and storing the blood products, which include additional labour, equipment, supplies and overhead costs. Fourth, inpatient transfusion costs include nursing time, along with equipment, supplies and overhead costs. Finally, the cost of a unit of blood must account for the blood that is wasted or spoiled throughout the collection, production and distribution processes. In addition to the cost of collection and storage of blood products, one must also consider the costs of

diverse reactions resulting from transfusions. Clearly, the costs to society and to the health care system will increase if blood products are used inappropriately; i.e. in over-transfusion.

Figure 1 depicts the economic breakdown of a unit of red blood cells (RBC) calculated by Amin *et al.* [15]. In 1995, a unit of red cells cost US$264.81 [15]. In 2009, it was estimated that a unit of red cells cost $450 CAD [16].

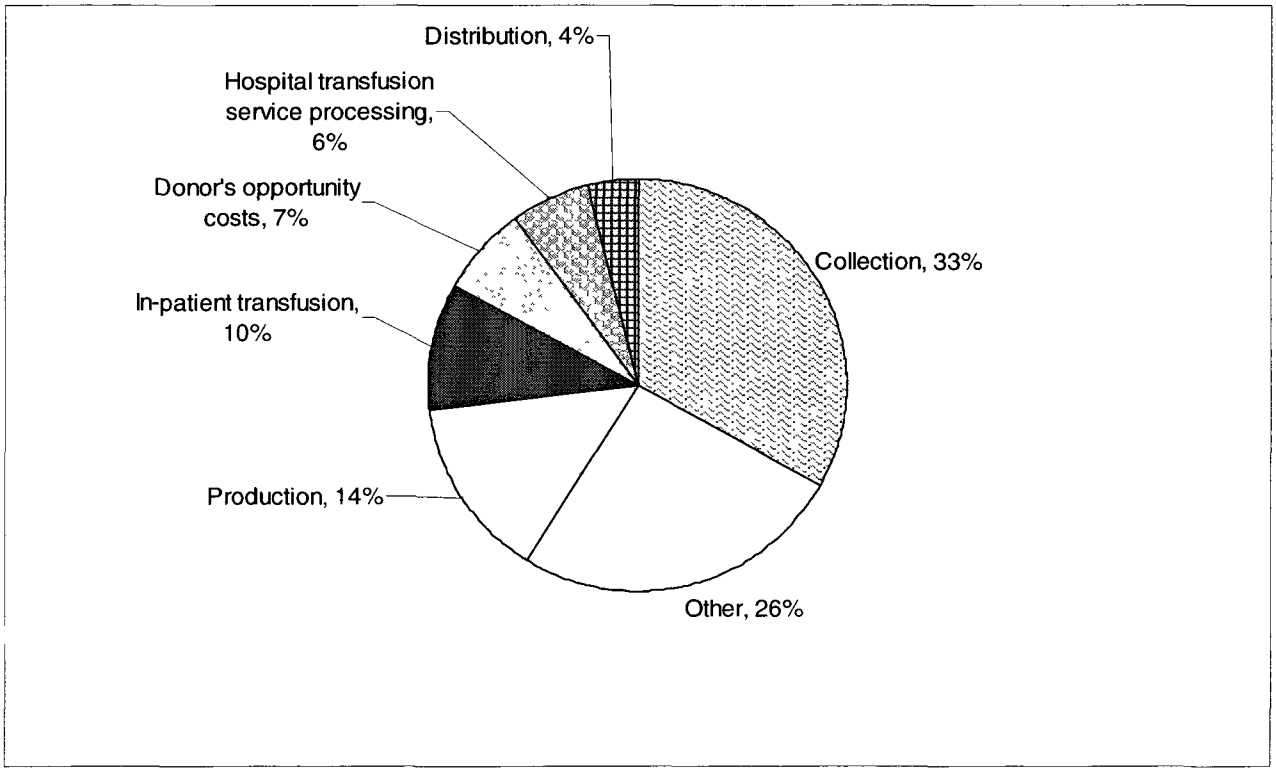

Figure 1.1: Distribution of blood costs from Amin et al., Transfusion 2004; 44:1479-1486

Blood is a limited resource, but the demand for blood products continues to increase [6]. Significant resources are needed to properly collect, test, store and distribute blood products; and these costs are rising as testing and donor referral rates continue to increase [17].

Suboptimal Transfusion Practices

There is considerable published evidence that transfusion practice is suboptimal. One indicator of suboptimal transfusion practice is inappropriate transfusions. The actual rate of inappropriate transfusion is not known, but estimates suggest that as many as 25% of transfusions may be inappropriate [18, 19]. Additional examples of inappropriate transfusion practices are included later in this thesis as part of *Chapter Two.*

A second indicator of suboptimal transfusion practice is widespread variation in transfusion rates. For example, Hébert *et al.* [20], demonstrated that Canadian intensive care units (ICUs) differ significantly when comparing the number of patients transfused per day. A study of preoperative and critically ill patients reported that red cell transfusion rates varied between 23.8% and 51.9% across Canadian medical centres [21]. These variations in transfusion practice suggest that patients are inappropriately transfused. Studies of transfusion variability do not distinguish between over and undertransfusion.

Additional evidence suggests overtransfusion is the problem. An audit of UK orthopaedic surgery patients suggested that patients were being unnecessarily transfused [22]. Murphy *et al.* [22], reported that after receiving just one or two units of blood during surgery, most patients were discharged with hemoglobin (Hb) values of 100 g/L. Had these patients not been transfused, their Hb would have been around 80 g/L (a level not expected to impair recovery) [23]. Over transfusing increases patients' exposure to the risks of transfusion, not to mention unnecessarily taxes an overburdened health care system.

Transfusion Guidelines

In response to the concerns over risks and cost, guidelines regarding red cell transfusions have become increasingly restrictive. Prior to the 1980's transfusions were generally considered to be a low risk procedure with enormous clinical benefits [24] and patients were routinely transfused to keep hemoglobin (Hb) levels above 100 g/L [25]. Transfusion practice was originally scrutinized in the early 1980's because of the risk of transmitting infectious diseases through blood, namely HIV & hepatitis. Advances in screening and testing have greatly reduced the risk of transfusion transmitted infections, yet the remaining transfusion related risks have continued to fuel the current trend towards lower transfusion triggers. Guidelines, recommendations and protocols now present much lower transfusion triggers than those widely accepted before 1980; guidelines often use Hb values as low as 70 g/L.

Guidelines continue to play an important role in transfusion practice. Turgeon *et al.*[26], report that "Published clinical practice guidelines were the most important source cited by anesthesiologists to guide RBC transfusion;" other sources of transfusion guidance include review articles, educational conferences, clinical trials and institutional practice guidelines [26]. Table 1 identifies several commonly used guidelines, the year of publication and summarizes the recommendations for RBC transfusion.

Table 1.1: Summary of Guidelines related to red blood cell (RBC) transfusion

Guideline and source (website)	Date	Recommendations based on Hemoglobin (Hb)
American Association for Blood Banks (AABB) Technical Manual 16th edition [27]	2008	"A hemoglobin of <6 g/dL almost always requires transfusion and a hemoglobin of >10g/dL rarely (but occasionally) requires intervention."
CBS Canadian Blood Services' Clinical Guide to Transfusion [28]	2006	Refer to CMAJ Guidelines and TRICC trial results.
Medical Advisory Committee of the American Red Cross - New England Region Blood Services [29]	2003	"Patients may become symptomatic from lack of oxygen carrying capacity when the Hgb falls below 8 gm/dL. Younger, healthy patients may tolerate a lower Hgb. Few patients will tolerate a Hgb less than 6 gm/dL."
Clinical Practice Guidelines for the use of Blood Components - National Health and Medical Research Council and the Australasian Society of Blood Transfusion [30]	2001	RBC transfusion is likely to be inappropriate when Hb>100g/L, may be appropriate when Hb is in the range 70–100g/L and likely to be appropriate when Hb<70g/L
British Committee for Standards in Haematology (BSCH) [31]	2001	Red cell transfusion is not indicated when Hb concentration is >10/g/dL. Red cell transfusion is indicated when Hb concentration is <7g/dL. The correct strategy when Hb 7–10/g/dL is less clear.
CMAJ Guidelines for red blood cell and plasma transfusion for adults and children [32]	1997	"For clinically stable patients who are not at risk for coronary artery disease, transfusion is more likely to be beneficial when Hb is less than 60 g/L, but not when Hb is greater than 80 g/L, as long as normal blood volume is maintained and patient assessment is ongoing."
American Society of Anesthesiologists Task Force (ASATF) Practice guidelines for blood component therapy. [33]	1996	"The generally accepted hemoglobin level for transfusing patients with acute blood loss is 7 g/dL, with those patients having a level of 6 g/dL almost always requiring transfusion but those with a level of 10 g/dL rarely needing it"

Restrictive Transfusion Practice

Research supports a restrictive transfusion practice for RBCs, but the strongest evidence has not been specific to orthopaedics until recently. The strongest evidence supporting a restrictive transfusion practice is in critical care patients. A multi-centre, randomized, controlled clinical trial of Transfusion Requirements In Critical Care (TRICC) compared a restrictive transfusion strategy (red cells transfused at Hb level of 70 g/L, Hb levels maintained at 70-90 g/L) to a liberal transfusion strategy (red cells transfused at Hb level of 100g/L, Hb levels maintained at 100-120 g/L) in adult critical care patients [34]. In this study the restrictive group received 54% fewer red cells than the liberal group and did not show increased morbidity or mortality. In fact, the patients in the restrictive transfusion group had a non-significant decrease in mortality. The TRICC study concluded that the restrictive strategy was at least as effective as the liberal strategy. Using a similar threshold to that used in the TRICC trial, Transfusion Requirements in the Pediatric Intensive Care Unit (TRIPICU) trial also demonstrated that a restrictive strategy was at least as effective as the liberal strategy in critically ill pediatric patients [35], while the Premature Infant in Need of Transfusion (PINT) study demonstrated little benefit of higher hemoglobin in extremely low birth weight infants [36].

The TRICC trial also performed a subgroup analysis of patients with cardiac disease[1]. Although this study did not demonstrate that patients with cardiac disease have more adverse outcomes using the restrictive strategy, other large observational studies have found that anaemia was associated with an increase in mortality rates among patients with

[1] In the TRICC trial patients with cardiac disease were the only subgroup with increased mortality in the restrictive transfusion group. However, this difference was not statistically significant.

ischemic heart disease [37, 38]. Specifically, Carson *et al.*, [37] concluded that perioperative patients with cardiovascular disease had higher mortality than patients without cardiovascular disease when their Hb was 100 g/L or less[37].

Orthopaedic Population

The use of restrictive transfusion practices in orthopaedic patients has been controversial (i.e. do the results from the TRICC trial apply to this dissimilar population?) Orthopaedic patients are generally older, with more chronic health problems (including more heart disease) than the critical care patients included in the TRICC trial [39]. Carson *et al.* [40] , presently are analyzing the results of the transfusion trigger trial for Functional Outcomes in Cardiovascular Patients Undergoing Surgical hip fracture repair (FOCUS) to address this uncertainty. The randomized clinical trial will provide high quality evidence with regards to the effect of transfusion thresholds on recovery, mortality and morbidity in patients 50 years of age or older who underwent surgery for hip fracture and had a history of cardiovascular disease [41]. Like in the TRICC trial, patients were randomized into two groups: transfusion threshold of 100 g/L or less than 80 g/L when anaemia symptoms occurred [41]. Preliminary results suggest that conservative transfusion practices had "no adverse effects on ability to walk, 60-day follow-up mortality, falls, readmission rates, or fatigue in this high-risk group of elderly patients with underlying cardiovascular disease or cardiovascular risk factors" [41]. That is to say the FOCUS trial presents new, high quality evidence to support restrictive transfusion practice in orthopaedics.[2]

[2] The results of the focus trial were not widely available at the time of the interviews (*Chapter Three*) or survey (*Chapter Four*) portion of this project.

The Need for Theory Based Interventions

Interventions that reduce inappropriate transfusions have the potential to improve patient care and reduce costs to health care systems. Accordingly, there is a need to review the effectiveness of existing interventions to reduce inappropriate transfusions. Current evidence suggests that interventions to reduce blood transfusion may be effective. Successful interventions to reduce blood transfusion include guidelines, audits, education and algorithms for prescribing blood [42, 43]. However, the conclusions from these studies are weak because the intervention studies were poorly designed and were limited by the Hawthorne effect, publication biases, and temporal issues.

Clinical Problem

The clinical problem addressed in this thesis is inappropriate transfusion practices by Canadian orthopaedic surgeons. We understand that transfusion practice is suboptimal and consequently patients are exposed to avoidable risks. However, we do not understand the factors that influence this professional behaviour and therefore, without additional research, we can only speculate as to how best to improve patient care.

The focus of this thesis is to understand the influences on professionals' behaviours, namely the influences on *watching and waiting instead of transfusing red blood cells* in orthopaedic surgeons. In addition to understanding influences, we will use theoretical framework to methodologically guide the study of this professional behaviour. It should be noted that watching and waiting is not the opposite of transfusing of transfusing a patient, but it is the clinical alternative. Francis *et al.[44]*, describe continuous monitoring (i.e. watching and waiting) as the established alternative to transfusing a patient.

Intensive Care Units (ICUs) and surgical wards are consistently the largest users of blood products [45, 46]; Canadian data suggest that Orthopaedic surgery is the largest user of RBC [47]. Studies of inappropriate transfusion practices in the UK and Canada have already looked at RBC use in intensive care settings [48]; therefore, the interviews and survey portion of this study will address the use of red cells in orthopaedics.

Developing an intervention is not a specific goal of this thesis. Nonetheless, a more complete understanding of transfusion behaviour will better position researchers to design interventions in the future. Theory supported interventions are anticipated to be more effective and will likely reduce the burden of researchers by limiting the number clinical trials needed to change behaviour [49, 50].

Knowledge Translation

This thesis will research professional behaviour within the field of *Knowledge Translation* [3] (KT). KT is an established field that studies the uptake of research into practice [51-53]. Evidence suggests that clinical research is not optimally translated into practice. For example, studies suggest that up to 40% of patients do not receive care according to current scientific guidelines [54]. Eccles *et al.* [49] , describe the uptake of research findings into routine health care as "haphazard and unpredictable"(p.107). In

[3] There is a need to address the confusion about terminology and overlapping processes [48]. For this thesis we will use the Canadian Institutes of Health Research definition of *Knowledge Translation* (KT) [49] the "exchange, synthesis and ethically sound application of knowledge—within a complex system of interactions among researchers and users" (p 32) in concert with the "acknowledgement that the KT process occurs in a complex social system of interactions among stakeholders" proposed by Graham *et al* , [48] KT research contains many sub specialties, Estabrooks *et al* [50] further describe KT to encompass similar research areas and buzzwords such as "evidence-based decision making, research utilization, innovation diffusion, knowledge transfer, research dissemination, research implementation, and research uptake"(p.28)

response to this problem, Eccles *et al.*, recommend using a systematic approach. They suggest building a robust knowledge base to support implementation of research findings into clinical practice [49].

This research will be in line with a recent systematic review which specifically recommended that [55] "*Further research is required to develop and validate coherent theoretical framework of health professionals and organizational behaviour change to inform better choice intervention in research and service settings.*" (p.67). As recommended in the review by Grimshaw *et al.* [55] , we will apply existing theories rather than attempt to develop a theory *de novo*.

Psychological Theories and Frameworks

Many psychological theories have been used to structure interventions in other areas of health care. Theories to inform change in practice exist at various levels: individual, group, organization and system wide[56]. In this thesis we will focus on individual level theories. There are two main reasons supporting the choice of individual level theories. First, the research base is more extensive for individual level behaviour [57]. This is because the majority of interventions and *knowledge translation* research is targeted at individuals and therefore the evidence base is larger at this level. Second, in the specific case of blood transfusion, it is the individual surgeon who decides whether to transfuse a patient or not.

There are several potential barriers to using theories to design interventions. First, there are numerous behavioural theories to choose from [58]. This can make the task of selecting a relevant and valid theory challenging. Second, even if you can identify and

select valid theories, it is conceptually difficult to include all theories in a cohesive project. In the past, practical and methodological barriers often limit studies to one or two theories[59]. Third, until recently, there was a lack of validated methods to choose theories [58]. There is little evidence to guide a researcher's decisions when it comes to asking the following questions: Which theories best apply to my research question? Are the theories validated or evaluated in my specific context?

To address these issues we will use the theoretical domain interview (TDI) methods which group theoretical constructs into a list of 12 "theoretical domains"[4] [58]. The methods presented by Michie *et al.* [58], continue to develop, and by using these qualitative interview methods, they propose that any behaviour of interest can be analyzed to determine which of the 12 domains are relevant.

Thesis Overview

This thesis contains five chapters exploring blood use in orthopaedics. This chapter, *Chapter One*, is an introduction of topics covered by this thesis including background information on transfusions, orthopaedics and theory based interventions. *Chapter Two* is a systematic review of existing interventions to reduce inappropriate blood transfusion. It will present a summary of existing interventions to reduce transfusions detailing the types of interventions, the theoretical basis of the interventions, and the effectiveness of the interventions. It will summarize the quality of evidence supporting interventions while

[4] Michie *et al.*, define a *domain* as an area of interest; a sphere of thought, action or knowledge. They define a *theoretical domain* as group of related theoretical constructs and define a *construct* as a concept specially devised to be part of a theory.

delineating any gaps in the existing knowledge base. *Chapter Three* is a qualitative analysis of semi-structured interviews with Canadian orthopaedic surgeons developed using TDI methods based on the Michie *et al.* [58] 12 theoretical domains: Knowledge; Skills; Social/Professional Role and Identity; Beliefs about Capabilities; Beliefs about Consequences; Motivation and Goals; Memory, Attention and Decision Processes; Environmental Context and Resources; Social Influences; Emotion; Behaviour Regulation; and Nature of the Behaviour. The qualitative analysis of the interviews will identify the behavioural theories that are potentially relevant to the decision to transfuse in orthopaedics. The interviews will inform the development of a postal survey. The methods used in *Chapter Three* will identify key constructs but will not provide causal links between the theories and the target behaviour. *Chapter Four* is a quantitative analysis of a theory based survey in orthopaedic surgeons to identify whether potential theories identified in *Chapter Three* are predictive of simulated behaviour and orthopaedic surgeons' intentions to *watch and wait instead of transfusing red blood cells.* Finally, *Chapter Five* will summarize the results of the systematic review, qualitative analysis and quantitative analysis; comment on the implications of this research and provide recommendations for additional research.

In conclusion, this thesis will employ methods from the field of *knowledge translation* to better understand professional behaviour. Within this innovative field it is recognized that using theory to develop interventions should improve patient care. We will examine the target behaviour, *watching and waiting instead of transfusing red blood cells* (RBC) among orthopaedic surgeons. Evidence gathered will ultimately support the design of an intervention to reduce inappropriate transfusion within orthopaedics. Furthermore, this

work will augment the *knowledge translation* knowledge base, supporting implementation research in other clinical areas.

CHAPTER TWO - A systematic review of interventions to reduce inappropriate transfusion

Background

Proper management of blood resources is an important public health issue for a number of reasons. First, blood products carry the risk of disease transmission from donor to recipient in addition to risks of reactions, infections and other serious transfusion specific complications [12]. Second, blood is a scarce resource with most countries depending on volunteer donors; therefore, we have a duty to use their blood donations responsibly. Third, there are also financial costs associated with inappropriate transfusion practices [15]. Finally, the costs to the health care system have increased as a result of increased testing and donor deferrals [42].

Red blood cells (RBC), fresh frozen plasma (FFP) and platelet concentrates are the most frequent blood products transfused [60]. Many guidelines have been published to manage these blood products. Yet, despite the evidence supporting restrictive transfusion practice in critical care patients [34] and orthopaedics patients [41] there remain large variations in transfusion practices both at the physician and institution level [21, 26, 37]. Overtransfusion presents the largest risk of exposure to harm; recent audits of transfusion practices report that patients are more likely to be overtransfused than undertransfused [22]. The inappropriate transfusion of patients not only exposes patients to harm but also increases the burden on health care systems [42].

Interventions that can reduce inappropriate transfusion will improve patient care and reduce costs to health care systems. Clearly, there is a need to review the effectiveness of existing interventions to reduce inappropriate transfusions. Common interventions implemented to reduce blood transfusion have included guidelines, audits, education and

algorithms for prescribing blood [42, 43]. However, the conclusions from these studies are weak because these intervention studies were poorly designed (before and after trials limited to one hospital) and often present the following limitations: influence of Hawthorne effect, publication bias, and temporal issues [42].

This review will provide an update on the state of the science since the review by Tinmouth *et al.* [42], published in 2005 (that included studies published up to 2003). In addition to the themes covered by the previous reviews, we will update the methodologies of the review with supplementary study assessment tools, such as the Cochrane Effective Practice and Organisation of Care Group (EPOC) tool for assessing risk of bias [61]. The effectiveness of these interventions will have implications relevant to the systemic costs and health consequences associated with transfusions.

Objectives

The aim of this systematic review is to estimate the effectiveness of interventions designed to reduce inappropriate blood transfusions by health care professionals.

Methods of the review

Criteria for considering studies for review

Types of Studies: We included Randomized Control Trials (RCTs), Controlled Before and After (CBA), and Uncontrolled Before and After (BA) intervention studies. Randomized Controlled Trials (RCT) measured the effect of an intervention using randomly assigned intervention and control groups [62]. Like RCTs, Controlled Before and After (CBA) studies measured the effect of an intervention using a concurrent control, however they did not randomly allocate the control and intervention groups [62].

Before and After (BA) studies lack random assignment and lack a concurrent control group to measure the effects of the intervention. We included all BA studies in the review and based on EPOC criteria [61] we reanalysed BA studies with at least three data points (per site) before and after the interventions as Interrupted Time Series (ITS) studies.

Types of Participants: Physicians and surgeons responsible for red blood cell (RBC), fresh frozen plasma (FFP) and platelet transfusions in all patient populations.

Types of Intervention: Any interventions targeted at physicians or surgeons to reduce inappropriate transfusions or the number of patients transfused. Studies involving non-human subjects or interventions involving autologous blood donations, matching strategies, pharmaceuticals or other patient focused technologies were excluded.

Types of Outcome Measures: Studies need to report at least one of the following outcomes

- Change in proportion of inappropriate/appropriate transfusions
- Change in proportion of patients over or undertransfused
- Change in number of transfusions
- Change in proportion of patients transfused
- Change in number of red cells (RBC, whole blood), fresh frozen plasma (FFP) or platelets units transfused
- Change in number of patients transfused

Search methods for identification of studies

Relevant studies up to September 2008 were identified by searching the following bibliographic databases (using OVID interface): Medline (1950-2008), EMBASE (1947-2008), Cochrane

Controlled Trials Database (CENTRAL) (1966-2008) and Psych INFO (1806-2008). Due to the unique characteristics of each database, separate search strategies for each database were designed with the assistance of an information specialist (JM) (see Appendix 2-A for the search string).

Study selection

After the search was completed we exported all relevant citations into Reference Manager. Then one reviewer (JE) excluded obviously irrelevant articles using the information in the titles and abstracts (Primary screen). Then a second reviewer (AT) excluded additional articles using the information in the titles and abstracts (secondary screen). Finally, one reviewer (JE) went through the full text articles and included the relevant articles (tertiary screen). When the reviewer was unsure whether to include an article, the decision was made through discussion with experts (AT & JG). For each excluded article the reviewers recorded their reasons for exclusion.

In addition to the database searches, we used supplementary methods to identify relevant articles: the reference lists of articles were checked for earlier articles, and expert input was sought. These additional search methods are recommended to increase article yields and are necessary to complete a quality systematic review [63]. Figure 2.1 outlines the process we used to identify relevant studies.

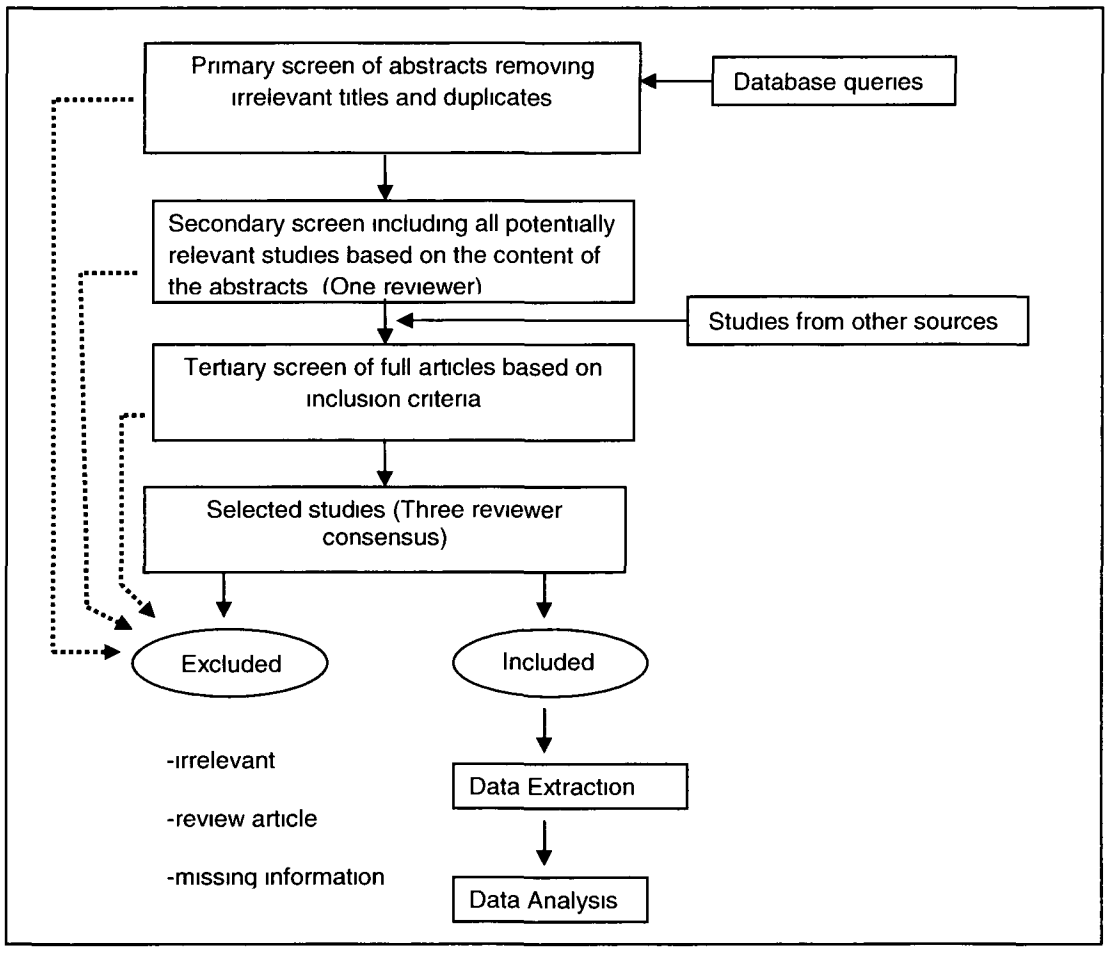

Figure 2.1: Schema of Literature Search Methods Used to Select Relevant Studies

Data extraction

Two independent reviewers (JE and NS) extracted the data from the identified studies using a common data extraction form, which we developed *a priori* based on the EPOC Data Collection Checklist (Appendix 2-B). We piloted the forms to ensure feasibility and comprehensiveness. The following data was extracted from all studies and recorded in an Excel spreadsheet:

(a) Study characteristics: place of study, date of publication, nature of intervention(s), theoretical basis of intervention, nature of comparator, nature of outcomes, population, setting, and methodology.

(b) Results of included studies with respect to inappropriate transfusion outcomes. In studies where appropriateness was reported, we included outcomes measured in terms of appropriateness (e.g. an increase in proportion of appropriate transfusions) and inappropriateness (e.g. a reduction of the number of inappropriate transfusions) but also included measure of transfusions in the "grey area" (e.g. number of transfusion where appropriateness was not clear cut). In this review we will consider a reduction of the overall number of transfusions, or overall number of patients transfused as an indicator of a reduction of inappropriate transfusions.

(c) Assessment of risk of bias.

Box 2.1: Summary of Cochrane Effective Practice and Organisation of Care Group's tools for assessing risk of bias [59].

Criteria for assessing studies with concurrent control group

1. Allocation sequence generated
2. Allocation concealed
3. Baseline outcomes similar
4. Baseline characteristics similar
5. Incomplete outcome data addressed
6. Outcomes assessed blindly
7. Protection against contamination
8. Free from selective reporting
9. Free from other bias

Criteria for assessing studies with historical controls

1. Intervention independent of other changes
2. Shape of intervention pre specified
3. Intervention to effect data collection
4. Knowledge of intervention adequately prevented
5. Incomplete outcome data addressed
6. Free from selective reporting
7. Free from other bias

Assessment of risk of bias

We assessed risk of bias using the Cochrane Effective Practice and Organisation of Care Group (EPOC) tool [61]. As recommended by The Cochrane Collaboration [64], we did not use a scale (or point system) to assess risk of bias: recognizing that the weighting of scale is difficult to justify and often an unreliable predictor of bias. Different study designs were assessed separately by indicating whether

each of the EPOC criterions was "done", "not done" or "unclear". We assessed any RCTs, and CBAs studies using the EPOC tool for assessing risk of bias in studies with a concurrent control group. We assessed ITS and BA studies using the EPOC tool for assessing risk of bias in studies with a historical control.

Randomized controlled trials (RCT) reduce the risk of bias by randomly assigning the intervention and control groups; ideally this will also evenly distribute any known and unknown confounders across groups, so that any difference will be due to chance [62]. This even distribution of confounder protects against selection bias.

Controlled before and after (CBA) studies have a concurrent control to account for maturation effects, and history threats to internal validity, however they do not randomly allocate the control and intervention groups [62]. Lack of random assignment presents several threats to validity [62] namely, selection bias.

Changes that occur over time, such as secular trends, are described as maturation effects [62]. Where possible we reanalyze the BA studies as if they were Interrupted time series (ITS) [65]to protect against the effect of maturation [62]. In this review, seven studies were reanalyzed as ITS.

Before and After (BA) studies lack random assignment and a concurrent control group and are therefore subject to numerous sources of bias. The lack of a concurrent control is a serious threat to the internal validity of a study [62]. Without a concurrent control, the effects of maturation can fluctuate enough so that before and after groups are non-comparable [62]. History effects identify concurrent initiatives that could explain changes between the before and after intervention groups. Without a concurrent control,

the effect of concurrent initiatives cannot be separated from those of the interventions [62].

Analysis

We presented data on the following details studies characteristics, details of intervention, outcomes, and risk of bias in tables. To facilitate interpreting the data from a large number of studies we stratified the studies into meaningful categories [66]. First we organized the studies by blood product type, sorting studies into three categories: red cells (including whole blood), fresh frozen plasma, and platelets. Second, within each blood product we stratified the studies based on study design: RCT and CBA, ITS and BA studies. As recommended by Petticrew and Roberts [66], we analyzed the studies within each category, and then we presented a synthesis of study results across all studies. For continuous outcomes we calculated the absolute difference and the relative difference; dichotomous outcomes were presented only as the absolute difference. Where available we reported the statistical significance for all study types and outcome.

As suggested by the EPOC data collection checklist [67], we reported outcome data using the following formats:

Meta analysis of all studies was not possible because of the differences in interventions, populations and methodologies of the primary studies. Because of this heterogeneity, we limited subgroup analysis to descriptive summaries of study outcomes across study design and study blood product categories. Cochrane Q test and the I^2 statistic were not appropriate for the data.

Methods for reanalysis

The CBA study [68] was reanalyzed as ITS because the control was national statistical data from other sites. This method of using a secondary source for control data was a

major threat to validity [62]. Therefore we treated the study as a simple Before and After (BA) design as opposed to a controlled before and after (CBA) study. To mitigate some of the threats to validity inherent in uncontrolled and controlled before and after studies [62] we reanalyzed seven studies as ITS studies. This was only possible for studies that contained at least three data points before and after the intervention [65]. Reanalysis of BA and CBA studies as ITS used the data from one study site: the primary study site. Initially, we estimated before and after data points from digital graphs using an electronic ruler. Then, we used linear regression (SPSS) to compare the data point before the intervention to those after the intervention [65]. We developed a model for each study outcome that fit the following variables: time, phase (pre-intervention = 0; post-intervention =1) and post intervention slope [69]. This model provided more robust estimates for the effect of the intervention by using the differences between pre and post slopes and corresponding p values. For comparison, the supplementary analysis results were presented alongside the published results.

Box 2.2 Analysis studies with concurrent control (RCT and CBA, including cluster trials)

Main outcome in natural units

Adjusted Absolute risk difference corrected for baseline performance (when available)

Calculated using the following formula:

Adjusted Absolute Difference =
[Control group before intervention – Intervention group before intervention] – [Control group after intervention – Intervention group after intervention]

Adjusted Relative Difference =
{[(Control group before – Intervention group before)/control group before] – [(Control group after – Intervention group after)/control group after]} x 100%

Box 2.3 Analysis of studies with historical controls

Interrupted Time Series (ITS)
Main outcome in natural units
-Intervention effect
-Difference between Slopes
Before and After Studies (BA)
Main outcome in natural units

Calculated differences using the following formulas:

Absolute difference =
(Intervention group - Control group)

Relative difference =
[(Intervention group – Control group) / Control group] x 100%

Unit of analysis

The unit of analysis is important to consider in cluster randomized trials (where intact social units eg hospitals, primary care practices) are randomised and data are collected upon individuals within the cluster (eg patients). A unit of analysis error occurs if the study is analysed using individual patient level data without accounting for the clustered nature of the data. Such unit of analysis errors do not affect the point estimate, but do overestimate the precision of the study resulting in p-values that are too small.

Results

Literature Search

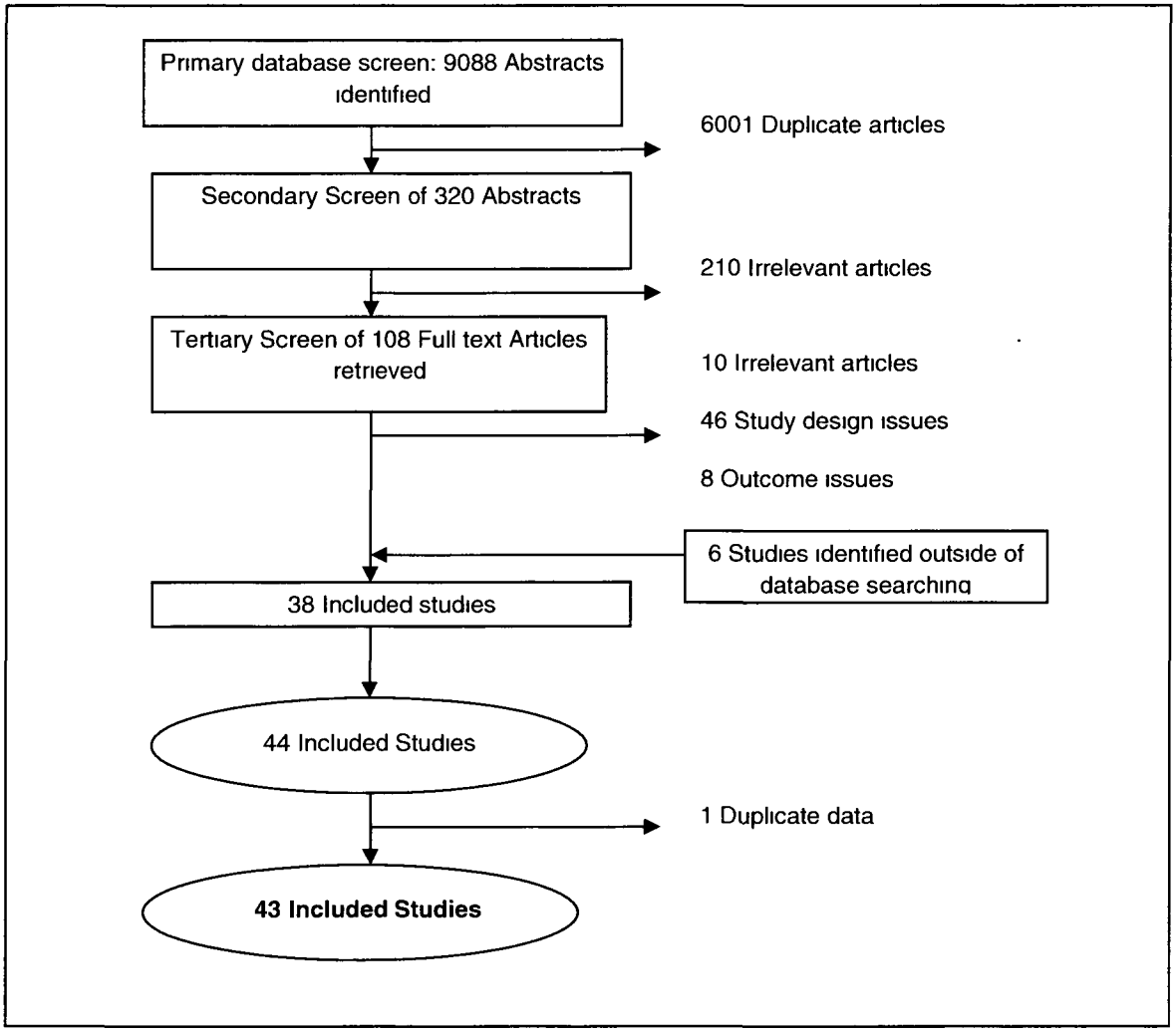

Figure 2.2: Summary of literature search performed detailing the outcomes of the Primary, Secondary and Tertiary screens

The search of the electronic databases identified 9027 citations. In the primary screen we identified 320 studies that potentially met our criteria. The secondary screen reduced the number of studies to 108 studies. The tertiary further reduced the database results to 38 studies. An additional six studies were identified using other methods (expert input and searching references of included papers). Finally, after the exclusion of one study which

published replicate data [70], a total of 43 studies [68, 71-112] met the inclusion criteria. These studies were published between 1987 and 2009.

These studies were performed in a variety of geographic locations including: 17 in the USA, 13 in the EU and UK, six in Oceania, five in Asia, one in Africa and one in South America. About half of the studies (n=21) looked at interventions to reduce blood transfusions in hospital wide populations, while the other half focused on specific populations (n=23): general surgery (n=16), critical care (n=6) and both general surgery and intensive care (n=1).

Included study designs included: Randomized Controlled Trials (RCT) (n=4), Controlled Before and After (CBA) (n=2; n=1 after removing the study reanalyzed as Interrupted Time Series), Interrupted Time Series (ITS) (n=7 derived from re-analysis of six BA and one CBA) and Before and After (BA) studies (n=38; n=32 after removing studies reanalyzed as ITS) BAs.
The BA studies all presented data collected from one site (i.e. hospital, unit or ward). The RCT studies reported data from between one and 12 sites while the CBA study only had two sites.

Red Blood Cells (RBC) were the most common blood product studied: 23 studies included RBC data (19 of these reported only RBC transfusion data while four of the studies looked at whole blood[5]). Fresh frozen plasma (FFP) was the second most

[5] Modern medical practice exclusively uses components of the blood red cells not whole blood. For this review, we grouped whole blood transfusions in with red cell transfusions because, like a red cell

common blood product: 19 studies looked at FFP, and six of these reported only FFP data. There were 12 studies that looked at platelets; one study looked only at platelet data. Overall 30 studies presented data on one type of blood product, five studies presented data on two types of blood products and eight studies presented data on three or more blood products.

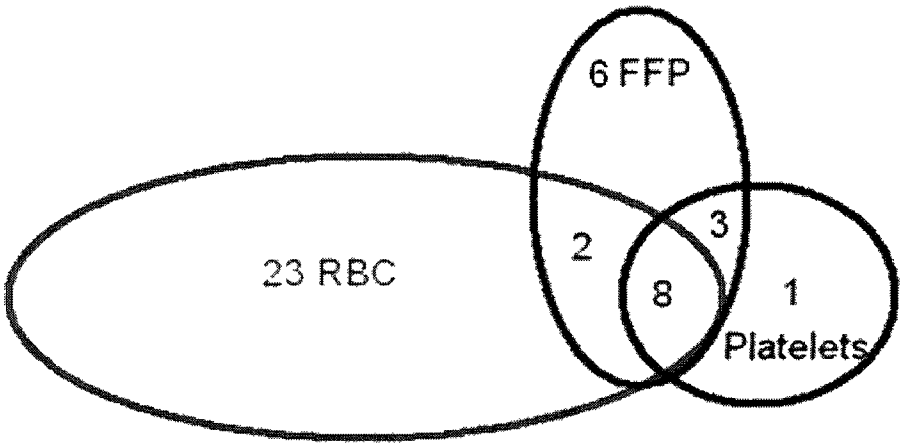

Figure 2.3: Venn diagram of blood product investigated in included studies

Interventions

Of the 43 studies identified, the majority (41/43) described multifaceted interventions to reduce inappropriate transfusion; the remaining two studies evaluated implementation of a new transfusion ordering form. The description of the interventions ranged from very vague to extremely detailed. As an example of an extremely detailed description, Garrioch *et al.* [80], detailed the timelines for education, who was educated, the length of educational presentations and discussions, the content of the educational presentation, include a copy of the guidelines and other intervention material. In contrast, Vos *et*

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transfusions, whole blood transfusions were primarily given to increase the hemoglobin levels to increase the amount of oxygen delivered to the tissues.

al.[111], simply describe the intervention as "*findings were distributed to all senior health staff in the region and resulted in consensus guidelines...these guidelines were then introduced through training workshops to all blood transfusion prescribes in the region.*" The actual components of this and other poorly described interventions were difficult to identify and categorize. Overall, 51% (22/43) of the included studies described the intervention with great detail (RCT 4/4; CBA 1/1; ITS 6/7; and BA 11/32), while 49% (21/43) of the studies provided poor descriptions (ITS 1/7; and BA 21/32) that lacked detail regarding the interventions duration, intensity, format or recipients. Of note, BA studies had the poorest reporting of intervention details.

There was poor reporting of theoretical rational to support the choice of interventions. The most common type of support for an intervention was historical, referencing an earlier study to support the intervention: 29/43 (67%) studies referred to at least one other study included in the review. Using a theoretical rationale to support the choice of intervention was far less common: 36/43 (84%) of studies made no mention of theoretical basis for interventions. Only seven studies mentioned theoretical concepts: seven mentioned knowledge, one mentioned habit and one mentioned resources as the reason for the interventions.

Education was mentioned in 18 studies (42%), new guidelines or policy in 26 studies (60%), audit and feedback in 13 studies (30%), and new forms or ordering systems in 13 studies (10 paper based, 3 computer based). Other less common components included: group meetings, discussions, local champions and "gatekeepers" to impose restrictions on blood usage. Using EPOC categories for intervention [67] the majority of interventions

were professional (including education, audits and feedback, and information). Some interventions, such as "gatekeeper" or hospital wide ordering systems could additionally be classified as organizational (sub type structural). There were no clear examples of financial or regulatory interventions.

Risk of Bias

None of the RCT studies fulfilled all of the EPOC risk of bias criteria. All of the RCT studies randomly assigned the intervention and control groups but two of the studies did not clearly explain how this was done. Only one study adequately described allocation concealment, two studies were unclear and one did not conceal the allocation. Overall, the RCT Studies fulfilled between three and six criteria. Specific examples of other sources of bias from the RCT studies are listed in Appendix 2-C. As shown in table 2.1, the CBA studies fulfilled only two of the EPOC risk of bias criteria.

Table 2.1: Summary of Effective Practice and Organisation of Care Group (EPOC) Risk of Bias criteria for studies with a concurrent control group.

Study (Date First author)	2007 Rothschild	2002 Bray	2001 Rubin	1993 Soumerai	2005 Eindhoven
Study design	RCT	RCT	RCT	RCT	CBA
Allocation sequence generated	+	?	+	+	-
Allocation concealed	+	?	?	?	-
Baseline outcomes similar	+	+	-	+	+
Baseline characteristics similar	+	+	-	+	+
Incomplete outcome data addressed	?	-	-	+	?
Outcomes assessed blindly	+	+	+	?	?
Protection against contamination	-	?	?	+	?
Free from selective reporting	+	?	+	+	-
Free from other bias	-	-	-	-	-
+ Done, -Not Done, ? Unclear					

Table 2.2: Summary of Effective Practice and Organisation of Care Group (EPOC) Risk of Bias criteria for Before and After studies reanalyzed as Interrupted Time Series

Date First author	2009 Sarode	2000 Muller	1998 Rehm	1997 Lam	1989 Ayoub	1988 Solomon	1994 Hawkins
Intervention independent of other changes	-	-	-	-	-	-	-
Shape of intervention pre specified	+	+	?	+	?	-	?
Intervention to effect data collection	-	-	+	+	-	+	-
Knowledge of intervention adequately prevented	-	?	?	?	-	?	-
Incomplete outcome data addressed	?	?	-	?	-	?	-
Free from selective reporting	-	+	-	-	-	-	-
Free from other bias	-	-	-	-	-	-	-

+ Done, -Not Done, ? Unclear

Overall the Interrupted Time Series (ITS) studies failed to satisfy the Effective Practice and Organisation of Care Group (EPOC) criteria for risk of bias. There were no examples of studies that conclusively supported the following EPOC criteria: intervention independent of other changes, knowledge of intervention adequately prevented, incomplete outcome data addressed, or were free from other bias. Forty-three percent (3/7) of studies specified the shape of intervention (some only as a general reduction or increase). Another 43% (3/7) of studies had interventions which may affect the data collection; this included implementation of new forms to record appropriateness and other new data collection procedures. Specific examples of other sources of bias from the ITS studies are listed in Appendix 2C.

Table 2.3: Summary of Effective Practice and Organisation of Care Group (EPOC) Risk of Bias criteria for Before and After studies

Date	First author	Intervention independent of other changes?	Shape of intervention pre-specified?	Intervention to effect data collection	Knowledge of intervention adequately prevented?	Incomplete outcome data addressed	Free from selective reporting	Free from other bias
2008	Mimica	-	-	-	?	?	+	-
2007	Perez	-	-	+	?	?	-	-
2006	Yeh	-	+	-	?	?	-	-
2005	Hui	-	-	-	?	?	-	-
2005	Spencer	-	-	+	?	?	-	-
2004	Garnoch	-	-	+	?	?	?	-
2004	Kakkar	-	-	-	?	?	-	-
2004	Rana	-	-	+	?	?	?	-
2004	Petaja	-	-	-	?	?	-	-
2003	Ballantyne	-	-	-	-	?	-	-
2003	Pentti	-	-	-	?	?	?	-
2002	Torella	-	-	-	?	?	?	-
2001	Capraro	-	-	-	?	?	-	-
2001	Tobin	-	-	-	?	?	-	-
2000	Hamedullah	-	-	+	-	?	-	-
2000	Mallett	-	-	-	-	-	-	-
1999	Kanter	-	-	-	-	?	-	-
1998	Audet	-	-	+	-	?	-	-
1998	Giovanetti	-	-	+	?	?	-	-
1997	Johshi	-	-	+	?	?	-	-
1997	Lucas	-	-	+	-	?		-
1996	Cheng	-	-	+	?	-	-	-
1996	Lam	-	-	-	?	-	-	-
1996	Marconi	-	-	-	?	?	?	-
1995	Littenberg	-	-	+	?	?	?	-
1994	Brandis	-	-	-	?	-	-	-
1994	Vos	-	-	-	?	-	-	-
1993	Morisson	-	-	-	?	-	?	-
1990	Barnette	-	-		?	?	-	-
1988	McCullough	-	-	+	?	?	?	-
1987	Shanberge	-	-	-	?	?	-	-

+ Done, -Not Done, ? Unclear

There were several EPOC risks of bias criteria that were not satisfied by a single BA study: intervention independent of other changes, intervention to effect data collection,

knowledge of intervention adequately prevented, incomplete outcome data addressed, or free from other bias (see table 2.2). Thirty-eight percent (12/32) of studies had interventions which may affect the data collection; this included implementation of new forms to record appropriateness and other new data collection procedures. Specific examples of other sources of bias from the ITS studies are listed in Appendix 2C.

Statistical analysis

In the RCT studies, all but one study Rubin *et al.* [103] used appropriate methods to control for unit of analysis issues. In the included CBA Eindhoven *et al.* [79] did not used appropriate methods to control for unit of analysis issues. In the study by Eindhoven *et al.* [79] and Rubin *et al.* [103], the unit of analysis error will not affect the point estimate, but will overestimate the precision of the study resulting in p-values that are too small. Therefore, although the results presented by the authors were statistically significant, if analyzed properly this may not be the case[6].

Transfusion outcomes

Transfusion outcomes are divided into two main categories: outcomes related to the *appropriateness* of the transfusion and outcomes related to the *volume* transfused (number of patients or volume of blood). Both types of transfusion outcomes are presented below in tables stratified by blood product types: Red cells RBC (including whole blood), Fresh Frozen plasma (FFP), and platelets. These tables are further divided by study designs and outcome categories.

a) **RBC**

[6] Re-analysis of the Eindhoven *et al.* [77] and Rubin *et al.* [101] were not possible because of limitations in the reported data.

There were a total of 54 outcome measures (16 measures of appropriateness and 38 measures of volume) reported in the 27 studies of interventions to reduce inappropriate RBC transfusion.

The data with the lowest risk of bias came from four RCT studies [76, 102, 103, 113]. The RCT studies presented both appropriateness and volume outcomes.

Table 2.4: RCT Studies investigating interventions to reduce inappropriate RBC transfusion

Year	First author	Country	Clinical area	Number of sites	Intervention	Outcome Measure	Adjusted Absolute (Relative) Risk Difference	p value
2007	Rothchild	USA	HW	1 (staff randomized n=535)	Computerized decision support	% Inappropriate orders	-8%*	<0 0001
2002	Bray	India	HW	12 (6 Control)	Self Education forms, Education, Guidelines	Units per admission	-0 02* (-8%**)	NA
						Transfusion requests per admission	-0 05* (-2%**)	NA
						% inappropriate	-2%*	NA
2001	Rubin	Australia	HW	10 (5 Control)	Guidelines, Individual teaching and feedback	% appropriate	2%*	Error
						% unknown	-1%*	Error
1993	Soumerai	USA	Surgery & medical	4 (2 Control)	Guidelines, Audit and Letter	% Inappropriate (surgery)	-20%*	0 006
						% inappropriate (medical)	2%*	NS
						% appropriate (medical)	2%*	NS

HW-Hospital wide, *calculated Adjusted Absoluter Risk Difference, **calculated Adjusted Relative Risk Difference, NA- not available, NS- difference is not significant at p<0 05, Error – not reported because of unit of analysis error

A change in inappropriate transfusion rate was reported in three of the four RCT studies: two studies reported a decrease in inappropriate red cell transfusions; one study reported an increase in two populations. The change in inappropriate red cell transfusion ranged from -20% to +2% (mean -9%) across all RCT studies. Only two of the measures of inappropriateness [102, 103] were reported as statistically significant. There was a unit

of analysis error in Rubin *et al.*[103], and therefore the significance of the study's results should be discounted.

One RCT study [76] reported volume outcomes: units per order, and units per transfusion. Both of these volume outcomes presented reductions in the volume of RBC transfused, however, the reductions were relatively small: a decrease of 0.02 units of red cells per admission and a decrease of 0.06 red cell transfusions per admission. There were no statistical tests of theses comparisons to support whether these small reductions in volume transfused were statistically significant.

There was one CBA study investigating RBC usage, Eindhoven *et al.* [79]. This CBA study presented four volume outcomes that were all statistically significant, but this significance should be discounted because of a unit of analysis error. There was no CBA data reporting appropriateness outcomes for RBC.

Table 2.5: CBA Studies investigating interventions to reduce inappropriate RBC transfusion

Year	First author	Country	Clinical area	Number of sites (control)	Intervention	Outcome Measure	Difference	p value
1995	Eindhoven	Netherlands	Surgery	2 (1)	Coaching and voluntary use of guidelines	% transfused (1 yr)	-11	Error
						Red cells unit per patient (1 yr)	-0 5	Error
					New form, Guideline enforces with audit	% transfused (2 yrs)	-24	Error
						Red cells units per patient (2 yrs)	-0 8	Error
HW-Hospital wide								

There were no ITS studies identified but we reanalyzed five BA and one CBA as ITS. There are a total of six outcome measures from four reanalyzed ITS studies: no measures of appropriateness and six measures of volume. When looking at the intervention effect

(or step effect), half (3/6) of the volume outcomes reported statistically significant decreases. Half (3/6) of the slope differences presented reductions in the volume of RBC transfusions, and one of the six slope differences was significant.

Table 2.6: ITS analysis investigating intervention to reduce inappropriate RBC transfusion: Volume outcomes

Year	First author	Country	Clinical area	Intervention	Outcome Measure	Intervention Step Effect (p value) †	Slope Difference (p value) †	Published results (p value)
2009	Sarode	USA	HW	Education, New protocol	Units	-2076 67 (0 07)	1520 (0 046)	-12 6% (p<0 001)
2004	Muller	Switzerland	Surgery	Flow chart reminder, local champion	Percent transfused	-49 48 (0 001)	-3 15 (0 26)	-15 2% (p<0 05)
					1000 units per hospital	0 113 (0 57)	0 042 (0 62)	NA
					Units per knee surgery	-0 313 (0 015)	-0 040 (0 29)	-0 43 (p<0 05)
1998	Rehm	USA	HW	New Forms,	transfusion per patient	-0 007 (0 25)	-0 003 (0 32)	-26% (p<0 01)
1997	Lam	USA	HW	Self auditing form	Units per month	-0 007 (0 11)	0 002 (0 18)	t=-2 53 (p=0 01)

HW- Hospital wide, Indicates outcome was statistically significant before reanalysis, † data was reanalysis using SPSS

There were eight BA studies reporting appropriateness outcomes (9 inappropriate). All nine measures of inappropriate RBC transfusions reported decreases. The absolute difference in inappropriate transfusions ranged from -4% to -33.5% (mean -19%). Three of the four measures of reduced inappropriateness [97, 100, 109] were reported as statistically significant. Outcome measures which did report significance statistics were all significant (5/10).

There were 17 BA studies reporting 32 RBC volume outcomes (10 reported transfusion rate, 6 transfusions per admission, 7 transfusions per patient, and 9 total volumes of blood)

Eight (8/10) measures of RBC transfusion rate reported decreases. The studies presented a range of absolute difference in RBC transfusion rates, ranging between -50% and +30% (mean -8%). Three studies reported statistical significance (all decreases), one decrease was not significant, and the remaining six studies did not report statistical significance.

Table 2.7: Before and After studies investigating intervention to reduce inappropriate RBC transfusion: Appropriateness Outcomes

Year	First author	Country	Clinical area	Guideline (Source)	Intervention	Outcome Measure	Absolute Difference	p value
				% Inappropriate (% avoidable)				
2006	Rana	USA	ICU	Hb <70-100g/L depending on clinical factors (EU Commission 1999)	Education Form w Guidelines Audit & feedback	% inappropriate	-13 20%*	<0 01
2003	Pentti	Finland	ICU	Hb <80g/L (Local guideline)	Computerized ordering, Decision support	% inappropriate	-31%*	<0 0001
2001	Tobin	Australia	HW	Hb <70-100g/L depending on clinical factors (local guidelines)	Guidelines, Order Form, Audit & Feedback	% inappropriate (3yr)	-13%*	<0 0001
						% inappropriate (6yr)	4%*	0 449
1998	Giovanetti	Italy	Surgery	NIH 1985	Audit & Feedback, Guidelines, quality assurance program	% Units over transfused	-27 1%*	NR
						% Patients over transfused	-33 5%*	NR
1998	Audet	USA	Orthopaedic	Local (estimate blood loss <1,000mL and pre transfusion HCT <24%	Meetings, hospital wide plans, new form	% avoidable transfusions (all)	-23 5%*	0 001
						% avoidable transfusions (allogenic)	-22 8%*	0 001
1997	Joshi	UK	Surgery	Local (Discharge Hct <36%, Hct>39%)	Education, guidelines, Local champions	% inappropriate	-20 7%	NR
1994	Vos	Tanzania	HW	Hb <40 to <100 g/L depending on patients (BCSH 2004, AABB 2004)	Guidelines, Education, and Workshop	% avoidable	-5%*	NR

ICU – intensive care unit, Hb – Haemoglobin, (Int-Ctl) – intervention minus control) ICU – intensive care unit, Hb – Haemoglobin, Hct- Hematocrit (Int-Ctl) – intervention minus control, HW – hospital wide, BCSH – British Committee for Standards in Haematology, AAMM – American Association of Blood Banks, Tx – transfusions, NR –Not reported, *calculated

Table 2.8: Before and After studies investigating intervention to reduce inappropriate RBC transfusion: Volume Outcomes

Year	First author	Country	Clinical area	Intervention	Outcome Measure	Absolute Difference *	Relative Difference	p value
% Transfused (transfusion rate)								
2007	Perez	USA	ICU	Computerized order entry	% transfused	-5%	NA	0 01
2005	Spencer	UK	Surgery	Education, Guidelines, "Gate-keeper"	% transfused	31%	NA	NR
2004	Garrioch	UK	HW	Education, Guideline, Reminders and Audit & feedback,	% transfused	-0 90%	NA	0 006
2004	Ballantyne	UK	Surgery	New protocol, policy and guidelines	% transfused	-19%	NA	<0 001
2002	Torella	UK	Surgery	New Policy, and audit and feedback	% transfused	-26%	NA	0 006
2001	Caparo	Finland	Surgery	Policy, education and Audit and feedback,	% transfused (Allogenic)	-26%	NA	<0 01
2000	Mallett	UK	Anesthesia	Guidelines, Audit, *Equipment for testing Hb*	% transfused	-2 26%	NA	NR
1999	Kanter	USA	Surgery & OB Gyn	Audit and Feedback	% transfused (Allogenic)	-1 10%	NA	0 4
					% transfused (Overall)	-6 3%	NA	0 03
1998	Giovanetti	Italy	Surgery	Audit and Feedback, Guidelines, quality assurance program	% transfused	-10 9%	NA	NR
1997	Joshi	UK	Surgery	Education, guidelines, Local champion	% transfused	-50%	NA	NR
1995	Littenberg	USA	ICU	External Check	% transfused	-4 10%	NA	0 4
				Education, Guidelines, Form	% transfused	2 8%	NA	NR
Transfusions / admission (unit/admission, units/1000 Admissions)								
2007	Perez	USA	ICU	Computerized order entry	Transfusion /Admission	-0 22	-20%*	<0 001
2006	Rana	USA	ICU	Education Form w Guidelines Audit& feedback	Transfusion /Admission	-0 22	-20%*	NR
1997	Lucas	Solomon Islands	HW	Guidelines and Audit	Units per 1000 admission	-28 3	-30%*	NR
1995	Littenberg	USA	ICU	External Check	Units/admission	-0 36	-18%*	0 6
				Education, Guidelines, Form	Units/admission	-0 17	-9%*	NR
1994	Brandis	Australia	Surgery	Guidelines, Education, Increase lab shifts (Hb data)	Units/1000 Admissions	-40	-29%*	0 005
Transfusions/patient (units/ patient)								
2007	Perez	USA	ICU	Computerized order entry	Transfusion /patient	-0 2	-13%*	0 045
2008	Mimica	Brazil	Neonatal	Guidelines	Units per patient	-0 55	N/A	NR
1995	Littenberg	USA	ICU	External Check	Units/patient/day	-0 02	-5%*	0 96
				Education, Guidelines Form	Units/patient/day	-0 01	-3%*	NR
1993	Morisson	USA	OB Gyn	Meetings, Flow chart Teaching, local champion	Units/patient	-0 39	-12%*	NR
					Patient Transfusion /month	-19 2	-60%*	NR
Total units Transfused (units/time)								
2004	Garrioch	UK	HW	Audit & feedback, guidelines, Educations and reminders	Patients transfused	-62	-20%*	NR
					Total Units	-213	-19%*	NR
2006	Yeh	Taiwan	HW	Computer Form, Audit and feedback	Units/month	-673	-15%*	NR
1997	Lucas	Solomon Islands	HW	Guidelines and Audit	Units per 1000 operations	-64 1	-23%*	NR
1996	Lam	USA	HW	Guideline, Order form, Check, Audit and Feedback	Units used (Slope)	-0 0014	N/A	NR
1995	Littenberg	USA	ICU	External Check	Total Units	4	1%*	NR
				Education, Guidelines, Form	Total Units	-40	-10%*	NR

1994	Brandis	Australia	Surgery	Guidelines, Education, Increase lab shifts (Hb data)	Total units transfused	-65	-19%*	NR
1993	Morisson	USA	OB Gyn	Meetings, Flow chart, Teaching, local champion	Total units	-672	-62%*	NR
					Units/month	-67 2	-75%*	NR

ICU – intensive care unit, (Int-Ctl) – intervention minus control, HW – hospital wide, OB Gyn – Obstetrics and gynecology, Hb – Haemoglobin, Tx – transfusion, NR –Not reported, NA – Not applicable to the data, *calculated

All six measures of RBC transfusions per admission reported decreases. The absolute difference in units per admission outcomes ranged from -0.04 to -0.36 (mean -0.17), the relative difference ranged from -9% to -29% (mean -21%). Only two of these four studies reported significant differences in units per admission [75, 98]. All seven measures of RBC transfusions per patient reported decreases. The absolute difference in units per patient outcomes ranged from -0.01 to -0.55 (mean -0.23); the relative difference ranged from -5% to -13% (mean -8%). Only one of these four studies reported significant differences in units per patient [98]. Eight (8/9) measures of total RBC units reported decreases. The studies presented a range of relative difference in units transfused between -75% and +1% (mean -27%). None of these four studies reported significant differences in units transfused. Overall, 90% (28/31) of the volume outcomes reported in BA studies presented a decrease in the amount of RBC transfusions.

b) **FFP**

There are a total of 28 outcome measures (12 measures of appropriateness and 16 measures of volume) reported in 21 studies regarding interventions to reduce inappropriate FFP transfusion.

There were no RCT studies addressing FFP usage.

Table 2.9: ITS analysis investigating intervention to reduce inappropriate FFP transfusion: Volume outcomes

Year	First author	Country	Clinical area	Intervention	Outcome Measure	Intervention Step Effect (p value) †	Slope Difference (p value) †	Published results (p value)
1989	Ayoub	USA	Surgery	Education, Guideline inservice program, Audit & feedback,	Units per year	-516 17 (0 97)	-189 52 (0 3)	-1000 per year, -46% (NR)
1988	Solomon	USA	HW	Guidelines, Education, face to face visits,	Units per month	-15 14 (0 04)	-0 702 (0 6)	-52% (NR)
1994	Hawkins	New Zealand	HW	Audit and gate keeper	Units per 1000 population	1 615 (0 02)	-0 370 (0 1)	-33 4, 55% (NR)
1997	Lam	USA	HW	Self auditing form	Units per month	-0 082 (0 001)	0 001 (0 9)	t=-1 64 (p=0 10)
2009	Sarode	USA	HW	Education, New protocol	Units	-895 17 (0 5)	-1357 5 (0 2)	-59 9% (p<0 001)

† data was reanalysed using SPSS, ICU – intensive care unit, BCSH – British Committee for Standards in Haematology , Hb – Haemoglobin, (Int-Ctl) – intervention minus control, NR –Not reported, NA – Not applicable to the data, *calculated,** Indicates outcome was statistically significant before reanalysis

There were no ITS studies identified addressing FFP usage, but four BA studies provided data that we re-analyzed as ITS. There are a total of five outcome measures from five reanalyzed ITS studies: no measures of appropriateness and four measures of volume. When looking at the intervention effect, two (2/5) of the volume outcomes reported statistically significant decreases, one presented a statistically significant increase. Four (4/5) of the slope differences presented reductions in amount of FFP transfusions, yet none of the four slope differences were significant.

Table 2.10: BA Studies investigating intervention to reduce inappropriate FFP transfusion: Appropriateness Outcomes

Year	First Author	Country	Clinical area	Guideline (Source)	Intervention	Outcome Measure	Absolute Difference (Int-Ctl)	p value
% Inappropriate								
2006	Yeh	Taiwan	HW	BSCH 2004, AABB 2004	audit and feedback,	% inappropriate	-5 2%*	NR
					computerized form, education	% inappropriate	-30%*	NR
2005	Hui	Australia	HW	NHMRC & ASBT 2001	Audit and Feedback, guidelines, self educating form	% inappropriate	4%*	0 05
2004	Kakkar	India	HW	BSCH	Education, audit guidelines, reminders	% inappropriate	-26 6%	NR
2004	Petaja	Finland	NICU	Local	New Form, Audit and Feedback	% inappropriate	-17%*	0 0001
2003	Pentti	Finland	ICU	Local	Computerized ordering forms	% inappropriate	-47%*	0 4
2001	Tobin	Australia	HW	Local (reported in Tuckfield 1997)	Guidelines, form with check "gatekeeper"	% inappropriate (3 yr follow-up)	-10%*	0 0001
						% inappropriate (6 yr follow-up)	+13%*	0 04
2000	Hamedullah	Pakistan	Anesthesia	BSCH 1992	Audit & Feedback Guidelines Education	% inappropriate	-7 %*	NR
1996	Cheng	China	HW	BSCH 1992	Self educating form, monthly feedback	% inappropriate	-58%*	0 05
% Grey area								
2000	Hamedullah	Pakistan	Anesthesia	NR (BSCH 1992)	Audit & Feedback Guidelines Education	% conditional	29%*	NS
2005	Hui	Australia	HW	NHMRC & ASBT 2001	Audit and Feedback, guidelines, self educating form	% Grey area	-8%*	0 05
% Appropriate								
2005	Hui	Australia	HW	NHMRC & ASBT 2001	Audit and Feedback, guidelines, self educating form	% appropriate	4%*	0 05
1990	Barnette	USA	Surgery	NIH 1985	Lectures, Questionnaires, informal group discussions	% inappropriate	31%*	0 05

ICU – intensive care unit, Hb – Haemoglobin, (Int-Ctl) – intervention minus control) ICU – intensive care unit, Hb – Haemoglobin, (Int-Ctl) – intervention minus control, HW – hospital wide, BCSH – British Committee for Standards in Haematology , AAMM – American Association of Blood Banks,NIH- National Institute of Health (USA), NR –Not reported, NS – Not Significant, *calculated

There were eight BA studies reporting appropriateness outcomes (10 inappropriate, 1 appropriate, and 2 "grey area" outcomes). Seven of the ten measures of inappropriate FFP

transfusion rates reported decreases. The decrease ranged from -38% to +13% (mean -18%). Five of the measures of inappropriateness [78, 83, 97, 99, 109] were reported as statistically significant. There was only two measures of appropriate transfusion both presenting statistically significant increases of +4% and +31%.

There were nine BA studies reporting 17 volume outcomes (3 reported transfusion rate, 1 transfusion per admission, 1 transfusion per patient, and 7 total volume of blood). All three measures of FFP transfusion rate reported statistically significant decreases. The studies presented a range of absolute difference between -19% and -0.83% (mean -9%) in FFP transfusion rates. The one measure of FFP transfusions per admission reported decreases. The absolute difference for units per admission outcomes was -28%, (a relative difference of -30%). Two studies presented data on units per patient outcomes; one presented an absolute increase of 0.41 doses of FFP per patient (relative increase of 10%) and the other presented a decrease with an absolute difference of FFP units per patient of -1.19 (relative difference was -13%). Five studies presented outcomes reflecting total FFP units transfused. Four (4/6) of total unit outcomes presented decreases in the volume of transfusions. The relative difference in volume of FFP units transfused ranged from the decrease ranged from -86% to +94% (mean -38%). Only one of these reductions in units of FFP was statistically significant [88]. Overall, 77% (10/13) of the volume outcomes reported in BA studies presented a decrease in the amounts of FFP transfusions.

Table 2.11: BA Studies investigating intervention to reduce inappropriate FFP transfusion: Volume Outcomes

Year	First author	Country	Clinical area	Intervention	Outcome Measure	Absolute Difference*	Relative Difference	p value
% transfused (transfusion rate)								
2001	Caparo	Finland	Surgery	Education, Policy audit and feedback	% transfused	-7%	NA	0 002
1990	Barnette	USA	Surgery	Lectures, Questionnaires, informal group discussions	% transfused	-19 14%	NA	0 001
					% transfused	-0 83%	NA	0 01
Transfusions / admission (unit/admission, units/1000 Admissions)								
1997	Lucas	Solomon Islands	HW	Guidelines and Audit	Units per 1000 admission	-28 3	-30%*	NR
Transfusions/patient (units/ operation)								
2005	Hui	Australia	HW	Audit and Feedback, guidelines, self educating form	Dose per patient	0 41	10%*	NR
Transfusions/patient								
1990	Barnette	USA	Surgery	Lectures, Questionnaires, informal group discussions	Mean transfusion per patient	-1 19	-33%*	NR
Total units Transfused (units/time)								
2006	Yeh	Taiwan	HW	Audit and Feedback, computerized form, education	Average monthly FFP usage	-7231	-74%*	NR
2005	Hui	Australia	HW	Audit and Feedback, guidelines, self educating form	Units of FFP	1	0 25%*	NR
2004	Petaja	Finland	NICU	Computerized form	Units FFP	-40	-86%*	NR
				Audit and feedback	Units FFP	40	94%*	NR
1996	Lam	USA	HW	Gate keeper	Used Units (Slope)	-0 0017	NA	0 5
1993	Morrison	USA	Ob Gyn	Flow chart, education, local champion	Units FFP	-110	-88%*	NR
1987	Shanberge	USA	HW	Audit & feedback, Education, and guidelines	Units per year	-1977	-77%	NR

ICU – intensive care unit, (Int-Ctl) – intervention minus control, HW – hospital wide, OB Gyn – Obstetrics and gynecology, Hb – Haemoglobin, Tx – transfusion, NR – not reported ICU – intensive care unit, (Int Ctl) – intervention minus control, OB Gyn – Obstetrics and gynecology, NR –Not reported, NA – Not applicable to the data, *calculated

c) Platelets

There are a total of 19 outcome measures (8 measures of appropriateness and 11 measures of volume) reported in 12 studies regarding interventions to reduce inappropriate FFP transfusion. There were no RCT studies addressing platelet usage

Table 2.12: ITS analysis investigating intervention to reduce inappropriate Platelet transfusion: Volume outcomes

Year	First author	Country	Clinical area	Intervention	Outcome Measure	Intervention Step Effect (p value) †	Slope Difference (p value) †	Published results (p value)
1994	Hawkins	New Zealand	HW	Audit and gate keeper	Units per 1000 population	-0 667 (0 6) †	-0 105 (0 9) †	Difference not significant (NR)
1997	Lam	USA	HW	Self auditing form	Units per month	-0 092 (0 6) †	0 09 (0 9) †	t=-1 88 (p=0 06)
2009	Sarode	USA	HW	Education, New protocol	Units	-51 00 (0 79) †	-42 5 (0 7) †	-25 4% (p<0 001)
† data was reanalyzed using SPSS, HW –Hospital wide,** Indicates outcome was statistically significant before reanalysis								

Table 2.13: BA Studies investigating intervention to reduce inappropriate Platelet transfusion: Appropriateness Outcomes

Year	First Author	Country	Clinical area	Guideline (Source)	Intervention	Outcome Measure	Absolute Difference *	p value
% Inappropriate (% avoidable)								
2005	Hui	Australia	HW	NHMRC & ASBT, 2001	Education, New form, audit and feedback	% inappropriate	-2 %	0 025
2004	Kakkar	India	HW	BSCH	Education, guidelines, reminders, audit	% inappropriate orders	-26 6%	NR
2004	Petaja	Finland	NICU	(Local)	Computerized ordering,	% inappropriate	NR	NR
2003	Pentti	Finland	ICU	(Local)	Computerized ordering, Decision support	% inappropriate	-20%	0 6
2001	Tobin	Australia	HW	(Local)	Guidelines, Education and "Gate-keeper"	% inappropriate (3 yr follow-up)	-10%	<0 0001
2001	Tobin	Australia	HW	(Local)	Guidelines, Education and "Gate-keeper"	% inappropriate (6 yr follow-up)	14%	0 004
1996	Cheng	Hong Kong	HW	BSCH 1992	New Form, Guideline, monthly feedback	% inappropriate	-10%	0 05
% Transfusions in grey area								
2005	Hui	Australia	HW	NHMRC & ASBT, 2001	Education, New form, audit and feedback	% inappropriate	-4 %	0 025
% Appropriate								
2005	Hui	Australia	HW	NHMRC & ASBT, 2001	Education, New form, audit and feedback	% appropriate	5%	0 025
ICU – intensive care unit, NICU –Neonatal ICU, Hb – Haemoglobin. (Int-Ctl) – intervention minus control, HW – hospital wide, BCSH – British Committee for Standards in Haematology , AAMM – American Association of Blood Banks, HW – hospital wide, (Int-Ctl) – intervention minus control), NHMRC & ASBT – Australian National Health and medical Research Council and the Australian Society of Blood Transfusion. NR –Not reported, NA – Not applicable to the data, *calculated								

There were no ITS studies identified but three BA studies provided data that could be re-analysed as ITS. There are a total of three outcome measures from three re-analyzed ITS

studies: zero measures of appropriateness and three measures of volume. Two (2/3) of the slope differences presented reductions in amount of platelet transfusions, yet none of the slope differences or intervention effects was statistically significant.

There were six BA studies reporting appropriateness outcomes for platelet transfusions (7 inappropriate, 1 appropriate, and 1 grey area outcomes). Five of the seven measures of inappropriate PT transfusion reported decreases. The decreases ranged from -26.6% to +14% (mean -9%). Four of the measures of inappropriateness [78, 83, 97, 109] were reported as statistically significant. There was only one measure of appropriate and grey area transfusion: an absolute increase of 5% ($p<0.025$) and an absolute decrease of -4% ($p<0.025$) (Hui, 2005), respectively.

There were eight BA studies reporting ten volume outcomes (1 reported transfusion rate, 1 transfusion per admission, 2 transfusions per patient, and 6 total volume of blood). The lone study reporting platelet transfusion rate reported a significant decrease of 6%. The one measure of platelet transfusions per admission also reported decreases: the absolute difference for units per admission outcomes was -7%, (relative difference -22%). Two studies presented data on units per patient outcomes; one presented an absolute increase of 0.91 doses of platelet per patient (relative increase of 22%) and the other presented a decrease with an absolute difference of number of units of platelet per patient of -2 (relative difference was -4%). Six studies presented outcomes reflecting total platelet units transfused. Four (4/6) of total unit outcomes presented decreases in the amount of transfusions. The relative difference in platelet units transfused ranged from -59% to +18% (mean -12%). Only one of the reductions in units of platelet was statistically

significant [88]. Overall, 63% (5/8) of the volume outcomes reported in BA studies presented a decrease in the amount of platelet transfusions.

Table 2.14: BA Studies investigating intervention to reduce inappropriate Platelet transfusion: Volume Outcomes

Year	First author	Country	Clinical area	Intervention	Outcome Measure	Absolute Difference *	Relative Difference	p value
Transfusion rate								
2001	Caparo	Finland	Surgery	Policy, education and Audit and feedback,	Allogenic Transfusion rate	-6%	NA	0 001
Transfusions / admission (unit/admission, units/1000 Admissions)								
1996	Cheng	China	HW	New Form, Guideline, monthly feedback	Units/100 Admissions	-7	-22%*	NR
Transfusions/patient (units/ patient, patients Transfused/week)								
2005	Hui	Australia	HW	Education, New form, audit and feedback	Dose/patient	0 91%	22%*	NR
1988	McCullough	USA	HW	Guidelines	Patient Transfused/week	-2	-4%*	NR
Total units Transfused (units/month)								
2006	Yeh	Taiwan	HW	Computer Form, Audit and feedback	Units/month	-1196	14 %*	0 014
2004	Petaja	Finland	NICU	Computerized ordering,	Total Units	28	18%*	NR
2004	Petaja	Finland	NICU	Computerized ordering, with feedback	Total Units	-108	-59%*	NR
1996	Cheng	China	HW	New Form, Guideline, monthly feedback	Total units/ 3 months	-1159	-17%*	<0 05
1994	Hawkins	New Zealand	HW	Approval program and audit	NR	No Change	NA	NR
1988	McCullough	USA	HW	Guidelines	Total units/year	-10414	-14%*	NR

ICU – intensive care unit, NICU –Neonatal ICU, (Int-Ctl) – intervention minus control, HW – hospital wide, (Int-Ctl) – intervention minus control, NR –Not reported, NA – Not applicable to the data, * calculated

Discussion

This review process identified a variety of evidence with regards to the effectiveness of interventions to reduce inappropriate transfusion practice. Ninety-five percent (41/43) of the interventions were multifaceted including various combinations of education, new guidelines, policy, audit and feedback, new ordering forms or systems, group discussions, local champions and "gatekeepers". There were eight studies that reported appropriateness outcomes, 27 studies that reported volume outcomes, and eight studies

that reported both appropriateness and volume outcomes. We considered a reduction of the volume transfused as an indicator of a reduction of inappropriate transfusions and therefore value actual measures of appropriateness as higher level evidence than the volume outcomes.

The 43 studies we identified present a hierarchy in the evidence based on the outcomes and study designs. There were four randomized controlled trials (RCT), one controlled before and after (CBA), seven interrupted time series (ITS) and 32 before and after studies (BA). In terms of study design, we consider studies with a concurrent control [Randomized Control Trials (RCT)] as higher evidence than those without [uncontrolled Before and After (BA)]. The evidence from ITS and CBA studies fall in between RCT and BA evidence.

Red Cells (RBC): Evidence from one RCT study, Soumerai *et al.* [113], suggests that red cell transfusion practice may be improved in some specific populations (i.e. surgeons) but these results have yet to be replicated. The other three RCT studies did not produce statistically or clinically significant results. The lone CBA study, Eindhoven *et al.* [79], presented a relatively small reduction in transfusions which had questionable clinical significance and the confidence intervals had units of analysis errors. ITS studies presented statistically significant improvements to transfusion practice in 3/6 studies for red cell outcomes while BA studies reported improvement in transfusion practice in 100% (8/8) for appropriateness outcomes and 90% (27/31) for volume outcomes.

Fresh frozen plasma (FFP): Interrupted time series (ITS) studies presented statistically significant intervention effects in 60% (3/5) for FFP outcomes, while before and after (BA) studies presented statistically significant improvements to transfusion practice 62% (8/13) for FFP appropriateness outcomes and 75% (9/12) for FFP volume outcomes.

Platelets: Interrupted time series (ITS) studies presented statistically significant improvements to transfusion practice 0% (0/3) for platelet outcomes while before and after (BA) studies presented significant improvements in 71% (5/7) for platelet appropriateness outcomes and 56% (5/9) for platelet volume outcomes.

Risk of Bias: The uncontrolled before and after (BA) studies presented the most serious risks of bias issues because the BA study design is defenceless against many threats to internal validity. Therefore, the results from the BA studies should be interpreted with extreme caution. That is to say we should place less weight on these results when compared to the results of studies with concurrent controls. For example when reviewing the red cell outcomes, we should not necessarily trust the conclusions drawn from BA studies which suggested that interventions were more successful at reducing inappropriate red cells transfusion than the RCT, CBA and ITS data would indicate. Only 40% (2/5) of the studies with concurrent controls (RCT and CBA) and 50% (2/4) of ITS studies reported interventions that significantly reduced inappropriate red cell transfusion. In contrast, 63% (5/8) of BA studies suggested that interventions to reduce inappropriate red cell transfusion were statistically significant.

Before and after (BA) studies that could not be reanalyzed as Interrupted Time Series (ITS) present the highest risk of bias. BA studies do not have a concurrent control to account for maturation effects and history threats to internal validity, because they do not randomly allocate the control and intervention groups, and because these studies cannot be statistically adjusted to account for secular changes.

Publication timelines: The first RCT was published by Soumerai *et al.* [113], in 1993. This review identified 29 before and after (BA) studies published after 1993 but only four controlled trials. In general, this review revealed that there is limited evidence supporting the effective interventions to reduce inappropriate transfusions. There is a lack of quality evidence (i.e. RCT or CBA studies) to support the effectiveness of intervention to reduce inappropriate FFP and platelet transfusions.

Figure 2.4 presents the studies by publication date and study design, visually depicting the overwhelming proportion of Before and After (BA) studies. Because of high risk of bias, these BA studies do little to advance the knowledge base, and add even less to the conclusions of previous research. We have already discussed that the majority of the evidence in this review came from uncontrolled BA and acknowledged the risk of bias concerns that this type of study presents. Although considered stronger quality of evidence, RCT and CBA studies in this review also presented significant risk of bias. We need to develop a more coherent way to improve the knowledge base.

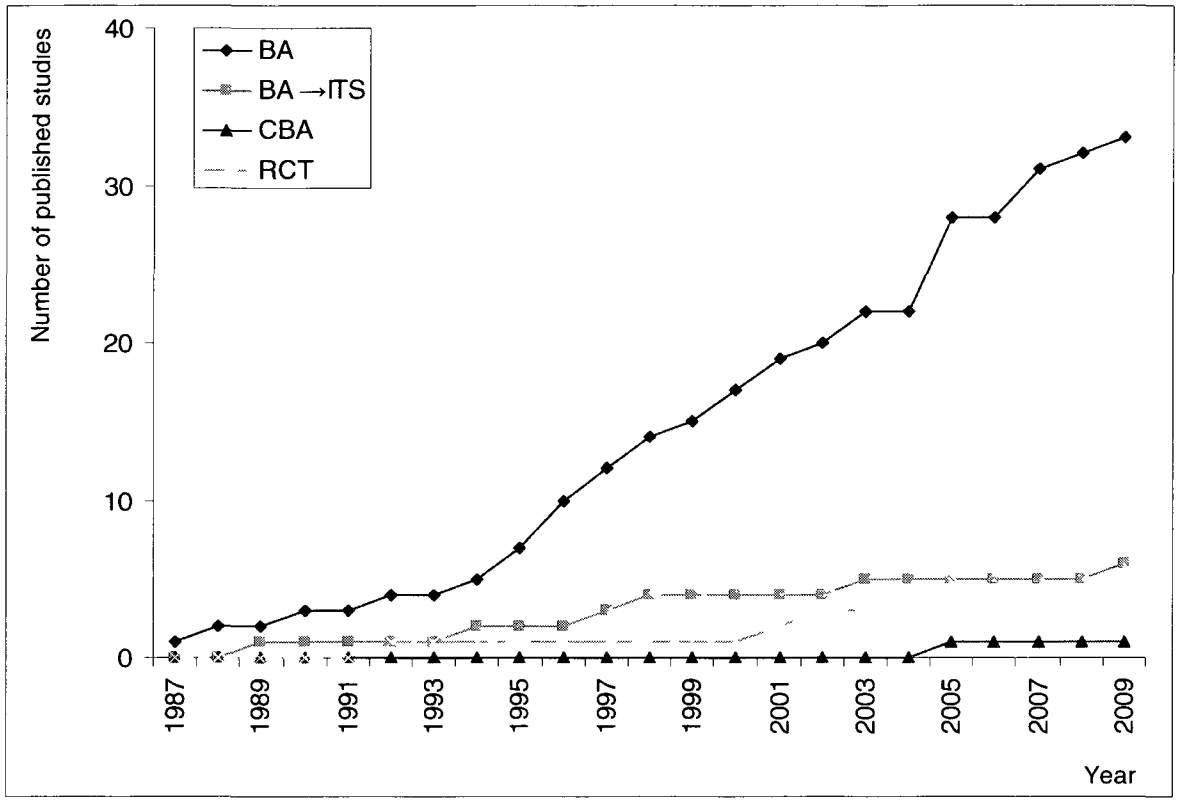


Figure 2.4: Published studies identified in this review plotted against time (by study design)

Strengths

This systematic review identified 21 additional studies not included in previous reviews. Many of these studies were published after the publication of the previous reviews, however, some were not. One possible explanation for this improvement is that the enhanced search strategy may have identified studies not previously reviewed.

In addition to the identification of additional studies, an added strength of this review is that it employed methods not used in the previous reviews. Analysis of intervention rationale and risk of bias assessment will add to the depth and quality of the knowledge base. Moreover, reanalysis of BA studies as ITS studies strengthens the quality of evidence by accounting for threats to internal validity. When reanalysed as ITS, the

results of 43% (6/14) of the BA outcomes changed from significant to non-significant. In this review, none of the differences in slopes were significant after reanalysis yet 43% (6/14) outcomes presented statistically significant changes in the intervention effect. This suggests a step effect (Figure 2.5), where the intervention did not change the slope (or rate) but did change the absolute number (i.e. volume).

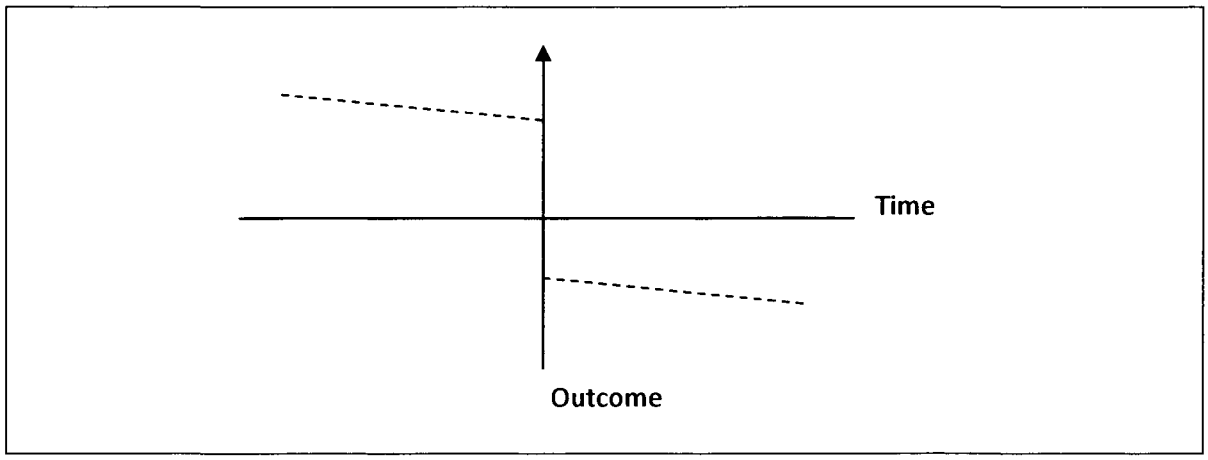


Figure 2.5: Example of a step effect in an Interrupted Time Series (ITS) analysis

Limitations

There are several factors that limit the conclusions drawn in this review. First, there was a general lack of reporting in the primary literature. Specifically there was a lack of emphasis placed on detailing the interventions. Approximately half (49%) of the interventions were not well described and therefore difficult to categorize. Michie *et al.*, reported a similar concern: "behaviour change interventions are not well described; when they are described, the terminology used is inconsistent" (p. 40). Even in the studies that adequately described the interventions there is no way to tease apart the role that each of the aforementioned components played in changing transfusion practice. We were unable to conduct subgroup analysis by intervention type because of this reporting

issue. Furthermore systematic poor reporting of behavior change interventions reduces scientific replication and restricts the development of successful interventions[114].

Second, most studies did not justify the choice of a given intervention or use theory to inform the choice of interventions. Only one study [113] reported a thorough methodology to designing the intervention based on the target population. Aside from historical reasoning, there was little to explain why researchers chose specific interventions in the included studies. Davies *et al.* [50], reported a similar observation in a systematic review of implementation research: there is poor justification for the choice of intervention and limited use of theory in studies. This result is not surprising because using theoretical frameworks to support the choice of intervention is uncommon in many areas of research [115].

A final limitation is the low quality of published studies. Previous reviews [42, 43] concluded that the current literature base is insufficient to determine the relative effectiveness of interventions designed to reduce inappropriate blood transfusions by health care professionals. Although this review identified additional studies not included in previous reviews, employed a better search strategy, and used additional analysis methodologies, the general conclusions remain unchanged. It is disappointing that the quality of the evidence has not improved and we are likely wasting research resources and not advancing knowledge in robust way.

Future research

After reviewing the literature regarding interventions designed to reduce inappropriate blood transfusions by health care professionals one important unanswered question remains: "**Do the interventions work**?" To answer this question we need to design and conduct high quality studies to judge the effectiveness of interventions. These studies need to describe the interventions and detail the components of the interventions. Instead of a plethora of low quality studies, research efforts would be more effectively employed in larger RCT studies which have higher internal validity. Moreover, systematic development of interventions targeted to specific populations help further focus research efforts.

Another area of future research would ask: "**Does theory enhance intervention effectiveness?"** To explore this issue, studies should systematically apply theory to design interventions. The importance of choosing an intervention should be emphasized. Interventions should not be based solely on what others have done, but the interventions should be specifically targeted to the study populations. We agree with the recommendations made by Davies *et al.* [50], that "future research should explicitly identify the justification for the interventions" and that "Greater use of explicit theory to understand barriers, design interventions, and explore mediating pathways and moderators is needed to advance the science of implementation research" (p 14).

Conclusions

This review suggests that it may be possible to change transfusion practice through interventions. However, this review does not provide any conclusions supporting the best way to change transfusion practice. There were 43 studies identified covering the three most common blood products. Collectively, these studies demonstrate that there is an

interest improving transfusion practice; however, the quality of the published studies is generally poor. Only one RCT study [113] suggested that a clinically and statistically significant reduction in inappropriate RBC transfusions was possible in a select population, but this result has not been replicated using quality methods. Consequently, we are unable to properly answer questions regarding the relative effectiveness of interventions. We need a better understanding of transfusion behaviours before we can effectively change clinical practice. Without the adoption of coherent and systematic research methods, we risk continuing to publish redundant low quality studies that add little to the knowledge base.

CHAPTER THREE – Understanding red cell prescribing in orthopaedics:

Qualitative Analysis of interviews

Introduction

As introduced in *Chapter One* of this thesis, there are risks and costs associated with every blood transfusion. The risks of transfusion include infectious and non-infectious reactions. The costs of transfusions can be measured in dollars spent by health care systems to collect, process, store and administer blood products including the costs to treat any adverse outcomes of transfusions. Furthermore, there are additional societal costs incurred as blood is collected from volunteer donors who volunteer their time along with their donation.

Research in intensive care settings supports restrictive transfusion practice; a multi-centre, randomized, controlled clinical trial of Transfusion Requirements In Critical Care (TRICC) demonstrated that a restrictive transfusion strategy is at least as effective as a liberal transfusion strategy in a critical care setting [34]. However it was not clear whether this evidence was applicable to other populations such as orthopaedic patients. Orthopaedic patients are generally older with more chronic health problems (including more heart disease) than critical care patients [39]. Therefore the use of restrictive transfusion practices in orthopaedic patients is controversial; do the results from the TRICC trial apply to this dissimilar population? Carson *et al.*[40], recently completed the transfusion trigger trial for Functional Outcomes in Cardiovascular patients Undergoing Surgical hip fracture repair (FOCUS) Trial to address this uncertainty. Preliminary results suggest that restrictive transfusion practices had no adverse effects among this high risk population[41]. That is to say the FOCUS trial presents new, high quality evidence to support restrictive transfusion practice in orthopaedics.

There is considerable published evidence that transfusion practice is suboptimal. Indicators of suboptimal practice include inappropriate transfusion rates [18, 19], variation in transfusion rates [21, 26]. Additional evidence suggests overtransfusion is the problem. An audit of UK orthopaedic surgery patients suggested that patients were being unnecessarily transfused [22]. Over transfusing overexposes patients to the risks of transfusion, and unnecessarily taxes health care systems.

This suboptimal practice presents an opportunity to improve transfusion practices within orthopaedics. Orthopaedic surgeons are among the largest users of red cell products [116]; high red cell usage compounds the risks associated with transfusion. Reducing inappropriate transfusion in this high usage setting has the potential to improve transfusion practices by significantly reducing patient's exposure to harm and reducing the systemic costs to collect, store and administer blood.

Interventions to reduce inappropriate transfusions have been developed and tested empirically. *Chapter Two* of this thesis presented a systematic review of interventions used to reduce inappropriate transfusions across various patient and practitioner populations. Interventions included Education, Guidelines, Policies, Forms, and Audit & Feedback methods. The results from *Chapter Two* reconfirm the conclusions previous from systematic reviews by [42, 43]. The evidence supporting interventions was low quality and consequently the relative effectiveness of interventions continues to remain unclear. A second observation from *Chapter Two* is that researchers rarely used theories to develop or justify interventions and in the majority of studies did not even support the choice of intervention with empirical evidence.

There is emerging interest in using behavioural theories to design interventions; however, this practice is not yet commonplace. It has been argued that using a theoretical basis will lead to better behavioural change interventions [49, 59]. There have been many theoretical models developed to explain behaviour; yet, across a variety of research contexts (including transfusion in orthopaedics), theoretical rationale is rarely presented to support the chosen intervention [50, 55].

There is a need for validated methods to systematically develop theory based interventions to better influence health professional behaviour change; however, there are several barriers to using theory to design interventions. First, there are numerous behavioural theories to choose from [117]. This can make the task of selecting a theory challenging. Second, even if one can identify and select valid theories, it is conceptually difficult to include all theories in a cohesive project. In the past, practical and methodological barriers often limited studies to just one or two theories [59]. Third, until recently there was a lack of validated methods to choose theories [58]. There is little evidence to guide researchers when it comes to answering the following questions: Which theories best apply to my research question? Are the theories relevant and valid for my research question?

Michie *et al.* [58], present a comprehensive solution to some of the methodological issues surrounding the development of theory based interventions. A group of UK psychologists reduced 33 potentially relevant behavioural theories (containing 128 theoretical constructs) into a more manageable list a list of 12 "theoretical domains" [58], see Table 3.1.

Table 3.1: Theoretical domains and their component constructs

Domains	**Constructs** - Adapted from Michie *et al* [56]
(1) Knowledge	Knowledge, Knowledge about condition/scientific rationale, Schemas, mindsets and illness representations, Procedural knowledge
(2) Skills	Skills, Competence/ability/skill assessment, Interpersonal skills, Coping strategies
(3) Social/ Professional Role and Identity	Identity, Professional identity/boundaries/role, Group/social identity, Social/group norms, Alienation/organisational commitment
(4) Beliefs about Capabilities	Self-efficacy, Control – of behaviour and material and social, environment, Perceived competence, Self-confidence/professional confidence, Empowerment, Self-esteem, Perceived behavioural control, Optimism/pessimism
(5) Beliefs about Consequences	Outcome expectancies, Anticipated regret, Appraisal/evaluation/review, Consequences, Attitudes, Contingencies, Reinforcement/ punishment/consequences, Incentives/rewards, Beliefs, Unrealistic optimism, Salient events/sensitization/critical incidents Characteristics of outcome expectancies – physical, social, emotional, sanctions/rewards, proximal/distal, valued/not valued, probable/improbable, salient/not salient, perceived risk/threat
(6) Motivation and Goals	Intention, stability of intention/certainty of intention, Goals, (autonomous, controlled), Goal/target setting, Goal priority, Intrinsic motivation, Commitment, Distal and proximal goals, Transtheoretical model and stages of change
(7) Memory, Attention and Decision Processes	Memory, Attention, Attention control, Decision making
(8) Environmental Context and Resources	Resources/material resources (availability and management), Environmental stressors, Person x environment interaction, Knowledge of task environment
(9) Social Influences	Social support, Social/group norms, Organisational development, Leadership, Team working, Group conformity, Organisational , climate/culture, Social pressure, Power/hierarchy, Professional , boundaries/roles, Management commitment, Supervision, Inter-group , conflict, Champions, Social comparisons, Identity, group/social identity, Organisational commitment/alienation, Feedback, Conflict – competing , demands, conflicting roles, Change management, Crew resource, management, Negotiation, Social support personal /professional/organisational, intra/interpersonal, society/community, Social/group norms subjective, descriptive, injunctive norms, Learning and modeling
(10) Emotion	Affect, Stress, Anticipated regret, Fear, Burn-out, Cognitive , overload/tiredness, Threat, Positive/negative affect, Anxiety/depression
(11) Behavioural Regulation	Goal/target setting, Implementation intention, Action planning , Action , planning, Self monitoring, Goal priority, Generating alternatives, Feedback, Moderators of intention-behaviour gap, Project management, Barriers and facilitators
(12) Nature of the Behaviour	Routine/automatic/habit, Breaking habit, Direct experience/past , behaviour, Representation of tasks, Stages of change model

Using the methods proposed by Michie *et al.* [58], qualitative enquiry can identify which theoretical domains are likely relevant to a target behaviour. The 12 domains were purposefully selected to provide a broad coverage of theories [58]. This breadth enables the domains to inform intervention development in any number of research contexts.

Michie *et al.* [58], proposed using interviews to tease out which domains best apply to a given context. These theoretical domains interviews (TDI) were used in studies by Francis *et al.*, [44] to better understand "watching and waiting instead of transfusing RBC" in intensive care unit (ICU) and neonatal ICU physicians. This thesis represents part of the continued development of the theoretical domains interview methods. Briefly, domains relevant to the behaviour are identified through semi-structured interviews. Then behaviour theories (those that include the domains and constructs identified in the interviews) can be used for further research into the target behaviour.

Ultimately, better understanding of the target behaviour should lead to the development of better interventions in order to change the target behaviour. In addition to interventions better tailored to the specific research contexts, theory based methods could also reduce the cost of research. That is to say, researchers need only test relevant interventions with large empirical studies, reallocating the resources from intervention studies that are irrelevant and theoretically destined to fail.

This chapter outlines the use of theory based methods to better understand transfusion behaviour among Canadian orthopaedic surgeons. It employs theoretical domains interviews to identify which domains, constructs and theories are potentially relevant to the target behaviour. The interviews will identify candidate theories that could predict the target behaviour. *Chapter Four* of this thesis then uses the results of the interviews to test the predictive ability of these candidate theories. Specifically, the interview data will guide the design of a survey to empirically identify which behavioural theories best predict transfusion behaviour in a sample of Canadian orthopaedic surgeons.

Methods

In this study we interviewed orthopaedic surgeons using semi-structured (one-to-one) interviews to better understand the behaviour of interest: *watching and waiting instead of transfusing red blood cells* (RBC) in Orthopaedics. In more detail the target behaviour can be described as follows:

- Target: Orthopaedic surgeons responsible for transfusing patients
- Action: Watching and waiting instead of transfusing red cells
- Context: In patients with borderline hemoglobin
- Time: When the physician first learns of the borderline hemoglobin value

The interview content was based on the 12 theoretical domains developed by Michie *et al.* [58]. The final version of interview schedule is included in Appendix 3-A.

Materials

The interview schedule was based on a similar schedule developed by Francis *et al.* [118] for a study performed on intensive care unit (ICU) and neonatal ICU (NICU) consultants in the United Kingdom (UK). The interview schedule addressed the 12 behavioural domains developed by Michie *et al.* [58], that are derived from theoretical constructs relevant to changing health behavior (listed in Table 3.1).

Each domain was covered by at least one question; prompts were used to address the specific constructs within the domains. The interview was piloted with local surgeons to ensure face validity and feasibility. The interview schedule was adapted as our study progressed; minor changes were made throughout the pilot interviews to address practical issues such as interview length, repetition, wording etc. A cognitive psychologist (JB)

and a transfusion specialist (AT) were consulted. They reviewed the audio files of pilot interviews to ensure accurate representation of psychological constructs and adequate coverage of transfusion issues.

Interview Procedure

The surgeons were recruited to represent a broad range of opinions and attitudes and to reflect various practice settings (academic and community) and geographic regions. A "snowball" method was used to identify interviewees: initially we approached orthopaedic department heads from various centres across Canada to identify surgeons (including themselves) who would be willing to participate in a thirty minute interview. The interview participants were asked to recommend 2-3 potential participants for additional interviews, [although some interviewees recommended as many as 13 other surgeons]. Once we contacted the orthopaedic surgeons by email, phone or fax; we sent a letter describing the study and a copy of the consent form (Appendix 3-B) to those who agreed to participate. We offered the interviewees an honorarium of $100 for participating in the study interviews to maximize participation [119] and to compensate the physicians for their time.

Interviews were continued until the researchers determined that a saturation of ideas was reached. Saturation of ideas was defined as the point at which future additional interviews were not expected to elicit new beliefs.

The interviews were completed either by phone or in person. The interviews were conducted by one trained interviewer (JE) following the interview schedule (Appendix 3-A). Each interview was digitally recorded and then interview audio files were transcribed.

Interview Analysis

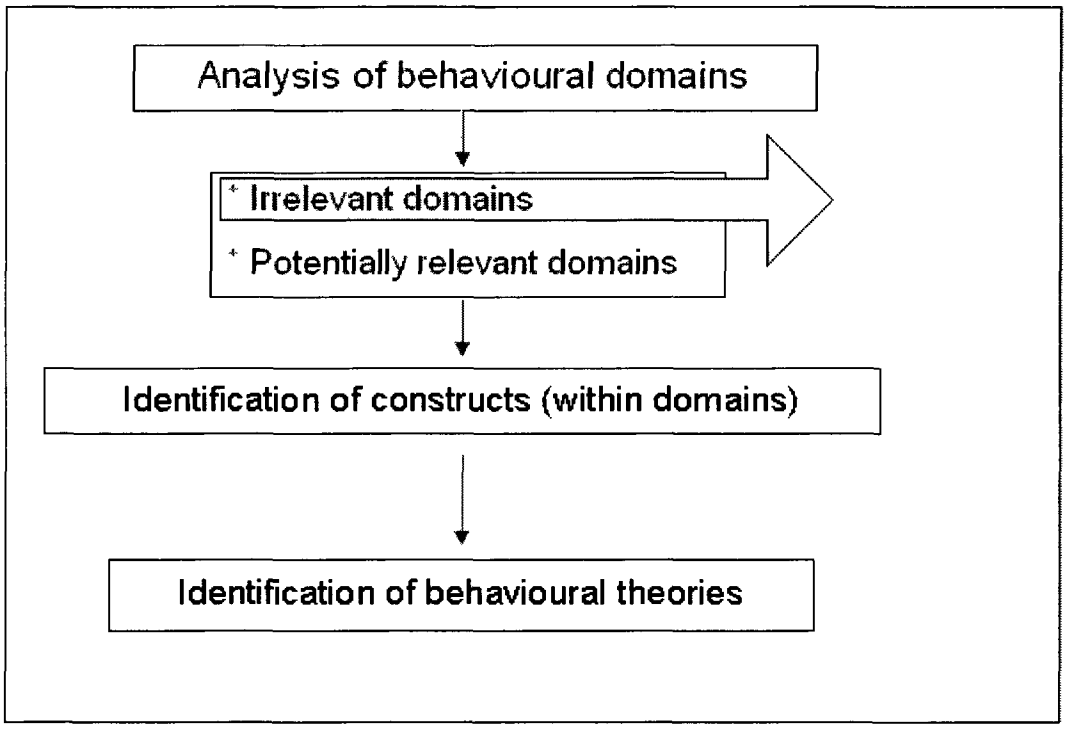


Figure 3.1: Outline if process used to analysis the interview conducted with Canadian Orthopaedic surgeons

a. Identification of potentially relevant theoretical domains

The methods of analyses for this study were developed through an iterative process. First, two researchers (JE & RI) analyzed two pilot interview transcripts together and developed a coding strategy (see Appendix 3-C for outline of domain coding decision rules). Second, after coding the first two interviews, we confirmed that the coding strategy was reliable and made only small changes to simplify the coding strategy. Using the developed coding strategy, the remaining nine interviews were independently scored, classifying utterances into the appropriate theoretical domains. Coders could classify the same utterance into multiple domains. The results for all independently coded interviews (n=11) were reviewed by two coders, recording agreement and discussing coding issues.

If coders coded the same utterance differently, the statement would be coded into all domains identified by both coders. Therefore disagreements were resolved by including the opinions of both reviewers.

We assessed percent agreement between coders for each utterance as follows:

i. Complete agreement – When an utterance was coded in the same domain by both the coders, it was counted as complete agreement (Counted as one complete agreement point under the selected domain)
ii. Domain disagreement – When an utterance was coded in different domains by the coders, it was counted as domain disagreement (Counted as one domain disagreement point in each of the selected domains)
iii. Discrepancy – When an utterance was completely missed by one of the coders, it was counted as discrepancy (Counted as one discrepancy point in the selected domain)

Together, the two researchers (RI & JE) identified the specific beliefs elicited in each domain. A specific belief represents a collection of similar utterances that provide greater detail about the role of the domain plays in influencing the target behaviour [119]. We recorded the frequency that each specific belief was presented (i.e. X out of N interviews presented the specific belief "Y" at least once) in an Excel spreadsheet. Descriptive statistics (mean, average, and standard deviation) were calculated using Excel functions.

Using methods similar to those employed by Francis *et al.*, [119] the domains of interest were selected based on the frequency that a specific belief was presented and the content of the specific belief. Briefly, we classified domains as relevant (likely to influence

change in the target behaviour) and irrelevant (not likely to influence change in the target behaviour). We would classify the domains as relevant if (1) they presented conflicting beliefs that would clearly influenced the decision to watch and wait; or (2) they presented both a belief that the domain that clearly influenced the decision to watch and wait, and that the belief was reported by a majority of the interviewees. For example, if the Motivation and Goals domain presents conflicting beliefs about transfusion practice then it was be selected as a relevant domain (e.g. *Watching and waiting conflicts with other goals* in opposition to *Watching and waiting is compatible with other goals*). Similarly if the majority of interviews (e.g. 6 of 11 interviews) report the belief that *there is not enough evidence to support watching and waiting in orthopaedic patient populations* then the Knowledge domain will be selected.

Domains that did not completely satisfy the aforementioned criteria were identified as irrelevant. For example, if the belief that *emotion does not affect my decision to transfuse* is consistently reported, it will be concluded that the Emotion domain is not relevant to this behaviour.

b. Identification of constructs

Following the identification of the relevant domains, the beliefs were mapped onto behavioural constructs. All of the specific beliefs from the relevant domains were independently mapped to constructs by two members of the research team who were psychologists (JF & JB). They were provided the list of specific beliefs and a list of psychology constructs adapted from Michie *et al.* [58], and asked to independently assign

constructs from the relevant domains to the specific belief. We recorded the frequency that each construct was identified (coders could map to more than one construct).

c. Identification of behavioural/psychological theories

Using the comprehensive list of psychology constructs identified by the two coders and through discussions with a health psychologist (JF), the research team identified the behavioural theories that best represent the constructs. These candidate theories were used to derive a predictive survey about the target behaviour (see *Chapter Four*).

Results

Interviews Summary

We initially contacted 35 orthopaedic surgeons by email, phone or fax; eleven of those agreed to participate in an interview. The eleven orthopaedic surgeons (10 male, 1 female) from centres across Canada took part in the interviews. Surgeon ages ranged from 40 to 71 years (mean=50, SD =10.3) and have between 6.5 and 30 years experience (mean=17.1, SD =8.5). The surgeons were recruited to represent a broad range of opinions and attitudes. A purposeful sample reflecting various practice settings (8 academic and 3 community) and geographic regions (4 Western Canada, 5 Ontario, 1 Quebec, and 1 Maritimes) was realized. The interviews lasted between 14.1 and 30.3 minutes (mean=22.0, SD=5.8). Table 3.2 provides a summary of the interviews performed.

Ten interviews were performed and analyzed. The 10th interview produced two additional beliefs; therefore an 11th interview was performed. The 11th interview did not

produce any additional beliefs. Therefore, after the 11th interview no additional interviews were performed.

Table 3.2: Summary of Interviews with 11 Canadian Orthopaedic Surgeons

Interview	Time (minutes)	City	Province	Setting	Sex	Years experience	Age
1 (P)	17 33	Ottawa	ON	Academic	M	-	-
2 (P)	14 13	Ottawa	ON	Academic	M	-	-
3	21 37	Toronto	ON	Academic	M	10	40
4	19 85	Toronto	ON	Academic	M	30	71
5	30 32	Halifax	NS	Academic	M	10	42
6	15 72	Vancouver	BC	Academic	M	14	44
7	29 92	Perth	ON	Community	M	21	55
8	24 98	Winnipeg	MN	Academic	M	6 5	40
9	28 98	Calgary	AB	Academic	M	17	49
10	21 43	Kelowna	BC	Community	M	30	59
11	18 05	Montreal	QC	Community	F	15	50
Mean	22 0					17 1	50 0
SD	5 8					8 5	10 3

- Data not collected, (P) Pilot interview, SD Standard deviation (calculated using Excel)

Table 3.3: Percent agreement across domains for utterances identified in 11 interviews with orthopaedic surgeons

Domain	Complete Agreement	Domain disagreement	Discrepancy	Total utterances counted
1	38 (86%)	5 (11%)	1 (2%)	44
2	25 (83%)	5 (17%)	0	30
3	55 (72%)	13 (17%)	8 (18%)	76
4	22 (49%)	20 (44%)	3 (7%)	45
5	47 (80%)	7 (12%)	5 (11%)	59
6	55 (72%)	14 (18%)	7 (16%)	76
7	62 (76%)	18 (22%)	2 (5%)	82
8	27 (60%)	13 (29%)	5 (11%)	45
9	25 (49%)	23 (45%)	3 (7%)	51
10	31 (82%)	4 (11%)	3 (7%)	38
11	23 (31%)	50 (68%)	0	73
12	24 (36%)	41 (62%)	1 (2%)	66
Mean	36 2 (65%)	17 8 (30%)	3 2 (7%)	57 1
SD	14 7 (19%)	14 5 (20%)	2 6 (6%)	17 2

(%) rounded to whole number therefore may not total 100%, Complete agreement – When an utterance was coded in the same domain by both the coders, Domain disagreement – When an utterance was coded in different domains by the coders, Discrepancy – When an utterance was completely missed by one of the coders

Percent Agreement

A summary of the percent agreement between coders (JE and RI) is included in Tables 3.3 and 3.4. Table 3.3 presents the agreement by behavioural domain. The percent agreement across the 12 theoretical domains ranged from 31% to 86%; the average percent agreement across domains was 65% (SD 19%). The domains with the lowest percent agreement were Behavioural Regulation (32%), Nature of the Behaviour (36%), Social Influences (45%) and Beliefs about Capabilities (49%). Table 3.4 presents the results by interview number. The percent agreement across the 11 interviews ranged from 43% to 76%; the average percent agreement across behavioural domains was 64% (SD 8.9%). The interview with the lowest percent agreement was interview #5 (43%), and was also the longest interview (30.32 min).

Table 3.4: Percent agreement across interview for utterances identified in 11 interviews with orthopaedic surgeons

Interview	Complete agreement	Domain disagreement	Discrepancy	Total utterances counted
1	17 (61%)	9 (36%)	1 (3%)	27
2	20 (76%)	6 (21%)	1 (3%)	27
3	21 (64%)	7 (28%)	3 (8%)	30
4	20 (72%)	7 (25%)	1 (4%)	28
5	13 (44%)	12 (40%)	5 (17%)	30
6	17 (63%)	8 (30%)	3 (9%)	28
7	11 (55%)	7 (35%)	3 (11%)	21
8	17 (67%)	6 (24%)	3 (10%)	26
9	20 (69%)	5 (24%)	2 (7%)	27
10	12 (60%)	7 (33%)	2 (6%)	21
11	18 (71%)	4 (15%)	4 (15%)	26
Mean	63 6%	28 04%	8%	26 4
SD	8 91%	7 46%	4 %	3 3

(%) rounded to whole number therefore may not total 100%, Complete agreement – When an utterance was coded in the same domain by both the coders, Domain disagreement – When an utterance was coded in different domains by the coders, Discrepancy – When an utterance was completely missed by one of the coders

Identification of specific beliefs

There were a total of 55 specific beliefs identified across the 11 interviews. The number of specific beliefs recorded for each interview ranged from 20 to 31 (Mean=26, SD=3.3). Each of the 55 specific beliefs was mentioned in approximately half of the interviews (Range 1-11, Mean= 5.6, SD=2.4). Figure 2 graphically presents the specific beliefs elicited across the 11 interviews. The number of novel beliefs elicited in the interviews began to level off by interview #5. Table 3.5 summarizes the specific beliefs identified, highlighting the number of beliefs per interview, the number of new beliefs per interview and the accumulation of beliefs across the 11 interviews. Specific beliefs that were mentioned in two or fewer interviews were not included in further analysis.

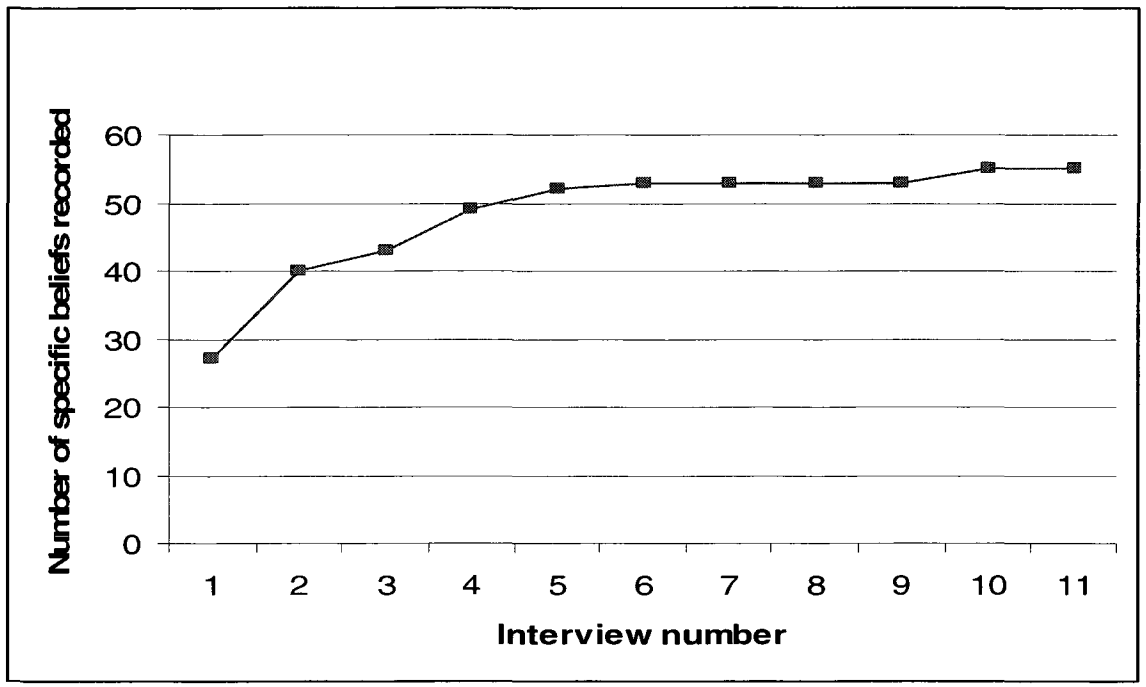


Figure 3.2: Plot of cumulative specific beliefs from 11 interviews with orthopaedic surgeons

Table 3.5: Summary of specific beliefs elicited from the 11 interviews with orthopaedic surgeons

Interview Number	1	2	3	4	5	6	7	8	9	10	11	Mean	SD
Number of beliefs per interview	27	27	31	28	30	27	20	26	27	21	26	**26.4**	**3.3**
Number of NEW beliefs per interview	27	13	3	6	3	1	0	0	0	2	0	**5.0**	**8.3**
Number of REPEATED beliefs per interview	0	14	28	22	27	26	20	26	27	19	26	**21.4**	**8.3**
Cumulative Beliefs	27	40	43	49	52	53	53	53	53	55	55	N/A	N/A
SD – Standard deviation; N/A – Analysis not appropriate													

Identification of behavioural domains

We classified each of the domains as potentially relevant or irrelevant to the decision to watch and wait in orthopaedics.

Potentially relevant domains: We identified the following eight domains as potentially relevant and likely to influence the target behaviour (**in the Table 3.6):

- Knowledge: Knowledge was relevant because a majority of interviews (6/11) identified that there is a need for more evidence to support watching and waiting in orthopaedics[7]. Also, there were strong and conflicting beliefs presented about the clarity (or lack of clarity) of the available evidence across interviewees.

- Beliefs about consequences: This domain was relevant because it presented many beliefs about the consequences and benefits of watching and waiting. Every interviewee suggested that this domain plays a large role in the decision making process in orthopaedic surgeons.

- Motivation and goals: This domain was relevant because it presented conflicting ideas about the importance of watching and waiting, whether it

[7] The results of the FOCUS trial were not available at the time of the interviews.

conflicts (or is compatible) with other goals, especially with the rehabilitation of orthopaedic patients. This variation is worth investigating further as it may explain, at least in part, the variation in practice.

- Social influences: This domain was relevant because it identified several social influences on surgeons' decision to watch and wait including patient preferences, and the opinions of physiotherapists and residents.
- Behavioural regulation: This domain was relevant because it presented many beliefs detailing ways to improve watching and waiting behaviour. The surgeons interviewed referred to more education, alternatives to transfusion and various forms of audit and feedback as ways to improve practice. A consistent idea was that presently they would not want to change their practice, but would consider changing only if better evidence or a guideline/protocol was available.
- Social/Professional role and identity: This domain was potentially relevant because there was some doubt as to the importance of roles and guidelines. There was doubt as to the strength of the beliefs presented about how guidelines influence practice. Some said their practice followed guidelines, some said they did not, others were unsure. Some said guidelines were somewhat important, others somewhat disagreed. This domain also introduced the role that residents play in the decision to watch and wait suggesting that this domain may be tapping constructs better explained through the domain Beliefs about capabilities.

- Beliefs about capabilities: This domain was potentially relevant because it presented conflicting influences on the target behaviour. The surgeons said they are confident but admit that others often make the decision to watch and wait, furthermore; some surgeons report variation in practice among the resident and on-call staff. Both of these influential beliefs were only present in 5/10 interviews. Part of this issue may be that many ideas presented in this domain also tap other relevant domains including Social/professional role and identity, and Environmental context and resources.

- Environmental context: This domain was potentially relevant because it suggested that monitoring of the patients and blood availability could play a role in the decision to watch and wait. The researchers disagreed on the strength of influence this belief would have on watching and waiting. Furthermore, this influential belief was only present in 5/10 interviews.

Irrelevant domains: We identified the following four domains as not relevant because the interview suggested that these domains do not influence the target behaviour.

- Skills: This domain was not relevant because skills were consistently (10/11) reported as easy and the surgeons reported that you need only normal clinical skills to watch and wait.

- Emotion: This domain was not relevant because most surgeons discussed emotion only in term of patient preferences and concern for the patient. The majority (9/11) of surgeons stated that their own emotions (stress or anxiety) would not influence their decision to watch and wait.

- Memory: This domain is not relevant because the majority of surgeons (6/11) reported that although the decision requires some thought, it is generally an easy decision. They added that they do not forget to watch and wait.

- Nature of the behaviour: This domain is not relevant because it did not present any new beliefs that would influence the decision to watch and wait. The surgeons repeated or elaborated ideas they had addressed in other domains. Furthermore, this domain revealed that the majority of surgeons report that they usually do watch and wait

Table 3.6: Summary table of specific beliefs arranged by 12 theoretical domains elicited from semi-structured interviews with 11 Canadian orthopaedic surgeons[8]

Domain	Specific Beliefs	Sample Quote (interview number)	Frequency (out of 11)
**Knowledge	The evidence supporting watching and waiting in orthopaedics is weak	"we don't really understand what the pluses or minuses are of just watching and waiting with someone with borderline" (Ortho2) "I don't think it is clear, because I think there is a lot of controversy over blood as a drug itself, its efficacy for transfusions" (Otho5)	6
	The evidence is fairly clear	"There is what is called TRICC study, I think that is what changed a lot of people's concepts of transfusion, or the practice of transfusion " (Ortho10) "my understanding is that the evidence is quite clear there is no downside to a low hemoglobin in an otherwise healthy patient" (Ortho3)	4
Skills	The skills need to watch and wait are not difficult	"I would say that with proper training the skills are quite easy and straight forward" (Ortho9)	10
	Communication skills are needed	"You need to engage not only your personal skills and when you do a ward round of the patient, but you also need to engage medical staff, enquire with them how the patient is mobilizing and also you need to engage with physiotherapists who are intricately involved in mobilizing the patient " (Ortho7)	5
	Clinical skills are needed	"Evaluative skills, clinical skills, a broad level of skills" (Ortho10)	7
**Professional Role	Watching and waiting is part of the professional role of a surgeon	"Yes Well because it is your patient, you need to be able to manage that and it is part of the preoperative management" (Ortho1)	9
	My colleagues agree with how I transfuse	"most of us are on the same wave length" (Ortho11)	6
	I don't know if my	"my colleagues are the other orthopaedic surgeons, they would	4

[8] Specific beliefs that were mentioned in two or fewer interviews were not included Table 3.6.

	colleagues agree with my practice	have no idea of when I am watching and waiting, because we punch in independently, we all have our own independent practices" (Ortho4)	
	Guidelines would not affect my professional autonomy	"No, I have no ego" (Ortho6)	6
	I think my practice coincides with published guidelines	'I don t strictly adhere, there are some guidelines within our health region and I use them as guidelines only For the most part, they weren t really any different than my own personal kind-of guidelines anyway " (Ortho9)	6
**Beliefs about capabilities	I am confident that I am able to watch and wait	"Well yes I am relatively confident, Yea " (Ortho9)	10
	We give the residents the autonomy to make the decision to transfuse	"Well it should be the staff, but I think sometimes they think they are doing us a favour when they are doing rounds in the morning, so they are making the decision on that level We give them a lot of autonomy to manage the patient " (Ortho5)	6
	When I hand over a patient, I don't have control whether they watch and wait	"if I am not in the hospital or close by, or if it happens in the evening, then the resident on call is paged, and there are no specific guidelines for that resident, then I think that and if the variability, the resident's interpretation or house staff on the importance of the hemoglobin or transfusion practice That is the biggest impact, relief factor " (Ortho2) "junior residents they may be transfusing somebody before I would have like them too, so that does happen on occasion" (Ortho8)	5
**Beliefs about consequences	Benefit Avoiding the complication of transfusion	"if you can avoid a transfusion, then you can get rid of the risks of transfusion related problems, and transfusion reactions, reactions to the preservatives, reactions, like infectious reactions " (Ortho3)	8
	Disadvantage Concerns over cardiac complication	"Well you know, I think if they have got a cardiac history, I think you are running risk of having some cardiac events " (Ortho8) "So the negative consequences could be cardiac, ischemia, also more difficulty in rehabilitating, lack of energy Lack of energy to rehabilitate " (Ortho1)	5
	Disadvantage Concerns over delayed recovery and increased length of stay	"you know we could delay their stay, you know they get unclear they get a blood clot, or they have gotten up and they are so dizzy and barfy and they could fall down Sure there are disadvantages to watching and waiting" (Ortho5)	4
	Benefits outweigh the cost	"Probably yes because I think there are risks associated with blood transfusions You know I think there are fewer risks with watching and waiting to be honest with you " (Ortho7)	8
	I think the costs are irrelevant to my decision	"The costs, I am not even aware of the costs " (Ortho4)	3
**Motivation	It is a priority to avoid transfusions	"Extremely important, because I think again as I mentioned, if the patient ends up having a transfusion, to me that is a failure of what we wanted to accomplish in terms of minimizing the morbidity of a surgical intervention ' (Ortho2) "I want to transfuse as little as possible, I want my transfusion rate to be as low as possible " (Ortho6)	5
	Conflicting goals Patient rehabilitation would directly conflict with watching and waiting	"I am always concerned that that may affect their rehabilitation or how well [they're] able to get up and start going after surgery" (Ortho9)	8
Memory, Attention and Decision processes	W&W is an easy decision	"Well I would say most of the time it is relatively straight forward so I wouldn't call it difficult " (Ortho9)	6
	You need to put thought into the decision to watch and wait	"Yea, I think that thought processes play into it " (Ortho5)	6
	You have to considered the patients history, current symptoms, rehabilitation and preferences	"ask how old is the patient, I ask what their cardiac status is, and then I ask are they having any symptoms of low hemoglobin, are they dizzy when they get out of bed, are they weak, are they tired, and that's about it And how do they feel about getting a transfusion " (Ortho4)	6
**Environmental	There are no time	"Time constraints on my part? No" (Ortho8)	6

contexts and resources	constraints that affect whether I can watch and wait		
	I would be more likely to watch and wait if I knew that the patient was well monitored	"The quality of the nursing staff and whether I could depend on them to monitor the patient closely" (Ortho8)	5
	Blood shortages would affect my decision to transfuse	" in fact the blood supply issues would tend to promote watching and waiting as oppose to transfusing " (Ortho1) " if I was in a situation where I was told it may take a long time or difficult to get blood, I would probably be more likely to get things ready to go and transfuse proactively " (Ortho3)	5
**Social influences	I considerer the opinions of other colleagues (physio, nurses, and consult services)	"you know I have to rely on the physiotherapists and the nurses a lot to tell me" (Ortho5) "Medical consultation services may recommend strongly for a transfusion, we would defer usually to the decision, if they did make the recommendation " (Ortho1)	8
	The residents and on-call staff can make the decision to transfuse	'No they [residents, on call staff] would not influence me, they would just manage it directly without consulting with me " (Ortho2)	6
	Most patient prefer to watch and wait	"because most patients don't want transfusions " (Ortho11) "everybody in the whole world particularly Canada is freaked out about blood because of the history we have been through" (Ortho5)	5
Emotion	My own emotions do not affect my decision	[I am] an orthopaedic surgeon, emotions don't play a role at all here	9
	I consider patient emotions when making my decision	"I always ask the patients to get a sense on how they feel, because there is nothing more stressful for them to have a resident who is very busy, blowing in and out of the morning, they never really met them before And all of a sudden someone is coming in with a bag of blood in their hand and they haven't had enough time to think about it, they haven't had their questions answered So I think that can cause anxiety " (Ortho5)	9
**Behavioural Regulation	You need to get the hemoglobin value to make a decision	"getting the hemoglobin early in the morning as during the day if you could make a timely decision based on that, you have time assess the patient yourself and see if they are symptomatic, etc" (Ortho5)	6
	We treat the patients the same whether we watch and wait or transfuse	"I think a lot of patients we watched and wait so we know we don't do anything differently" (Ortho 7)	4
	We use alternative to transfusion	"Well we would order iron right away, we don't sort of, we are not going to transfuse them, we have to increase their iron stores " (Ortho 11)	3
	We need more training and education	"Nursing education would help me Education to the nurses by the nurses, and if they would buy into it, they will be taught then. and that would be very helpful " (Ortho 6)	4
	I would not change my practice	"Not right now, I am pretty happy with the way we do it right now " (Ortho 4)	4
Nature of the Behavior	Frequently come across patients with borderline hemoglobin	"More than 50% of the time " (Ortho 10) "Certainly post-surgery everybody has a hemoglobin issue " (Ortho 5)	7
	I usually watch and wait	"Usually do? Absolutely " (Ortho 7)	10
	I err on the side of transfusing	"I am probably going to err on the side of transfusing" (Ortho 3)	4

Table 3.7: Summary table of identified theories, constructs and specific beliefs from relevant domains as coded by two independent experts

Relevant Domain	Specific Belief (ORTHOPAEDIC SURGEONS)		Constructs identified by Coder 1	Constructs identified by Coder 2	Agreement	Suggested Theory based on constructs
Knowledge	1	The evidence supporting watching and waiting in orthopaedics is weak	Knowledge about scientific rationale	Scientific rational	2/2	Knowledge-attitude-belief model (general and scientific rational)
	2	The evidence is fairly clear	Knowledge about scientific rationale	Scientific rational	2/2	Knowledge-attitude-belief model (general and scientific rational)
Professional Role	3	Watching and waiting is part of the professional role of a surgeon	Professional role	Professional ID/ boundaries/role	2/2	Theory of Planned Behaviour
	4	My colleagues agree with how I transfuse	Social norms	Social group norms	2/2	Normative model of work team effectiveness, Theory of Planned Behaviour
	5	I don't know if my colleagues agree with my practice	Social norms	Social group norms	2/2	Normative model of work team effectiveness, Theory of Planned Behaviour
	6	Guidelines would not affect my professional autonomy	? Perhaps organisational commitment?	Social group norms	1/2	Personal Projects Analysis, Normative model of work team effectiveness
	7	I think my practice follows [coincides with?] published guidelines	? Professional autonomy	Social group norms	1/2	Normative model of work team effectiveness, Theory of Planned Behaviour
Beliefs about capabilities	8	I am confident that I am able to watch and wait	Self-efficacy and professional confidence	Perceived behavioural control (PBC)	1/2	Social Cognitive Theory, Theory of Planned Behaviour
	9	We give the residents the autonomy to make the decision to transfuse	Control of environment (low)	Control?	2/2	Theory of Planned Behaviour
	10	When I hand over a patient, I don't have control whether they watch and wait	Control of environment (low)	PBC		Theory of Planned Behaviour
	11	Benefit Avoiding the complication of transfusion	Outcome expectancy / behavioural belief	Consequents	1/2	Social Cognitive Theory, Operant Learning Theory
Beliefs about consequences	12	Disadvantage Concerns over cardiac complication	Outcome expectancy / behavioural belief	Outcome expectancy	2/2	Social Cognitive Theory
	13	Disadvantage Concerns over	Outcome expectancy /	Consequents	2/2	Social Cognitive Theory

		delayed recovery and increased length of stay	behavioural belief			
	14	The benefits of Watching and Waiting outweigh the cost	Attitude	Belief	2/2	Theory of Planned Behaviour
	15	I am unaware of the costs of watching and waiting	Outcome expectancy / behavioural belief	Attitude	1/2	Social Cognitive Theory, Theory of Planned Behaviour
	16	It is a priority to avoid transfusions	Goal priority	Goal priority	2/2	Personal Projects Analysis
Motivation	17	Conflicting goals Patient rehabilitation would directly conflict with watching and waiting	Goal priority	Distal and proximal goals	2/2	Personal Projects Analysis
	18	There are no time constraints that affect whether I can watch and wait	Resources	Environmental stressor	2/2	Theory of Planned Behaviour, Control theory
Environmental contexts and resources	19	I would be more likely to watch and wait if I knew that the patient was well monitored	Person x environment interaction	Environmental stressor	2/2	Theory of Planned Behaviour, Control theory
	20	Blood shortages would affect my decision to transfuse	Resources	Resources	2/2	Theory of Planned Behaviour, Control theory
	21	Most patients prefer to watch and wait	Subjective norm / injunctive norm	Inter-group conflict	1/2	Theory of Planned Behaviour
Social influences	22	The residents and on call staff can make the decision to transfuse	[Doesn't seem relevant to my behaviour]	Team working	1/1	Normative model of work team
	23	I consider the opinions of other colleagues (physiotherapists, nurses, and consult services)	Subjective norm / injunctive norm	Team working	1/2	Theory of Planned Behaviour, Normative model of work team
	24	You need to get the haemoglobin value to make a decision	Barriers and facilitators	Barriers and facilitators	2/2	Theory of Planned behaviour
Behavioural Regulation	25	We need to monitor the patients in the same way whether we watch & wait or transfuse	Goal priority	Barriers and facilitators	1/2	Personal Projects Analysis, Theory of Planned Behaviour
	26	We use alternatives to transfusion	Generating alternatives	Barriers and facilitators	1/2	Action Planning, Theory of Planned Behaviour
	27	We need more training and education	Barriers and facilitators	Moderators	1/2	Personal Projects Analysis, Theory of Planned Behaviour
	28	I would not change my practice	Goal setting (low)	Moderators	1/2	Personal Projects Analysis, Theory of Planned Behaviour

Identification of behavioural theories

Through discussions[9] (JF, RI, JG, JB and JE) identified six behavioural theories and/or frameworks relevant to the decision to watch and wait in orthopaedics including: Theory of Planned Behaviour (TPB)[120], Social Cognitive Theory (SCT)[121], Knowledge-attitude-behaviour model (KAB)[122], Operant Learning Theory (OLT)[123], Normative Model of Work Team Effectiveness (NMWTE)[124], Personal Project Analysis (PPA)[125] and Implementation Intentions (II) [126]. These theories and frameworks are detailed in Appendix 3-D and discussed in *Chapter Four*. Table 3.7 presents the results of the two coders (JF, JB) and the agreement between the two coders as to the theories that best represent the constructs.

[9] The selection of theories was based on expert input and judgment The theories were chosen to parsimoniously cover all domains and constructs identified in the interviews In selecting theories we also discussed other factors such as whether the theories include elements that can be changed (i e able to changing behaviour), and whether theories that have already been operationalised into survey

Discussion

Using interviews and qualitative analysis methods we identified eight domains that were potentially relevant to the target behaviour: *watching and waiting instead of transfusing RBCs.* The eight potentially relevant domains were Knowledge, Professional Role, Beliefs about Consequences, Beliefs about Capabilities Motivation and Goals, Environmental Context and Resources Social Influences, and Behavioural Regulation. We consulted with health psychologists who identified constructs for each specific belief identified in each of the relevant eight domains identified in the interviews.

From these constructs we proposed a list of six behavioural theories that best represent the constructs: Theory of Planned Behaviour (TPB)[120], Social Cognitive Theory (SCT)[121], Knowledge-attitude-behaviour model (KAB)[122], Operant Learning Theory (OLT)[123], Normative Model of Work Team Effectiveness (NMWTE)[124], Personal Project Analysis (PPA)[125].

Theoretical domain interview methods employ qualitative techniques to understand behaviour. These methods provide a systematic way to analyze interview data in a variety of contexts. The qualitative analysis methods provide detailed summaries of interviews and understanding of the target behaviour. Unlike more structured interview methods, the theoretical domain interviews allow for interviewees to bring up ideas not envisioned by the researchers. Specific beliefs also provide insight into the target behaviour that can be further investigated using quantitative methods.

The theoretical domain interview methods for selecting theoretical frameworks have been previously used by Francis *et al.*, [44] to investigate transfusion practice in UK intensive care physicians (adult and neonatal) and in an unpublished Canadian study that investigated transfusion practice in intensive care physicians. These studies also investigated transfusion practices using theoretical domain interview methods and identified similar theories and frameworks. The domains beliefs about consequence and behavioural regulation were consistently identified as relevant to changing transfusion behaviour. Theories and domains indentified in the studies are outlined in Table 3.8.

Table 3.8: Summary of research using theoretical domains interviews to identify relevant domains and theoretical frameworks

Study	Providers and patients	Relevant domains	Selected theories and frameworks
Francis et al, 2009 (UK)	Intensive care (adult)	Beliefs about Capabilities, Beliefs about Consequences, Social Influences, Behavioural Regulation	TPB, SCT, OLT, NMWTE, Control theory.
Francis et al, 2009 (UK)	Intensive care (neonatal)	Knowledge, Beliefs about Capabilities, Beliefs about Consequences, Social Influences, Behavioural Regulation	TPB, SCT, KAB, OLT, NMWTE, Control theory.
OHRI unpublished (Canada)	Intensive care (adult)	Knowledge, Social Professional Role and Identity, Beliefs about Capabilities, Beliefs about Consequences, Motivation and Goals Social Influences, Behavioural Regulation	TPB, SCT, KAB, OLT, NMWTE, PPA, Control theory
Current study (Canada)	Orthopaedic surgeons (adult)	Knowledge, Beliefs about Consequences, Motivation, Social Influences, Behavioural Regulation	TPB, SCT, KAB, OLT, NMWTE, PPA, Control theory

TPB – Theory of planned behaviour, SCT – Social Cognitive Theory, KAB – Knowledge-attitude-belief model, OLT - Operant Learning Theory, NMWTE – Normative Model of Work Team Effectiveness PPA- Personal Project Analysis

Strengths

We improved the method used by Francis *et al.*, [118] by using two content reviewers instead of one. We employed two independent coders to analyze the interviews transcripts; this allowed us to report percent agreement at both the domain and interview level. The percent agreement in the interviews ranged from 44% to76% (mean 64%), while the percent agreement ranged from 31%to 86% (mean 65%) for domains. This percent agreement is too low to be acceptable for standard reliable reliability measures.

However, the purpose of the two coders was not only to investigate inter-coder reliability, but to improve the quality of the data analysis. By having two reviewers we were able to add to the analysis. For example the reviewers coded statements in different domains approximately a third of the time (28% across interviews; 30% across domains). This variation would not have been captured had we used one reviewer. Similarly, the discrepancy was 8% across interviews; 7% across domains; without the two reviewers statements would have been missed. Using two reviewers allowed us to err on the side of inclusion: including more statements and coding the statement in more domains in the analysis.

When the two reviewers agreed on a statement we scored it as an agreement point in the relevant domain. When we disagreed and placed the same statement into different domains, we scored it a disagreement point in each divergent domain that it was coded into. This method exaggerated the discrepancy because each disagreement was recounted for each additional domain that a specific belief was coded into.

There are several explanations for the discrepancies between reviewers. One interesting observation was that the longest interview was also the interview with the highest rate of discrepancy. This suggests that the length of interview may play a role in reliability. One hypothesis is that longer interviews generate a larger volume of ideas and this variety of ideas and statements is more difficult to classify. If this hypothesis is correct, then shorter interviews would be easier to more reliably code. However, they consequently may lack the depth of understanding that longer interviews would provide. In this study we only had 11 interviews, which did not provide enough of a sample to properly investigate the role interview length plays on coding discrepancies.

We believe that using two coders enhances the qualitative analysis methods. Two points of view increase the content coverage and quantifying percent agreement adds to the reliability of the measure. These enhanced methods are easily replicable and therefore should be used in future professional behavioural change studies. Additionally, these methods are broad and therefore can be employed to a wide variety of target behaviours.

Limitations

Using theoretical domain interviews to understand watching and waiting in orthopaedics has several limitations. First, the theoretical domains interview methods still require further development. The domains were designed to be broad and inclusive, and as a consequence there is overlap between domains. To deal with this overlap we developed decision rules specific to this behaviour. Despite these decision rules we were still only able to reliably code the interview content 65% of the time. The original domains were developed through a consensus process in 2005. It may be worthwhile revisiting these domains to more practically define the domains (especially those with lower agreement) and re-write the

domain questions to reflect lessons learned from this and other practical applications of these methods.

A second weakness in these methods is the dependency on experts. These methods allow us to identify a domain of interest for a target behaviour, but the methods rely heavily on psychologists to guide the identification of the relevant theories. The theoretical domain interview methods would be more accessible if there was an easier way to identify theories relevant to changing the professional health behaviour.

Future Research

Using qualitative methods to analyze the content of interviews highlighted several areas in need of research. While scoring percent agreement, we identified issues that we hypothesized to affect agreement: some domains and some interviews seemed to be more difficult to reliably code. To properly investigate the relationship between inter-coder reliability with interview content, length and complexity; researchers need additional observations. Potentially, combining the data from the Canadian and British transfusion studies could help address these questions.

The qualitative analysis of the interviews identified the behavioural theories that are potentially relevant the decision to transfuse in orthopaedics. We emphasize that the methods in this chapter do not provide causal links between the theories and the target behavior. Using a postal survey (*Chapter Four*), we will empirically quantify the predictive value of the theories suggested in this chapter; however, we expect that the survey will not capture the same level of detail presented in this chapter. These details and nuances are key to understanding our target behaviour. The qualitative analysis of the interviews provides

the content for the survey. Qualitative methods will guide the selection of the theories from which question items will be derived and guide the development of simulated behaviour scenarios to be used in the survey.

Considerations for *Chapter Four*

Michie *et al.* [58]condensed 33 potentially relevant behavioural theories (containing 128 theoretical constructs) into a more manageable list a list of 12 "theoretical domains" [58]. Using interviews to guide survey development will further reduce the length of the survey because only eight domains need to be addressed. In this research, we will also use interview content to develop relevant transfusion scenarios. Ideally relevant scenarios will engage respondents and greatly add to our understanding of transfusion practice. Overall interview analysis will reduce the burden on responders, while providing a systematic way to select relevant theories. This will maximize depth so that we can understand the target behaviour, without compromising on the breadth of theories we can consider.

At this point we chose to eliminate the Normative Model of Work Team Effectiveness (NMWTE) from future analysis. Every construct mapped onto Normative Model of Work Team Effectiveness also mapped onto the Theory of Planned Behavior or personal Project analysis. Removing this theory shortened the length of the survey without compromising the breadth of survey contents.

In conclusion, we were able to analyze the interviews using the theoretical domains interview methods and identify eight domains that are potentially relevant to the target behaviour. These methods are useful for generating hypotheses to guide future research investigating professional behaviour change. We hypothesize that the constructs within

these domains can identify factors important to improving transfusion practice in orthopaedics. Furthermore, these methods and principles are nonspecific and therefore can be applied to a wide range of professional behaviours. In the subsequent chapters, we will empirically predict the relevance of these domains and constructs to *watching and waiting instead of transfusing red cells* in orthopaedics.

CHAPTER FOUR – Understanding red cell prescribing in orthopaedics:

A predictive survey of transfusion intentions.

Background

In *Chapter One* of this thesis we presented evidence suggesting that transfusion practices are suboptimal. Transfusion rates vary among hospitals, services and individual physicians [26]without a clear clinical explanation for these differences [21]; furthermore, evidence suggests that overtransfusion is putting patients at risk [22]. In *Chapter Two* we identified a clear interest in reducing inappropriate transfusion; however the majority of studies addressing this issue were of low quality. The intervention studies suggest that we may be able to reduce inappropriate transfusions however; we could not gain any insight into how best to improve transfusion practices.

Studies rarely report the justification for the choice of intervention and report the use of theories to guide the development of an intervention even less frequently [50]. We observed similar results in *Chapter Two* with only a few studies providing justification for the choice of intervention, and even fewer used psychological theories to guide the research. However, there is growing interest in using psychological theories to inform the development of interventions.

Knowledge Translation

Knowledge translation is the study of methodologies that seeks to improve patient care by promoting the uptake of research findings into practice [51]. The Canadian Institutes of Health Research defines knowledge translation as the "exchange, synthesis and ethically sound application of knowledge—within a complex system of interactions among researchers and users."[52].

Within the field of knowledge translation, it has been argued that using a theoretical basis to understand behaviour will optimize the development of interventions [49, 59]. Better understanding of the target behaviour based on theory will lead to interventions better tailored to the specific research contexts. Using theory as a basis for the improvement of interventions is a developing research area. Several studies have used theory to inform the development of interventions, but these methods are not commonplace [50].

Physiological Theories

In *Chapter Three* we detailed a qualitative study involving orthopaedic surgeons to identify theories that are potentially relevant to *watching and waiting instead of transfusing red cells.* The identified theories were Theory of Planned Behaviour (TPB)[120], Social Cognitive Theory (SCT)[121], Operant Conditioning (OC)[123], Personal Project Analysis (PPA)[125] and Knowledge-Attitude-Behaviour (KAB)[122] model[10].

The six theories we recognized (table 4.1) can be separated into two categories: motivational theories and action theories. Motivational theories support the belief that motivation (or intention) determines behaviour [59]. For motivational theories the best predictors of behaviour are expected to be those items that best predict intention. Action theories support the belief that other factors (in addition to intention) predict behaviour [59]. Action theories can be pre or post intentional. Post-intentional theories (theories that explain behaviour with constructs that act on behaviour after intention) are not expected to predict intention as well as pre-intentional theories [59].

[10] Through consultation with experts (JF, IR) Implementation Intentions (II) [125] was added to the list of theories to explore post-intention constructs.

Table 4.1: Behavioural Theories and Constructs

Theory/framework • **constructs**	**Brief summary**	**Pre or post intentional**	**Reference**
Motivational theories			
Theory of Planned Behaviour (TPB) • Intention • Subjective norms • Perceived Behavioural Control • Attitude	The Theory of Planned Behaviour proposes that one's strength of intention and one's degree of control predicts behaviour Additionally, attitudes, subjective norms, and perceived behavioural control directly affect intention	Pre Intentional	(Ajzen, 1991)
Social Cognitive Theory SCT) • Self Efficacy • Anticipated consequences	Social Cognitive Theory emphasizes that behaviour can be predicted through anticipated outcomes and Self Efficacy	Pre Intentional	(Bandura, 1988)
Knowledge-Attitude-Behaviour (KAB) • Knowledge • Attitude	The Knowledge-Attitude-Behaviour model proposes that knowledge about a behaviour attitude about the behaviour will predict the behaviour	Pre Intentional	(Bettinghaus, 1986)
Action theories			
Operant Conditioning (OC) • Anticipated Consequences • Habit	Operant Conditioning suggests that consequences (reinforcement and punishment) predict behaviour· positive consequences reinforce the behaviour until it becomes habitual	Pre & Post Intentional	(Skinner, 1953)
Implementation Intentions (II) • Action planning (post-intentional)	Implementation Intentions proposes that, in addition to intention, having a plan (when, where and how) will predict behavioural outcomes	Post Intentional	(Gollwitzer & Brandstatter, 1997)
Personal Project Analysis (PPA) • Goal Priority (post-intentional)	Personal Project Analysis is a framework proposing that behaviour outcomes can be predicted through goal hierarchy (is behaviour in conflict or does it facilitate other goals)	Post Intentional	(Presseau, Sniehotta & Little, 2008)

In this chapter we describe the development and analysis of a theory based questionnaire to identify which theoretical constructs and specific beliefs influence orthopaedic surgeons' decision to watch and wait instead of transfusing red cells. Using the theory based questionnaire, we will empirically quantify the relevance of the constructs and beliefs highlighted in *Chapter Three*, and identify which variables are important to the development of future intervention studies.

Methods

Development of the questionnaire

Using methods previously described by Francis *et al.* [44, 118, 127], we developed a questionnaire to predict orthopaedic surgeons' intention to watch and wait instead of transfusing red cells. The questionnaire was based on the analysis of theoretical domain interviews with orthopaedic surgeons described in *Chapter Three*. The theory based questionnaire was presented in four sections. As recommended by Francis *et al.* [127], the survey began with a detailed description of the behaviour we are studying:

> "***We would like you to think about how you might ...manage in-patients with borderline haemoglobin by watching and waiting instead of transfusing red cells***. When we say borderline haemoglobin, we are thinking about those in-patients where the decision about transfusing might need more thought. There will be in-patients you would definitely transfuse; in-patients you would definitely not transfuse; and in-patients where there is a grey area, where the decision about transfusing is less clear cut. **That is what we mean by borderline haemoglobin."**

Part 1 (Factors influencing the management of borderline haemoglobin) was developed based on the theories identified as part of the analysis of *Chapter Three*. We included five theories/models this first part of the predictive survey: Theory of Planned Behaviour (TPB), Social Cognitive Theory (SCT), Operant Conditioning (OC), Implementation Intentions (II), and Personal Project Analysis (PPA)[11]. These theories and models were chosen because they have been evaluated in other settings and because they contain constructs that can be changed to affect behaviour [59].

[11] Knowledge-Attitude-Behaviour (KAB) model was operationalised in Part 2 of the questionnaire.

Table 4.2: Constructs operationalised into the theory based questionnaire

Theory / Framework	Predictor constructs included in questionnaire
TPB	Attitude (direct) Attitude (indirect) Subjective Norms Perceived Behavioural Control (direct) Perceived Behavioural Control (indirect) Intention (direct estimation) Intention (Strength of Intention)
SCT	Self Efficacy Anticipated Consequences
KAB	Knowledge Attitude (direct) Attitude (indirect)
OC	Anticipated Consequences Habit
PPA	Goal Priority
II	Action planning

Theory of planned behaviour (TPB), Social Cognitive Theory (SCT), Operant Conditioning (OC), Implementation Intentions (II), Personal Project Analysis (PPA) and Knowledge-Attitude-Behaviour (KAB) model

The individual questions were developed using standard measures and standard methods to build a theory based questionnaire [127]. The Theory of Planned Behaviour (TPB) constructs were operationalised into standard question items developed by Francis *et al.* [127].

Part 1 measured intention using two methods. The first measure of intention was *Direct Estimation of Intention* [127]. Participants were asked to estimate the number of patients (out of ten) that they expected to watch and wait instead of transfusing red cells. The second measure of intention, *Strength of Intention,* was measured using two items scored on a seven point Likert scale [127]:

> 6. When I first discover an in-patient has borderline haemoglobin, I have in mind to *manage them by watching and waiting instead of transfusing red cells.*
> 7. I intend to *manage in-patients with borderline haemoglobin by watching and waiting instead of transfusing red cells.*

Where possible, Francis *et al.* [127] recommend that TPB items be measured directly (e.g. by asking about overall attitude) and indirectly (e.g. by asking about specific behavioural beliefs). The questionnaire included two belief based constructs: Attitude and Perceived Behavioural Control (PBC). These belief based constructs were measured using both direct and indirect questionnaire items. Direct and indirect items measure the same construct different ways. For example, to evaluate Attitude (direct measures), surgeons were asked to rate the following three statements on a seven point Likert scale (strongly agree to strongly disagree):

> (a) The benefits of managing in-patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells* outweigh the harms
> (b) Managing in-patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells* is more often the right thing to do than the wrong thing to do
> (c) When I manage in-patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells* I feel pleased with my decision

Indirect item measures evaluate the same construct using different content. The content for the indirect items was developed based on the beliefs identified in *Chapter Three*. For example, Attitude (indirect measures) was evaluated using the following content:

1 In general *managing an in-patient with borderline haemoglobin by watching and waiting instead of transfusing red cells* would
   a) Decrease the patient's length of stay in hospital
   b) Improve the patient's clinical condition
   c) Save resources (e g., cost, blood, etc)
   d) Reduce the risk of the patient contracting
2 In general how important do you consider these outcomes to be?
   a) Decrease the patient's length of stay in hospital
   b) Improve the patient's clinical condition
   c) Save resources (e g., cost, blood, etc.)
   d) Reduce the risk of the patient contracting

All constructs identified from theories (theories other than TPB) were operationalised into questionnaire items by adapting the methods presented by Francis *et al.* [127] with the assistance of a health psychologist (JF) and other experienced team members (RI, JG, JB).

All questionnaire items developed in Part 1 from Theory of Planned Behaviour (TPB), Social Cognitive Theory (SCT), Operant Conditioning (OC), Implementation Intentions (II), and Personal Project Analysis (PPA) theories were measured using a seven point Likert scale (with the exception of Direct Estimation of Intention).

Part 2 (Transfusion factors in orthopaedic surgery patients) was developed to assess surgeons' knowledge of the risk and the associated costs of red cell transfusions. We included this section because *knowledge* was identified as a construct potentially relevant to the target behaviour as part of the interview process and was mapped to the Knowledge-Attitude-Behaviour (KAB) model. To address knowledge, we included questionnaire items that were developed with the help of a haematologist (AT).

Part 3 (How would you manage this patient?) was developed to assess behaviour. This section of the questionnaire contained three clinical scenarios developed with input from a haematologist (AT) and an orthopaedic surgeon (GD). For each scenario, participants were provided with a brief description of four clinically similar patients with varying haematology results and were asked whether they would transfuse each patient (and if so, how many units).

Part 4 (Background) asked participants for demographic information including gender, age, province of practice, years of practice, number of beds in their orthopaedic service and whether they worked with residents.

The final questionnaire consisted of 64 items, three clinical scenarios and nine demographic questions. The questionnaire was piloted with a group of 10 orthopaedic surgeons who were asked to complete the questionnaire and provide feedback. Small changes to wording were made as a result of piloting. A final copy of the question is included in Appendix 4-A.

Sample size

In *Chapter Three* we identified a maximum of ten theoretical constructs (predictor variables per model) that were potentially relevant to the target behaviour. Multiple regressions require a minimum of $50 + 8\ m$ (where m is the number of predictor variables) [128] Using ten predictor variables, the sample size required is 130 respondents. In order to examine individual predictors, a minimum sample of $104 + m$ is required [128]. Looking at 10 predictor variables would therefore require 114 respondents. To satisfy these requirements, we aimed to collect responses from 150 orthopaedic surgeons. Assuming a conservative response rate of 30%, we mailed 500 questionnaires.

Survey Procedure

The questionnaire was mailed to a random sample of 499 orthopaedics surgeon registered with the Canadian Orthopaedic Association (and living in Canada[12]). We conducted the survey using modified Dillman methods [129]. In the first week, we mailed an introduction letter to all 499 potential participants. In week two we mailed 499 survey packages containing the following items: an invitation letter describing the survey; a theory based questionnaire; and a prepaid, self addressed envelope. In week five we mailed reminder postcards to non-responders. Then, in week seven we mailed another survey package to the

[12] One surgeon was excluded from our mailing because of an international mailing address. This reduced our sample from 500 to 499.

non-responders. We included data from questionnaires returned (by fax or post) within 12 weeks of the mailing of the first questionnaire packages.

Survey data was entered into Microsoft Excel spreadsheets by the Data Management Services staff at the Ottawa Hospital Research Institutes' Ottawa Methods Centre. Additionally, Data Management Services staff performed quality assurance to test the accuracy and completeness of the data. Data was imported into SPSS v.17 for further analysis.

Scoring of the survey

Intention scores were presented as mean of the single direct estimation item (raw score out of ten) and as the mean of the strength of the two intention items [127]. The *knowledge score* was calculated based on how many correct answers they provided in Part 2 (raw score out of five).

Constructs composed of multiple questionnaire items were presented as a mean score of the included items. Within each construct, we standardized the direction of variable items[13] [127].

Scores for compound constructs, such as Attitude (indirect measure) and Subjective Norms, were presented as a mean score of the sum of the product of the items [127]. For example to score Attitudes (indirect measure): first, the product of behavioural belief (questionnaire

[13] For constructs such as Perceived Behavioural Control, we recoded the items that had negatively worded endpoints (20 & 21 items a, b,c, f, and g), so that higher numbers would reflect a positive endpoint (e.g. an answer of 6 becomes score of 2; a score of 4 remains a 4). This was also done for Anticipated Consequences (items 3b, and 4) and Habit (items 14 a, and c).

questions 1a-d) and outcome expectation (questionnaire questions 2a-d) was calculated for each of the four beliefs (a-d); second, these products were summed [(1a x 2a) + (1b x 2b) + (1c x 2c) + (1d x 2d)] and divided by four to create an overall mean *attitude score*.

Behaviour was simulated with written scenarios. The scenario vignettes were scored in two ways. First an *appropriateness score* was calculated for each participant: 1 point for each appropriate response (raw score out of 12). We based the appropriateness scored based on the results of the publication of the Transfusion Trigger Trial for Functional Outcomes in Cardiovascular Patients Undergoing Surgical hip fracture repair (FOCUS) trial [41]. According to the results of the FOCUS trial, there were a total of four patients for whom it was appropriate to transfuse one unit of red cells and eight for whom it was appropriate to watch and wait. Second, a *volume score* was calculated for each participant: the sum red cell units transfused across the scenarios (raw score out of 16).

The reliability of direct constructs was calculated using Cronbach's alpha (>2 items) and Pearson's Correlation Coefficient (≤2 items) across all appropriate construct items. As recommended by Francis *et al.*, [127] constructs with Cronbach's alpha scores of greater than 0.6 were included in the questionnaire. Constructs with low reliability across items were analysed further, looking at the mean and distribution of responses for possible explanations for low reliability. Where appropriate, items were dropped from constructs to try to improve reliability[14]. Internal consistency was not calculated for raw scores (such as volume transfused) or indirect constructs because these measures are not expected to be

[14] *Anticipated consequences* was the only construct with a Cronbach's alpha scores less than 0.6. Removing constructs did not improve the reliability of this construct.

reliable across items. Indirect items are not conceptually similar; for example, when analyzing Attitude (indirect measures) one's belief that it is important to "*Decrease the patient's length of stay in hospital*" is not expected to correlate with one's belief that it is important to "*Save resources*".

Unanswered questions were coded as missing for the data analysis. When individual items were missing we calculated all possible theory constructs, but excluded any constructs with missing information from the models.

Survey Analysis

The bivariate correlations were calculated for all constructs using Pearson's correlation in SPSS v.17. Correlations were considered strong if the absolute value of the Pearson's correlation coefficient was larger than 0.3 [119]. Then, for each theory we used multiple linear regressions to identify significant predictors of intention (Strength of Intention and direct estimation) and simulated behaviour (volume and appropriateness). Models were constructed for each theory to include all constructs listed in table 4.2. Statistical significance and standardized beta coefficients for variables and R^2 values for models were recorded.

KAB and TPB models were developed using hierarchical regression [119]. In all KAB models, first we included direct measures of attitude only; second, we added indirect measures of attitude. We used hierarchical regression to test if adding indirect attitude significantly improved the R^2 values of the KAB models.

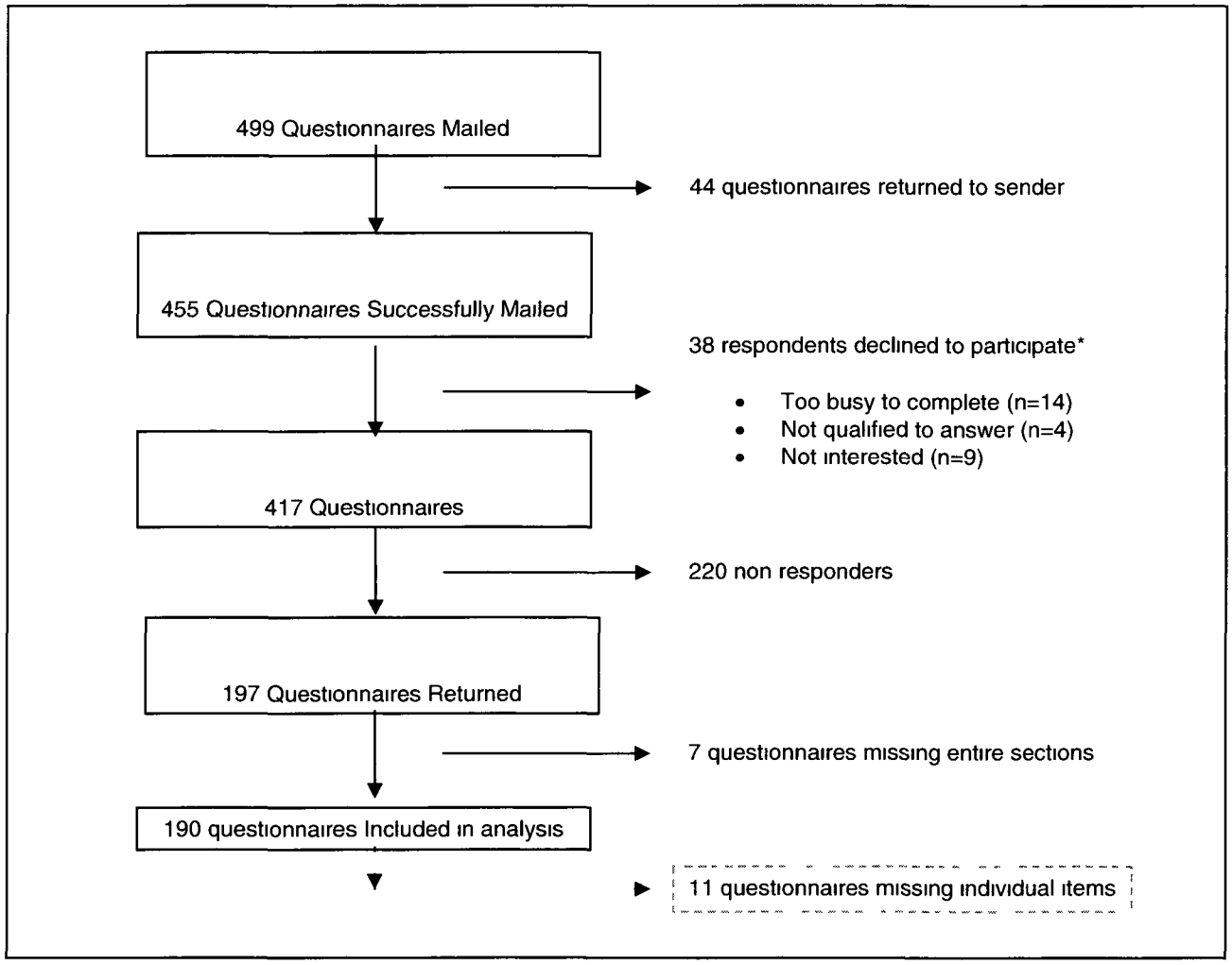
When predicting intention in TBP models, first the models included direct measures only; second, we added indirect measures; and third we added knowledge. When predicting behaviour, we built two TPB models for each outcome (volume and appropriateness). One TBP model included only PBC Direct and Direct Estimation of Intention construct, the other TPB model included only PBC Direct and Strength of Intention Constructs. To both versions of the TPB model predicting behaviour we added the knowledge construct and used hierarchical regression to test if this construct significantly improved the R^2 values of the models. We recorded statistical significance, standardized beta coefficients for significant variables and R^2 values for all TPB models.

Finally, a stepwise regression was performed using all construct to identify the best overall model to explain each measure of intention and behaviour. Statistical significance for the best model, standardized beta coefficients for significant variable and R^2 values were recorded.

Results

Response rate

We received questionnaires from 197 individuals (response rate of 43%: 190/455). Of the 197 questionnaires, we excluded seven because the questionnaires were not complete. Incomplete questionnaires were either missing data from an entire section (n=5) or because of fax transmission errors (n=2). Less than 3% of the included questionnaires (n=11) contained at least one question that was not answered by participants.



Notes * Respondents could select more than one reason to decline

Figure 4.1: Flow chart of Orthopaedic Survey responses

Sample description

Of the 190 questionnaires we included in the analysis, 92.5% were completed by males, 7.5% by females. The average age of the respondents was 49.7 years old and they had an average of 15.9 years of experience as an orthopaedic surgeon. As detailed in table 4.3, 68.8% of the surgeons reported working with residents and the average number of beds in the average ward was 46.9.

Table 4.3: Sample description form responses to survey

Proportion (%)		
Male		92.5
Female		7.5
Province	British Colombia	17.4
	Alberta	17.4
	Saskatchewan	5.8
	Manitoba	3.7
	Ontario	36.8
	Quebec	5.3
	New Brunswick	4.7
	Nova Scotia	4.7
	Prince Edward Island	-
	Newfoundland/Labrador	2.1
	Territories	0.5
Work with residents		68.8
Mean (Standard deviation)		
Age		49.7 (10.3)
Years of practice		15.9 (10.4)
Beds in service		46.9 (63.0)

Survey results

Table 4.4 presents the reliability and mean values for variables included in regression analysis. Table 4.5 presents the correlation coefficients for variables included in regression analysis.

Table 4.4 Summary of regression variables, means, and alphas for survey items and constructs

Theory/ Framework	Construct	Items	Item mean	Standard Error of the mean	Item min	Item max	Skewness	Construct Reliability[1]	Construct Mean (standard deviation)
Individual Constructs									
TBP	Attitude (Ind) Behavioural beliefs	Part1_q1a	3.06	0.10	1	7	0.493	-	4.51 (0.81)
		Part1_q1b	3.64	0.09	1	7	0.264		
		Part1_q1c	5.30	0.11	1	7	-1.055		
		Part1_q1d	6.06	0.10	1	7	-2.010		
	Attitude (Ind) Outcome evaluations	Part1_q2a	4.99	0.12	1	7	-0.783	-	5.65 (0.82)
		Part1_q2b	6.56	0.05	4	7	-1.550		
		Part1_q2c	4.97	0.10	1	7	-0.341		
		Part1_q2d	6.09	0.09	1	7	-1.969		
	*Attitude (Dir)	Part1_q16a	5.23	0.08	1	7	-0.636	0.792	5.29 (0.93)
		Part1_q16b	5.42	0.08	1	7	-0.826		
		Part1_q16c	5.22	0.08	1	7	-0.594		
	Subjective Norms Motivation to comply	Part1_q5a	3.29	0.11	1	6	0.106	0.806	3.41 (1.08)
		Part1_q5b	3.76	0.11	1	7	-0.136		
		Part1_q5c	3.99	0.11	1	7	-0.345		
		Part1_q5d	3.60	0.11	1	7	0.052		
		Part1_q5e	2.86	0.11	1	7	0.617		
		Part1_q5f	3.12	0.10	1	6	0.072		
	Subjective Norms Normative beliefs	Part1_q15a	5.10	0.12	1	7	-0.795	0.675	4.49 (0.91)
		Part1_q15b	4.83	0.10	1	7	-0.776		
		Part1_q15c	5.22	0.09	1	7	-0.683		
		Part1_q15d	4.55	0.10	1	7	-0.708		
		Part1_q15e	3.30	0.12	1	7	0.214		
		Part1_q15f	4.06	0.11	1	7	-0.358		
	**Strength of Intention	Part1_q6	5.83	0.09	1	7	-1.603	[0.738]	5.83 (1.18)
		Part1_q7	5.66	0.08	1	7	-1.286		
	**Direct Estimation of Intention	Part1_q11	7.94	0.12	2	10	-0.856	-	7.94 (1.63)
	*PBC (Dir)	Part1_q8	5.13	0.12	1	7	-0.829	0.772	4.46 (1.40)
		Part1_q9	4.78	0.12	1	7	-0.507		
		Part1_q10	3.48	0.13	1	7	0.284		
	*PBC (Ind) Watching and waiting	Part1_q20a_inv	5.75	0.10	1	7	-1.621	-	3.88 (0.67)
		Part1_q20b_inv	4.14	0.10	1	7	-0.015		
		Part1_q20c_inv	4.58	0.10	1	7	-0.431		
		Part1_q20d	5.97	0.08	2	7	-1.692		
		Part1_q20e	5.71	0.08	1	7	-1.233		
		Part1_q20f_inv	4.57	0.09	2	7	-0.365		
		Part1_q20g_inv	5.44	0.09	1	7	-0.909		
	*PBC (Ind) transfusing	Part1_q21a_inv	2.05	0.07	1	7	1.842	-	4.19 (0.68)
		Part1_q21b_inv	4.42	0.10	2	7	0.318		
		Part1_q21c_inv	3.52	0.10	1	7	0.659		
		Part1_q21d	2.20	0.08	1	7	1.350		
		Part1_q21e	2.96	0.11	1	7	0.716		
		Part1_q21f_inv	3.40	0.10	1	7	0.630		
		Part1_q21g_inv	2.51	0.09	1	7	1.198		
SCT	*Self Efficacy	Part1_q12	5.56	0.07	2	7	-0.946	0.652	4 19 (0.95)
		Part1_q19a	5.21	0.11	1	7	-0.954		
		Part1_q19b	2.80	0.11	1	7	0.906		
		Part1_q19c	3.31	0.11	1	7	0.475		
PPA	*Goal Priority	Part1_q13a	5.15	0.09	1	7	-0.690	0.715	4.52 (0.78)
		Part1_q13b	4.83	0.09	1	7	-0.405		
		Part1_q13c	3.58	0.11	1	7	0.036		

OC	*Anticipated consequences	Part1_q3a	3.44	0.01	1	7	0.136	0.432	4.22 (0.93)
		Part1_q3b_Inv	4.24	0.10	1	7	0.282		
		Part1_q4_Inv	4.99	0.10	1	7	-0.313		
	*Habit	Part1_q14a_inv	5.58	0.10	1	7	-1.136	-	4.52 (0.85)
		Part1_q14b	4.84	0.10	1	7	-0.530		
		Part1_q14c_Inv	1.68	0.07	1	7	2.658		
II	*Action Planning	Part1_q17a	5.49	0.08	2	7	-0.992	0.94	5.57 (1.02)
		Part1_q17b	5.54	0.08	2	7	-0.876		
		Part1_q17c	5.66	0.07	2	7	-1.016		
		Part1_q17c	5.66	0.07	2	7	-1.016		
Calculated constructs									
TPB	*Attitude (Indirect) (out of 49)	Part1_q1 x Part1_q2 (4 items)	See Individual Constructs above					-	26.00 (6.55)
		Part1_q1 x Part1_q2 (3 items a,b,c Only)	See Individual Constructs above					-	22.13 (7.14)
	*Subjective Norms (out of 49)	Part1_q5 x Part1_q15 (6 items)	See Individual Constructs above					0.792	16.24 (6.46)
KAB	Knowledge (out of 5)	Part2_q2_a	0.97	0.01	0	1	-5.966	-	2.32 (0.82)
		Part2_q2_b	0.74	0.03	0	1	-1.084		
		Part2_q2_c	0.09	0.02	0	1	2.900		
		Part2_q3_score	0.14	0.03	0	1	2.066		
		Part2_q4_score	0.32	0.04	0	1	0.758		
		Knowledge	2.32	0.06	1	5	0.476		
Scenarios	**Appropriateness (out of 12)	Senario1_Score	2.68	0.06	0	4	-0.433	-	7.43 (1.70)
		Senario2_Score	2.90	0.06	0	4	-0.791		
		Senario3_Score	1.84	0.06	0	4	0.356		
		Appropriatness	7.43	0.13	2	12	-0.364		
	**Total _transfused (out of 48)	Total_Transfused_1	2.48	0.15	0	14	1.618	-	8.18 (4.69)
		Total_Transfused_2	1.76	0.14	0	12	2.188		
		Total_Transfused_3	3.95	0.14	0	10	0.268		
		Total_Transfused_3	8.18	0.35	0	31	0.893		

Notes: Theory of planned behaviour (TPB), PCB perceived behavioural control; Social Cognitive Theory (SCT); Operant Conditioning (OC); Implementation Intentions (II); Personal Project Analysis (PPA); Knowledge-Attitude-Behaviour (KAB) model;
* Construct used as predictor in linear regression; **outcome measure in linear regression; - not calculated
1 reliability of direct constructs was calculated using Cronbach's alpha (>2 items) and [Pearson's Correlation Coefficient (≤2 items)]

Predicting intention

Average Strength of Intention (7.94/10) and Direct Estimation of Intention (5.83/7) scores indicate that intention was relatively high. Figure 4.2 and 4.3 depicts the distribution of both measures of intention: a) Direct Estimation of Intention and b) Strength of Intention.

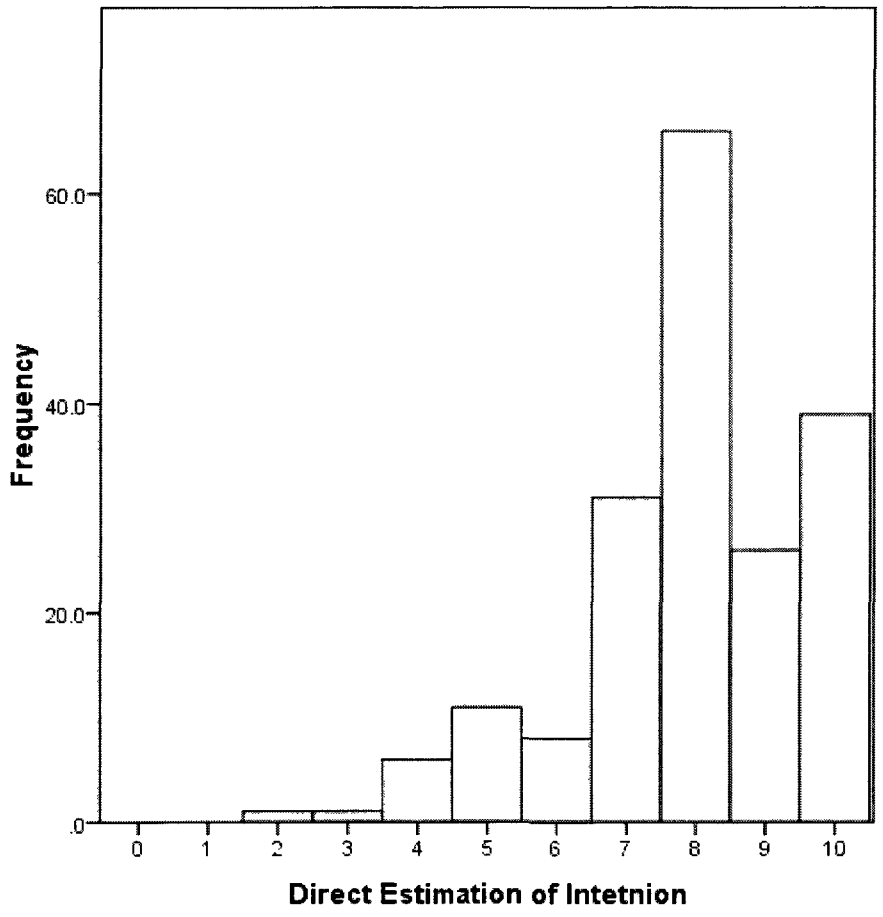


Figure 4.2: Histogram of the Direct Estimation of Intention outcome (Single item raw score out of 10)

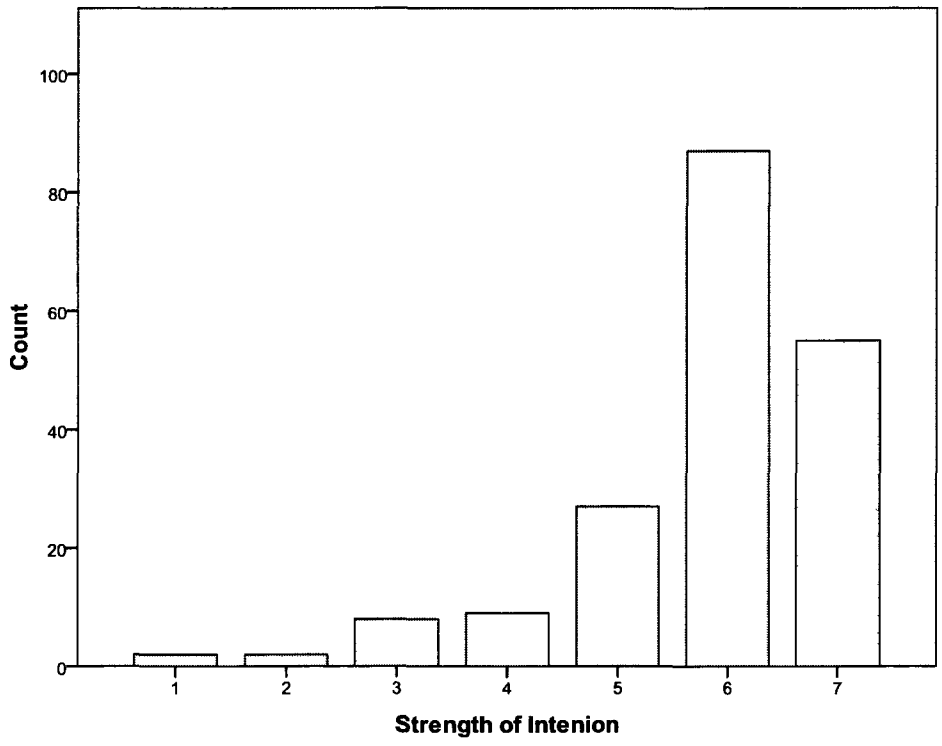


Figure 4.3: Distribution of the Strength of Intention outcome variable (Mean of two items scored using 7 point Likert scale)

Univariate analysis

Bivariate correlations between Direct Estimation of Intention and all variables were statistically significant ($p<0.05$) (Table 4.5). Direct Estimation of Intention strongly correlated with the following predictor variables (in decreasing magnitude): Attitude (direct), Self efficacy, Action Planning, Habit, PBC (indirect for watching and waiting and for transfusing), and anticipated consequences. Direct Estimation of Intention was not strongly correlated with the Appropriateness or Volume scores.

Table 4.5: Correlation matrix of variables (Pearson correlation coefficients)

	Total units transfused	Appropriateness	Intention Direct estimation	Strength of Intention	Knowledge Score	Attitude Direct	Attitude Indirect	Subjective Norms	PBC Direct	PBC Indirect WW	PBC Indirect TX	Self Efficacy	Anticipated Consequences	Habit	Goal Priority	Action Planning
Total units transfused	1	- 869**	- 211**	- 152*	- 100	- 182*	- 048	- 082	- 069	- 148	190*	- 252**	- 060	- 254**	- 086	- 113
Appropriateness	- 869**	1	256**	208**	108	196**	010	141	062	179*	- 179*	255**	096	207**	110	110
Intention Direct estimation	- 211**	256**	1	537**	154*	553**	238**	- 147*	268**	390**	- 378**	466**	352**	390**	240**	406**
Strength of Intention	- 152*	208**	537**	1	067	518**	205**	- 185*	261**	306**	- 271**	375**	360**	316**	177*	259**
Knowledge Score	- 100	108	154*	067	1	134	- 036	- 151*	027	066	- 059	012	011	161*	047	114
Attitude Direct	- 182*	196**	553**	518**	134	1	365**	000	330**	378**	- 329**	402**	451**	479**	456**	464**
Attitude Indirect	- 048	010	238**	205**	- 036	365**	1	032	118	231**	- 255**	164*	272**	253**	210**	365**
Subjective Norms	- 082	141	- 147*	- 185*	- 151*	000	032	1	- 121	048	177*	- 022	- 145	- 005	204**	- 134
PBC Direct	- 069	062	268**	261**	027	330**	118	- 121	1	262**	- 141	298**	200**	214**	113	337**
PBC Indirect WW	- 148	179*	390**	306**	066	378**	231**	048	262**	1	- 548**	541**	293**	204**	190*	229**
PBC Indirect TX	190*	179*	378**	271**	059	329**	255**	177*	- 141	- 548**	1	407**	- 246**	191*	124	288**
Self Efficacy	- 252**	255**	466**	375**	012	402**	164*	- 022	298**	541**	- 407**	1	248**	327**	260**	385**
Anticipated Consequences	- 060	096	352**	360**	011	451**	272**	- 145	200**	293**	- 246**	248**	1	281**	150*	181*
Habit	- 254**	207**	390**	316**	161*	479**	253**	- 005	214**	204**	- 191*	327**	281**	1	358**	318**
Goal Priority	- 086	110	240**	177*	047	456**	210**	204**	113	190*	- 124	260**	150*	358**	1	241**
Action Planning	- 113	110	406**	259**	114	464**	365**	- 134	337**	229**	- 288**	385**	181*	318**	241**	1

Notes ** Correlation is significant at the 0 01 level (2 tailed), * Correlation is significant at the 0 05 level (2-tailed), PBC – Perceived Behavioural Control, TX- transfusing red cells, W&W - watching and waiting

Bivariate correlations between Strength of Intention and all variables were statistically significant ($p<0.05$) with the exception of Knowledge. Direct Estimation of Intention strongly correlated with the following predictor variables (in decreasing magnitude): Attitude (direct), Self Efficacy, Anticipated Consequences, and Habit, PBC (indirect for watching and waiting). Strength of Intention was not strongly correlated with the Appropriateness or Volume outcomes.

Both measures of intention produce negative correlation coefficients when associated with Total Units Transfused, Subjective Norms, and PBC (indirect for watching and waiting). This suggests that strong intentions to watch and wait reduce the number of units transfused, and that strong Subjective Norms and strong Attitude reduce one's intention to watch and wait.

Multivariate analysis

In Table 4.7 we reported the R^2, Adjusted R^2 and significant predictors (including standardized beta coefficients) of intention for each model identified through linear regression. All of the theoretical models produced R^2 that were significantly different from zero ($p<0.001$).

The Theory of Planned Behaviour was the best model at predicting both Strength of Intention and directed estimation of intention. Adding indirect measures significantly increased the R^2 for Direct Estimation of Intention (R^2 change 0.056, $p=0.06$) but decreased R^2 for Strength of Intention (R^2 change 0.021, $p=0.225$).

As detailed in table 4.6, Attitude (direct measure) construct was a significant predictor of Strength of Intention in both TPB models. Subjective Norms and Attitude (direct measures) constructs were a significant predictor of Strength of Intention in models that only contained direct TPB items, while Perceived Behavioural Control (PBC) for watching and waiting and Attitude (direct measures) constructs were significant predictors of Strength of Intention in TPB models that included both direct and indirect TPB items.

Table 4.6: Summary of the regression results for intention models

Theory/ Framework	**Multiple R^2**	**Adjusted R^2**	**Significant individual predictors (Standardized Beta Coefficients)**
Prediction of Direct Estimation of Intention			
***TBP (Direct)	0.316	0.302	Attitude Direct (.495***)
***TPB (Direct & Indirect)	0.371	0.345	PCB Indirect W&W (.163*) Attitude Direct (.404***)
***SCT	0.277	0.269	Self Efficacy (.403***) Anticipated consequences (.253**)
***OC (OLT)	0.221	0.213	Habit (.316***) Anticipated consequences (.273***)
***PPA	0.207	0.203	Goals priority (.455***)
***II	0.165	0.160	Action Planning (.406***)
***KAB	0.320	0.312	Attitude Direct (.545***)
Prediction of Strength of Intention			
***TBP (Direct)	0.288	0.274	Subjective Norms (-.204**) Attitude Direct (.490***)
***TPB (Direct & Indirect)	0.309	0.280	Subjective Norms (-.209**) Attitude Direct (.431***)
***SCT	0.219	0.210	Self Efficacy (.303***) Anticipated Consequences (.289***)
***OC (OLT)	0.181	0.172	Habit (.233**) Anticipated Consequences (.296***)
***PPA	0.167	0.163	Goals Priority (.409***)
***II	0.067	0.062	Action Planning (.259***)
***KAB	0.255	0.246	Attitude Direct (.506***)

* p< 0 05, ** p<0 01, *** p<0 001, NS – not statistically significantly p>0 05,
[1]TPB model 1 included only PBC Direct and Intention (Strength of Intention),
[2]TPB model 2 included only PBC Direct and Intention (direct estimation)
Theory of planned behaviour (TPB), Social Cognitive Theory (SCT), Operant Conditioning (OC), Implementation Intentions (II), Personal Project Analysis (PPA) and Knowledge-Attitude-Behaviour (KAB) model

The mean knowledge score was 2.32 (out of 5) indicating that surgeons' knowledge of transfusion risks and costs were low. Adding knowledge as a construct to either TPB model did not increase the R^2 for models predicting intention (Strength of Intention R^2 change <0.001, p=0.203; Direct Estimation of Intention R^2 change 0.007, p=0.197)

Combining the constructs from all theories (Table 4.7), the best model for Direct Estimation of Intention included Attitude (Direct measures), Self Efficacy, Subjective Norms, and Perceived Behavioural Control (when watching and waiting) and Habit. The best model for prediction for Direct Estimation of Intention included Attitude (Direct measures), Self Efficacy and Subjective Norms

Table 4.7: Using stepwise modelling of all variables (highest R^2) to predict intention

Outcome	Significant variables in model	(Standardized Beta Coefficients)	R^2	Adjusted R^2	Model significance
Direct estimation intention	Attitude Direct	.398***	.474	.454	p<0.001
	Self Efficacy	.155*			
	Subjective Norms	-.161**			
	PBC W&W	.177**			
	Habit	.162**			
Strength of Intention	Attitude Direct	.611***	.398	.381	p<0.001
	Subjective Norms	-.042**			
	Self Efficacy	.240**			

* p< 0 05, ** p<0 01, *** p<0 001, PBC W&W - Perceived Behavioural Control (when watching and waiting)

Predicting simulated behaviour

The mean appropriateness score was 7.43 (out of a possible 12) and the mean volume score was 8.18 (out of a possible 16). These scores indicate that in 40% of scenarios, the surgeons transfused patients inappropriately and in terms of amount on average they

transfused twice as many units as appropriate. Figure 4.4 and 4.5 demonstrates the distribution of both measures of behaviour: a) transfusion appropriateness and b) transfusion volume.

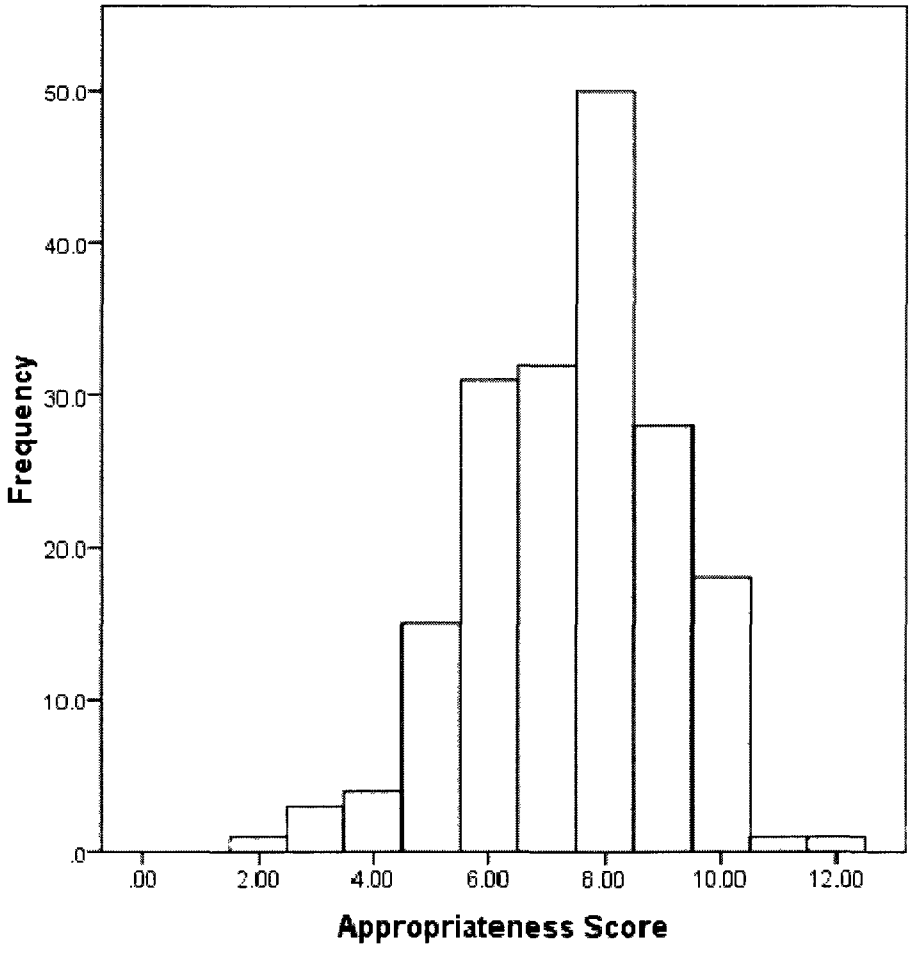


Figure 4.4: Distribution of the Appropriateness Scores calculated based on transfusion triggers described by Carson et al, (2009) (Single item scored out of 12)

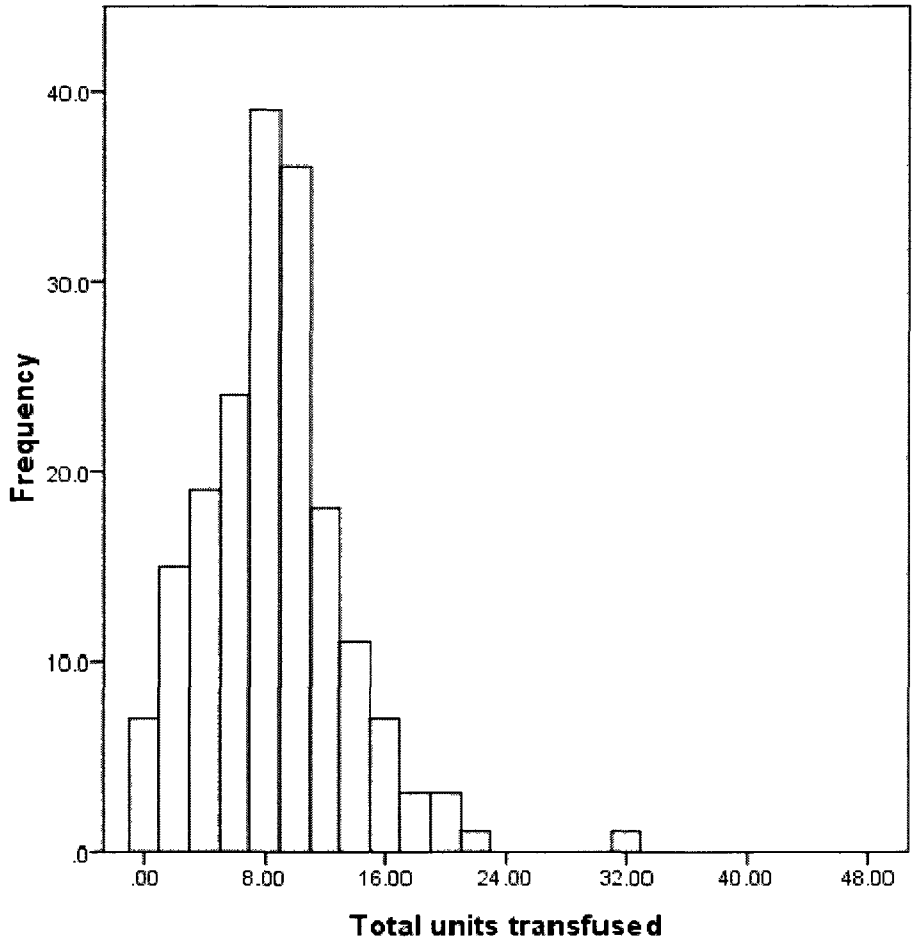


Figure 4.5: Histogram of the Volume scores reported by Canadian Orthopaedic Surgeons (Raw score out of 48)

Univariate analysis

Bivariate correlations between Appropriateness and other variables were statistically significant ($p<0.05$) for following variables: Total units transfused, Direct Estimation of Intention, Strength of Intention, Attitude (direct), PBC (indirect for watching and waiting and for transfusing), Self Efficacy, and Habit (Table 4.5). Appropriateness was not strongly correlated with any predictor variables, but was strongly correlated with the volume score.

Bivariate correlations between volume and other regression variables were mostly negative, with the exception of Perceived Behavioural Control (indirect for transfusing). Total Units Transfused was significant ($p<0.05$) correlated with the following variables: Appropriateness, Direct Estimation of Intention, Strength of Intention, Attitude (direct), Perceived Behavioural Control (indirect for transfusing), Self Efficacy, and Habit (Table 4.5). Total Units Transfused was not strongly correlated with any predictor variables, but was strongly correlated with Appropriateness.

The measure of simulated behaviour produced opposite correlations; that is to say, where one predictor was negatively associated with the volume score, the same predictor was positively associated with the appropriateness score. For example, Attitude was positively associated with appropriateness score but negatively associated with volume. This suggests that strong attitudes toward watching and waiting reduced the number of red cell units transfused and increased transfusion appropriateness. The sole positive correlation between Perceived Behavioural Control (indirect for transfusing) and total units transfused suggested the opposite: that Perceived Behavioural Control over transfusing increases the number of red cell units transfused, and decreases transfusion appropriateness.

Multivariate analysis

The regression analysis tested the theoretical models using all of the constructs included in the theories. In Table 4.8 we report the R^2, Adjusted R^2 and significant predictors

(with standardized beta coefficients) for each model identified through linear regression. Models for the Theory of planned behaviour (TPB), Social Cognitive Theory (SCT), and Operant Conditioning (OC), produced an R^2 that were significantly different from zero when predicting Appropriateness and Volume. The theoretical model based on Personal Project Analysis (PPA) predicted Volume, but did not significantly predict Appropriateness. Implementation Intention (II) did not significantly predict Appropriateness or Volume. There was no clear "best model" for predicting behaviour. Four of the six models analyzed were significant predictors of each behavioural outcome with relatively low R^2 values. When modeled, the theoretical constructs for SCT and OC best predicted simulated behaviours in terms of volume; while SCT and TPB best predicted simulated behaviours in terms of appropriateness.

Table 4.8: Summary of the regression results for simulated behaviour model

Theory/ Framework	**Multiple R^2**	**Adjusted R^2**	**Significant individual predictors (Standardized Beta Coefficients)**
Simulated behaviour (Appropriateness outcomes)			
*TBP Dir [1]	0.040	0.029	Strength of Intention (-.195*)
***TPB Dir [2]	0.076	0.065	Direct Estimation of Intention (.279***)
**SCT	0.068	0.057	Self Efficacy (.430**)
*OC	0.045	0.034	Habit (.192*)
II			NS
*PPA	0.022	0.017	Goal Priority (-.148*)
*KAB	0.041	0.029	Attitude Direct (.167*)
Simulated behaviour (Volume outcomes)			
TBP Dir [1]			NS
**TPB Dir [2]	0.054	0.043	Direct Estimation of Intention (-.236**)
**SCT	0.064	0.053	Self Efficacy (-.247**)
**OC	0.065	0.054	Habit (-.255**)
II			NS
PPA			NS
*KAB	0.037	0.025	Attitude Direct (.382*)

* p< 0 05, ** p<0 01, *** p<0 001, NS – not statistically significantly p>0 05,
[1]TPB model 1 included only PBC Direct and Intention (Strength of Intention),
[2]TPB model 2 included only Perceived Behavioural Control (PBC) Direct and Intention (direct estimation)
Theory of planned behaviour (TPB), Social Cognitive Theory (SCT), Operant Conditioning (OC), Implementation Intentions (II), Personal Project Analysis (PPA) and Knowledge-Attitude-Behaviour (KAB) model

Adding indirect measures did not significantly increase the R^2 for appropriateness (with Direct Estimation of Intention: R^2 change 0.012, p=0.582; with Strength of Intention: R^2 change 0.024, p=0.282) or volume outcomes (with Direct Estimation of Intention: R^2 change 0.009, p=0.710; with Strength of Intention: R^2 change 0.021, p=0.362).

As detailed in table 4.9, adding knowledge as a construct to TPB models did not increase the R^2 for models predicting behaviour.

Table 4.9: Results of adding Knowledge constructs to TPB models for simulated behaviour outcomes

Models			**R^2 change**	**P value**
Direct TPB measures	Direct Estimation of Intention	Appropriateness	0.004	0.383
		Volume	0.004	0.366
	Strength of Intention	Appropriateness	0.008	0.221
		Volume	0.008	0.241
Direct and indirect TPB measures	Direct Estimation of Intention	Appropriateness	<0.001	0.854
		Volume	0.002	0.620
	Strength of Intention	Appropriateness	0.003	0.489
		Volume	0.005	0.370

TPB – Theory of planned behaviour

Combining the constructs from all theories (Table 4.10), the best model for predicting appropriateness included Subjective Norms, and Self Efficacy. The best model for predicting total volume transfused included Habit, Subjective Norms, and Self Efficacy.

Table 4.10: Using stepwise regression modelling of all variables (highest R^2) to predict behaviour

Outcome	Significant variables	Beta	R^2	Adjusted R^2	Model significance
Appropriateness	Self Efficacy	.274*	.125	.112	p<0.001
	Subjective Norms	.219*			
Total transfused	Habit	-.233**	.154	.136	p<0.001
	Self Efficacy	-.189*			
	Subjective Norms	-.173*			

Significance * p< 0 05, ** p<0 01, *** p<0 001,

Overall, all of the models predicting behaviour produced lower R^2 compared to the models used to predict intention. In all measures of behaviour, Implementation Intention (II) models were not significant predictors of behaviour (p>0.05). In most models (with the exception of OC), Direct Estimation of Intention produced models with higher R^2 values than Strength of Intention.

Discussion

Identification of relevant theories and constructs

Multivariate analysis identified Theory of Planned Behaviour (TPB) as the best theory to predict intention to watch and wait. TPB models explained 37% of the variation in intention. Univariate and multivariate analysis of theoretical models suggests that the intention to watch and wait is consistently associated with the following constructs: Attitude, Self Efficacy, Anticipated Consequences and Habit. The Subjective Norms construct was not significantly correlated to intention (univariate analysis); however, when we included this construct in the linear regression, it was a significant predictor of intention. When combining all of the constructs (from all theories) stepwise linear regression identified Attitude, Self Efficacy, Subjective Norms, Perceived Behavioural

Control, and Habit as constructs in the best model to predict intention. This model explained 45% of the variation in directly estimated intention.

Multivariate analysis did not identify a theory that was the best predictor of the target behaviour. The better models at predicting behaviour were based on the constructs from the Theory of Planned Behaviour (TPB) and Operant Conditioning (OC). These models explained 8% of the Appropriateness (TBP) and 5% of the variation in Total Units Transfused (OC). Univariate and multivariate analysis of theoretical models suggests that the simulated behaviour was consistently associated with the following constructs: Direct Estimation of Intention, Self Efficacy, and Habit. When combining all of the constructs (from all theories) stepwise linear regression identified Self Efficacy, Subjective Norms as constructs in the best model to predict Appropriateness, while Self Efficacy, Subjective Norms, and Habit were the constructs included in models that best predicted Total Units Transfused. These models explained 13% of the variation in Appropriateness and 14% of the variation in Total Units Transfused.

Models based on Implementation Intentions (II) and Personal Project Analyses (PPA) were the poorest predictors of both intention and behaviour. It is not surprising that models based on II were not good at predating intention or behavior. Unlike TPB there are no standardized methods to properly assess Implementation intention by self report. Furthermore, II research has primarily focused on "one off" behaviours [126]. Therefore the relevance of II to repeatedly watching and waiting is uncertain. PPA is also a

relatively new framework, lacking standardised methods to assess goal priority using self reported survey data.

Difference between intention and behaviours

All theoretical models were better predictors of intention than behaviour. The model that predicted behaviour had relatively lower R^2 and lower significance when compared to those than prediction of intention.

The Theory of Planned Behaviour (TPB) proposes that intention in the antecedent to behaviour, yet all intentions do not result in behaviour [120]. A systemic review of 185 published studies reported that an average TPB accounted 39% of the variance in intention for 27% of the variance in behaviour [130].

Our TPB were models accounted for 37% of the variation in intention and 7% of the variance in behaviour. Therefore it is not surprising that this survey identified that measures for intentions were better explained by regressions model than the measures for behaviour [131, 132]. What is more unexpected is that TPB models only explained a small proportion of the variation of behaviour.

This survey indicated that intentions to watch and wait are high. We interpreted these high intentions in two ways. First, we purposely did not define borderline hemoglobin with a value, or transfusion trigger. Therefore a surgeon could honestly intend to watch and wait, while reporting a low appropriateness score and high volume score because their individual transfusion trigger is higher than that suggested by the recently completed

study by Carson *et al.* [41]. Using a higher threshold for the appropriateness of transfusion thresholds might result in better prediction of behaviour. Second, when intentions are high there is only a small margin to improve behaviour by improving intention. This suggests that we should focus on post intentional theories to improve transfusion practice.

Earlier in this chapter we classified theories as pre-intentional or post-intentional. Pre-intentional theories include the Theory of planned behaviour (TPB), Social Cognitive Theory (SCT), Operant Conditioning (OC), and Knowledge-Attitude-Behaviour (KAB). Post-intentional theories include Operant Conditioning (OC), Implementation Intentions (II), and Personal Project Analysis (PPA). As expected, post-intentional theories were poorer predictors of intention than the pre-intentional theories.

Difference between volume and appropriateness

Transfusion volume and transfusion appropriateness are conceptually very different. This stems from the idea that watching and waiting is not directly opposite to transfusing which is apparent in the scoring of the Perceived Behavioural Control items. When recoded to reflect the same directionality Perceived Behavioural Control to watch and wait often differs from Perceived Behavioural Control to transfuse. This conceptual difference between outcome measures may also explain the observation that when one predictor was negatively associated with Total Units Transfused, the same predictor was positively associated with Appropriateness.

In this survey our predictors were worded in relation to watching and waiting. We scored our appropriateness outcomes measure based on watching and waiting behaviour but Volume outcomes were based on transfusing behaviour. Specifically, we scored the appropriateness outcomes based on the results of the FOCUS trial [41]. In each of the three scenarios it was appropriate to watch and wait in three of the four patients presented. We scored volume as the absolute number of red cell units respondents indicated that they would transfuse. Therefore the appropriateness outcome was expected to have better correspondence with the predictors than the volume outcome because the predictors did not address transfusing but rather the antithetical behaviour of watching and waiting. This difference between outcome measures also explains the observation that predictors negatively associated with Total Units Transfused were positively associated with Appropriateness.

Strengths

The strength of this research is that we were able to investigate a behaviour using replicable theoretical methods. We had an adequate sample size to analyse linear models with as many as 10 predictor variables. This survey provided additional details in addition to the information gathered in the interviews *Chapter Three*. Specifically, we were able to quantify the relevance of individual theories and identify specific constructs that predict intention and the behaviour.

Limitations

For practical reasons, only a limited number of theories and questionnaire items were included in the survey. Limited survey length meant we could not test all constructs with multiple questions. A second limitation is that not all surveys items are validated

measures. Intention and the other TPB items have been tested in many clinical contexts [44, 59], but the same is not true for all other theories. We created scenarios *de novo* to simulate transfusion behaviour. These vignettes measure simulated behaviour which could be very different from actual behaviour. Furthermore, appropriateness was strictly scored using transfusion triggers suggested by Carson *et al.* [41]. Sensitivity analysis would be useful to explore whether less rigid scoring would affect our ability to predict behaviour. Without additional research, we are unable to conclude that the scenario vignettes are valid measures of behaviour.

Conclusions

We developed a questionnaire that indentified cognitive factors influencing orthopaedic surgeons' decisions to watch and wait instead of transfuse red cells. We identified TPB is the best model for predicting intention to transfuse but could not identify the "best model" for predicting behaviour. We recommend considering the following constructs when developing interventions to reduce inappropriate transfusions: Attitude, Self Efficacy, Anticipated Consequences, Habit, Subjective Norms and Intention.

The postal survey allowed us to increase our confidence and refine the findings from the previous semi-quantitative interviews. This additional information is important to the development of interventions. Using these methods we were able to obtain a better understanding of the "active ingredients" of interventions. We recommend using the methods presented in this chapter to further investigate behaviour in additional research contexts. Further research will build a knowledge base that will continue to inform the use of theoretical constructs in other research questions.

CHAPTER FIVE – Overview and Final Conclusions

Final Discussion

The overall objective of this project was to better understand the determinants of *watching and waiting instead of transfusing red blood cells* (RBC) among orthopaedic surgeons. This thesis employed a variety of methods to understand this professional behavior. The results of a systematic review of the literature, qualitative analysis of interview data and quantitative analysis of survey data provide a broad understanding of this target behaviour. Although not a specific goal of this project, the work from my MSc. thesis will ultimately support the design of an interventions to reduce inappropriate transfusion by orthopaedic surgeons.

As outlined in *Chapter One*, the clinical problem addressed by this thesis is inappropriate transfusion in orthopaedic surgery. Transfusion practice is suboptimal and consequently patients are exposed to avoidable risks. Furthermore, the factors that influence this professional behaviour are not known and without understanding these factors, we can only speculate as to how best to improve patient care. *Knowledge translation* is an established field that endeavours to improve patient care by promoting the uptake of research findings [51]. It was from the field *Knowledge translation* that we identified methods to guide our research into the professional behaviour of transfusing RBC.

Systematic review of interventions to reduce inappropriate transfusions

In *Chapter Two* we summarized existing interventions studies to reduce transfusions, detailed the types of interventions, the theoretical basis of the interventions, and the risk of bias of the included studies. This review identified 43 studies relating to interventions to reduce inappropriate transfusion of three different blood products: red blood cells

(RBC), fresh frozen plasma (FFP) and platelets. The large number of published studies on this topic demonstrated that there is an interest in reducing inappropriate transfusions. However the majority of published studies were before and after (BA) studies, which were low quality and subject to numerous risks of bias. Only one Randomized Control Trial (RCT) [113] suggested that a clinically significant reduction in inappropriate RBC transfusions was possible in a select population, but this result has not been replicated using quality methods. Consequently we concluded that the current literature base is insufficient to determine the relative effectiveness of interventions designed to reduce inappropriate blood transfusions by health care professionals.

As detailed in *Chapter Two*, there are additional limitations to the literature. First, behaviour change interventions were generally poorly reported, which consequently limits the scientific replication and restricts the development of successful interventions. Second, most studies did not justify the choice of a given intervention or use theory to inform the choice of interventions.

Based on our systematic review of the literature, we identified a lack of justification and theoretical support for interventions to reduce inappropriate transfusion. We looked to the field of *Knowledge translation* for methods to inform and enhance the development of interventions. As identified in *Chapter One*, we identified that understanding of the influences on a professional behaviour is key to developing successful interventions.

Qualitative interviews

In *Chapter Three*, we sought to understand our target behaviour using qualitative theory based methods. We analyzed the content of 11 theoretical domain interviews with orthopaedic surgeons to better understand transfusion behaviour. These qualitative methods provided a systematic way to analyze interview data. From the interview analysis we identified eight theoretical domains that are potentially relevant to the target behaviour: knowledge, motivation, social influences, behavioural regulation, beliefs about consequences, professional role, beliefs about capabilities and environmental context and resources. From these domains we identified six behavioural theories that would be included in a survey. The relevant theories included the Theory of Planned Behaviour (TPB), Social Cognitive Theory (SCT), Operant Conditioning (OC), Implementation Intentions (II), Personal Project Analysis (PPA) and Knowledge-Attitude-Behaviour (KAB). The methods used in *Chapter Three* identified key constructs and domains but did not provide causal links between the theories and the target behaviour, but did provide a rich description of beliefs within this population.

Predictive Survey

In *Chapter Four*, we sought to quantify the relevance of the theories and constructs identified in *Chapter Three*. As outlined in *Chapter Four* we developed and analyzed a theory based survey. We quantified whether select theories and constructs identified in *Chapter Three* were predictive of an orthopaedic surgeons' intentions to *watch and wait instead of transfusing red blood cells.* As a result of this quantitative analysis we identified that the Theory of Planned Behaviour (TPB) is the best model for predicting intention to transfuse but we could not identify the "best model" for predicting behaviour. The best theoretical model for predicting intention (TPB) accounted for 37% of the

variance in intention (R^2 =0.371, Adjusted R^2=0.345). The best theoretical models for predicting behaviour accounted for 7% of the variance in Appropriateness (Theory of Planned Behaviour (TPB): R^2 =0.076, Adjusted R^2=0.065) and accounted for 8% of the variance in Volume (Operant conditioning (OC): R^2 =0.045, Adjusted R^2=0.034). As suggested in *Chapter Four*, using a higher threshold for the appropriateness of transfusion thresholds might result in better prediction of behaviour.

Stepwise modeling identified that Appropriateness was best predicted using two constructs: Self Efficacy and Subjective Norms (R^2 =0.125, Adjusted R^2=0.112) while Volume was best predicted using three constructs: Habit, Self Efficacy and Subjective Norms (R^2 =0.154, Adjusted R^2=0.136). Overall, we identified the following constructs as relevant to professional behaviour of transfusion: Attitude, Self Efficacy, Anticipated Consequences, Habit, Subjective Norms and Intention.

Table 5.1: Comparison of relevant constructs identified using qualitative and quantitative analysis methods.

Qualitative Interview Analysis	**Quantitative Predictive Survey**
Constructs identified as potential relevant to the target behaviour	**Constructs identified as significant predictors of intention**
Knowledge about scientific rationale, Scientific rational Professional, Professional role, ID/ boundaries/role, Social norms, Social group norms, Organizational commitment, Professional autonomy, Perceived behavioural control. Self-efficacy and professional confidence, Consequents, Outcome expectancy, Attitude, Belief, Control of environment, Resources, Person environnement interaction, Environmental stressor, Inter-group conflict, Team working, Goal priority, Distal and proximal goals	Attitude, Perceived behavioural control, Subjective norms, Self Efficacy, Anticipated consequences, Habit, Goals priority, Action Planning.
	Constructs identified as significant predictors of simulated behaviour
	Intention, Self Efficacy, Habit, Goal Priority, Attitude,

There is value in conducting a theory based survey in addition to theoretical domain interviews. As shown in table 5.1, the analysis of the interviews identified 23 constructs that were potentially relevant to the target behaviour. When we tested these constructs in a predictive survey, we specified eight constructs that are significantly relevant to the intention to *watch and wait instead of transfusing red blood cells,* and five constructs that are significantly relevant to the behaviour. Both the interviews and the predictive surveys identified Attitude, Perceived Behavioural Control, Subjective Norms, Self Efficacy, Anticipated Consequences, and Goal Priority as relevant; however, the interview analysis did not identify the importance of Habit and Action Planning constructs. Therefore, we concluded that there is value in conducting a postal survey. The survey analysis provided a more concise list of significantly relevant constructs and theories than then interviews.

Table 5.2: Comparison of relevant theories identified using qualitative and quantitative analysis methods.

Qualitative Interview Analysis	**Quantitative Predictive Survey**
Theories identified as potential relevant to the target behaviour	**Theories identified as significant predictors of intention**
Theory of Planned Behaviour (TPB) , Social Cognitive Theory (SCT), Knowledge-Attitude-Behaviour Model (KAB), Operant Learning Theory (OLT), Normative Model of Work Team Effectiveness (NMWTE), Personal Project Analysis (PPA)	Theory of planned behaviour (TPB), Social Cognitive Theory (SCT), Operant Conditioning (OC), Implementation Intentions (II), Personal Project Analysis (PPA), Knowledge-Attitude-Behaviour (KAB)
	Theories identified as significant predictors of simulated behaviour
	Theory of Planned Behaviour (TPB), Social Cognitive Theory (SCT), Operant Conditioning (OC), Knowledge-Attitude-Behaviour (KAB)

As shown in table 5.2, the analysis of the interviews identified six theories/frameworks that were potentially relevant to the target behaviour. When we tested these theories

using a predictive survey, we specified six theories that were that were significantly relevant to the intention to *watch and wait instead of transfusing red blood cells,* and four theories that are significantly relevant to the behaviour. There was not a large difference in the number of the theories identified in the interviews when compared to those found to be significant in the survey. Therefore, by conducting a postal survey in addition to a qualitative analysis we were able to qualitatively support the relevant theories.

Implication for Interventions

The results of the thesis contributed to our understanding of watching and waiting in orthopaedics and will ultimately help in the development of future tailored interventions. Our survey analysis suggests that we should focus on motivational theories, but there are significant post-intentional factors we should also consider.

Table 5.3: Theoretical Constructs and Behavioural Changes Techniques

Behaviour change techniques proposed by Michie *et al.*[132]	Relevant construct					
	Attitude	Self Efficacy	Anticipated Consequences	Habit	Subjective Norms	Intention
Goals/target specified behaviour or outcome						•
Self-monitoring		•	•	•		•
Rewards, incentive						•
Graded tasks (starting with easy tasks)		•				•
Increasing skills problem solving, goals setting		•				•
Coping skills		•				
Rehearsal of relevant skills		•				
Planning, implementation				•		
Prompts triggers, cues				•		
Social processes of encouragement, pressure, support	•	•			•	•
Persuasive communication			•			•
Information regarding behaviour			•			•
Modeling/ demonstrative behaviour by others					•	
Feedback		•	•			
Self talk		•				
Motivational interviewing		•				•
•Techniques proposed to be relevant to the respective theoretical construct by Michie *et al* [132]						

We should focus on motivational theories because these theories were the best predictors of intention. We can use the identified predictive constructs to guide the choice of behavioural change techniques that may apply to this population. Michie *et al.* [133], developed a list of behavioural change techniques and linked the techniques to theoretical constructs. A summary of the relevant behavioural techniques is included in Table 5.3. This matrix identifies potential techniques that should be considered when developing an intervention.

We should also identify which of the techniques will apply to the target behaviour in the targeted population. Ajzen [134] proposed that the greater the relative weight of a construct, the more likely changing that construct will influence intentions and therefore ultimately change behaviour. From our step wise analysis of all constructs, Attitude was predominantly the strongest predictor.

Yet we also identified that post-intentional constructs (such as Habit) may be more relevant. A possible example of an intervention addressing Habit may endeavor to change the routine with the aim of jolting out the undesirable behavior and replacing it with the desired one. In the case of watching and waiting in orthopaedics surgery, this may involve adding an extra step to the transfusing process: to make surgeons think about what they are doing instead of acting habitually. In our systematic review, Mallet *et al.* [91], specifically addressed Habit with the implementation of departmental guidelines enforcing measuring hemoglobin (Hb) before starting a transfusion. Other examples of

interventions identified in the systematic review that could potentially address habit include new ordering procedures, new transfusion request forms or "gate keepers".

This chapter had identified a range of techniques and constructs that should be considered when developing an intervention. The next step is to use a formal process, such as intervention mapping combination of techniques would optimize the interventions [133].

The qualitative analysis of interviews can provide details to inform interventions not available in the qualitative survey analysis. The specific beliefs presented by orthopaedic surgeons will help tailor interventions to this specific population. Some of the specific beliefs relevant to developing a "Social processes of encouragement, pressure, and support" intervention may include:

"I consider the opinions of other colleagues (physiotherapist, nurses, and consult services)"

"The residents and on-call staff can make the decision to transfuse"

"We give the residents the autonomy to make the decision to transfuse"

"Patient rehabilitation would directly conflict with watching and waiting"

"I would be more likely to watch and wait if I knew that the patient was well monitored"

"When I hand over a patient, I don't have control whether they watch and wait"

While specific beliefs that may inform post-intentional interventions include:

"We need more training and education"

"There are no time constraints that affect whether I can watch and wait"

"I would be more likely to watch and wait if I knew that the patient was well monitored"

"You need to get the hemoglobin value to make a decision"

"We need to monitor the patients in the same way whether we watch & wait or transfuse"

"Blood shortages would affect my decision to transfuse"

Future research

Throughout this thesis we identified two key elements for future research: the need to do proper clinical trials and the need to develop interventions using theories. First, after reviewing the literature regarding interventions designed to reduce inappropriate blood transfusions, the relative effectiveness of interventions remained unclear. To address this issue, we need additional research using high quality and well reported intervention studies to judge the relative effectiveness of interventions. Specifically, larger RCT studies which have higher internal validity should be conducted to improve on the current knowledge base.

A second area for future research is development of an intervention to reduce inappropriate transfusions. As previously mentioned, developing an intervention was not a specific goal of this thesis. Nonetheless, a more complete understanding of transfusion behaviour will better position researchers to design interventions in the future. We must use systematic methods to build an understanding of the "active ingredients" for interventions. A knowledge base needs to be generalisable to other research questions in other research context. Our conclusions demonstrate, as highlighted in previous recommendations, that the use of theory promises a better understanding of barriers, better designed interventions, and is necessary to advance the science of implementation research [50].

ChapterThree and *Chapter Four* of this thesis stem from the need for theory based interventions. In *Chapters Three* and *Four* we used (and improved on) methods to incorporate theory into the design of an intervention. We advocate that future

intervention research must include similar theory based methodologies. The methods provide clear models to use psychological theories to understand the factors that influence a behaviour and then tailor intervention to change that behaviour. Moreover, more researchers can access the benefits of these methods and develop a better understanding of factors that influence behaviour across a variety of research contexts. This issue is important to move the field of *Knowledge translation* forward as the methodologies can be used to other issues in transfusion medicine and other fields.

Final Conclusions

There is an interest in reducing inappropriate transfusions; however, presently we lack the quality evidence required to support an effective intervention. As previously mentioned, developing an intervention is not a specific goal of this thesis. Nonetheless, a more complete understanding of transfusion behaviour will better position researchers to design interventions in the future.

We must use systematic methods to build an understanding of the "active ingredients" of interventions. We recommend using the methods presented in this thesis to investigate behaviour in additional research contexts. When using these methods, we continue to better the understanding of the "active ingredients" of interventions. Moreover, further research will build a knowledge base more readily applied to other research questions. Theory supported interventions are anticipated to be more effective [59] and will likely reduce the burden on researchers by limiting the number clinical trials needed to change behaviour.

Potential conflict of interest

None known.

Ethics

This study was approved by The Ottawa Hospital (TOH) Research Ethics Board

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Appendices

Appendix 2-A: Search strategy

(adapted from strategy used by Wilson et al., 2002 with help from AT and JM)

Medline (Ovid) (Searched 1950 to Sep 2008)

1. exp blood transfusion/
2. exp blood component transfusion/
3. exp erythrocyte transfusion/
4. plasma exchange.mp.
5. transfu$.mp.
6. or/1-5
7. exp education/
8. ed.fs.
9. educat$.mp.
10. exp guidelines/
11. guideline$.tw,sh.
12. exp practice guidelines/ or practice guidelines.tw.
13. exp guideline adheraUNCLEARe/
14. exp jurisprudeUNCLEARe/
15. Medical staff/ed [Education]
16. exp personnel, Hospital/ed [Education]
17. exp professional competeUNCLEARe/
18. adaptation, psychological/ or knowledge, attitudes, practice/
19. exp decision making/
20. Medical audit/
21. exp knowledge, attitudes, practice/ or knowledge, attitudes,
22. physician's practice patterns/
23. practice.mp.
24. Decision Making, Computer-Assisted/
25. (decision-mak$ or decision mak$).tw.
26. quality control
27. quality assuraUNCLEARe, health care/
28. or/7-27
29. randomized controlled trial.pt.
30. random$.tw.
31. control$.tw.
32. intervention?.tw.
33. evaluat$.tw.
34. or/29-33
35. animal/
36. human/
37. 35 not (35 and 36)
38. 34 not 37
39. 6 and 27
40. 38 and 39

Embase (Ovid) (Searched 1947 to Sep 2008)

Similar to the Medline with a few changes 1- use EMBASE EPOC filter, 2- additional MeSH terms (MeSH terms not available in Medline)

1 Randomized controlled trial/
2 random$ tw
3 experiment$ tw
4 (time adj series) tw
5 (pre test or pretest or post test or posttest) tw
6 impact tw
7 intervention$ tw
8 chang$ tw
9 evaluat$ tw
10 effect? tw
11 compar$ tw
12 control$ tw
13 or/1-12
14 Nonhuman/
15 13 not 14
16 author's strategy and 15
17 exp exchange blood transfusion/
18 medical personnel

Psych Info (Ovid) (Searched 1806 to Sep 2008)

1 treatment guidelines
2 Medical Personnel/
3 Health Personnel Attitudes/
4 exp BLOOD VOLUME/
5 expBLOOD/
6 exp BLOOD TRANSFUSION/
7 or 1-3
8 or 4-6
9 7 and 8

Cochrane Central Register of Controlled Trials (Ovid) (Searched 1966 to Sep 2008)

1 transfusion mp [mp=title, original title, abstract, name of substaUNCLEARe word, subject heading word]
2 exp blood transfusion/
3 blood component transfusion/
4 blood transfusion, autologous/
5 blood transfusion, intrauterine/
6 exchange transfusion,
7 whole blood/
8 plasma
9 or/ 1-8

Appendix 2-B: Data Extraction Forms

Data Extraction Form

Name of reviewer:
Date:
Study reference. (Author, Year, Journal)

1. Study data

1.1 Study design

(□) 1.1.1 **RCT**	Additional Description of study:
(□) 1.1.2 **CCT**	
(□) 1.1.3 **CBA**	
(□) 1.1.4 **ITS**	Data collection methods:
(□) 1.1.5 **Non-CBA**	

1.2 Setting

1.2.1 Academic status

(□) University based/teaching setting (i.e. not simply university affiliation)
(□) Non-teaching setting
(□) Mixed
(□) NOT CLEAR

1.2.2 Location of study: (Country, region, state/prov., city)

(□) NOT CLEAR

1.2.3 Source of funding: (□) NOT CLEAR; (□)

1.2.4 Clinical specialty

(□) General/family practice
(□) Hematology
(□) Surgery
(□) Paediatrics
(□) Obstetrics and gynaecology
(□) Radiology
(□) Other (specify) _____
(□) Not applicable (i e hospital wide)
(□) NOT CLEAR

1.2.5 Characteristics of participating providers

(□) Physicians
(□) Nurses
(□) Mixed (specify)
(□) NOT CLEAR

Additional description of providers

1.2.6 Patient Population: (□) Paediatric, (□) Adult, (□) Mixed; (□) NOT CLEAR;

1.2.7 Additional Description of patients :

1.2.7 Number of patients included in the study *(e g those who entered the study)*

a) Episodes of care (Tx/Admissions)	(⊔)NOT CLEAR	
b) Patients	(□)NOT CLEAR	
c) Providers	(⊓)NOT CLEAR	
d) Practices	(□)NOT CLEAR	
e) Hospitals	(□)NOT CLEAR	
f) Communities or regions	(⊔)NOT CLEAR	

2. Interventions

2.1 Type of intervention (state all interventions for each comparison/study group)

(List)	Group 1	Group 2
2.1.1. Professional:		
a Educational Meetings		
b Educational Material		
c Local consensus processes		
d Educational Outreach visits		
e. Local opinion leaders		
f Audit & Feedback		
g Reminders (including computer aided decision)		
h Marketing		
i Mass Media		
2.1.2 Financial:		
2 1 2 1 Provider interventions		
2.1.3 Organisational		
2 1 3 1 Provider orientated interventions		
2.1.3.3 Structural interventions		
2.1.4 Regulatory interventions (may overlap with 2 1 2 and 2 1 3)		

2.2 Nature of desired change

(⊓) Reduction of transfusions
(⊏) Increase in appropriate transfusion
(□) Modification of established management (e.g increased appropriate, reduction inappropriate)
(□) NOT CLEAR

2.3 Control(s)

(⊔) No intervention control group
(□) Standard practice control group
(⊓) Untargeted behaviour
(⊓) Other (another intervention)

Additional description of controls.

2.4 Development of intervention:

2 3.1 **Theory Use**	(⊓)Explicitly theory based (⊔)Some conceptual basis (⊓)Theoretical constructs used (□)Not clear	Notes:
2.3.2 **Choice of intervention**	(□) Formal process (theory/ framework) (□) Informal process (⊓) Historical/referenced paper (⊓) Not clear	(Consumer involvement?)

6. **Results** (use extra page if necessary)

6.1 For RCTs and CCTs

a) State the main results of the main outcome(s), for each study group in natural units

b) For each available **comparison**, report the baseline and post intervention differences between study and control groups, in natural units Include statistical significance (sig) if reported Indicate if the unit of randomisation and analysis were different

6.2 For CBAs and non-CBA's

a) State the main results of the main outcome(s), for each study group, in natural units

b) For each study group, report baseline and post intervention results Calculate the pre-post intervention difference for each outcome in natural units (i e the post-intervention outcome minus the pre-intervention outcome)

c) For each available comparison, calculate the difference across study groups of the pre post intervention change (i e if for an outcome measure ΔE is the pre-post intervention change in the experimental/intervention group, and ΔC is the pre-post intervention change in the control group, this will be ΔE-ΔC)

Record results

List Statistical tests Performed:				

3.2.2 Risk of bias for studies for Interrupted Time Series (ITS) designs and non-controlled before and after (non-CBA) designs	YES	NO	NOT CLEAR	Notes
a) Intervention independent of other changes?				
b) Shape of intervention effect pre-specified?				
c) Intervention to affect data collection?				
d) Knowledge of allocation adequately prevented? (Blind analysis)				
e) Incomplete outcome data addressed?				
f) Free from selective reporting?				
g) Free from other bias?				

5. Outcomes

5.1 Description of the main outcome measure(s).

5.1.1 Health professional outcomes/process measures:

BLOOD COMPONENTS

(□) Whole Blood
(□) RBC
(□) FFP
(□) Platelets
(□) Other:

(□) Change in proportion of inappropriate/appropriate transfusions
(□) Change in proportion of patients over or under transfused
(□) Change in number of transfusions
(□) Change in proportion patients transfused
(□) Change in number of units transfused
(□) Change in number of patients transfused
(□) Other:

5.1.2 Definitions of Health professional outcomes/process measures: (record definition)

Definition of over transfusion:

Definition of under transfusion:

Definition of inappropriate transfusion:

Use of "grey" zone to define inappropriate transfusion?

5.1.3 Economic variables:

(□) Cost Data Provided
(□) Not Clear

Additional description of economic variables:

5.1.4 Length of follow up:

____DAYS _____Mon _____Yrs

Additional description of Follow up:

2.5 Intervention components

Provider	(❒) NOT CLEAR	Notes:
Format	(❒)Interpersonal (❒)Paper (❒)Audio/visual (❒)Computer/interactive (❒) Multiple media used (❒) NOT CLEAR	
Setting	(❒) In practice setting (❒) Not in practice setting (❒) NOT CLEAR	
Recipients	(❒) Individual, (❒) Group, (❒) NOT CLEAR	
Intensity	(❒) NOT CLEAR	
Duration	(❒) NOT CLEAR	
Proximity to clinical decision-making:	(❒) NOT CLEAR	
Additional Details of intervention: (❒)YES; (❒) NO: Describe:		

3. Methods

3.1 Unit of allocation (of intervention)

(❒) Patient
(❒) Provider
(❒) Practice
(❒) Institution
(❒) Community
(❒) Other (specify)
(❒) NOT CLEAR

3.2 Unit of analysis (of outcomes)

(❒) Patient
(❒) Provider
(❒) Practice
(❒) Institution
(❒) Community
(❒) Other (specify)
(❒) NOT CLEAR

3.2 Risk of Bias

3.2.1 Risk of bias for studies with a separate control group (Go to 6.4.2 and 6.4.3 for the quality criteria for ITS and non-CBA, respectively)	YES	NO	NOT CLEAR	Notes
a) Allocation sequence generated?				
b) Allocation concealed?				
c) Baseline outcome measures similar?				
d) Baseline characterises similar?				
e) Incomplete outcome data addressed?				
f) Where outcome assessed blindly?				
g) Protection against contamination?				
h) Free from selective reporting?				
i) Free from other bias?				

6.3 For ITSs

a	Number of points pre and post		
b	Number of patients or measurement units (eg laboratory tests) in whole series		
c	Time interval between points		
d	Report pre and post intervention means		
e	Report absolute change in natural units		
f	Report percentage relative change		
g	Report the model used and statistical significance		
h	Is information on the value of individual observations over time only reported graphically in the original paper	(□) YES, (□) NO	
Did you have to do any re-analysis?		(□) YES, ( ) NO [if yes answer i-k]]	
i	Report change in level and p-value in natural units		
j	Report change in slope and p-value in natural units		
k	Report the autocorrelation coefficient		

6.4 Additional results

Appendix 2-C: Included Study Information Table (arranged in alphabetical order)

First author	Date	Country	Clinical specialty	Blood Product	Number of sites (Control)	Risk of bias Issues	Design	Intervention	Outcome measures
Audet	1998	USA	Orthopaedics	RBC	5	Data collection was retrospective, data collection periods spanned different seasons and varied in length, data collection methods differed between study groups (new form), Patient characteristics not adequately reported	BA	Programs that included development of a five independent hospital wide quality improvement teams and plans. Hospital based teams developed programs that included educational programs and system-level (i.e. new policies, blood ordering forms, surgery scheduling) interventions. The intervention was not well described.	% avoidable transfusions (all, allogenic)
Ayoub	1989	USA	Surgery & medical	FFP	1	Participant were aware of audit, Changes in trend may have resulted from "highly publicized risk ...public reluctance"; retrospective analysis of charts (data quality was reported to be low)	ITS	The department initiated an education program on appropriate FFP usage including: result of an audit, NIH consensus Conference Statements on FFP, risk of FFP, case studies an ongoing in-service program. The intervention was not well described.	Total units
Ballantyne	2003	UK	Surgery	Blood (RBC)	1	Data collection time periods not clearly reported, study groups differed on treatment and this procedure was a significant predictor of transfusion.	BA	Introduction of a new transfusion protocol and adoption of appropriate transfusion guidelines and an audit of all knee surgeries based on the guidelines. The intervention was not well described.	transfusion rate
Barnette	1990	USA	Surgery	FFP	1	Patient characteristics not adequately reported	BA	Program involved Formal Educational lectures (focusing on epidemiology of transmittable diseases and correct role of transfusion in patient care), follow up questionnaire to test knowledge and small informal meeting to discussion transfusion practice. Intervention was	% inappropriate, transfusion rate, % transfused, transfusions per patient

								well described.	
Brandis	1994	Australia	ICU & Surgery	RBC	1	Patient characteristics not adequately reported, intervention effect cannot be separated from concurrent provincial wide scrutiny of transfusions,	BA	Education program and monitoring of transfusion practices. And changes to policies including a lower transfusion trigger, checking hemoglobin before and after transfusions, 24 hour lab shifts, few elective transfusions at night, and registrar approval of transfusions. The intervention was not well described.	Units per 1000 admissions
Bray	2002	India	HW	RBC	12 (6)	Data collection for interventions and controls periods differed in length and time of year; Missing data from some hospitals, Intervention and control hospitals were matched based on geographical location, organization, hospital size and patient population	RCT	Simple hospital based interventions including self educating transfusion request form, educating and informing physicians of existing guidelines early in the transfusion process. Intervention was well described.	% of transfusion not compliant with guidelines, Unit per admission
Capraro	2001	Finland	Surgery	RBC, FFP & Platelets	1	Data collection time periods not clearly reported, Patient characteristics not adequately reported	BA	result of national audit were summarized and presented at various meetings to allow physician to compare their transfusion policies to others. Policies were then developed to encourage better use of blood. The intervention was not well described.	% patient transfused, units per patient
Cheng	1996	China	HW	FFP & Platelets	1	Patient characteristics not adequately reported, data collection methods differed between study groups (new form)	BA	Implementation of a hospital wide self educating transfusion request form, detailing BSCH guidelines. Feedback was given monthly and guideline where strictly enforced in most cases. Intervention was well described.	% inappropriate

Eindhoven	2005	Netherlands	Surgery	RBC	2 (1)	Equal number of patient reported at each hospital but did not adequately describe selection methods.	CBA	For one year physician and nurses received regular coaching on appropriate transfusion. Posters outlining guidelines were posted everywhere the physician could decide to transfuse. An additional colored form (6-7-10 Flexinorm) was added to every patient's medical record to detail argument for transfusion. Intervention was well described.	% of patients transfused, Units per patient
Garrioch	2004	UK	HW	RBC	1	Author acknowledge nation trend of decreasing blood use, hematology patients excluded	BA	Hospital wide program that included educational meetings and face-to-face meeting to discuss transfusion practice, laminated cards detailing guidelines, reminder labels on all blood that asked "Does this transfusion comply with written hospital guidelines". Intervention was well described.	% transfused, total patients transfused, total units,
Giovanetti	1998	Italy	Surgery	Whole Blood (RBC)	1	Patient characteristics not adequately reported, data collection methods differed between study groups	BA	Quality improvement program that included a transfusion committee to oversee development of transfusion indicators and to monitor transfusion practice through audits. Audit data was collected daily and audit team visited the wards daily. Intervention was well described	% units overtransfused, &% patients overtransfused, % transfused
Hamedullah	2000	Pakistan	Anesthesia	FFP	1	Data collection methods differed between study groups (retrospective vs. prospective), Patient characteristics not adequately reported, Staff were aware of the audit	BA	Computerized audit of transfusion practices from which the result were presented at departmental meeting. After audit was discussed BSCH guidelines were distributed and the audit was repeated. The intervention was not well described.	% inappropriate, % conditional

Hawkins	1994	New Zealand	HW	FFP & Platelets	1	Data collection time periods not clearly reported; Platelet outcome data not reported; some outcomes compared blood bank records to prospective audit results, hospital was aware of intervention,	(CBA) ITS	Mandatory hematologist approval process for all FFP and platelets followed by an audit to assess appropriateness of transfusions. Intervention was well described.	Units per 1000 population per year
Hui	2005	Australia	HW	FFP & Platelets	1	Patient characteristics not reported, authors reported problems assessing appropriateness outcomes	BA	Program that included a self educating request form, detailing NHMRC guidelines and an ongoing audit of transfusion practices. Appropriateness of transfusion was assessed within 48 hours of transfusion. Intervention was well described.	% inappropriate, % in grey area, % appropriate, dose per patient, total units,
Johshi	1997	Ireland	Surgery	RBC	1	Data collection time periods not clearly reported, patient characteristics not adequately reported, Patients with missing data were excluded, collection methods differed between study groups (retrospective vs. prospective)	BA	Quality assurance program that included audit of transfusion practices based on guidelines. Physicians were informed of the results of a previous audit and provided with current transfusion guidelines. Intervention was well described.	% inappropriate, % transfused
Kakkar	2004	India	HW	FFP	1	Data collection time periods not clearly reported, Patient characteristics not reported; data collection periods spanned different seasons and varied in length, disease outbreak during intervention period that would that was hypothesized to bias towards appropriate FFP usage.	BA	BSCH Guidelines were distributed as leaflets and ongoing education program where local leadership to encourage appropriate transfusion practices. The physicians were not aware that the study was ongoing. Intervention was well described.	% inappropriate orders
Kanter	1999	USA	OB Gyn	Blood (RBC)	1	Historical data collection was all retrospective from chart reviews, staff was aware of review, the effect of simultaneous patient education intervention was not controlled for	BA	Education intervention that include a 1 hour meeting with staff to discussion transfusion practice. The educator provide material detailing risks, and specialty specific national level guidelines. Intervention was well described.	Transfusion rate (overall, allogenic)

Lam	1997	USA	HW	RBC, FFP & Platelets	1	Used different data collection methods before and after intervention; seasonal difference between control and intervention; follow up differed in length from intervention	ITS	Retrospective peer review and physician self- auditing system whereby blood bank staff attached a new form to blood unit physican were asked to complete the form. Physician were informed of the research through a memo listing guidelines. Intervention was well described.	Units per patient per month
Lam	1996	USA	HW	RBC, FFP & Platelets	1	Patient characteristics not adequately reported, missing data from pediatric and Obstetric units, no standardized reviewing, lack of consistent peer review methods, between hospital data used a comparison for some outcome* (*this data was not included in the review because there was no baseline data)	BA	Retrospective peer review system where the hospital transfusion committees appointed transfusion reviewers to monitor transfusion practice. There were no specific criteria or standardized training for reviewers. The intervention was not well described.	Slope of total units
Littenberg	1995	USA	ICU	RBC	1	Data collection periods spanned different seasons, data collection methods differed between study groups (new form & retrospective vs. prospective)	BA	Three phase intervention that included (1) a review of transfusion practice, (2) provider education, implementation of a new order form witch displayed practice guidelines, and (3) strict policy for reviewing blood orders. Intervention was well described.	Total units transfused
Lucas	1997	Solomon Islands	HW	Blood (RBC)	1	Patient characteristics not adequately reported, data collection methods differed between study groups, forms ran out during first audit, blood bank did not supply high quality data, intervention not implemented to authors standards	BA	Local transfusion committee developed guidelines and educate local providers. An audit of transfusion practice based on the content of the educational strategy. The intervention was not well described.	Units per 100 admission, Units per 100 operations
Mallett	2000	UK	Anesthesia	RBC	1	Data collection time periods not clearly reported, Data collection periods spanned different seasons, Patient characteristics not	BA	The introduction of departmental guidelines where it was mandatory to measure Hb before starting a transfusion. Addition Equipement was also	% transfused

						adequately reported		purchased to facilitate Hb testing The intervention was not well described	
Marconi	1996	Italy	HW	RBC, Plasma	1	Data collection periods spanned different seasons, outcome were not reported for all blood types	BA	A complex quality assurance program including a new computerized ordering system that requires patient information and laboratory results as well as restricted permissions to limit the number of physicians that could order blood ("gate keeper"). Intervention was well described	Rate of compliant requests, Proportion transfused,
McCullough	1988	USA	HW	Platelets	1	Data collection time periods not clearly reported, data collection methods likely differed between study groups	BA	Local transfusion committee developed guidelines for platelet transfusion through audits of practice and consultations with medical staff The intervention was not well described.	Patients transfused per week; total units per year
Mimica	2008	Brazil	Neonatal ICU	RBC	1	Data collection periods spanned different seasons, patient blood lose was higher in the control periods,	BA	Neonate were transfused according to a strict guideline. No detail were given to the dissemination methods for this guideline. The intervention was not well described.	Units per patient
Morisson	1993	USA	OB Gyn	RBC, FFP	1	Data collection methods differed between study groups (new form)	BA	Educational and audit process Education included lectures on the risk of transfusion and way to avoid unnecessary transfusions, journal club and rounds. The quality assurance audit reviewed transfusion practice Practitioners were audit and informed by house staff if there practice was not compliant with guidelines. Intervention was well described	Units per patient, patients transfused per month
Muller	2000	Switzerland	Surgery	Auto (RBC)	1	Excluded patient with adverse events, timing of intervention and control not clearly described.	ITS	One page flow chart was added to the charts of patients undergoing joint replacement, and ongoing endorsement of appropriate transfusion practice by	% of patients transfused, 1000s of Units, units per

								chief physician. Intervention was well described.	joint replacement
Pentti	2003	Finland	ICU	RBC, FFP, Platelets	1	Data collection periods spanned different seasons, case mix differed between data collection periods	BA	Computerized auditing module was added to the computer system of a local blood bank to automatically alert prescriber if transfusion request did not meet transfusion criteria. The intervention was not well described.	% inappropriate
Perez	2007	USA	ICU	RBC	1	Data collection periods spanned different seasons; Patient selection was not adequately detailed, bleeding patients were excluded, break in data collection periods not explained, data collection methods differed between data collection periods	BA	Computerized ordering system that includes decision aids in the transfusion request process. The intervention was not well described.	% transfused, transfusion per patient
Petaja	2004	Finland	NICU	FFP, Platelets	1	Data collection periods spanned different seasons, Platelet data not completely reported	BA	Automatic computerized auditing system that informed the prescriber. if request did not meet transfusion criteria and requested additional patient information. Intervention was well described.	% inappropriate
Rana	2004	USA	ICU	RBC	1	Patient selection was not adequately detailed, data collection methods differed between data collection periods	BA	New protocol that included computerized transfusion ordering system combined with a decision support algorithm. The new protocol was presented to staff during division educational conferences. The intervention was not well described.	% inappropriate, transfusion per admission
Rehm	1998	USA	HW	RBC	1	Control data was from a chart review, intervention data from prospective lab data, did not report data for all outcomes, patient selection was not clear, timing of control and intervention were not	ITS	Educational program focusing on general and specialty physicians, new transfusion request form that detailed the new transfusion guidelines. Audit and feedback based on these guidelines was also provided. Intervention was well	Units transfused per patient days of hospitalization per year

						clear.		described.	
Rothchild	2007	USA	HW	RBC	1	Randomization occurred within the same hospital; did not adjust for the effect of physicians working on the same teams	RCT	Introduction of a computerized physician ordering system with decision support screens randomized to individual physicians. Intervention was well described.	% inappropriate transfusion orders
Rubin	2001	Australia	HW	RBC	10 (5)	Baseline rates differed between control and intervention; missing Hb values not discussed; seasonal differences I between reporting periods	RCT	Letter was sent to the CEO of all participating hospitals presenting hospital specific results of a transfusion audit. Research team members visited staff meetings at each of the Intervention hospitals to further present the result of the audit. Intervention was well described.	% inappropriate transfusions
Sarode	2009	USA	HW	RBC, FFP & Platelets	1	Use of alternative therapies was mentioned but not adequately described; likely affected by time;	ITS	Hospital wide program that included: Guideline distribution, and audit where on-call resident was contacted for every transfusion not meeting guidelines. Author also provided education and developed protocols to guide appropriate transfusion practice. Intervention was well described.	Unit per year
Shanberge	1987	USA	HW	FFP	1	Data collection periods spanned different seasons and varied in length, did not report data for less successful interventions	BA	Hospital wide education and audit of transfusion practice. Every weekday transfusion services discussed every patient transfused in the last 24 hours. Transfusions not indicated were discussed one on one with the prescriber (individual teaching). The intervention was not well described.	Units per year
Solomon	1988	USA	HW	FFP	1	Retrospective data collection methods that differed between intervention and control periods, seasonal difference between intervention and control periods,	ITS	A Hospital wide program that included: a chart review of randomly selected patients, 30 minute educational presentation, distribution of NIH guidelines, new FFP request form, blood	Unit per month

						inadequate explanation how patients were selected		bank staff insured that to check patient hematology result before processing request. Intervention was well described.	
Soumerai	1993	USA	Medical & Surgery	RBC	4 (2)	Seasonal variation between reporting periods; used intention to treat analysis	RCT	A trained physician educator conducted educational visits to hospitals, lead group presentation and distributed guidelines and other educational material. Intervention was well described.	% of transfusion not compliant with guidelines
Spencer	2005	UK	Surgery	RBC	1	Data collection time periods not clearly reported, data collection periods spanned different seasons and varied in length, data collection methods differed between data collection periods	BA	Audit of practice lead to the development of local guidelines. A new form (with guidelines) was introduced into practice where every transfusion had to be justified. The intervention was not well described.	Transfusion rate
Tobin	2001	Australia	HW	RBC, FFP, Platelets	1	Missing data from baseline group, between hospital data used a comparison for some outcome* (*this data was not included in the review because there was no baseline data)	BA	Intervention had two phases: (1) Transfusion guidelines were used to evaluate transfusions (2) a "gatekeeper" reviewed a subset of transfusion requests and discussed inappropriate orders with prescribers. The intervention was not well described.	% inappropriate
Torella	2002	UK	Surgery	RBC	1	Data collection periods spanned different seasons, patient characteristics not reported. Entire year between control on intervention periods.	BA	The hospital transfusion developed a policy and audited transfusion practice. The intervention was not well described.	% transfused

Tuckfield	1997	Australia	HW	RBC, FFP, Platelets	1	Data collection periods spanned different seasons, data collection methods differed between study groups (new form & retrospective vs. prospective), Patient characteristics not adequately reported, Study presented data also included in Tobin (2001). Study was excluded to remove duplicate data.	BA	Intervention had two phases: (1) Transfusion guidelines were used to evaluate transfusions (2) a "gatekeeper" reviewed a subset of transfusion requests and discussed inappropriate orders with prescribers. The intervention was not well described.	% inappropriate
Vos	1994	Tanzania	HW	RBC	1	Data collection periods spanned different seasons and varied in length, collected data from only 85% of patients, patient selection was not detailed,	BA	Audit of local transfusion practice lead to the development of Guidelines. The guidelines were presented to all prescribers in educational transfusion workshops. The intervention was not well described.	% avoidable
Yeh	2006	Taiwan	HW	RBC, FFP, Platets	1	Data collection periods spanned different seasons; Patient characteristics not reported	BA	Intervention involved education session covering appropriate transfusion and BSCH 2004 guidelines. The audit system would reject FFP requests if they did not conform with guidelines. And results from computerized audit were reviewed weekly by chiefs of staff. The intervention was not well described.	Units per month

ICU – intensive care unit; Hb – Haemoglobin; (Int-Ctl) – intervention minus control) ICU – intensive care unit; Hb – Haemoglobin; (Int-Ctl) – intervention minus control; HW – hospital wide; BCSH – British Committee for Standards in Haematology ; AAMM – American Association of Blood Banks;NIH- National Institute of Health (USA); NR –Not reported; NS – Not Significant; *calculated.

Appendix 3-A: Final version of interview schedule for Orthopaedic interviews.

Semi-Structured Interview Schedule for watching and waiting in Orthopaedic Surgeons (May 28th, 2009)

Introduction: *The general aim of the interview is to enable us to understand how you manage a patient with borderline hemoglobin with regards to transfusion. We want to know what influences you when you are face with the decision to watch and wait. There is no right or wrong answers here; we are trying to understand how different clinicians approach this issue, so please answer frankly.*

Are you ready to get started?

Set the scene re: asking about "managing a patient with borderline Hb by watching & waiting instead of transfusing RBCs" – I'd like you to think about that for a moment...
When I say borderline Hb, I'm thinking about those patients when the decision about transfusing might not be clear (not those you'd definitely transfuse or those you'd def not transfuse), you know, where there's a bit of a grey area...
What would you consider borderline Hb?

I'd like to start with some basic question about your practice:

1. **In general, when you first learn that a patient has borderline Hb, how you manage a that patient?**

(*Prompt: What do you feel you do well? What do you feel you could do better?)*

Thank you.

Now for the rest of the interview, I have some slightly more specific questions about what influences your decision regarding patients with borderline Hb. Some questions may seem repetitive, but please bear with me as the questions are derived from different theories of human behavior and we are trying to figure out which theories best apply in this area.

Nature of the Behavior

1. As an orthopaedic surgeon, how often do you come across patients with a borderline Hb?

Skills

2. What skills are needed to watch and wait?

(Prompt: Easy or difficult?)

Memory, Attention and Decision Processes

3. Is watching and waiting instead of transfusing automatic component of your job?

4 Is this something you would have to think about a lot?
(Prompt Was it an easy or a difficult decision, Weigh pros and cons etc)

5 What thought processes might guide your decision to manage a patient with borderline Hb by watching & waiting?
(Prompt Thrust on thinking, thinking about xyz factors some could be clinical, others relatives' preferences, uncertainty about the evidence, time until the patient is discharged, how ill the patient looks,

6 Do you sometimes forget to manage a patient with borderline Hb by watching and waiting instead of transfusing? When does this happen? (Prompt trick/strategies to remember?)

Social/Professional role & identity

7 Is watching and waiting instead of transfusing part of the professional role of the orthopaedic surgeon?
b Why or why not?
c Is it you who makes the decision to watch and wait?
(Prompt some components are vs aren't)

8 Is there anything in your professional role that influences your decision to watch and wait instead of transfuse RBCs?
(Prompt professional training, a protocol, an order set, other technologies)

9 Do your colleagues generally agree with you on this issue?

Beliefs about Capabilities

10 Are you confident that you are able to watch and wait instead of transfusing RBC in the way you would like to?

11 What problems/barriers prevent you from *watching and waiting instead of transfusing RBCs* in the way you would like?
(Prompt internal or external issues)

12 What would help you overcome these problems/difficulties? (Prompt skills training in medical curriculum, communication techniques, formal training programs, CME, educational material on line or by mail)

Environmental Context & Resources

13 What aspects of your clinical environment (physical vs resource factor) influence whether or not you are able to manage a patient with borderline Hb by *watching and waiting instead of transfusing RBCs*?

(Prompt lack of time, blood shortages, etc)

14 Are there any competing tasks or time constraints that might influence whether or not you manage a patient with borderline Hb by watching and waiting instead of transfusing?

Social Influences

15 Would any other team members influence whether or not you manage patients with borderline Hb by watching & waiting instead of transfusing RBCs
(Prompt who else, Other clinicians, medical staff including nurses and residents/fellows, relatives. CBS, to what extent)

16 How might the views/opinions of others affect you managing a patient with borderline Hb by watching & waiting?

Emotion

17 Does watching and waiting instead of transfusing evoke an emotional response (or worry) in you?

18 Do patient emotions ever affect whether you manage their borderline Hb by watching and waiting instead of transfusing? Explain

19 Do your own emotions (or worry) ever affect your decision to manage a patient with borderline Hb by watching and waiting instead of transfusing? Explain

Beliefs About Consequences

20 In your opinion, if surgeon watches and waits instead of transfusing a patient with borderline Hb is better for the patients?? Why or why not?

21 Do you feel that there are harms or disadvantages associated with managing a patient with borderline Hb by watching and waiting instead of transfusing? What are they?

22 What are the benefits associated with managing a patient with borderline Hb by watching and waiting instead of transfusing?

23 Do you feel that the benefits of managing a patient with borderline Hb by watching and waiting instead of transfusing outweigh the costs? Why or why not?

Motivation and Goals

24 How important is it to manage a patient with borderline Hb by watching and waiting instead of transfusing?
(Prompt is it a priority?)

25 Do you set goals for yourself or your practice wrt managing a patient with borderline Hb by watching and waiting instead of transfusing?
(Prompt goals within yourself? external?)

26 Would there be anything else that you want to do or achieve that might interfere with your practice wrt a patient with borderline Hb by watching and waiting instead of transfusing?

27 Are there any incentives that motivate you to manage a patient with borderline Hb by watching and waiting instead of transfusing?
(Prompt goals within yourself? external?)

Knowledge

28 How clear is the evidence around managing a patient with borderline Hb by watching and waiting instead of transfusing?
b What is your interpretation of the evidence?

29 Do you adhere to any guideline with respect to transfusing RBCs?

30 How do you use it? Why do you (/don't you) use it? What do you think of it?

31 What are your thoughts about transfusion guidelines in general?
(Prompt Professional autonomy?)

Behavioural Regulation

32 When face with a patient with borderline hemoglobin, Is watching and waiting something you would usually do?

33 What would you have do to manage a patient borderline Hb by watching and waiting instead of transfuse RBCs?

34 If you wanted to implement changes in your own practice (individual/team setting/practice setting) to encourage watching and waiting instead of transfusion, what would be some ways to do this?
(Prompt Role of Protocol or guidelines, How to encourage W&W in others i e residents)

That's all the questions I have for you has anything occurred to you about this topic that we haven t asked about?

Thank you!

Now I have a few demographic questions for you:

1. **What type of setting do you practice in? (community vs. academic.)**
2. **How many of years in practice do you have?**
3. **What year were you born in?**

Finally, Recommend other surgeons? With different views? Different practice setting?

Finally, Would you prefer to receive the cheque payable to your institution c/o yourself or to give us your SIN# and home address to have made payable to you?

Appendix 3-B: Study Information letter consent form

The Ottawa Hospital | L'Hôpital d'Ottawa

Implementation Research in Transfusion Medicine: Improving Red Blood Cell Transfusion Practice

Purpose of Study

Red blood cell transfusions are a commonly used medical therapy. However, we know there is wide variation in the practice of red blood cell transfusions and a significant percentage of transfusions are inappropriate. The purpose of this study is to determine the knowledge and beliefs that affect physicians' decisions to transfuse red blood cells. This information will be used to develop interventions to change red blood cell transfusion practice. Eventually these interventions will be tested in randomized controlled trials.

Study Procedures

You are being asked to take part in this study because you are either a critical care physician or an orthopoedic surgeon in Canada. We are focusing on these 2 physician groups in this study.

If you choose to participate, we will conduct an interview (in person or by phone) to explore your knowledge and beliefs regarding blood transfusions. The interview will take approximately 30 minutes to complete.

Possible Risks

There are no anticipated risks for your participation in this study. You do not have to answer any questions that make you uncomfortable.

Benefits of the Study

This study may help to better understand red blood cell transfusion practice. In the future, this may help your patients and other patients receive better care.

Withdrawal from the Study

You may withdraw from this study at any time. You may also, upon request, have the information you have provided removed from the study at any time.

Confidentiality

The interviews will be recorded and then transcribed. Digital recordings of the transcripts will be kept on password protected computers. The transcribed recordings will be kept on password protected computers and/or in locked research offices at all times. The transcripts will be coded with a unique identification number and no personal identifiers will be included in the transcripts. At the end of the study, the digital recorded interviews will be deleted. The transcripts will be kept for 15

years as per hospital policy at which time all paper documents will be shredded and electronic files will be deleted.

All results of this study will be kept confidential. You will not be identifiable in any publications or presentations resulting from this study. Any information that leaves the research office will be coded with a unique identification number and you will not be identifiable by name. No records with identifiable information will leave the Ottawa Hospital. The Ottawa Hospital Research Ethics Board and Canadian Blood Services may review your relevant study records for audit purposes.

Costs

You will be paid $100.00 for the interview, to compensate you for your time.

Questions about this Study

If you have any questions about this study, you may contact Jennifer Eyvindson, the research assistant or Dr. Alan Tinmouth

This protocol has been approved by The Ottawa Hospital Research Ethics Board. The Board considers all ethical aspects of hospital research projects with human participants. If you have any questions concerning your rights as a research participant, you may contact the Chairperson of The Ottawa Hospital Research Ethics Board

Consent

I have read this 2-page information and consent form, and have had the opportunity to ask any questions about the study. I am under no obligation to participate in this study.

My questions and/or concerns have been answered to my satisfaction and I agree to participate in this study. If I decide at any point that I would like to withdraw my consent, I may do so at any time.

Signatures

Physician

Name: _____ Signature: _____ Date: _____

Investigator/Delegate

Name: _____ Signature: _____ Date: _____

Appendix 3-C: Domain Coding Decision Rules

Guide to interview analysis: (Domain Number): 1. knowledge; 2. skills; 3 social/professional role and identity; 4. beliefs about capabilities; 5. beliefs about consequences; 6 motivation and goals; 7. memory, attention and decision processes; 8. environmental context and resource; 9. social influences; 10. emotion; 11. behaviour regulation; and 12. nature of the behaviours

1. The behaviour of interests

a. Specifically about the behaviour

i. *Doing the behaviour*

1. Do they usually do the behaviour? (7)
2. How do they do the behaviour? (12)
3. How often do they do the behaviour? (12)

ii. Evidence supporting/opposing behaviour

1. Studies and trials (1)
2. Guidelines
   a. What the guidelines say (1)
   b. Purpose of guidelines (3)
   c. Importance of guidelines (1,3)
   d. Credibility of guidelines (3)
   e. Do they follow guidelines (3)
   f. Should guidelines determine behaviour (3)
   g. Do Guideline conflict
      i. with themselves
         1. self standards (3)
         2. limits to autonomy (3)
      ii. outside themselves
         1. with other goals (6)
         2. with other guidelines (6)
         3. with other professional groups
            a. Specific named groups (3)
            b. Other groups individuals (9)
3. Protocols
   a. Anything about protocols (1)
4. Relationship between guidelines and evidence
   a. Guidelines and evidence (1)
   b. Credibility of guidelines (3)
   c. Purpose of guidelines (3)
   d. The guideline do not apply to everyone (1)

iii. *What is needed to do the behaviour?*

1. Skills
a. What skills are needed (2)
b. How difficult are the skills (2)

2. Changes to the system → see 1.c Ways to improve

b. Result of the behaviour
   i. *Benefits of the behaviour to*
      1. Patient (5)
      2. System (5)
      3. Physician
         a. rewards/incentive (5 or 6)
         b. Work load (5)
         c. Stress (10)
         d. Emotions (10)
   ii. *Consequences of the behaviour to*
      1. Patient (5)
      2. System (5)
      3. Physician
         a. Work load (5)
         b. Stress (10)
         c. Emotions (10)
   iii. *Weight costs and benefits of the behaviour*
      1. Do the costs outweigh the benefits? (5)

c. Ways to improve
   1. Any changes to the system? (4, 11, 12)
   2. Strategies to change behaviour (11)
2. **Internal Issues (with in themselves),**
   a. Actions
      i. Presently
         1. What do they do [wrt the behaviour] (12)
         2. Motivation
            a. Are they motivated (6)
            b. What motivates them
               i. External rewards and incentive (5,6)
               ii. Other internal motivation (6)
      ii. Future
         1. What could be done better (4, 11, 12)
         2. How would they, themselves, do it (1)

   b. Thoughts/feelings
      i. Presently
         1. What do they think about
            a. Do they usually do the behaviour (7)
            b. How they decide whether (to do behaviour)
               i. Cognitive resource
                  1.How much do they think about it? (7)
                  2.Decision making formulas (7)
                  3.Combination of factors that lead to decisions (7)
                  4.Single factors that will decide behaviour (7)

ii. Motivation
1.How much motivation to do it (6)
2.Are there incentives/rewards (5, 6)
3.Are there conflicting goals (6)
iii. Reasons not to do the behaviour
1.Limitation of guideline/evidence (1)
2.Clinical factors →go to 3.c
3.Other people (Human factors) →go to 3.a
4.Environmental (Non-human factors) →go to 3.b

c. Capabilities and Abilities
i. Self Efficacy
1.How confident are they to so the behaviour (4)
2.How easy is it to do the behaviour (4)
3.Do they have control over the behaviour (4)
ii. Skills
1.What skills are needed (2)
2.How difficult are the skills (2)
iii. Capabilities of others
1.How do other influence control of the behaviour
a.Social → go to 3.b. Human factors

d. Benefits or consequences of the behaviour → go to 1.b. Result of the behaviour

ii. Future

1. What could be done better (4, 11, 12)
2. How would they, themselves, do it (11)

3. External Issues (Resources)

a. Non Human factors

i. Physical Resources

1. Present resources and issues
   a. Physical, material resources (8)
   b. Time constraints and competing tasks (8)
   c. Role of physical resources on control of the behaviour (4)
2. Future resources →go to 1.c. Ways to improve

b. Human factors

i. Staffing Resources

1. Existing resources
   a. Staffing Issues (8)
   b. Social issues (9)
   c. Role of staffing issues on control of the behaviour (4)
2. Future resources →go to 1.c. Ways to improve

ii. Social issues

1. Social influences

a. Role models (9)
b. Influence of personal professional standards (3)
c. Opinions or actions of identified groups (3)
d. Other social issues that affect behaviour (9)

2. Role of social issues on control of the behaviour (4)

c. Clinical Factors
   i. Clinical Factors that may influence the decision (7)
   ii. Single factors that will decide behaviour (7)
   iii. Decision making formulas or combination of factors that lead to decisions (7)
   iv. Gaps in evidence or knowledge about clinical factors (1)
   v. Clinical factors make each patient unique (3)

d. Internal issues → go to **2. Internal Issues (Themselves)**

Appendix 3-D: Brief Description of Behavioural Theories

In this project we identified behavioural theories that were relevant to our target behaviour. Behavioural theories can be separated into two categories: motivational theories and action theories.

Motivational Theories:

Motivational theories support the belief that motivation (or intention) determines behaviour, therefore motivational theories are pre-intentional. In this project motivational theories included: Operant Conditioning (OC), Social Cognitive Theory (SCT), Knowledge-Attitude-Behaviour (KAB) and Theory of Planned Behaviour (TPB). For these motivational theories the best predictors of behaviour are expected to be those items that best predict intention.

Operant Conditioning (OC)

Skinner's theory of operant conditioning (1953) is the oldest theory included in this project. Operant conditioning suggests that consequences (reinforcement and punishment) predict behaviour: positive consequences reinforce the behaviour until it becomes habitual. The model includes two main constructs: Anticipated consequences and Habit

Social Cognitive Theory (SCT)

Social Cognitive Theory (SCT) was proposed by Bandura (1988). The theory proposes that behaviour is determined by incentives, the theory emphasizes that behaviour can be predicted through anticipated outcomes and Self Efficacy constructs.

Knowledge-Attitude-Behaviour (KAB)

The Knowledge-Attitude-Behaviour model was proposed by Bettinghaus (1986). The model explains behaviour through the idea that knowledge and attitude will predict the behaviour. The model included two main constructs: Knowledge and Attitude.

Theory of Planned Behaviour (TPB)

Theory of Planned Behaviour (TPB) was proposed by Ajzen (1991). This theory contains four construct which influence behaviour. Subjective norms, Perceived behavioural control, Attitude and Intention affect behaviour. Subjective norms, Perceived Behavioural

Control, Attitude effect behaviour through Intention, while Perceived Behavioural Control can also affect behaviour directly.

Action Theories:

Action theories support the belief that other factors (in addition to intention) predict behaviour. And can be pre or post intentional. Action theories in this project include Operant Conditioning (OC), Implementation Intentions (II) and Personnal Project Annalysis (PPA). Post-intentional theories (theories that explain behaviour with constructs that act on behaviour after intention) are not expected to predict intention as well as pre-intentional theories [59].

Operant Conditioning (OC)

Skinner's theory of operant conditioning (1953) is the oldest theory included in this project. Operant conditioning suggests that consequences (reinforcement and punishment) predict behaviour: positive consequences reinforce the behaviour until it becomes habitual. The model includes two main constructs: Anticipated Consequences and Habit

Implementation Intentions (II)

Implementation intension was proposed by Gollwitzer & Brandstatter (1997). This framework proposes that, in addition to intention, having a plan (when, where and how) will predict behavioural outcomes. This framework contain only one main construct that acts after intention: Action Planning.

Personal Project Analysis (PPA)

Personal Project Analysis was proposed by Presseau, Sniehotta & Little (2008). This framework is the newest theory included in this project. The PPA framework proposes that behavioural outcomes can be predicted through goal hierarchy (is behaviour in conflict or does it facilitate other goals?). It contains one main construct that acts after intention: Goal Priority.

Appendix 4-A: Survey package and mailing material including information letters, postcard reminder theory based questionnaire.

Ottawa Hospital Research Institute
OHRI IRHO
Institut de recherche de l'Hôpital d'Ottawa

January 4, 2010

Dear Dr.:

In the next few days, you we will be receiving a survey to evaluate the factors that influence surgeons' **management of orthopaedic patients with borderline hemoglobin levels**. This is an academic study based out of the University of Ottawa Centre for Transfusion research. You are likely aware of the significant amount of research evaluating red cell transfusion in the critical care done by our group in conjunction with the critical care community in Canada (e.g. the TRICC trial). This study is an extension of this important research into the area of **Knowledge Translation**.

The aim of our research is to find out which psychological concepts can best help us understand oethopsedic surgeons' behaviours with regard to managing patients with borderline hemoglobin levels. The ultimate goal of our project is to design an intervention to promote the evidence based practice of restrictive transfusion practice. This survey is the initial step and will be sent broadly to 400 academic and community surgeons who work in orthopaedics.

Addressing the issue of inappropriate red cell transfusions is of great importance for patient care. By reducing inappropriate red cell transfusions, we save a valuable and limited resource provided by volunteer blood donors, and reduce potentially serious adverse transfusion reactions.

This study is funded by the Canadian Blood Services and is being administered by the University of Ottawa Centre for Transfusion Research, Ottawa Hospital Research Institute, and the Ottawa Hospital. This study has been approved by the Ottawa Hospital Research Ethics Board (#2007434-01H).

We thank you in advance for your participation and support of this research project.

Sincerely,

Dr. Alan Tinmouth, MD, MSc
Principal Investigator
Scientist, Ottawa Health Research Institute
Assistant Professor, University of Ottawa

Co-Investigators
Dr. Geoff Dervin, MD, MSc
Dr. Paul Hebert, MD, MSc
Dr. Jeremy Grimshaw, MD, PhD
Dr. Lauralyn McIntyre, MD, MSc
Dr. Alexis Turgeon MD, MSc
Dr. Ryan Zarachanski, MD
Dr. Dean Fergusson, PhD
Dr. Jamie Brehaut, PhD
Dr. Jill Francis, PhD

Ottawa Hospital Research Institute
OHRI IRHO
Institut de recherche de l'Hopital d'Ottawa

January 13 2010

Re: Survey of Canadian orthopaedic surgeons – RBC transfusion practice

Dear Dr

A few days ago we sent a letter **requesting your participation in our survey** to determine the factors that influence the **management of patients with borderline hemoglobin.** The survey is enclosed It should take approximately **20 minutes** of your time Upon completion of the survey we will send you **a $20 Gift Card as a token of our appreciation.** We would be grateful if you would complete the survey and **return it using the self-addressed, pre-stamped envelope** provided, or by **faxing it**

The aim of our survey is to determine which psychological concepts best help us to understand the management of patients with borderline hemoglobin levels By reducing inappropriate red cell transfusions we save a valuable resource and reduce serious adverse transfusion reactions The ultimate goal of our project is to design an intervention to promote the evidence based restrictive transfusion practice

This is an academic study funded by the Canadian Blood Services and being administered by the University of Ottawa Centre for Transfusion Research, Ottawa Hospital Research Institute, and the Ottawa Hospital

Please note that you are under no obligation to participate, and can decline to answer any questions Your responses will remain anonymous, but we have written an identifying number on your questionnaire for our record keeping - this will allow us to identify your returned questionnaire and ensure that no follow up reminders will be sent to you Should you decide not to complete the questionnaire, please return it to us so that we may remove your name from our list and ensure that no further correspondence will be sent Results from this study will only be reported in aggregate, identifying no individuals If you have any questions about the study, please call Dr Alan Tinmouth or email him at Unfortunately the survey is only available in English as we were not able to validate the questions and responses for a translated survey

Thank you again for participating in this study

Dr. Alan Tinmouth MD MSc
Principal Investigator
Scientist, Ottawa Health Research Institute
Assistant Professor, University of Ottawa

Co-Investigators
Dr Geoff Dervin MD
Dr. Paul Hebert MD
Dr. Dean Fergusson PhD
Dr Jamie Brehaut PhD
Dr. Jill Francis PhD
Dr. Jeremy Grimshaw MD PhD
Dr. Lauralyn McIntyre MD
Dr. Alexis Turgeon MD
Dr. Ryan Zarychanski, MD

P S *We would greatly appreciate your time in completing our survey However if you do not wish to complete it and would prefer not to receive any more reminders about it please tick the most appropriate box below and return this letter to us*

- ☐ *I am too busy to respond to surveys*
- ☐ *I have no interest in this particular topic*
- ☐ *I do not feel qualified to answer the questions in this survey*
- ☐ *Other Please specify* _____

This project has been approved by the Ottawa Hospital Research Ethics Board, protocol #2007434-01H

Ottawa Hospital Research Institute
OHRI IRHO
Institut de recherche de l'Hopital d'Ottawa

February 19, 2010

Re: Survey of Canadian orthopaedic surgeons – RBC transfusion practice

Dear Dr.:

This is a follow-up letter **requesting your participation in our survey** to determine the factors that influence the **management of patients with borderline hemoglobin.** The survey is enclosed. It should take approximately **20 minutes** of your time Upon completion of the survey we will send you **a $20 Gift Card as a token of our appreciation.** We would be grateful if you would complete the survey and **return it using the self-addressed, pre-stamped envelope** provided, or by **faxing it**

The aim of our survey is to determine which psychological concepts best help us to understand the management of patients with borderline hemoglobin levels By reducing inappropriate red cell transfusions, we save a valuable resource and reduce serious adverse transfusion reactions The ultimate goal of our project is to design an intervention to promote the evidence based restrictive transfusion practice

This is an academic study funded by the Canadian Blood Services and being administered by the University of Ottawa Centre for Transfusion Research, Ottawa Hospital Research Institute, and the Ottawa Hospital.

Please note that you are under no obligation to participate, and can decline to answer any questions. Your responses will remain anonymous, but we have written an identifying number on your questionnaire for our record keeping - this will allow us to identify your returned questionnaire and ensure that no follow up reminders will be sent to you. Should you decide not to complete the questionnaire, please return it to us so that we may remove your name from our list and ensure that no further correspondence will be sent. Results from this study will only be reported in aggregate, identifying no individuals. If you have any questions about the study, please call Dr. Alan Tinmouth or email him Unfortunately, the survey is only available in English as we were not able to validate the questions and responses for a translated survey

Thank you again for participating in this study.

Dr. Alan Tinmouth MD MSc
Principal Investigator
Scientist, Ottawa Health Research Institute
Assistant Professor, University of Ottawa

Co-Investigators
Dr Geoff Dervin MD
Dr. Paul Hebert MD
Dr. Dean Fergusson PhD
Dr Jamie Brehaut PhD
Dr. Jill Francis PhD
Dr. Jeremy Grimshaw MD PhD
Dr. Lauralyn McIntyre MD
Dr. Alexis Turgeon MD
Dr. Ryan Zarachanski, MD

P.S *We would greatly appreciate your time in completing our survey However, if you do not wish to complete it and would prefer not to receive any more reminders about it, please tick the most appropriate box below and return this letter to us*

- _ *I am too busy to respond to surveys*
- ☐ *I have no interest in this particular topic.*
- ☐ *I do not feel qualified to answer the questions in this survey*
- ☐ *Other Please specify* _____

This project has been approved by the Ottawa Hospital Research Ethics Board, protocol #2007434-01H

A REMINDER

Dear Colleague:

You have been asked to participate in a study of Canadian orthopaedic surgeons' views on ***management of patients with borderline hemoglobin***. Your name was selected as one of 400 orthopaedic surgeons in Canada to participate in the study. The aim of our research is to find out if psychological concepts of behaviour can help us understand orthopaedic surgeons' behaviours regarding management of patients with borderline hemoglobin. The final results will be used to design an intervention to promote evidence based restrictive transfusion practice. We mailed you a copy of the survey approximately two weeks ago. Upon completion of the survey we will send you a $20 gift card of as a token of our appreciation.

We would very much appreciate your input to our work. If you have any questions or concerns, please do not hesitate to contact me via email

Sincerely,

for: Dr. Alan Tinmouth (MD, MSc)
Dr. Geoff Dervin (MD, MSc)

Confidential

OHRI IRHO

Surgeons' use of red blood cells in Orthopaedics

The purpose of this questionnaire is to provide a better understanding of postoperative transfusion practice in orthopaedic surgery.

We would like you to think about how you might...

manage in-patients with borderline haemoglobin
by *watching and waiting instead of transfusing red cells.*

When we say borderline haemoglobin, we are thinking about those in-patients where the decision about transfusing might need more thought. There will be in-patients you would definitely transfuse; in-patients you would definitely not transfuse; and in-patients where there is a grey area, where the decision about transfusing is less clear cut. **That is what we mean by borderline haemoglobin.**

All of the questionnaire items will refer to hypothetical in-patients with borderline haemoglobin. We will ask you later what you consider to be borderline haemoglobin.

Most questions are answered by circling one number; a few require more time to answer.
Some questions may seem to be very similar but they are different and it is important to answer them all.
Please try not to take too long over each response as we would like to know your immediate thoughts and experiences.
Your answers are completely confidential.

At first glance this questionnaire might seem long, however, our pilot testing with orthopaedic surgeons suggests that, once you start it, you would be able to work through it quite quickly. We think it will take 15-20 minutes to complete

Part 1: Factors influencing the management of borderline haemoglobin

	Strongly disagree						Strongly agree
1. In general managing an in-patient with borderline haemoglobin by *watching and waiting instead of transfusing red cells* would:							
a) Decrease the patient's length of stay in hospital	1	2	3	4	5	6	7
b) Improve the patient's clinical condition	1	2	3	4	5	6	7
c) Save resources (e g., cost, blood, etc)	1	2	3	4	5	6	7
d) Reduce the risk of the patient contracting a transfusion related infection	1	2	3	4	5	6	7

	Unimportant						Important
2. In general how important do you consider these outcomes to be?							
a) Decreasing the patient's length of stay in hospital	1	2	3	4	5	6	7
b) Improving the patient's clinical condition	1	2	3	4	5	6	7
c) Saving resources (e g , cost, blood, etc)	1	2	3	4	5	6	7
d) Reducing the risk of the patient contracting a transfusion related infection	1	2	3	4	5	6	7

	Strongly disagree						Strongly agree
3. If I routinely manage in-patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells* then:							
a) On balance, my life as an orthpaedic surgeon will be easier in the long run	1	2	3	4	5	6	7
b) On balance, the consequences for me as an orthpaedic surgeon (e g stress, time etc) will be worse in the long run	1	2	3	4	5	6	7
4. If I manage in-patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells*, it is likely that they will be worse off	1	2	3	4	5	6	7
5. I feel under pressure to manage in-patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells*, due to pressure from:							
a) Patients	1	2	3	4	5	6	7
b) Guidelines and protocols	1	2	3	4	5	6	7
c) Published literature	1	2	3	4	5	6	7
d) Physicians from other specialties	1	2	3	4	5	6	7
e) Physiotherapists and rehabilitation staff	1	2	3	4	5	6	7
f) Colleagues within orthopaedics	1	2	3	4	5	6	7

	Strongly disagree						Strongly agree
6. When I first discover an in-patient has borderline haemoglobin, I have in mind to manage them by *watching and waiting instead of transfusing red cells*	1	2	3	4	5	6	7
7. I intend to manage in-patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells*	1	2	3	4	5	6	7
8. Whether I manage in-patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells* is entirely up to me	1	2	3	4	5	6	7
9. I am confident that I can manage in-patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells* whenever I want to	1	2	3	4	5	6	7
10. I can overcome all obstacles, whatever they may be, in managing an in-patient with borderline haemoglobin by *watching and waiting instead of transfusing red cells*	1	2	3	4	5	6	7

11. When you first discover an in-patient has borderline haemoglobin, out of 10 in-patients in this category, how many would you intend to manage by *watching and waiting instead of transfusing red cells?*

0 1 2 3 4 5 6 7 8 9 10

	Not at all confident						Extremely confident
12. In general how confident are you in your ability to manage an in-patient with borderline haemoglobin by *watching and waiting instead of transfusing red cells?*	1	2	3	4	5	6	7

	Strongly disagree						Strongly agree
13. Considering all the other goals of care in orthopaedic surgery patients, managing an in-patient with borderline hemoglobin by *watching and waiting instead of transfusing red blood cells* is:							
a) Important	1	2	3	4	5	6	7
b) A high priority	1	2	3	4	5	6	7
c) In conflict with other goals	1	2	3	4	5	6	7

	Strongly disagree						Strongly agree
14. When I see in-patients with borderline haemoglobin, I automatically consider managing them by *watching and waiting instead of transfusing red cells* if their haemoglobin is:							
a) Rapidly declining (e g fallen 20g/L over 15 hours)	1	2	3	4	5	6	7
b) Slowly drifting down (e g fallen 20g/L over 4 days)	1	2	3	4	5	6	7
c) Stable	1	2	3	4	5	6	7
15. Before deciding to manage an in-patient with borderline haemoglobin *by watching and waiting instead of transfusing red cells* I take into account the opinions of:							
a) Patients	1	2	3	4	5	6	7
b) Guidelines and protocols	1	2	3	4	5	6	7
c) Published literature	1	2	3	4	5	6	7
d) Physicians from other specialties	1	2	3	4	5	6	7
e) Physiotherapists and rehabilitation staff	1	2	3	4	5	6	7
f) Colleagues within orthopaedics	1	2	3	4	5	6	7
16. In general:							
a) The benefits of managing in-patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells* outweigh the harms	1	2	3	4	5	6	7
b) Managing in-patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells* is more often the right thing to do than the wrong thing to do	1	2	3	4	5	6	7
c) When I manage in patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells* I feel pleased with my decision	1	2	3	4	5	6	7
17. I have a clear plan of:							
a) **How** I will manage in-patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells*	1	2	3	4	5	6	7
b) **When** I will manage in-patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells*	1	2	3	4	5	6	7
c) **Under what circumstances** I will manage in-patients with borderline haemoglobin by *watching and waiting instead of transfusing red cells*	1	2	3	4	5	6	7

18. If you have a plan, could you please describe it

	Strongly disagree						Strongly agree
19. I am confident that I can manage an in-patient with borderline haemoglobin by *watching and waiting instead of transfusing red cells*							
a) Even if residents are involved	1	2	3	4	5	6	7
b) When the patient's clinical condition deteriorates	1	2	3	4	5	6	7
c) When the patient is having difficulty rehabilitating	1	2	3	4	5	6	7
20. I would be more likely to manage an in-patient with borderline haemoglobin by *watching and waiting instead of transfusing red cells* if the patient:							
a) Has a history of cardiac problems	1	2	3	4	5	6	7
b) Is due to be discharged from the orthopaedic service	1	2	3	4	5	6	7
c) Is over 75 years of age	1	2	3	4	5	6	7
d) Has stable haemoglobin levels	1	2	3	4	5	6	7
e) Is adequately monitored by staff	1	2	3	4	5	6	7
f) Is having difficulty mobilizing	1	2	3	4	5	6	7
g) Is anticipated to lose blood	1	2	3	4	5	6	7
21. I would be more likely to manage an in-patient with borderline haemoglobin by *transfusing red cells* if the patient:							
a) Has a history of cardiac problems	1	2	3	4	5	6	7
b) Is due to be discharged from the orthopaedic service	1	2	3	4	5	6	7
c) Is over 75 years of age	1	2	3	4	5	6	7
d) Has stable haemoglobin levels	1	2	3	4	5	6	7
e) Is adequately monitored by staff	1	2	3	4	5	6	7
f) Is having difficulty mobilizing	1	2	3	4	5	6	7
g) Is anticipated to lose blood	1	2	3	4	5	6	7

Part 2 – Transfusion Factors in Orthopaedics Surgery Patients

1. **There are different opinions about what constitutes borderline haemoglobin. In your opinion, what constitutes borderline haemoglobin?**

2. **What are the 3 most frequent risks related to transfusion from the following list?**

Please tick the three most frequent:

a) ABO incompatible transfusions ☐

b) Errors in the process/administration of blood ☐

c) Transfusion associated acute lung injury ☐

d) Acute transfusion reactions (e.g. anaphylaxis) ☐

e) Transfusion transmitted viral infection ☐

f) Creutzfeldt-Jakob disease (variant or classical) ☐

g) Transfusion associated graft versus host disease ☐

3. **Out of the above list of adverse events, which is the most likely to cause mortality in Orthopaedics?**

Please circle the one that applies: a b c d e f g

4. **What is the average cost of a unit of red cells in Canada?**

Please tick the one that applies

a) $ 150 ☐

b) $ 300 ☐

c) $ 450 ☐

d) $ 600 ☐

e) $ 750 ☐

Part 3 - How would you manage this patient? **(Please tick only one option per patient)**

Scenario One

You have four patients on the ward who are post op day 1 following a right total hip arthroplasty for a fractured hip. All four surgeries were uncomplicated. The four patients have normal liver and renal function. Blood pressures and heart rates are within normal range with no postural changes for all patients. They are all receiving prophylactic low molecular weight heparin (LMWH) for DVT (deep vein thrombosis).

1.1 Mr. Jones is your first patient, a previously fit and well 75 year old male. Given the hematology results below, if this was your patient, how many units of red cells would you transfuse? (Please tick only one option)

	Pre-op	**Today** Post op Day 1
Haemoglobin (g/L)	140	98
INR	1.0	1.0
Platelets ($x10^9$/L)	351	235

None (Watch and wait)
1 unit of red cells
2 units of red cells
3 units of red cells
Other (please specify)
_____

1.2 Mr. Hamel is your second patient, a previously fit and well 75 year old male. Given the hematology results below, if this was your patient, how many units of red cells would you transfuse? (Please tick only one option)

	Pre op	**Today** Post op Day 1
Haemoglobin (g/L)	133	77
INR	1.0	1.0
Platelets ($x10^9$/L)	345	242

None (Watch and wait)
1 unit of red cells
2 units of red cells
3 units of red cells
Other (please specify)
_____

1.3 Mr LeBlanc is your third patient, a previously fit and well 75 year old male. Given the hematology results below, if this was your patient, how many units of red cells would you transfuse? (Please tick only one option)

	Pre op	**Today** Post op Day 1
Haemoglobin (g/L)	138	86
INR	1.0	1.0
Platelets ($x10^9$/L)	339	199

None (Watch and wait)
1 unit of red cells
2 units of red cells
3 units of red cells
Other (please specify)
_____

1.4 Mr. Green is your fourth patient, a previously fit and well 75 year old male. Given the hematology results below, if this was your patient, how many units of red cells would you transfuse? (Please tick only one option)

	Pre-op	**Today** Post-op Day 1
Haemoglobin (g/L)	131	69
INR	1.0	1.0
Platelets ($x10^9$/L)	341	199

None (Watch and wait)
1 unit of red cells
2 units of red cells
3 units of red cells
Other (please specify)
_____

Scenario Two

A physiotherapist brings four patients to your attention. The four patients are post-op day 4 after undergoing elective right hip replacement surgery for osteoarthritis. There was no evidence of perioperative bleeding and all four surgeries were uncomplicated. All the patients have normal liver and renal function and none of them have cardiovascular symptoms (e.g. palpitations, chest pain,dizziness) at rest or during physiotherapy. They are all receiving prophylactic low-molecular-weight heparin (LMWH) for DVT.

2.1 Mr. Bing (68 years old) is your first patient. He is having difficulty participating in rehabilitation. His blood pressure is 130/80 mmHg, heart rate is regular at 80 bpm. There is no evidence of myocardial ischaemia on the ECG. Given the hematology results below, if this was your patient, how many units of red cells would you transfuse? (Please tick only one option)

	Pre-op	Day 1 Post-op	Day 2 Post-op	Day 3 Post-op	**Today** (day 4)
Haemoglobin (g/L)	130	80	81	80	78
INR	1.0	1.0	1.0	1.0	1.0
Platelets ($x10^9$/L)	358	260	211	178	115

None (Watch and wait)
1 unit of red cells
2 units of red cells
3 units of red cells
Other (please specify) _____

2.2 Your second patient is Mr. Peters (67 years old). He is having difficulty participating in rehabilitation. His blood pressure is 135/80 mmHg, heart rate is regular at 82 bpm. There is no evidence of myocardial ischaemia on the ECG. Given the hematology results below, if this was your patient, how many units of red cells would you transfuse? (Please tick only one option)

	Pre-op	Day 1 Post-op	Day 2 Post-op	Day 3 Post-op	**Today** (day 4)
Haemoglobin (g/L)	132	75	69	69	69
INR	1.0	1.0	1.0	1.0	1.0
Platelets ($x10^9$/L)	366	260	211	178	115

None (Watch and wait)
1 unit of red cells
2 units of red cells
3 units of red cells
Other (please specify) _____

2.3 Your third patient is Mr. Lee (69 years old). He is having difficulty participating in rehabilitation. His blood pressure is 120/78 mmHg, heart rate is regular at 79 bpm. There is no evidence of myocardial ischaemia on the ECG. Given the hematology results below, if this was your patient, how many units of red cells would you transfuse? (Please tick only one option)

	Pre op	Day 1 Post op	Day 2 Post op	Day 3 Post-op	**Today** (day 4)
Haemoglobin (g/L)	129	84	84	88	87
INR	1.0	1.0	1.0	1.0	1.0
Platelets ($x10^9$/L)	365	250	204	186	107

None (Watch and wait)
1 unit of red cells
2 units of red cells
3 units of red cells
Other (please specify) _____

2.4 Your forth patient is Mr. Julian (68 years old). He is having difficulty participating in rehabilitation. His blood pressure is 130/80 mmHg, heart rate is regular at 85 bpm. There is no evidence of myocardial ischaemia on the ECG. Given the hematology results below, if this was your patient, how many units of red cells would you transfuse? (Please tick only one option)

	Pre-op	Day 1 Post-op	Day 2 Post-op	Day 3 Post-op	**Today** (day 4)
Haemoglobin (g/L)	135	97	98	98	97
INR	1.0	1.0	1.0	1.0	1.0
Platelets ($x10^9$/L)	360	249	206	190	102

None (Watch and wait)
1 unit of red cells
2 units of red cells
3 units of red cells
Other (please specify) _____

Scenario Three

You have four patients on the ward who are post-op day 1 that have all undergone elective right hip replacement surgery for osteoarthritis. All four surgeries were uncomplicated. There was no evidence of perioperative bleeding and the patients have normal renal and liver function. All four patients are receiving prophylactic low-molecular-weight heparin (LMWH) for DVT.

3.1 Mr. Souza (75 years old) is your first patient. He has had one previous myocardial infarction and occasional angina. It is day 1 and the patient's condition is stable with no cardiovascular symptoms (e.g. palpitations, chest pain, dizziness) at rest or during physiotherapy. Given the hematology results below, if this was your patient, how many units of red cells would you transfuse? (Please tick only one option)

	Pre-op	**Today** Post op (day 1)
Haemoglobin (g/l)	135	97
INR	1.0	1.0
Platelets (x10^9/L)	355	235

None (Watch and wait)
1 unit of red cells
2 units of red cells
3 units of red cells
Other (please specify)
_____

3.2 Your second patient is Mr. Henrie (74 years old). He has had one previous myocardial infarction and occasional angina. It is day 1 and the patient's condition is stable with no cardiovascular symptoms. Given the hematology results below, if this was your patient, how many units of red cells would you transfuse? (Please tick only one option)

	Pre-op	**Today** Post-op (day 1)
Haemoglobin (g/L)	138	88
INR	1.0	1.0
Platelets (x10^9/l)	350	235

Watch and wait
Transfuse 1 unit
Transfuse 2 units
Transfuse 3 units
Other (please specify)
_____

3.3 Your third patient is Mr. Victor (76 years old). He has had one previous myocardial infarction and occasional angina. It is day 1 and the patient's condition is stable with no cardiovascular symptoms. Given the hematology results below, if this was your patient, how many units of red cells would you transfuse? (Please tick only one option)

	Pre-op	**Today** Post op (Day 1)
Haemoglobin (g/L)	130	74
INR	1.0	1.0
Platelets (x10^9/L)	349	250

None (Watch and wait)
1 unit of red cells
2 units of red cells
3 units of red cells
Other (please specify)
_____

3.4 Your fourth patient is Mr. Serg (73 years old). He has had one previous myocardial infarction and occasional angina. It is day 1 and the patient's condition is stable with no cardiovascular symptoms. Given the hematology results below, if this was your patient, how many units of red cells would you transfuse? (Please tick only one option)

	Pre-op	**Today** Day 1 Post op
Haemoglobin (g/L)	138	69
INR	1.0	1.0
Platelets (x10^9/L)	341	199

None (Watch and wait)
1 unit of red cells
2 units of red cells
3 units of red cells
Other (please specify)
_____