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DEFINING, EVALUATING, AND IMPROVING THE PROCESS OF VERIFYING PATIENT IDENTIFIERS

A Dissertation Presented

by

JUNGHEE JO

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

September 2014

School of Computer Science

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DEFINING, EVALUATING, AND IMPROVING THE PROCESS OF VERIFYING PATIENT IDENTIFIERS

A Dissertation Presented

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ABSTRACT

DEFINING, EVALUATING, AND IMPROVING THE PROCESS OF VERIFYING PATIENT IDENTIFIERS

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Patient identification errors are a major cause of medication errors. During medication administration, failure to identify patients correctly can lead to patients receiving incorrect medications, perhaps resulting in adverse drug events and even death. Most medication error studies to date have focused on reporting patient misidentification statistics from case studies, on classifying types of patient identification errors, or on evaluating the impact of technology on the patient identification process, but few have proposed specific strategies or guidelines to decrease patient identification errors. This thesis aims to improve the verification of patient identifiers (VPI) process by making three key contributions to the patient identification literature.

First, to better understand the VPI process, we extended and formalized the requirements for VPI based on the Joint Commission's national patient safety guidelines. We showed the implications of these extended guidelines by applying them to artifacts typically used during medication administration (e.g., patient's statements about their identity, patient's identification band, medication label, and medication order). We found that nurses must choose from a considerable number of alternatives to comply with the extended guidelines. The alternatives vary depending on whether an artifact can be trusted prior to the start of the VPI process (from 16 to 8 for manual medication administration; from 8 to 1 for barcode medication administration), or what kind of information is encoded on the barcodes if the process involves barcode verification technology (from 3 to 1 when the ID band is initially considered a trusted artifact; from 8 to 3 when the ID band is not initially considered a trusted artifact).

Second, we evaluated whether nurses complied with the extended VPI guidelines when administering medications, using data from clinical simulations. Nurses' compliance with the extended guidelines was low under most conditions (2% - 5% for manual medication administration; 12% - 88% for barcode medication administration).

Third, we hypothesized that compliance would improve if healthcare workers were trained to follow a specific sequence of actions for VPI during medication administration (termed definitive procedure-based training), rather than their current training. We evaluated nursing students' compliance with the extended VPI guidelines using clinical simulation, with each student completing a simple task (administering one medication) and a complex task (administering two medications). We found that those students who received the definitive procedure-based training showed a significant increase in compliance on the simple task, but not on the complex task. Among the complying students, few of them followed the specific sequence of actions detailed in the definitive procedure-based training.

Our findings suggest further study is needed to investigate more effective approaches for improving the VPI process, perhaps by better supporting individuals as they complete the process (e.g., appropriately designed technology) or by improving approaches to training.

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CHAPTER 1

INTRODUCTION

Patient identification occurs during most healthcare processes involving patients. Processes affected by patient identification errors include patient registration, treatment (e.g., blood transfusion, medication administration, or surgery), and laboratory testing. Although the patient identification process may appear straightforward, studies have shown it to be complex and error-prone (Henneman et al., 2010; Mannos, 2003; National Patient Safety Agency, 2004; Sevdalis et al., 2009; Spruill et al., 2009).

Patient identification errors are one of the major causes of medication errors (Lisby et al., 2005; Mannos, 2003; Spruill et al., 2009). According to estimates by the Institute of Medicine, hospitalized patients experience approximately one medication error per day of their stay (Institute of Medicine, 2006). As shown in Figure 1.1, approximately 26% - 38% of medication errors occur during medication administration (Andersson et al., 2010; Leape et al., 1995). Further studies have found that up to 80% of these medication administration errors were due to patient misidentification (Lisby et al., 2005).

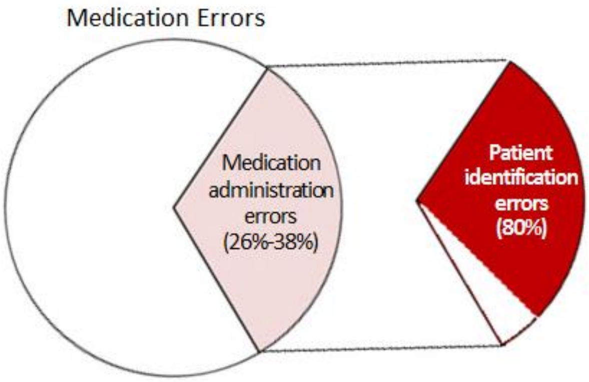

Medication Errors
Medication administration errors (26%-38%)
Patient identification errors (80%)

Figure 1.1. Proportion of medication errors attributable to patient identification errors

During medication administration, failure to correctly identify patients can lead to patients receiving incorrect medications, perhaps resulting in adverse drug events and even death (Schulmeister, 2008). Moreover, patient misidentification may also harm patients who do not receive their intended medications because their medications were erroneously given to other patients (Hakimzada et al., 2008; Ranger et al., 2004). Most patient identification studies to date have focused on reporting patient misidentification statistics from case studies (Henneman et al., 2010; Henneman et al., 2012; Leape et al., 1995), on classifying types of patient identification errors (Mannos, 2003; National Patient Safety Agency, 2004; Schulmeister, 2008), or on evaluating the impact of technology on the patient identification process (Henneman et al., 2012; Patterson et al., 2002; Snyder et al., 2010).

Several organizations have suggested guidelines to increase the accuracy of patient identification, including the National Patient Safety Agency, the Joint Commission on Accreditation of Healthcare, and the World Health Organization. In 2003 the Joint Commission introduced "Improve the accuracy of patient identification" as the first of its National Patient Safety Goals and has updated it annually. The Joint Commission guidelines for fulfilling this goal are: "Use at least two patient identifiers when providing care, treatment, and services … acceptable identifiers may be the individual's name, an assigned identification number, telephone number, or other person-specific identifier … the patient's room number or physical location is not used as an identifier …" (Joint Commission, 2013).

Healthcare facilities may train their workers by using policies and/or procedures based on their interpretations of these guidelines. Example healthcare facility guidelines are as follows:

- University Health Services at the University of Massachusetts Amherst (Amherst, MA): "*Verify 2 patient identifiers 1) Patient's Name 2) Patient's Date of Birth. If patient has a* *commonly used name, the patient's medical record number is the 3rd patient identifier*" (see Figure 1.2)

- Baystate Medical Center (Springfield, MA): "*... the two patient specific identifiers are: 1) the patient's stated full name (first and last) and 2) The medical record number on his/her ID band ... match two patient specific identifiers directly associated with the individual and the same two identifiers associated with the medication, blood product, specimen ...*" (Appendix A)
- Beth Israel Deaconess Medical Center (Boston, MA): "*... examples of patient identifiers include: Name, Date of birth, ... the two identifiers used to verify a patient's identity must be matched to the same two identifiers displayed on medication packaging, automatic medication dispensing machines ...* " (Appendix B)

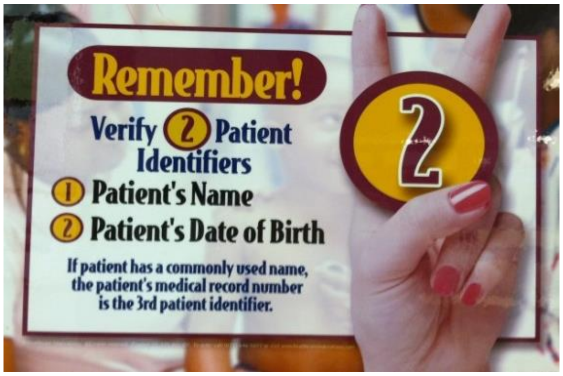

Remember!
Verify ② Patient Identifiers
① Patient's Name
② Patient's Date of Birth
If patient has a commonly used name, the patient's medical record number is the 3rd patient identifier.
2

Figure 1.2. Sign explaining patient identification guidelines at the University of Massachusetts Health Services

The Joint Commission guidelines, which influence healthcare facility policies and procedures, focus on how to select patient identifiers for verification. Unfortunately, the guidelines provide no guidance for how to select *pairs of artifacts* on which to match the patient identifiers. Here we use the term *artifact* to mean an entity containing at least two patient identifiers (e.g., ID Band), and thus an entity that could be used in the verification of patient identifiers (VPI) process. In our study, we consider patients to be artifacts and their statements about their identities to be patient identifiers.

Selecting pairs of artifacts for VPI is especially complex when several artifacts are involved in the process. As shown in Figure 1.3, (a), (b), and (c) seem to meet the Joint Commission guidelines of using at least two patient identifiers, but (c) may not prevent the patient from receiving the wrong medication if the top two artifacts pertain to one patient and the bottom two artifacts pertain to another.

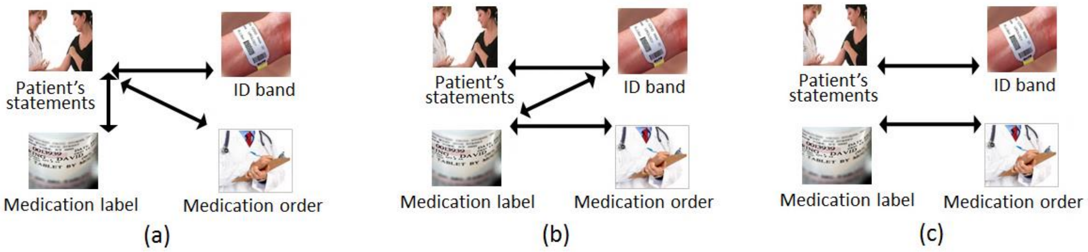

Patient's statements
ID band
Medication label
Medication order
(a)
Patient's statements
ID band
Medication label
Medication order
(b)
Patient's statements
ID band
Medication label
Medication order
(c)

Figure 1.3. Selection of pairs of artifacts

We suspect that extending the Joint Commission guidelines to include directions on how to select pairs of artifacts would help healthcare workers understand the VPI process better. The extended guidelines should include directions on how to select pairs of artifacts that are applicable to variety of healthcare processes (e.g., medication administration, blood transfusion) and to different types of artifacts (e.g., ID bands, blood products).

As previous studies suggest, patient identification errors are especially problematic during medication administration. We therefore examined the implications of our guidelines for artifacts commonly used during medication administration. The Joint Commission guidelines affect the VPI process differently depending on whether the medication administration process uses barcode verification technology (Barcode Medication Administration (BCMA)) or not (Manual Medication Administration (MMA)), so we explore the implications of both.

In the remainder of this thesis, we focus on nurses, as they play a vital role in identifying patient identification errors; however, the insights from this research should be applicable to other types of healthcare workers performing VPI. To gain insight into how well the extended Joint Commission guidelines are complied with, we measured current compliance by analyzing data from clinical simulations where nurses administered medications using MMA and BCMA.

We also suspect that training healthcare workers using explicit guidelines may improve compliance with the VPI guidelines. Thus, we designed a guideline-based training strategy for MMA, and evaluated the impact of the training on nursing students' compliance with the VPI guidelines.

In summary, this thesis approaches VPI as a complex process that is currently poorly defined and error-prone. Our research aims to achieve the following three goals:

1. Extend the Joint Commission guidelines for VPI with specific directions for selecting pairs of artifacts. We refer to the extended guidelines as "artifact-explicit guidelines". To achieve this goal, we created artifact-explicit guidelines and demonstrated the implications of these guidelines when applied to MMA and BCMA, respectively.
2. Evaluate current compliance with the artifact-explicit guidelines. To achieve this goal, we analyzed data collected from previous clinical simulation studies where nurses administrated medications to mock patients using MMA and BCMA (Henneman et al., 2010; Henneman et al., 2012).
3. Design and evaluate a training strategy to improve compliance with the artifact-explicit guidelines. To achieve this goal, we designed a guideline-based training strategy for

nursing students, and tested the efficacy of the training via an experiment where students conducted MMA in a simulated clinical setting.

From our research, we obtained three major findings that contribute to the patient identification literature. First, there are a considerable number of ways to conduct the VPI process that comply with the artifact-explicit guidelines. These alternatives vary depending on whether an artifact can be trusted prior to the start of the VPI process (from 16 to 8 for MMA; from 8 to 1 for BCMA), or what kind of information is encoded on the barcodes for BCMA (from 3 to 1 when the ID band is initially considered a trusted artifact; from 8 to 3 when the ID band is not initially considered a trusted artifact). Second, we found that under most conditions, nurses' compliance with the artifact-explicit guidelines was low (2% - 5% for MMA; 12% - 88% for BCMA).

Third, we found that our training strategy showed a significant increase in nursing students' compliance with the artifact-explicit guidelines; however, very few nursing students followed the exact steps outlined in the training.

The remainder of this thesis is organized as follows. Chapter 2 details related work by researchers who have analyzed the prevalence and types of VPI errors, and outlines previously proposed strategies to comply with the Joint Commission guidelines. Chapter 3 describes the requirements for artifact-explicit guidelines and the implications of these guidelines for MMA and BCMA. Chapter 4 details an evaluation of nurse compliance with the artifact-explicit guidelines for MMA and BCMA. Chapter 5 describes our proposed training strategy to improve compliance with the artifact-explicit guidelines, and our experimental evaluation of the training for nursing students conducting MMA. Chapter 6 summarizes our observations and provides directions for future work.

CHAPTER 2

RELATED WORK

Most prior work related to the VPI process has reported patient misidentification statistics from case studies, classified types of VPI errors, or evaluated the impact of technology on the VPI process. Only a few studies have proposed specific guidelines or strategies to decrease VPI errors. This chapter describes studies analyzing VPI errors and proposing strategies or guidelines to decrease VPI errors.

2.1 Analysis of VPI errors

Several studies have reported VPI errors statistics identified from case studies. Valenstein et al. (2006) and Dunn et al. (2010) measured the frequency of VPI errors detected in clinical laboratories. Valenstein et al. conducted a survey from 127 clinical laboratories for information about specimen misidentification, and found that overall rate of VPI errors was 55 errors per a million of billable tests. They also estimated that more than 160,000 adverse events per year resulted from misidentification of patients' laboratory specimens. Dunn et al. reported that VPI errors accounted for 182 of 253 adverse events which occurred in all of the test cycles. Henneman et al. (2010, 2012) reported the percentage of nurses who failed to identify VPI errors during medication administration in clinical simulations. They found that 39% of nurses in MMA and 8% of nurses in BCMA misidentified the patient and subsequently gave the medication to the wrong patient.

Other studies addressing the VPI process have classified types of VPI errors. Henneman et al. (2010) used the data from a medical center's voluntary safety reporting system for the classification (e.g., medication events, surgical events, laboratory events). Lippi et al. (2009) and Dunn et al. (2010) classified the types of VPI errors in laboratory diagnostics. Lippi et al.

classified factors that potentially contribute to VPI errors related to workflow, artifacts used in the VPI process, or the approach taken by healthcare workers performing the VPI process (e.g., ordering tests on the wrong patient, entering incorrect data). Dunn et al. classified the types of VPI errors based on 132 misidentification events occurring in laboratory medicine (e.g., patient identification bands were labeled for the wrong patient information, laboratory tests were ordered for the wrong patient).

The impact of technology on the VPI process has also been evaluated in some studies addressing the VPI process. Barcode verification technology has been strongly recommended to reduce VPI errors during medication administration. Several studies suggested that the barcode verification technology has the potential to improve patient safety by reducing medication errors (Paoletti et al., 2007; Poon et al., 2010; Rivish et al., 2010). One study reported that the barcode verification technology significantly reduced the number and types of medication administration errors (Cummings et al., 2005). Despite its potential benefits, some studies have shown that the barcode verification technology may create new kinds of errors and have unexpected impacts on patient safety (Akowski et al., 2008; Patterson et al., 2002; McDonald, 2006). Patterson et. al. identified five general negative side effects of BCMA implementation (Patterson et al., 2002) and Koppel et al. identified fifteen different types of workarounds caused by a BCMA system (Koppel et al., 2008).

2.2 Strategies to comply with the Joint Commission guidelines

Although several studies have discussed VPI errors in healthcare processes, few have proposed specific strategies or guidelines to decrease these errors. Lane et al. (2006) propose a hierarchical protocol for the ideal medication administration process. Their research suggests comparing the patient’s identification (ID) band to the patient’s chart during medication administration, but does not specify how to deal with other artifacts. To decrease incidents of patient misidentification before chemotherapy administration, Spruill et al. (2009) suggest matching two patient identifiers, the patient's name and medical record number (MRN), between two specific artifacts, namely the patient's ID band and the chemotherapy product label. With respect to the medication administration process, Paparella (2012) recommends matching any two patient identifiers suggested by the Joint Commission across three specific artifacts: the patient's statements about their identity, the patient's ID band, and the medication order. These studies, however, appear to focus on a specific process (e.g., medication administration, chemotherapy) or specific artifacts (e.g., patient's ID band, patient's chart, chemotherapy product label, medication order).

Henneman et al. (2010) suggest a strategy that is applicable to any number of artifacts for a set of selected processes. First, their strategy proposes using any two patient identifiers suggested by the Joint Commission and matching those identifiers between two specific artifacts: the patient's ID band and the patient's statements about their identity. Second, their strategy proposes matching identifiers on other artifacts to either the patient's statements or the patient's ID band. They do not generalize their two-step strategy, however, to healthcare processes such as laboratory testing, which may not involve a patient wearing an ID band. Thus, it may be important to establish general guidelines that can be universally applied to a wider range of healthcare processes.

CHAPTER 3

ARTIFACT-EXPLICIT GUIDELINES FOR VPI

The Joint Commission guidelines for VPI focus on how to select patient identifiers (e.g., name, date of birth, MRN) but not on how to select the pairs of artifacts (e.g., patient's statements, ID band, medication label) on which to match patient identifiers. In this thesis, we extended the Joint Commission guidelines to include direction on selecting pairs of artifacts, evaluated nurses' compliance with the guidelines, and designed a training strategy to improve compliance with the guidelines. This chapter describes our approach to extending the Joint Commission VPI guidelines, which we term "artifact-explicit guidelines." We also outline the implications of these artifact-explicit guidelines when applied to the manual medication administration (MMA) and barcode medication administration (BCMA) processes.

3.1 Requirements for artifact-explicit guidelines

To make the Joint Commission guidelines for VPI more precise, we proposed artifact-explicit guidelines to guide healthcare workers in selecting artifacts for VPI. We believe this extension is consistent with the intent of the Joint Commission guidelines. In this and the following chapters, we will use "Guidelines" to refer to these artifact-explicit guidelines, which are:

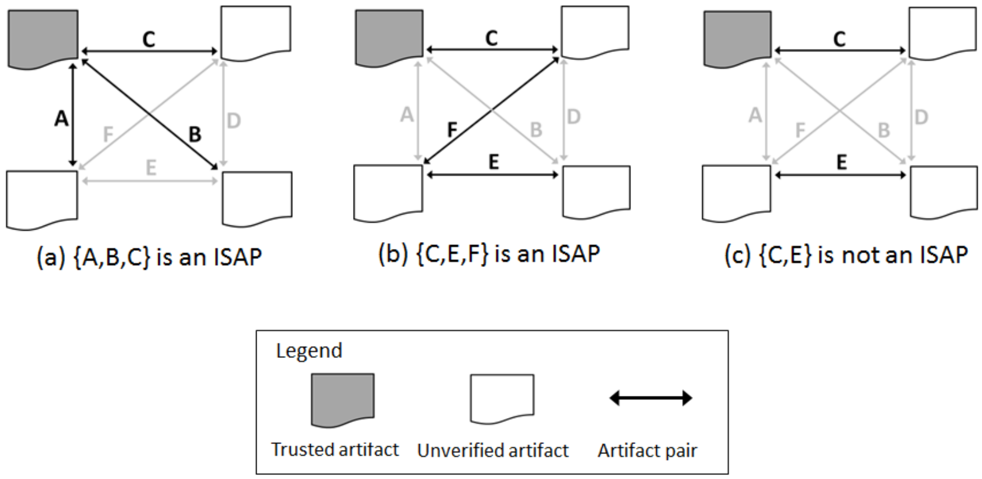
> *Before an artifact is used, assure that at least two patient identifiers on that artifact have been matched with the corresponding identifiers from another artifact that is considered to be trusted.*

An artifact is considered to be trusted if it is either known to have been previously verified (e.g., ID band on patient’s wrist) or assumed to be correct based upon direct evidence. We define a verified artifact to be an artifact with at least two patient identifiers that have been matched with the corresponding identifiers from another artifact that is considered to be trusted. For example, if the ID band is considered to be trusted and the medication label has not yet been evaluated (i.e., it is an unverified artifact), matching the patient’s name and date of birth (DOB) on the medication label with the name and DOB on the ID band allows the healthcare worker to now consider the medication label to be a verified, and thus trusted, artifact. The difference between verified and trusted artifact is that verified artifacts can be considered to be trusted but the opposite is not necessarily true because some artifacts can be immediately trusted so do not require further verification. For example, a patient’s statements about their identity (e.g., name and DOB) are generally assumed to be correct without verification. Prior to the start of the VPI process, there must be at least one trusted artifact whose patient identifiers can be matched to those identifiers from unverified artifacts.

Most healthcare processes tend to involve several unverified artifacts. To perform the VPI process when two or more unverified artifacts are involved, a set of artifact pairs must be identified. We introduce the term *artifact pair* to indicate that at least two identifiers on one artifact of the artifact pair are to be matched to the same identifiers on the other artifact of the artifact pair. In subsequent figures, we represent an artifact pair using a bidirectional edge between the two artifacts. A subset of the edges representing artifact pairs should form a path from each unverified artifact that will be used in the healthcare process to a trusted artifact. The selection of the artifact pairs and the matching of the identifiers for those pairs do not have to occur in any prescribed order. After these matches have been successfully conducted, the initially unverified artifacts that occur on this path are considered verified. We therefore introduce the term *identifying set of artifact pairs* to indicate a set of artifact pairs which is required to comply with the Guidelines:

- ***Definition****: An* ***I****dentifying* ***S****et of* ***A****rtifact* ***P****airs (****ISAP****) is a set of artifact pairs such that, for each artifact pair in the set, at least two of the identifiers for one of the artifacts in that artifact pair should be matched to the corresponding identifiers on the other artifact of that artifact pair. An ISAP must satisfy the following conditions:*
    - ***Condition 1:*** *A trusted artifact is included in at least one artifact pair in the set;*
    - ***Condition 2****: For each unverified artifact that will be used, there is a subset of artifact pairs that form a path to a trusted artifact.*

Figure 3.1 provides two examples of ISAPs and one example of a non-ISAP. In this figure, the bidirectional edges between the artifacts represent the artifact pairs. Each edge is labeled with a letter, A-F, with each dark edge indicating that the artifact pair is in the ISAP and a light edge indicating that the artifact pair is not in the ISAP. In Figure 3.1(a), the set of artifact pairs, {A,B,C}, satisfies both conditions and is an ISAP: a trusted artifact is included in at least one artifact pair in the set (A, B, and C satisfy Condition 1); for each unverified artifact on the top-right, bottom-left, and bottom-right, there is a subset of artifact pairs that form a path to the trusted artifact: {C}, {A}, and {B} respectively (satisfies Condition 2). In the same way, in Figure 3.1(b), {C,E,F} is an ISAP because a trusted artifact is included in at least one artifact pair in the set (C satisfies Condition 1); for each unverified artifact on the top-right, bottom-left, and bottom-right, there is a subset of artifact pairs that form a path to the trusted artifact: {C}, {F,C}, and {E,F,C} respectively (satisfies Condition 2). In Figure 3.1(c), {C,E} is not an ISAP because for each unverified artifact on the bottom-left and bottom-right, there is no path to the trusted artifact (violates Condition 2).



(a) {A,B,C} is an ISAP (b) {C,E,F} is an ISAP (c) {C,E} is not an ISAP

Figure 3.1. ISAP and non-ISAP examples

The requirements to comply with the Guidelines do not impose a specific ordering of the matching of identifiers among the artifact pairs. For example, in Figure 3.1(a), given the ISAP {A,B,C}, the artifact pairs can be selected in any order (i.e., ABC, ACB, BAC, BCA, CAB, or CBA) for VPI.

3.2 Implications of the artifact-explicit guidelines

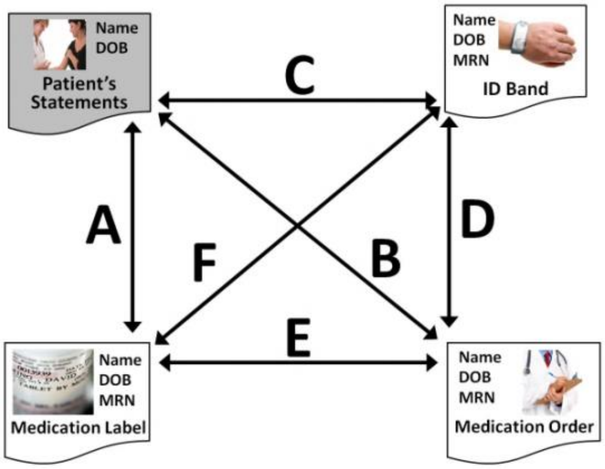
To understand the implications of the Guidelines, we applied the Guidelines to a specific set of artifacts typically used in medication administration (i.e., patient’s statements, medication label, medication order, and ID band) and associated patient identifiers (i.e., name, DOB, and MRN). The following assumptions underlay this thesis:

- A patient’s collective statements about their identity are considered a trusted artifact.

- All other artifacts are initially considered unverified artifacts, unless explicitly stated otherwise.
- If at least two patient identifiers are determined to be correct for an artifact, all of its identifiers are assumed to be correct.
- The medication label contains patient identification information.

These assumptions may not always be correct, as addressed in Chapter 4.4. In this thesis, we evaluated nurse compliance with the Guidelines during the medication administration process for a patient-identified medication, meaning that the medication contains patient identification information (e.g., medications for chemotherapy (Jacobson *et al.*, 2009; Spruill *et al.*, 2009)). Labels for common medications (e.g., aspirin) often do not contain this information. While the label on a patient identified medication includes patient identification information in a human readable form, the barcode on the medication label does not necessarily include this information, as the FDA's Bar Code Label Requirements do not require patient identification information be included in medication barcodes (FDA, 2011).

Figure 3.2 shows the typical artifacts and associated patient identifiers used in the medication administration process. The four typical artifacts result in six artifact pairs (A-F) potentially available for VPI. To perform the VPI process, an ISAP must be selected using a subset of the six artifact pairs. In addition, for each artifact pair in the selected ISAP, at least two identifiers on one artifact in the pair should be matched to the same identifiers on the other artifact in the pair. The two identifiers are selected from a small set of alternatives: the alternatives are restricted either to two available identifiers (i.e., name and DOB) for each of the three artifact pairs A-C, or three available identifiers (i.e., name, DOB, and MRN) for each of the three artifact pairs D-F. Because the identifiers are selected from a such a small set of alternatives, we did not consider alternatives in selection of identifiers in this thesis.



Note:

- Trusted artifact: Patient's Statements
- Unverified artifacts: Medication Label, Medication Order, and ID Band

Figure 3.2. Six artifact pairs with at least two of the same types of patient identifiers

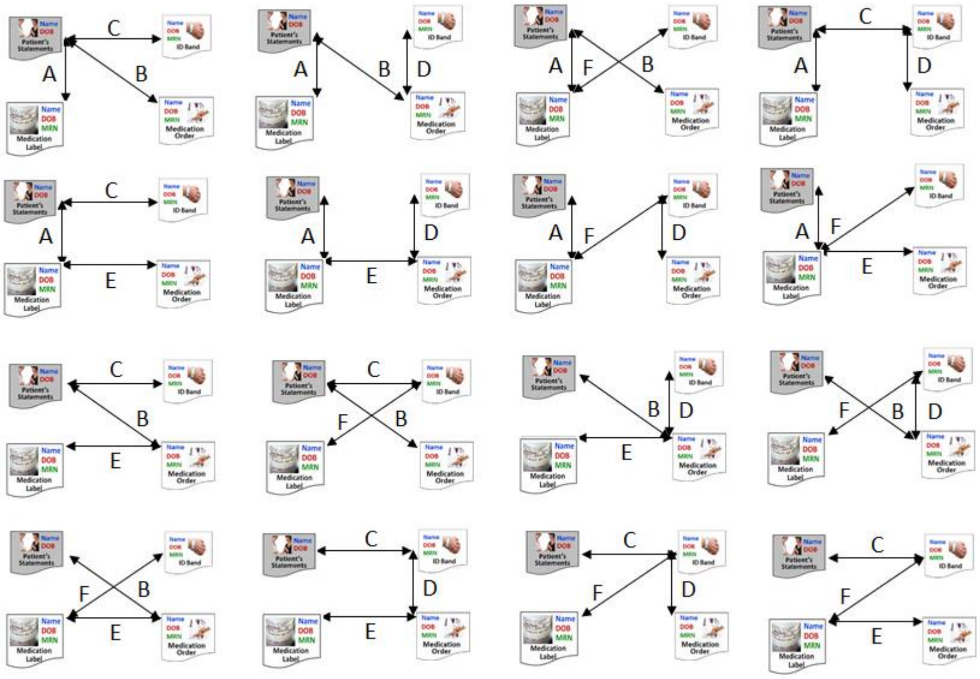
For the typical artifacts shown in Figure 3.2, where there is one trusted artifact and three unverified artifacts, the total number of possible ISAPs[1] is 38. Among these 38 possible ISAPs, there are 16 minimal ISAPs. A minimal ISAP ensures that healthcare workers conduct at least a minimal number of matches between artifacts to successfully perform the VPI process. For each minimal ISAP, additional matches for VPI could be performed by including one or more extra artifact pairs in the set.

Identifying the minimal ISAPs is a similar problem to finding a spanning tree - a minimal set of edges that connect all vertices in a complete graph in which each pair of vertices is connected by an edge (Kosowski *et al.*, 2005). Figure 3.3 shows these 16 possible minimal

---

[1] 38= $(\sum_{i=3}^{6} C_i^6)$ – 4, where 4 is the number of non-ISAPs composed of 3 artifacts pairs that do not satisfy either Condition 1 or 2.

ISAPs[2] illustrating that VPI can be accomplished in multiple ways. Each minimal ISAP is composed of three artifact pairs that can be selected in any order. In the following two sections, we explore several conditions (e.g., whether an artifact can be trusted prior to the start of the VPI process) and identify the possible minimal ISAPs allowable for each.


Name
DOB
Patient's Statements
Name
DOB
MRN
ID Band
Name
DOB
MRN
Medication Label
Name
DOB
MRN
Medication Order
C
A
B
A
B
D
A
F
B
C
A
D
C
A
E
A
D
E
A
F
D
A
F
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C
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E
C
F
B
B
D
E
F
B
D
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B
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C
D
E
C
F
D
C
F
E

Figure 3.3. Possible minimal ISAPs when there is one trusted artifact and three unverified artifacts

In the following sections, we show the implications of the Guidelines for MMA and BCMA.

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[2] When the order of examined artifact pairs is considered, the total number of possible minimal ISAPs is 96(= ($C^6_3 \times$ 3!) - 24), where 24 is the number of non-ISAPs composed of 3 artifact pairs that do not satisfy either Condition 1 or 2.

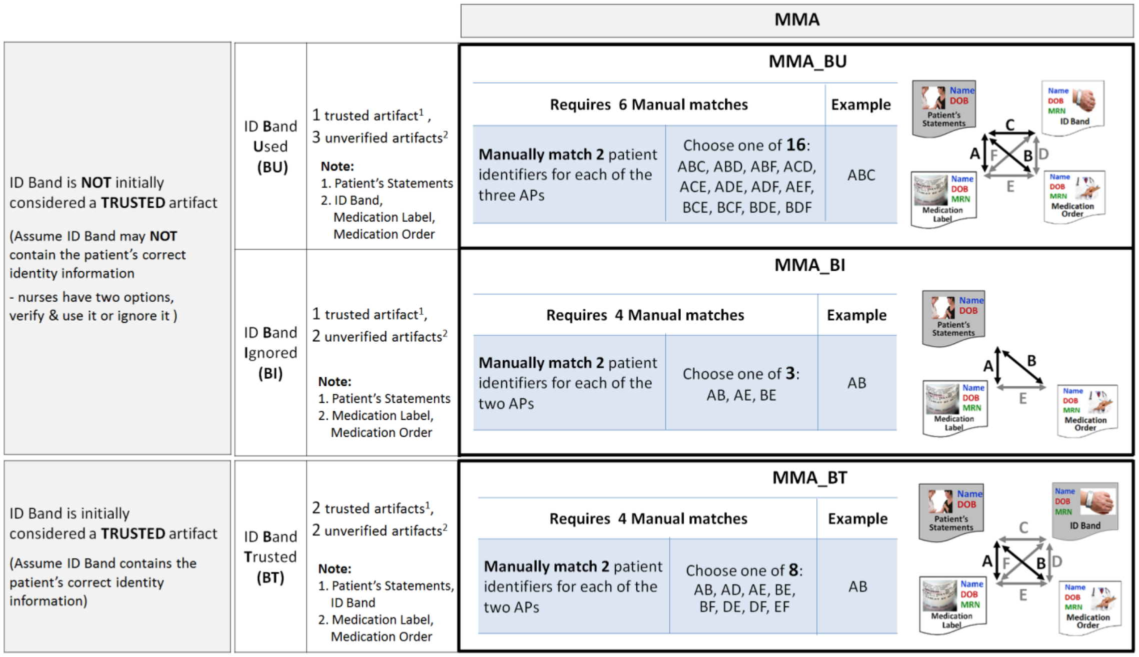
3.3 MMA

In the previous section, we described the 16 possible minimal ISAPs for the situation where there is one trusted artifact and three unverified artifacts used in MMA. In this section, we examine several cases and identify the possible minimal ISAPs allowable for each. These include whether the ID band is to be trusted or not, if it is not trusted whether it is to be used or ignored.

Ideally, the ID band should be verified and secured to the patient during registration prior to conducting the medication administration process, meaning that the ID band could be considered a trusted artifact. Studies have shown, however, that some patients' ID bands contain incorrect information (Dhatt et al., 2011; Sevdalis et al., 2009; Snyder et al., 2010). To show the impact of assuming a trusted ID band on the Guidelines, we take into account two cases in our analysis: the ID band is not initially considered a trusted artifact (i.e., it is an unverified artifact) and the ID band is initially considered a trusted artifact.

The leftmost column of Figure 3.4 includes a description of these two cases regarding the ID band. Note that the first case is divided into two sub-cases depending on whether the nurse verifies and uses the ID band or ignores the ID band. We use the abbreviation *ID Band Used (BU)* and *ID Band Ignored (BI)* for the first case and *ID Band Trusted (BT)* for the second case. The third column indicates the number of trusted artifacts and unverified artifacts for each case. The fourth column shows abbreviations for each of the 3 cases in MMA, a table including the total number of manual matches required for VPI, one example of the possible minimal ISAPs, and a figure depicting the example.

For each of the 3 cases, we identify all possible minimal ISAPs that satisfy the aforementioned conditions in Chapter 3.1 and the number of manual matches required for each of the minimal ISAPs. For example, the conditions for an ISAP in the case of *MMA_BU* are: a trusted artifact (i.e., patient's statements) is included in at least one artifact pair in the set (satisfies Condition 1); and for each unverified artifact (i.e., medication label, medication order, and ID band), there is a subset of artifact pairs that form a path to the trusted artifact (satisfies Condition 2). The total number of possible minimal ISAPs satisfying these conditions is 16, as shown in Figure 3.3. During the VPI process, for each of the three artifact pairs in the selected minimal ISAP, two patient identifiers on one artifact in the pair should be matched to the same identifiers on the other artifact in the pair; thus, the total number of required manual matches is 6, as shown in Figure 3.4. The figure depicting one example minimal ISAP {A,B,C} shows that the artifact pairs, A, B, and C, each represented by a dark edge, are in the minimal ISAP, and D, E, and F, each represented by a light edge, are not in the minimal ISAP. In the case of *MMA_BI*, the total number of possible minimal ISAPs is 3 ({A,B}, {A,E}, and {B,E}) and the total number of required manual matches for each of the minimal ISAPs is 4. In the case of *MMA_BT*, the total number of possible minimal ISAPs is 8 ({A,B}, {A,D}, {A,E}, {B,E}, {B,F}, {D,E}, {D,F}, and {E,F}) and the total number of required manual matches for each of the minimal ISAPs is 4.



			MMA			
ID Band is **NOT** initially considered a **TRUSTED** artifact (Assume ID Band may **NOT** contain the patient's correct identity information - nurses have two options, verify & use it or ignore it)	ID **Band** Used **(BU)**	1 trusted artifact^1 , 3 unverified artifacts^2 **Note:** 1. Patient's Statements 2. ID Band, Medication Label, Medication Order	**MMA_BU**	Requires 6 Manual matches: **Manually match 2** patient identifiers for each of the three APs	Choose one of **16**: ABC, ABD, ABF, ACD, ACE, ADE, ADF, AEF, BCE, BCF, BDE, BDF	Example: ABC
	ID **Band** Ignored **(BI)**	1 trusted artifact^1, 2 unverified artifacts^2 **Note:** 1. Patient's Statements 2. Medication Label, Medication Order	**MMA_BI**	Requires 4 Manual matches: **Manually match 2** patient identifiers for each of the two APs	Choose one of **3**: AB, AE, BE	Example: AB
ID Band is initially considered a **TRUSTED** artifact (Assume ID Band contains the patient's correct identity information)	ID **Band** Trusted **(BT)**	2 trusted artifacts^1, 2 unverified artifacts^2 **Note:** 1. Patient's Statements, ID Band 2. Medication Label, Medication Order	**MMA_BT**	Requires 4 Manual matches: **Manually match 2** patient identifiers for each of the two APs	Choose one of **8**: AB, AD, AE, BE, BF, DE, DF, EF	Example: AB

Figure 3.4. The minimal number of manual matches and an example of an associated minimal ISAP for the 3 cases in MMA

3.4 BCMA

In BCMA, barcodes are placed both on the patient's ID band and the medication label. Before medications are given to a patient, the barcode on the patient's ID band is scanned to automatically match the patient identifier(s) on the ID band with those from the Electronic Medical Record (EMR), thereby opening the patient's medication order screen within the EMR. Scanning the barcode on the ID band thus replaces the task of manually performing VPI between the ID band and the medication order, but only if the ID band barcode is encoded with at least two patient identifiers. The barcode on the medication is also scanned to match the medication name and dose of the medication with those of the medication order in the EMR. As described in Chapter 3.2, the label on a patient identified medication includes patient identifiers in a human readable form, but the barcode on the label does not necessarily include patient identification information; thus, a nurse still needs to manually performing VPI on the medication label using human-readable patient identifiers on the medication. Therefore, healthcare workers need to be aware of what information is encoded on the barcodes to perform a VPI process appropriate for that design. Figure 3.5 shows six artifact pairs available for manually performing VPI (A-F) and two barcode scans (Scan Band and Scan Med) represented by dotted edges.

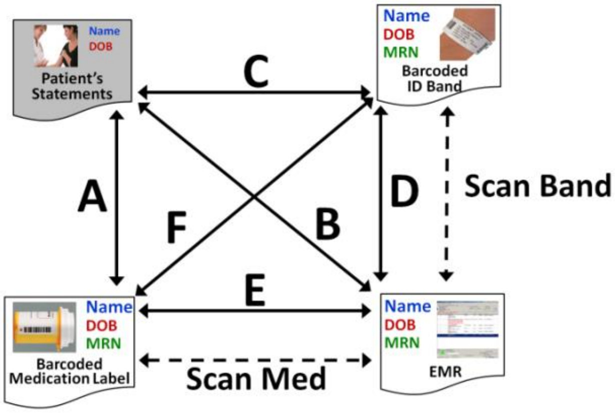


Figure 3.5. Six artifact pairs and two barcode scans available for VPI in BCMA

To show the impact of barcode design on VPI, we consider 6 barcode designs where the ID band and medication label barcodes are encoded with zero, one, or two patient identifiers. Note that the ID band barcode is encoded with at least one patient identifier, so we did not consider the case in which the ID band barcode is encoded with zero patient identifiers.

To show the impact of using a trusted ID band for each barcode design, we consider two cases in our analysis: *ID Band Used (BU)* and *ID Band Trusted (BT)*. Note that scanning the barcode on the patient's ID band is mandatory for conducting the VPI process in BCMA, so *ID Band Ignored (BI)* is not a possible case in BCMA. Therefore, we consider a total number of 12 cases in BCMA: 6 barcode designs in the case of *BCMA_BU* and 6 barcode designs in the case of *BCMA_BT*, as shown in Figure 3.6.

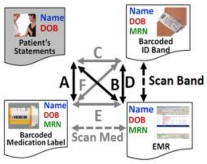
ID Band is **NOT** initially considered a **TRUSTED** artifact (Assume ID Band may **NOT** contain the patient's correct identity information - nurses have two options, verify & use it or ignore it)	ID **B**and **U**sed **(BU)**	1 trusted artifact[1] , 3 unverified artifacts[2] **Note:** 1. Patient's Statements 2. ID Band, Medication Label, Medication Order

BCMA

BCMA_BU

ID band barcode encoded with **1** patient identifier & **Medication label** barcode encoded with **zero** patient identifiers

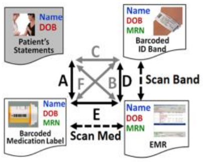
Requires 1 Scan + 5 Manual matches		Example
Barcode Scan	ID Band	Scan Band
Manually match 2 patient identifiers for each of the two APs	Choose one of **8**: AB, AC, AE, AF, BE, BF, CE, or CF	AB
Manually match 1 patient identifier for one AP (the other patient identifier is matched by the Scan Band)	D	D



Name
DOB
Patient's Statements
Name
DOB
MRN
Barcoded ID Band
C
A
F
B
D
Scan Band
Name
DOB
MRN
Barcoded Medication Label
E
Scan Med
Name
DOB
MRN
EMR

ID band barcode encoded with **1** patient identifier & **Medication label** barcode encoded with **1** patient identifier

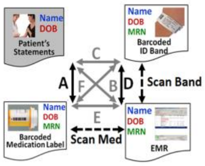
Requires 2 Scans + 4 Manual matches		Example
Barcode Scan	ID Band, Medication Label	Scan Band, Scan Med
Manually match 2 patient identifiers for one AP	Choose one of **3**: A, B, or C	A
Manually match 1 patient identifier for each of the two Aps (the other patient identifier for each AP is matched by the Scan Band & Scan Med)	DE	DE



Name
DOB
Patient's Statements
Name
DOB
MRN
Barcoded ID Band
C
A
F
B
D
Scan Band
Name
DOB
MRN
Barcoded Medication Label
E
Scan Med
Name
DOB
MRN
EMR

ID band barcode encoded with **1** patient identifier & **Medication label** barcode encoded with **2** patient identifiers

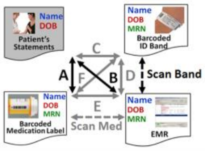
Requires 2 Scans + 3 Manual matches		Example
Barcode Scan	ID Band, Medication Label	Scan Band, Scan Med
Manually match 2 patient identifiers for one AP	Choose one of **3**: A, B, or C	A
Manually match 1 patient identifier for one AP (the other patient is matched by the Scan Band)	D	D



Name
DOB
Patient's Statements
Name
DOB
MRN
Barcoded ID Band
C
A
F
B
D
Scan Band
Name
DOB
MRN
Barcoded Medication Label
E
Scan Med
Name
DOB
MRN
EMR

ID band barcode encoded with **2** patient identifiers & **Medication label** barcode encoded with **zero** patient identifiers

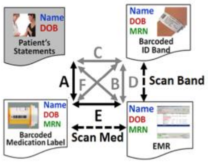
Requires 1 Scan + 4 Manual matches		Example
Barcode Scan	ID Band	Scan Band
Manually match 2 patient identifiers for each of the two APs	Choose one of **8**: AB, AC, AE, AF, BE, BF, CE, or CF	AB



Name
DOB
Patient's Statements
Name
DOB
MRN
Barcoded ID Band
C
A
F
B
D
Scan Band
Name
DOB
MRN
Barcoded Medication Label
E
Scan Med
Name
DOB
MRN
EMR

ID band barcode encoded with **2** patient identifiers & **Medication label** barcode encoded with **1** patient identifier

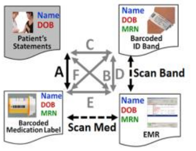
Requires 2 Scans + 3 Manual matches		Example
Barcode Scan	ID Band, Medication Label	Scan Band, Scan Med
Manually match 2 patient identifiers for one AP	Choose one of **3**: A, B, or C	A
Manually match 1 patient identifier for one AP (the other patient identifier is matched by the Scan Band)	E	E



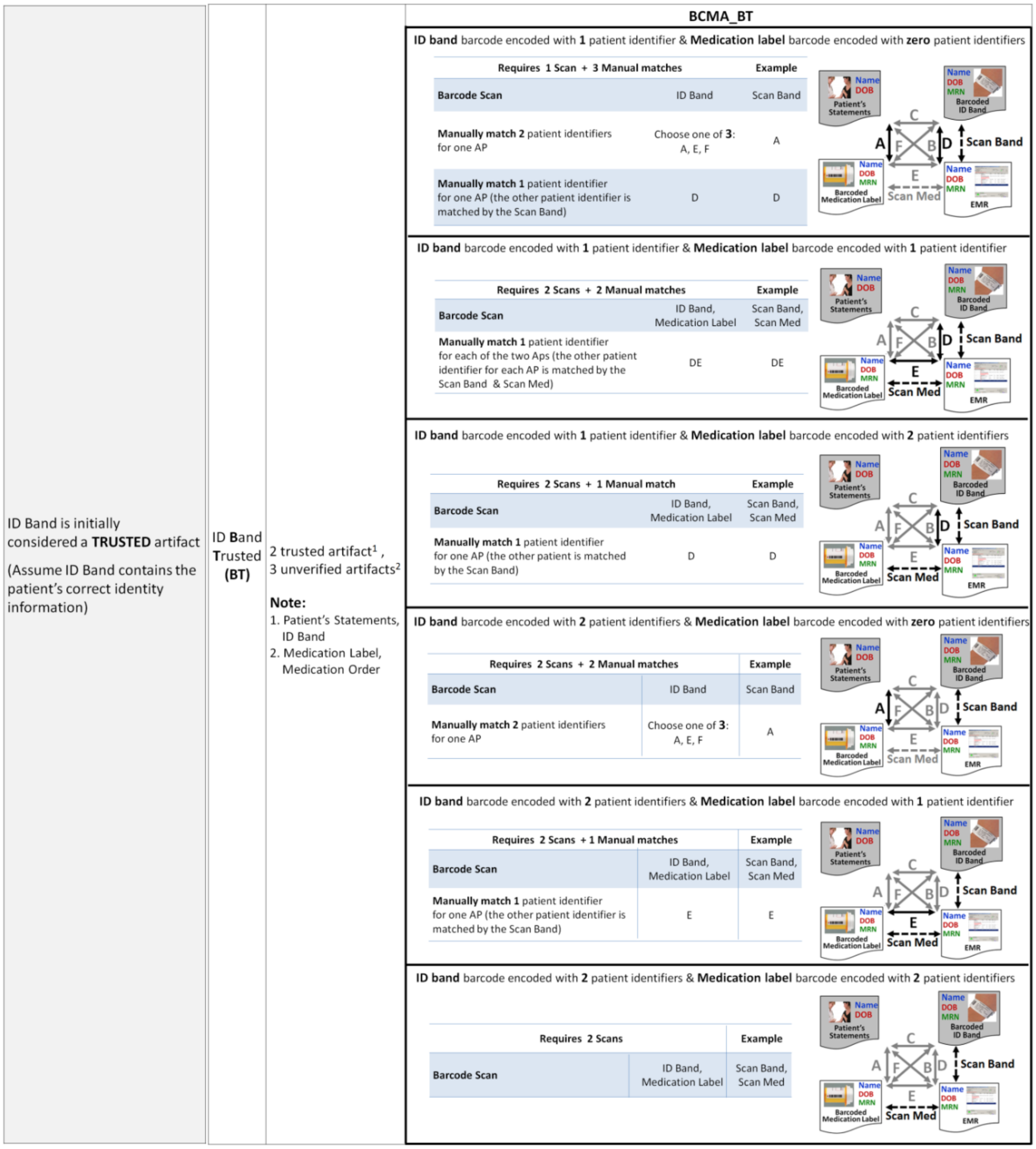
Name
DOB
Patient's Statements
Name
DOB
MRN
Barcoded ID Band
C
A
F
B
D
Scan Band
Name
DOB
MRN
Barcoded Medication Label
E
Scan Med
Name
DOB
MRN
EMR

ID band barcode encoded with **2** patient identifiers & **Medication label** barcode encoded with **2** patient identifiers

Requires 2 Scans + 2 Manual matches		Example
Barcode Scan	ID Band, Medication Label	Scan Band, Scan Med
Manually match 2 patient identifiers for one AP	Choose one of **3**: A, B, or C	A



Name
DOB
Patient's Statements
Name
DOB
MRN
Barcoded ID Band
C
A
F
B
D
Scan Band
Name
DOB
MRN
Barcoded Medication Label
E
Scan Med
Name
DOB
MRN
EMR



ID Band is initially considered a **TRUSTED** artifact

(Assume ID Band contains the patient's correct identity information)

ID **B**and **T**rusted **(BT)**

2 trusted artifact¹ , 3 unverified artifacts²

Note:

1. Patient's Statements, ID Band
2. Medication Label, Medication Order

BCMA_BT

ID band barcode encoded with **1** patient identifier & **Medication label** barcode encoded with **zero** patient identifiers

Requires 1 Scan + 3 Manual matches		Example
Barcode Scan	ID Band	Scan Band
Manually match 2 patient identifiers for one AP	Choose one of **3**: A, E, F	A
Manually match 1 patient identifier for one AP (the other patient identifier is matched by the Scan Band)	D	D

ID band barcode encoded with **1** patient identifier & **Medication label** barcode encoded with **1** patient identifier

Requires 2 Scans + 2 Manual matches		Example
Barcode Scan	ID Band, Medication Label	Scan Band, Scan Med
Manually match 1 patient identifier for each of the two Aps (the other patient identifier for each AP is matched by the Scan Band & Scan Med)	DE	DE

ID band barcode encoded with **1** patient identifier & **Medication label** barcode encoded with **2** patient identifiers

Requires 2 Scans + 1 Manual match		Example
Barcode Scan	ID Band, Medication Label	Scan Band, Scan Med
Manually match 1 patient identifier for one AP (the other patient is matched by the Scan Band)	D	D

ID band barcode encoded with **2** patient identifiers & **Medication label** barcode encoded with **zero** patient identifiers

Requires 2 Scans + 2 Manual matches		Example
Barcode Scan	ID Band	Scan Band
Manually match 2 patient identifiers for one AP	Choose one of **3**: A, E, F	A

ID band barcode encoded with **2** patient identifiers & **Medication label** barcode encoded with **1** patient identifier

Requires 2 Scans + 1 Manual matches		Example
Barcode Scan	ID Band, Medication Label	Scan Band, Scan Med
Manually match 1 patient identifier for one AP (the other patient identifier is matched by the Scan Band)	E	E

ID band barcode encoded with **2** patient identifiers & **Medication label** barcode encoded with **2** patient identifiers

Requires 2 Scans		Example
Barcode Scan	ID Band, Medication Label	Scan Band, Scan Med

Figure 3.6. The number of barcode scans, minimal number of manual matches, and an example of an associated minimal ISAP for the 12 cases in BCMA

For each of the 12 cases, we identify associated possible minimal ISAPs and the number of barcode scans and manual matches required for each of the minimal ISAPs. For example, the conditions for an ISAP in the case of *BCMA BU* when the ID band barcode is encoded with 1 patient identifier and the medication label barcode is encoded with zero patient identifiers are: a trusted artifact (patient's statements) is included in at least one artifact pair in the set (satisfies Condition 1); and for each unverified artifact (i.e., barcoded medication label, EMR, and barcoded ID band), there is a subset of artifact pairs that form a path to the trusted artifact (satisfies Condition 2). The total number of possible minimal ISAPs satisfying these conditions is 8. Figure 3.7 shows these 8 possible minimal ISAPs along with scanning the barcode on the ID band.

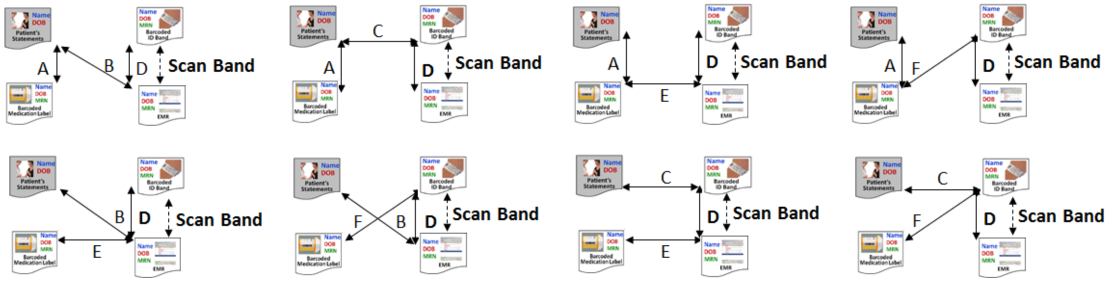

A
B
D
Scan Band
C
A
D
Scan Band
A
D
Scan Band
E
A
F
D
Scan Band
B
D
Scan Band
E
F
B
D
Scan Band
C
D
Scan Band
E
C
F
D
Scan Band
Patient's Statements
Barcoded ID Band
Barcoded Medication Label
EMR
Name
DOB
MRN

Figure 3.7. Possible minimal ISAPs in the case of *BCMA_BU* when the ID band barcode is encoded with 1 patient identifier and the medication label barcode is encoded with zero patient identifiers

For each of the three artifact pairs in the selected minimal ISAP, two patient identifiers on one artifact in the pair should be matched to the same identifiers on the other artifact in the pair, either manually or using a barcode scan. As shown in Figure 3.6, the actions required for the VPI process for this case is: scan the barcode on the ID band, manually match 2 patient identifiers for each of the two artifact pairs by choosing one of 8 sets (AB, AC, AE, AF, BE, BF, CE, and CF), and manually match 1 patient identifier for D because the other patient identifier is matched by scanning the ID band barcode. Thus, the total number of barcode scans is 1 and the total number of manual matches is 5. The figure depicting one example minimal ISAP {A,B,D} shows that A, B, and D, each represented by a dark edge, are in the minimal ISAP and C, E, and F, each represented by a light edge, are not in the minimal ISAP. In the case of *BCMA_BT* when the ID band barcode is encoded with 1 patient identifier and the medication label barcode is encoded with zero patient identifiers, the number of associated possible minimal ISAPs is 3 ({A,D}, {D,E}, and {D,F}). The actions required for the VPI process for this case is: scan the barcode on the ID band, manually match 2 patient identifiers for one artifact pair by choosing one of 3 artifact pairs (A, E, and F), and manually match 1 patient identifier for D because the other patient identifier is matched by scanning the ID band barcode. Thus, the total number of barcode scans is 1 and the total number of manual matches is 3.

3.5 Discussion

The number of possible minimal ISAPs and associated number of manual matches described in the previous sections leads to several observations. First, the VPI process that complies with the Guidelines can be accomplished in a considerable number of ways, which vary depending on the assumptions one makes about the context of the process, as described in Figure 3.4 and Figure 3.6. Second, trusting the ID band reduces the number of alternatives for conducting the process by at least 50%, regardless of whether BCMA is used or not: the number decreases from 16 to 8 (50%) in MMA, and from 8 to 3 (62%) or 3 to 1 (67%) in BCMA. Third, BCMA reduces the number of alternatives for conducting the process at least 50%, regardless of whether the ID band can be trusted or not: the number decreases from 16 to 8 (50%) or 16 to 3 (81%) when the ID band is not initially considered a trusted artifact, and from 8 to 3 (62%) or 8 to 1 (87%) when the ID band is initially considered a trusted artifact. Fourth, depending on what kind of information is encoded on the barcodes for BCMA, the number of alternatives for conducting the process and required manual matches vary, as described in Figure 3.6. Encoding the ID band and medication label barcodes with two patient identifiers reduces the number of alternatives and manual matches the most: the number of alternatives decreased from 8 to 3 (62%) and the number of manual matches decreased from 5 to 2 (60%) when the ID band is not initially considered a trusted artifact, and the number of alternatives decreased from 3 to 1 (67%) and the number of manual matches decreased from 3 to 0 (100%) when the ID band is initially considered a trusted artifact.

CHAPTER 4

EVALUATING COMPLIANCE WITH ARTIFACT-EXPLICIT GUIDELINES

As discussed in Chapter 2.2, Henneman et al. suggested a strategy to comply with the Joint Commission guidelines but lacked a full exploration of the way VPI could be completed (e.g., Henneman et al. considered only 4 out of the 16 alternatives to conduct the VPI process during MMA), and so we were interested in how well nurses complied with our detailed Guidelines.

This chapter describes our evaluation of nurse compliance using clinical simulation data from Henneman studies (2010, 2012). These studies were carried out at a 600 bed, urban, level 1 trauma, pediatric and tertiary referral center with an annual ED census > 100,000. The study was approved by the hospital's Institutional Review Board, and all nurse participants read and gave informed consent. The following subsections describe the procedure for collecting data and generating the sequences of nurses' activities, and our approach for analyzing how well nurses complied with the Guidelines.

4.1 Study procedure

Nurses administered medications in two different experiments. Twenty-eight nurses gave a medication to each of two patients (i.e., 56 trials) without the help of barcode verification technology (i.e., MMA) and twenty-five nurses gave a medication to one patient (i.e., 25 trials) with the support of barcode verification technology (i.e., BCMA). The experiments used the same four artifacts (i.e., patient's statements, medication label, medication order, and ID band) and associated patient identifiers (i.e., name, DOB, and MRN) typically used during in medication administration, as described in the previous chapter (see Chapter 3.2). In both experiments, a researcher led each nurse to a series of numbered rooms where students acting as patients were waiting. Each patient had an ID band secured to their wrist. For each patient, the researcher gave the nurse a medication order and a medication, each labeled with the patient identification information. The nurse then performed a medication administration process on each patient. All nurses wore an eye-tracking device that included a camera for recording a video with cross hairs showing where each nurse was looking throughout the process. In both experiments, nurses were told that the purpose of the study was to evaluate how healthcare workers use visual cues to perform tasks (Henneman et al., 2010); thus, they were not aware that the purpose of the study was to evaluate the VPI process.

After completing the simulations, we reviewed the eye-tracking videos for quality. Of the 56 videos created during MMA, we discarded 12 (21%) videos because of insufficient video quality, leaving 44 (79%) videos for our analysis. We included all 25 (100%) of the videos created during BCMA in the analysis.

We carefully translated the videos into traces. By trace, we mean the complete sequence of VPI-related events performed by a nurse. We defined event names based on a set of predefined activities associated with VPI during medication administration. Given the standardized set of event names, two researchers independently reviewed the videos and created the event sequences. In the few cases when there was disagreement between these two researchers on an event assignment, a third researcher reviewed the video and made the final decision on the event assignment.

4.2 Analysis approach

In analyzing the traces, we considered that an actual match between identifiers on two artifacts is unlikely to occur if there are too many intermediate events between the first and second part of the match. To denote the distance between theses intermediate events, we define Inter-Identifier Distance (Dist) to be the shortest distance (i.e., the number of intermediate events) between the first and second part of a match between identifiers on an artifact pair within a trace.

We assume a shorter Dist is more likely to lead to an actual match because working memory gradually decays, becoming progressively less precise as information is retained for longer periods of time (Cornelissen et al., 2000). In Figure 4.1 (a), the Dist of the match for name is 0 because there are no intermediate events between the first and second part of the match. The Dist of the match for DOB is 1 because there is one intermediate event (i.e., Looked at MRN on the ID Band) between the first and second part of the match. In our analysis, when determining whether nurses actually performed the match or not, we considered three values of Dist: Dist = 0, Dist ≤ 1, and any Dist (i.e., Dist ≤ infinity), to observe how compliance with the Guidelines varied depending on how relaxed we assumed the Dist value could be. In Chapter 4.4, we address the limitations of these three choices of Dist.

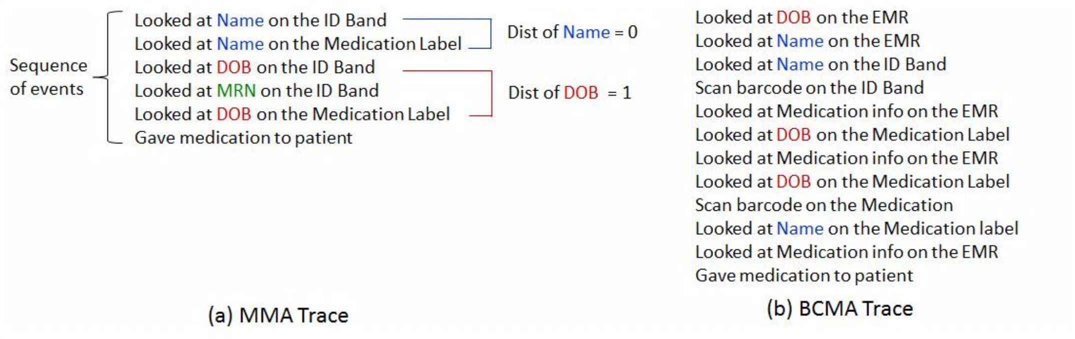

Sequence of events
Looked at Name on the ID Band
Looked at Name on the Medication Label
Looked at DOB on the ID Band
Looked at MRN on the ID Band
Looked at DOB on the Medication Label
Gave medication to patient
Dist of Name = 0
Dist of DOB = 1
(a) MMA Trace
Looked at DOB on the EMR
Looked at Name on the EMR
Looked at Name on the ID Band
Scan barcode on the ID Band
Looked at Medication info on the EMR
Looked at DOB on the Medication Label
Looked at Medication info on the EMR
Looked at DOB on the Medication Label
Scan barcode on the Medication
Looked at Name on the Medication label
Looked at Medication info on the EMR
Gave medication to patient
(b) BCMA Trace

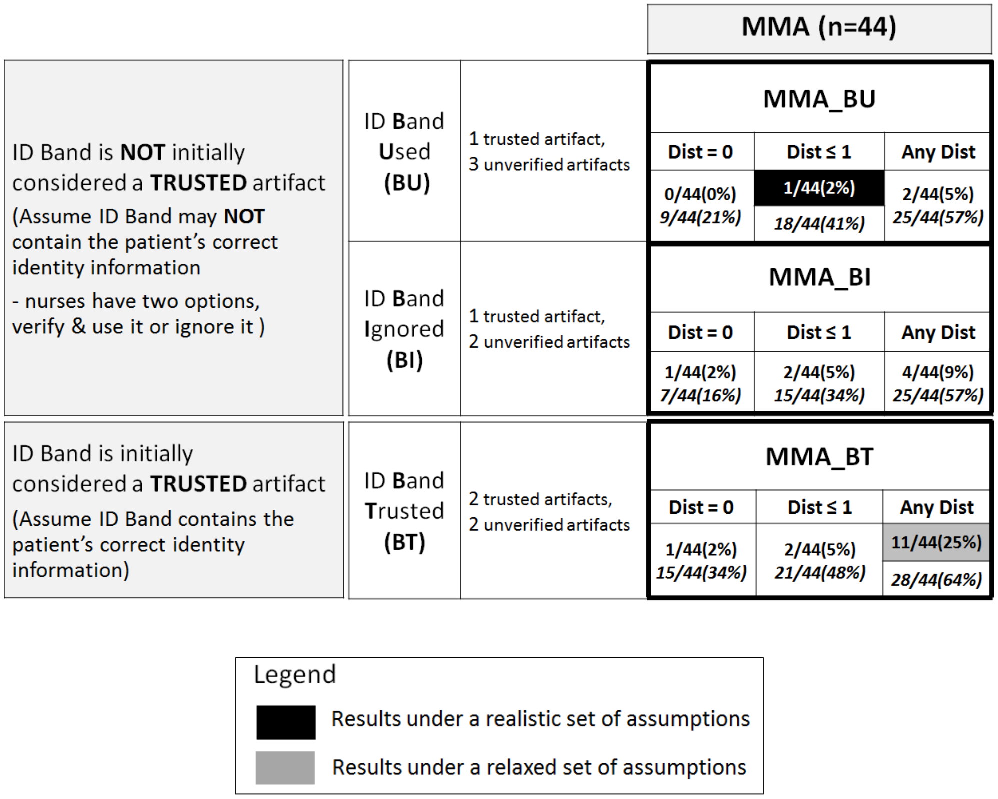
Figure 4.1. Sample shortened traces from nurses using MMA and BCMA

We also accounted for the fact that it was sometimes unclear which identifier the nurse was fixating on during the BCMA trials, largely because of glare on the computer screen. To address this limitation, we considered two assumptions: 1) while looking at the artifact, the nurse did not fixate on any identifiers on the artifact (which indicates a lower bound for the true number of identifier that the nurse fixated on) and 2) while looking at the artifact, the nurse fixated on every identifier on the artifact (which indicates an upper bound for the true number of identifier that the nurse fixated on). Under the former assumption, we found that almost no nurses complied with the Guidelines using BCMA. Hence, we considered only the results under the latter assumption in our analysis. While using this assumption yielded the best possible performance of nurses complying with the Guidelines, a surprisingly small percentage of nurses complied with the Guidelines, as is addressed in the following two sections

4.3 Results

The number and percentage of traces complying with the Guidelines is shown in Figure 4.2. The leftmost column includes a description of two cases depending on whether the ID band is trusted or not. The first case is divided into two sub-cases depending on whether the nurse verifies and uses the ID band or ignores the ID band. The third column indicates the number of trusted artifacts and unverified artifacts for each case. The tables in the fourth column show the numbers and percentages of traces complying with the Guidelines for each of the three values of Dist.

Since the success rate for matching at least two identifiers (upper numbers in non-italics) was often very low (e.g., 0% - 5% for MMA_BU), we wondered whether nurses matched at least one identifier instead of the recommended two identifiers. We therefore also counted the number of traces matching at least one identifier for each artifact pair in a selected minimal ISAP (lower numbers in italics), although we do not recommend this practice. The number of traces complying with the Guidelines was determined for each of the three values of Dist (Dist = 0, Dist ≤ 1, and any Dist), as described in the previous section. For example, in the case of MMA_BU, of the 44 traces, the number of traces complying with the Guidelines by matching at least two identifiers is: 0 (0%) for Dist = 0; 1 (2%) for Dist ≤ 1; and 2 (5%) for any Dist. The number of traces complying with the Guidelines by matching at least one identifier is: 9 (21%) for Dist = 0; 18 (41%) for Dist ≤ 1; and 25 (57%) for any Dist.



			MMA (n=44)		
ID Band is **NOT** initially considered a **TRUSTED** artifact (Assume ID Band may **NOT** contain the patient's correct identity information - nurses have two options, verify & use it or ignore it)	ID **B**and **U**sed **(BU)**	1 trusted artifact, 3 unverified artifacts	**MMA_BU**		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			0/44(0%) ***9/44(21%)***	■ **1/44(2%)** ***18/44(41%)***	**2/44(5%)** ***25/44(57%)***
	ID **B**and **I**gnored **(BI)**	1 trusted artifact, 2 unverified artifacts	**MMA_BI**		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			1/44(2%) ***7/44(16%)***	**2/44(5%)** ***15/44(34%)***	**4/44(9%)** ***25/44(57%)***
ID Band is initially considered a **TRUSTED** artifact (Assume ID Band contains the patient's correct identity information)	ID **B**and **T**rusted **(BT)**	2 trusted artifacts, 2 unverified artifacts	**MMA_BT**		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			1/44(2%) ***15/44(34%)***	**2/44(5%)** ***21/44(48%)***	▨ **11/44(25%)** ***28/44(64%)***

Legend

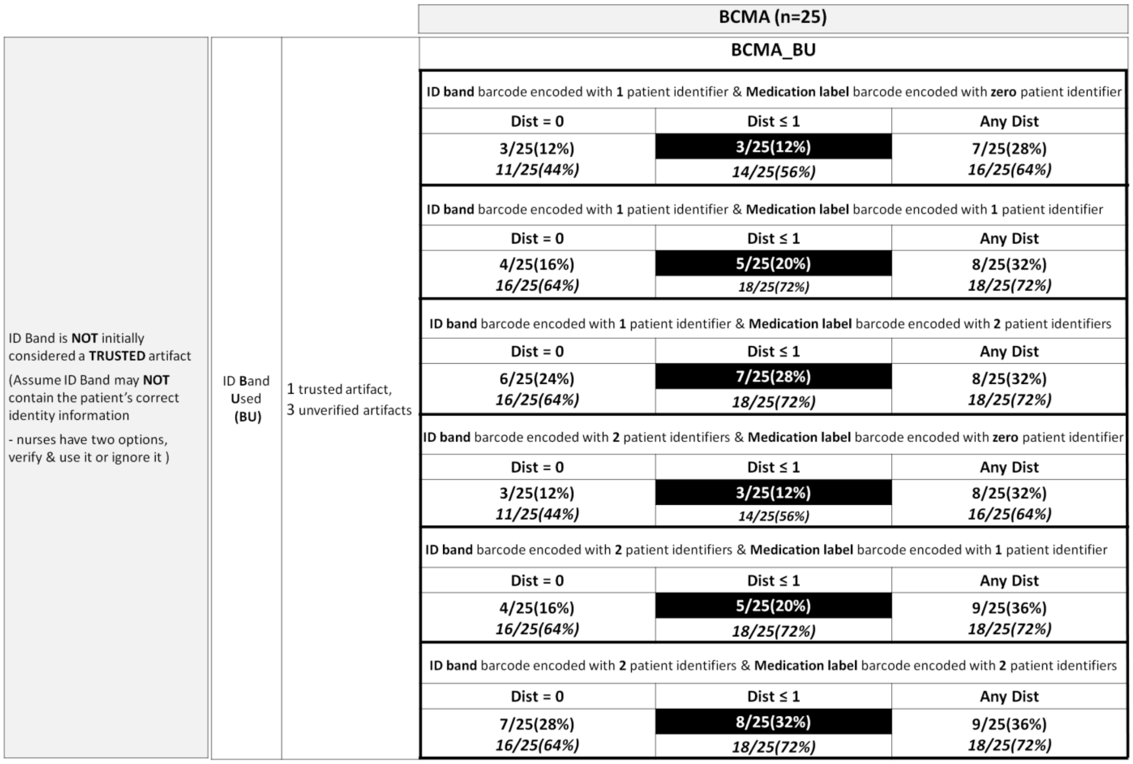
■ Results under a realistic set of assumptions

▨ Results under a relaxed set of assumptions

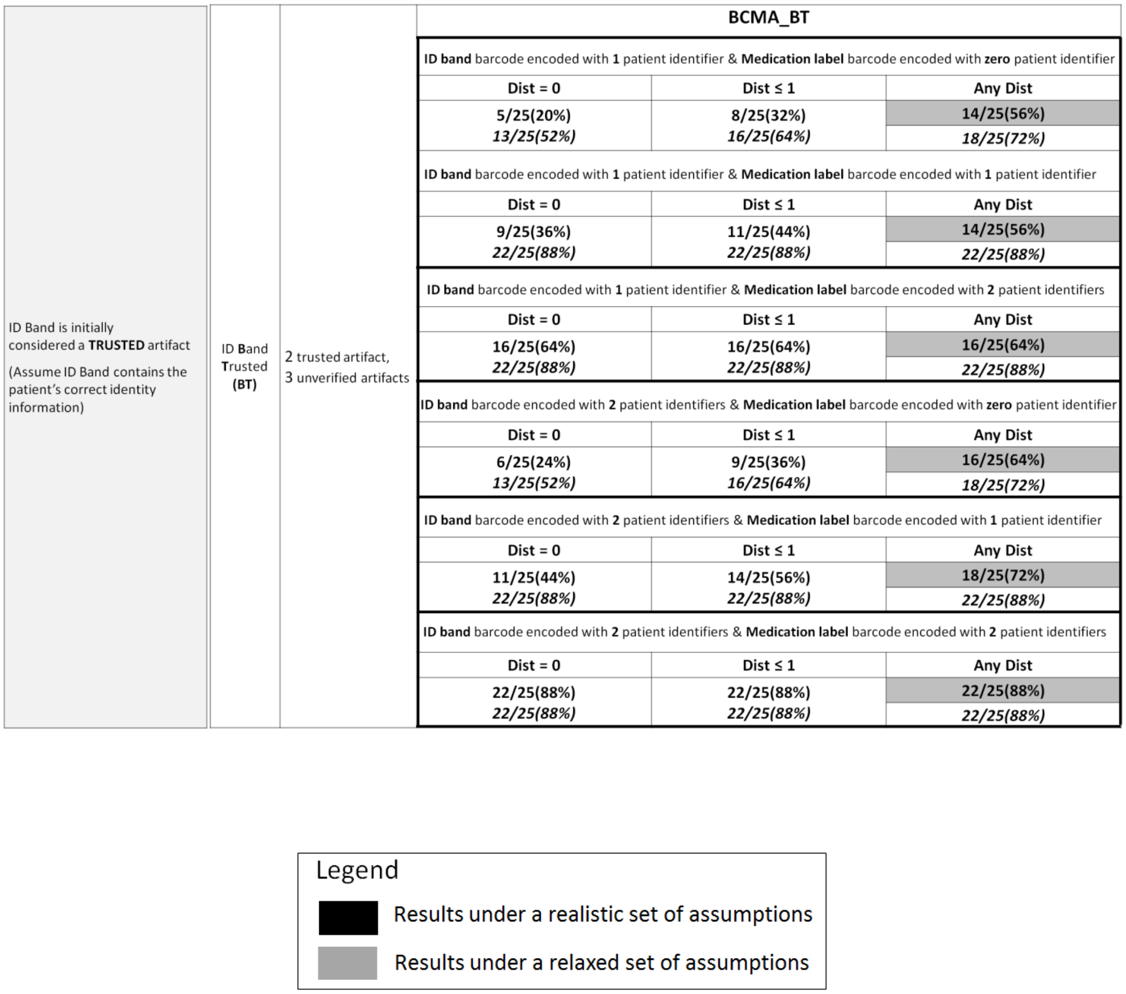
Figure 4.2. Number and percentage (rounded to the nearest integer) of traces complying with the Guidelines by matching at least two identifiers (upper numbers in non-italics) and by matching at least one identifier (lower numbers in italics) in MMA.

We compared results for what we consider a realistic set of assumptions (i.e., the ID band is not trusted, requiring its verification before being used and Dist ≤ 1) and a relaxed set of assumptions (i.e., the ID band is trusted and any Dist). In Figure 4.2, the results under the realistic assumptions are shown with a black background. The results under the relaxed assumptions are shown with a gray background. Under the realistic assumptions, the number of traces complying with the Guidelines is 1 out of 44 (2%). Under the relaxed assumptions, the number of traces complying with the Guidelines is 11 out of 44 (25%). Reducing the requirement of using at least two identifiers to using at least one identifier considerably increased the percentage of nurses complying with the Guidelines but would presumably increase the likelihood of VPI error. The percentages increased from 2% to 41% under the realistic assumptions and from 25% to 64% under the relaxed assumptions.

Figure 4.3 reproduces Figure 4.2 but replaces the results for MMA (i.e., the fourth column) with the results of BCMA - numbers and percentages of traces complying with the Guidelines for each of the 12 cases depending on what identifiers are encoded in the ID Band and medication label (see Chapter 3.4). Note that scanning the barcode on the patient's ID band is mandatory for conducting the VPI process in BCMA, so ID Band Ignored (BI) is not a possible case in BCMA and is thus excluded from this table.



			BCMA (n=25)		
			BCMA_BU		
ID Band is **NOT** initially considered a **TRUSTED** artifact (Assume ID Band may **NOT** contain the patient's correct identity information - nurses have two options, verify & use it or ignore it)	ID **B**and **U**sed **(BU)**	1 trusted artifact, 3 unverified artifacts	**ID band** barcode encoded with **1** patient identifier & **Medication label** barcode encoded with **zero** patient identifier		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			3/25(12%) ***11/25(44%)***	**3/25(12%)** ***14/25(56%)***	**7/25(28%)** ***16/25(64%)***
			ID band barcode encoded with **1** patient identifier & **Medication label** barcode encoded with **1** patient identifier		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			4/25(16%) ***16/25(64%)***	**5/25(20%)** ***18/25(72%)***	**8/25(32%)** ***18/25(72%)***
			ID band barcode encoded with **1** patient identifier & **Medication label** barcode encoded with **2** patient identifiers		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			6/25(24%) ***16/25(64%)***	**7/25(28%)** ***18/25(72%)***	**8/25(32%)** ***18/25(72%)***
			ID band barcode encoded with **2** patient identifiers & **Medication label** barcode encoded with **zero** patient identifier		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			3/25(12%) ***11/25(44%)***	**3/25(12%)** ***14/25(56%)***	**8/25(32%)** ***16/25(64%)***
			ID band barcode encoded with **2** patient identifiers & **Medication label** barcode encoded with **1** patient identifier		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			4/25(16%) ***16/25(64%)***	**5/25(20%)** ***18/25(72%)***	**9/25(36%)** ***18/25(72%)***
			ID band barcode encoded with **2** patient identifiers & **Medication label** barcode encoded with **2** patient identifiers		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			7/25(28%) ***16/25(64%)***	**8/25(32%)** ***18/25(72%)***	**9/25(36%)** ***18/25(72%)***



			BCMA_BT		
ID Band is initially considered a **TRUSTED** artifact (Assume ID Band contains the patient's correct identity information)	ID **B**and **T**rusted **(BT)**	2 trusted artifact, 3 unverified artifacts	**ID band** barcode encoded with **1** patient identifier & **Medication label** barcode encoded with **zero** patient identifier		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			5/25(20%) ***13/25(52%)***	**8/25(32%)** ***16/25(64%)***	**14/25(56%)** ***18/25(72%)***
			ID band barcode encoded with **1** patient identifier & **Medication label** barcode encoded with **1** patient identifier		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			9/25(36%) ***22/25(88%)***	**11/25(44%)** ***22/25(88%)***	**14/25(56%)** ***22/25(88%)***
			ID band barcode encoded with **1** patient identifier & **Medication label** barcode encoded with **2** patient identifiers		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			16/25(64%) ***22/25(88%)***	**16/25(64%)** ***22/25(88%)***	**16/25(64%)** ***22/25(88%)***
			ID band barcode encoded with **2** patient identifiers & **Medication label** barcode encoded with **zero** patient identifier		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			6/25(24%) ***13/25(52%)***	**9/25(36%)** ***16/25(64%)***	**16/25(64%)** ***18/25(72%)***
			ID band barcode encoded with **2** patient identifiers & **Medication label** barcode encoded with **1** patient identifier		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			11/25(44%) ***22/25(88%)***	**14/25(56%)** ***22/25(88%)***	**18/25(72%)** ***22/25(88%)***
			ID band barcode encoded with **2** patient identifiers & **Medication label** barcode encoded with **2** patient identifiers		
			Dist = 0	**Dist ≤ 1**	**Any Dist**
			22/25(88%) ***22/25(88%)***	**22/25(88%)** ***22/25(88%)***	**22/25(88%)** ***22/25(88%)***

Legend

■ Results under a realistic set of assumptions

▨ Results under a relaxed set of assumptions

Figure 4.3. Number and percentage (rounded to the nearest integer) of traces complying with the Guidelines by matching at least two identifiers (upper numbers in non-italics) and by matching at least one identifier (lower numbers in italics) in BCMA.

Depending on what information the nurses may have believed to be on the barcodes, the number of traces complying with the Guidelines ranges from 3 out of 25 (12%) to 8 out of 25 (32%) under the realistic assumptions and ranges from 14 out of 25 (56%) to 22 out of 25 (88%) under the relaxed assumptions. Reducing the requirement of using at least two identifiers to using at least one identifier considerably increased the percentage of nurses complying with the

Guidelines. For example, when the ID band barcode is encoded with 1 patient identifier and the medication label barcode is encoded with zero patient identifiers, the percentages increased from 12% to 56% under the realistic assumptions and from 56% to 72% under the relaxed assumptions.

BCMA increased compliance more than MMA. Assuming the barcodes on the ID band and medication label were encoded with two patient identifiers, the increase in the percentages was statistically significant (p = 0.001; Fisher exact test); however, assuming the barcode on the medication label was encoded with no patient identifiers, the increase was not statistically significant (p = 0.117; Fisher exact test).

4.4 Limitations

There are several limitations to our evaluation of nurse compliance with the Guidelines. First, the clinical simulations from the Henneman studies were conducted at a single hospital using emergency department nurses. We do not know whether the observed nurse behavior is comparable to that exhibited by other healthcare workers in other settings. Second, the simulated setting may not accurately reflect the actual clinical setting where there is more time pressure, noise, and interruptions. We would expect compliance to be even lower in a clinical setting where these pressures exist. Third, we had to discard 12 videos (21%) because of eye-tracking failures. Fourth, because of our small sample size, this analysis does not provide conclusive evidence about nurses' behaviors. Fifth, we assumed a patient's collective statements about their identity to be correct because at least one artifact must be trusted at the start of the process, but this may not always be true (e.g., altered level of consciousness, intellectual disability, language problem, patient deception). Sixth, we considered two situations in our analysis depending on whether the ID band was trusted or not. We do not know, however, whether or not nurses had been trained to trust the ID band. Seventh, we analyzed our results considering three values of intermediate events. If we knew more precisely the acceptable number of intermediate events between the first and the second part of a match, we could simplify the analysis of determining whether a nurse performed a match or not. Finally, our analysis made the assumption that if at least two patient identifiers were determined to be correct for an artifact, all of its identifiers were assumed to be correct. For example, two identifiers on an artifact could be verified and then two other identifiers on that artifact could be subsequently used to verify other artifacts. We don't know how frequently some, but not all, of the identifiers on an artifact are wrong. Since, this thesis did not focus on selecting patient identifiers, errors associated with some incorrect identifiers were not considered.

4.5 Discussion

We believe our Guidelines are consistent with the intent of the Joint Commission guidelines and made it possible for us to determine nurse compliance for VPI. When we evaluated whether nurses complied with the Guidelines during clinical simulations of medication administration, we found that a small percentage of nurses complied with the Guidelines regardless of whether they used MMA or BCMA. Note that the compliance in BCMA was measured under the assumption that the nurse fixated on every identifier on the computer screen when screen glare obscured our ability to identify what the nurse was actually fixating on during the trials. Thus, the number of identifiers assumed in this analysis is an upper bound on the true number of identifiers that the nurses actually matched; still, only 12% - 32% complied in BCMA. Regardless of which barcode design the nurses may have believed to be applicable, few nurses complied with the guidelines; compliance ranged from 12% assuming the barcode on the medication label was encoded with no patient identifiers to 32% assuming the barcodes on the ID band and medication label were encoded with two patient identifiers. One reason for such low compliance is that the nurses did not perform the manual match(es) still required in BCMA. For example, encoding two patient identifiers on the ID band and medication label barcodes still requires one manual match for compliance. Most nurses scanned the two barcodes but did not perform the required manual match and so did not comply with the Guidelines. Nurses' failures to comply with the Guidelines suggest that BCMA technology alone does not cover the VPI process, so there is a need for further studies to improve nurses' compliance.

Table 4.1. Summary of the percentage of traces complying with the artifact-explicit guidelines under a realistic set of assumptions.

	MMA	**BCMA**
Total	44	25
Compliance	1(2%)	3(12%) - 8(32%)

The use of barcodes in improving accurate patient identification has obtained considerable attention. Several studies suggest that the barcode verification technology that supports medication administration has the potential to improve patient safety by reducing medication errors (Paoletti et al., 2007; Poon et al., 2010; Rivish et al., 2010). Despite this benefit, some studies have shown that barcode verification technology may create new kinds of errors and have unexpected impacts on patient safety (Akowski et al., 2008; Patterson et al., 2002; McDonald, 2006). Our results show that the use of barcode verification technology improved compliance with the Guidelines (the percentages increased from 2% up to 32%). One possible interpretation of this result is that the improvement in compliance is due to a reduction in the cognitive burden associated with lowering the number of artifact pairs requiring manual matches.

Our findings suggest several ways of improving nurse compliance with the Guidelines that should be studied further. One possible reason for low nurse compliance with the Guidelines could be that nurses are not being trained adequately to fulfill the Guidelines. Nurse compliance might be improved by more carefully explaining the Guidelines, especially with respect to the selection of artifacts. Another reason for low compliance might be that the large number of alternatives allowed by the Guidelines makes the Guidelines difficult to remember. Thus, it may be possible to improve compliance by simplifying the process, perhaps by reducing the number of possible alternatives for VPI. For example, one way to reduce the number of alternatives for VPI, thereby reducing cognitive burden, would be to train healthcare workers to select one trusted artifact and use it to verify each of the other unverified artifacts that will be used.

For BCMA, compliance with the Guidelines may improve if healthcare workers are aware of the information encoded on barcodes, as the appropriate VPI process depends on the barcode design. Teaching healthcare workers a specific sequence of actions for VPI based on the chosen barcode design may prevent healthcare workers from having to choose among different alternatives. Selected strategies should also account for concerns that have been noted in other studies, such as time pressures, nurses' confidence in their existing practices, and the potential to irritate patients (Paparella, 2012; Phipps et al., 2012).

CHAPTER 5

IMPROVING COMPLIANCE WITH ARTIFACT-EXPLICIT GUIDELINES

In the study described in Chapter 4, we found that only a small percentage of nurses complied with the artifact-explicit guidelines, whether they were verifying patient identifiers manually or using barcode technology. In the study described in this chapter, we propose a guideline-based training strategy to improve compliance with the artifact-explicit guidelines. We then describe how we experimentally evaluated the proposed training method to an approach currently used in nursing student education.

5.1 Proposed training strategy

VPI training practices are not well-documented, thus we made several assumptions with the help of domain experts. We assume that the nurses who participated in our preliminary study received the following types of training, both focused on selecting appropriate patient identifiers, consistent with the emphasis of the Joint Commission guidelines:

- In nursing school, they were given textbook-based procedural guidelines
- In the workplace, they were given polices and/or procedures during their job orientation

We hypothesized that one reason for the low rate of nurse compliance could be that VPI training focuses on how to select patient identifiers but not on how to select artifact pairs. Nurse compliance might be improved if healthcare workers are trained using our proposed artifact-explicit guidelines, which include directions on the selection of artifact pairs.

Another reason for low compliance might be that the large number of alternatives allowed by the artifact-explicit guidelines makes the guidelines difficult to remember. Thus, it may be possible for us to improve compliance with the guidelines if we simplify the process by reducing the number of alternatives for VPI. One way to reduce the number of alternatives for VPI is to tell individuals exactly which steps to complete.

In this study, we proposed a strategy that would ideally improve compliance with the artifact-explicit guidelines by training individuals to follow an explicit sequence of actions for VPI, specifically with respect to the selection of artifact pairs. We term this type of training *definitive procedure-based training*. In the medical domain, healthcare workers use checklists, an approach similar to that of definitive procedure-based training. Checklists are widely used to reduce human error, thereby reducing the number of potential medical errors (Avrunin et al., 2012; Bergeron et al., 2001; Hales and Pronovost, 2006). Studies have shown that checklists contribute significantly to improvements in compliance with various key practices (Hall et al., 2004; Pronovost et al., 2003; Wolff et al., 2014).

We hypothesized that after receiving definitive procedure-based training, individuals will be better able to comply with artifact-explicit guidelines.

5.2 Definitive procedure

There are several approaches for specifying the definitive procedure to be used in the training, though they range in complexity.

One definitive procedure might say to match a currently unverified artifact with a trusted artifact. Thus, the first selected pair would include the trusted artifact and any unverified artifact. The next pair could include the trusted or newly verified artifact[3] and another unverified artifact, and so on. Using this definitive procedure, however, may make it difficult for healthcare workers to keep track of the status of each artifact - whether it is trusted, newly verified, or unverified - thus increasing the likelihood of error.

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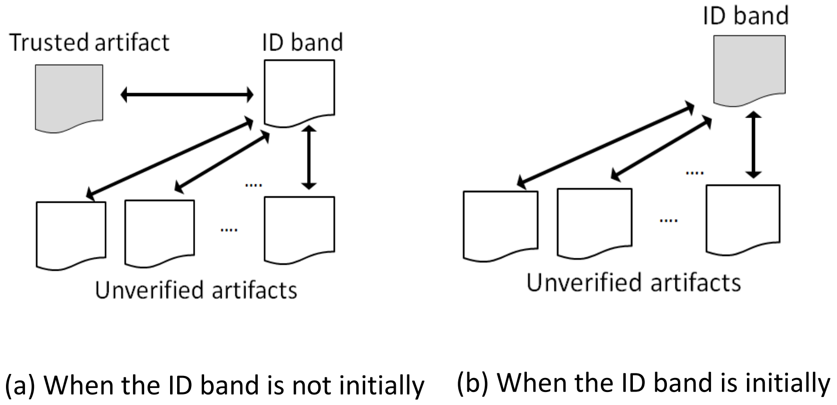
[3] The artifact was initially an unverified artifact but is now considered to be a verified artifact. This is because at least two patient identifiers have been matched with the corresponding identifiers from another artifact that is considered to be trusted.

Another definitive procedure might say to select one trusted artifact and use it to verify all unverified artifacts that will be used in the process. This definitive procedure is simple to follow, since all matches are done with the initially selected trusted artifact. In this case, however, if the trusted artifact is the patient’s statement confirming their identity, healthcare workers must continuously question patients, which may potentially irritate them.

Our definitive procedure states that healthcare workers should use the ID band as the trusted artifact, as it contains only patient identity information and is available for all patients. Ideally, the ID band should be verified and secured to the patient during registration, which would make the ID band a trusted artifact at the start of any later processes. Studies have shown, however, that some patients’ ID bands may contain incorrect information (Dhatt et al., 2011; Sevdalis et al., 2009; Snyder et al., 2010). Thus, this definitive procedure needs to take into account two cases: the ID band is not initially considered a trusted artifact or the ID band is initially considered a trusted artifact. When the ID band is not initially considered a trusted artifact, as shown in Figure 5.1 (a), healthcare workers should first verify the ID band using a trusted artifact (e.g., patient’s statements) and then use the trusted ID band to verify all unverified artifacts that will be used. When the ID band is initially considered a trusted artifact, as shown in Figure 5.1 (b), healthcare workers should use the ID band to verify all unverified artifacts that will be used.



(a) When the ID band is not initially (b) When the ID band is initially

Figure 5.1. Example of the definitive procedure

5.3 Research questions and hypotheses

In this study, we answered two broad research questions:

- Research question 1 (RQ1): Does definitive procedure-based training improve healthcare workers' compliance with the artifact-explicit guidelines more than does current training?

To address this question, we examined two sub questions. In the 'simple' task, participants administered one medication to a patient. In the 'complex' task, participants administered two medications to a patient. Regarding RQ1.1 and RQ1.2, we hypothesize that definitive procedure-based training will result in better compliance than does the current training (H1).

  - Research question 1.1 (RQ1.1): For the simple task, does definitive procedure-based training improve healthcare workers' compliance with the artifact-explicit guidelines more than does current training?

    - Research question 1.2 (RQ1.2): For the complex task, does definitive procedure-based training improve healthcare workers' compliance with the artifact-explicit guidelines more than does current training?

Ideally, the effectiveness of the training should be valid regardless of the task's complexity on which the training is to be applied. Thus, we examined whether the definitive procedure-based training produced consistent results across a simple (administering one medication) and a complex (administering two medications) task.

Additionally, the effectiveness of the definitive procedure-based training should be preserved when moving from the simple task to the complex task. That is, the smaller the decrement, the more useful the training. Our second research question is therefore as follows:

- Research question 2 (RQ2): Does definitive procedure-based training reduce the decrement in compliance with the artifact-explicit guidelines when moving from the simple task to the complex task more than does current training?

Regarding RQ2, we hypothesize that definitive procedure-based training will reduce the decrement in compliance when moving from the simple task to the complex task more than does current training (H2).

5.4 Experimental design

We conducted the experiment at the College of Nursing at the University of Massachusetts Amherst. During the experiment, we observed nursing students (n=48) as they conduct MMA in a simulated patient care setting. All participating nursing students were juniors and had learned about the concept of patient safety. For this experiment, we did not involve barcode technology since most hospitals still manually perform VPI when administrating medications. Even when barcode technology is used, there are still situations where VPI must be performed manually (e.g., barcode scanner errors). This experiment was approved by the University of Massachusetts Amherst's Institutional Review Board.

Participants were divided into two groups: one group was provided with current training material; another group was provided the definitive procedure-based training material. For the current training, a domain expert slightly modified the 'General Drug Administration Guidelines' obtained from a textbook[4] currently used at the College of Nursing at the University of Massachusetts Amherst (Figure 5.2).

We created the definitive procedure-based training materials with the help of a domain expert (Figure 5.3). The training materials serve as a guide for each step of the process, suggesting which specific artifact pairs should be selected and which two patient identifiers should be matched.

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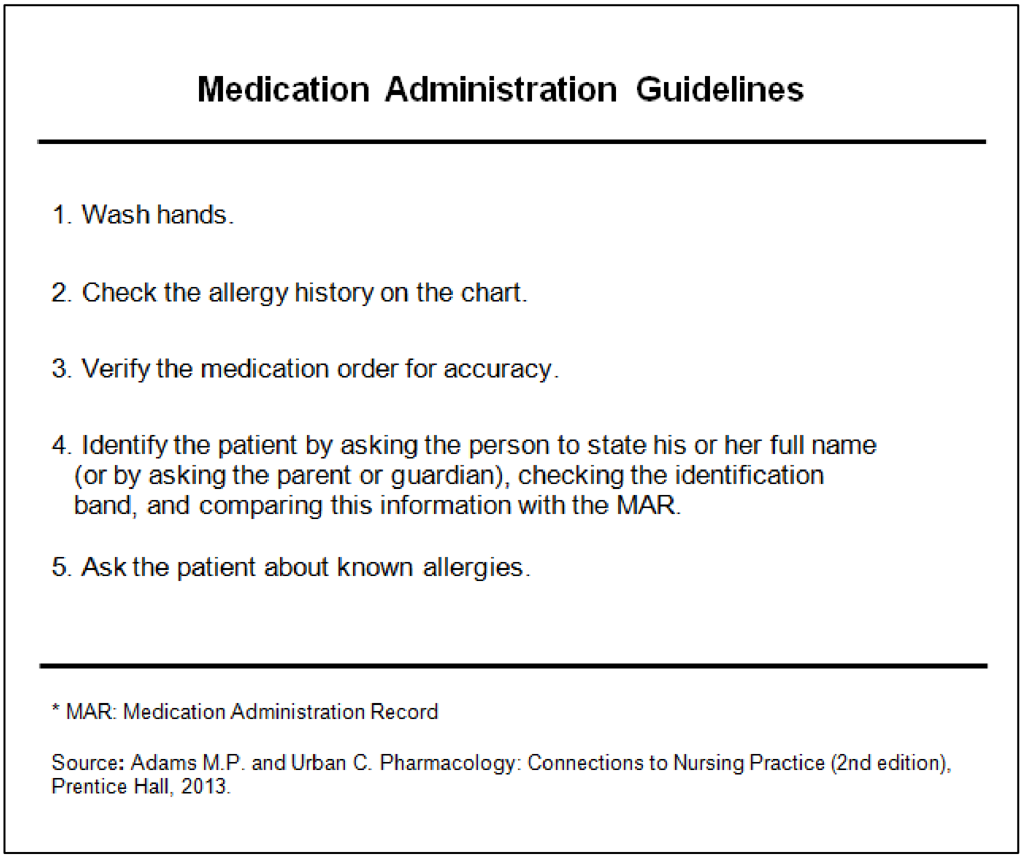
[4] Source: Adams M.P. and Urban C. Pharmacology: Connections to Nursing Practice, 2nd edition, Prentice Hall, 2013



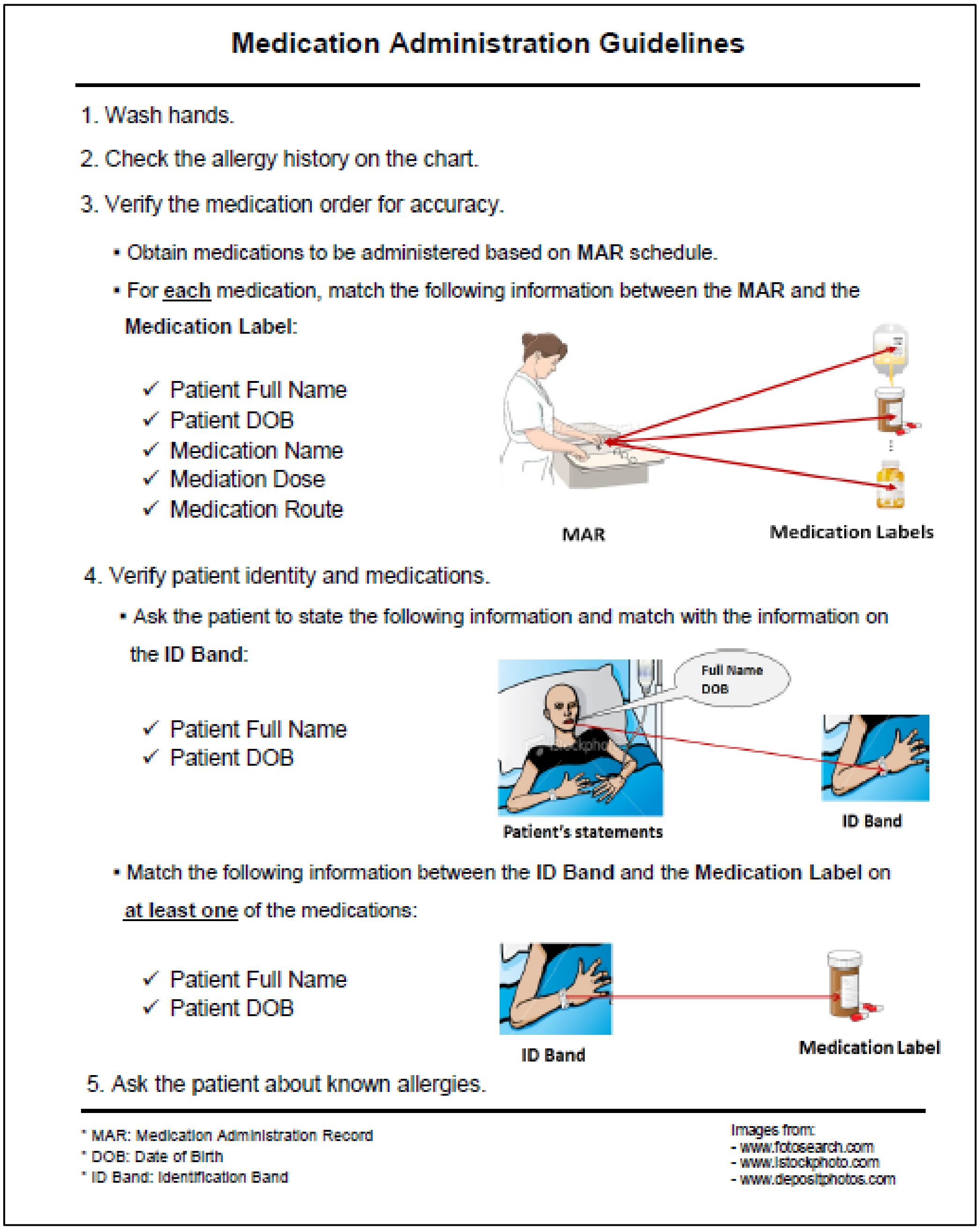
Medication Administration Guidelines

1. Wash hands.
2. Check the allergy history on the chart.
3. Verify the medication order for accuracy.
4. Identify the patient by asking the person to state his or her full name (or by asking the parent or guardian), checking the identification band, and comparing this information with the MAR.
5. Ask the patient about known allergies.

* MAR: Medication Administration Record

Source**:** Adams M.P. and Urban C. Pharmacology: Connections to Nursing Practice (2nd edition), Prentice Hall, 2013.

Figure 5.2. Current training material for MMA



Medication Administration Guidelines

1. Wash hands.
2. Check the allergy history on the chart.
3. Verify the medication order for accuracy.
    - Obtain medications to be administered based on **MAR** schedule.
    - For each medication, match the following information between the **MAR** and the **Medication Label**:
        - ✓ Patient Full Name
        - ✓ Patient DOB
        - ✓ Medication Name
        - ✓ Mediation Dose
        - ✓ Medication Route

4. Verify patient identity and medications.
    - Ask the patient to state the following information and match with the information on the **ID Band**:
        - ✓ Patient Full Name
        - ✓ Patient DOB

    - Match the following information between the **ID Band** and the **Medication Label** on **at least one** of the medications:
        - ✓ Patient Full Name
        - ✓ Patient DOB

5. Ask the patient about known allergies.

* MAR: Medication Administration Record
* DOB: Date of Birth
* ID Band: Identification Band

Images from:
- www.fotosearch.com
- www.istockphoto.com
- www.depositphotos.com

Figure 5.3. Definitive procedure-based training material for MMA

All participants read and signed informed consent forms. Each participant was asked to read a script and nursing report (Appendix C). The script described that the purpose of the study was to compare two methods for teaching medication administration; thus, the participants would not be aware that the purpose of the study is to evaluate the VPI process. The nursing report explained that the health condition of the patient and asked to administer medication(s) to the patient.

The experimental session consisted of four parts, as shown in Figure 5.4. In the first part (pre-test), all participants were asked to perform MMA given the following artifacts: a patient, an ID band on their wrist, a medication administration record (MAR), and a medication. In the second part (intervention), half of the participants were trained using the current training material (control group) and the other half were trained using our proposed definitive procedure-based training material (treatment group). In the third part (post-test with the simple task), all participants were asked to perform MMA, and were given the same artifacts that were used in the pre-test. In the fourth part (post-test with the complex task), all participants were asked to perform MMA, and were given two medications instead of one medication. We gave permission to participants to refer to the training material while they performed the process, but did not answer questions about the training materials.

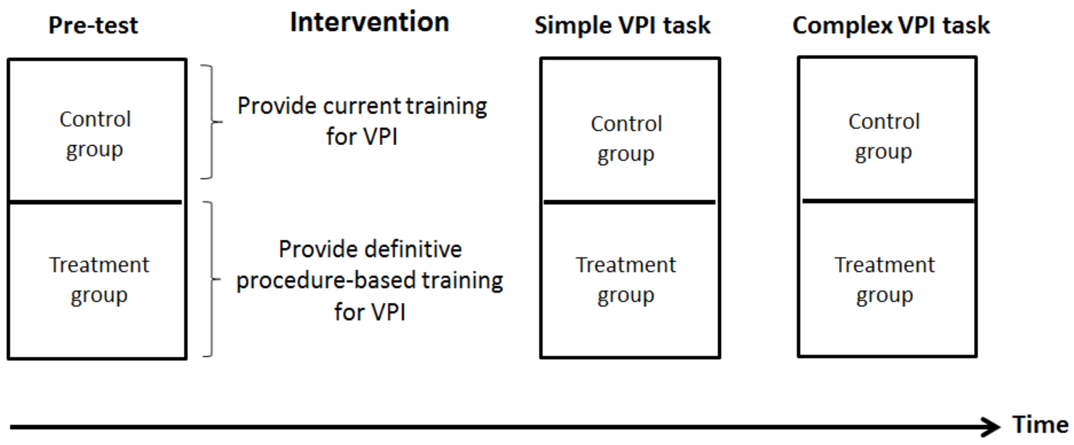
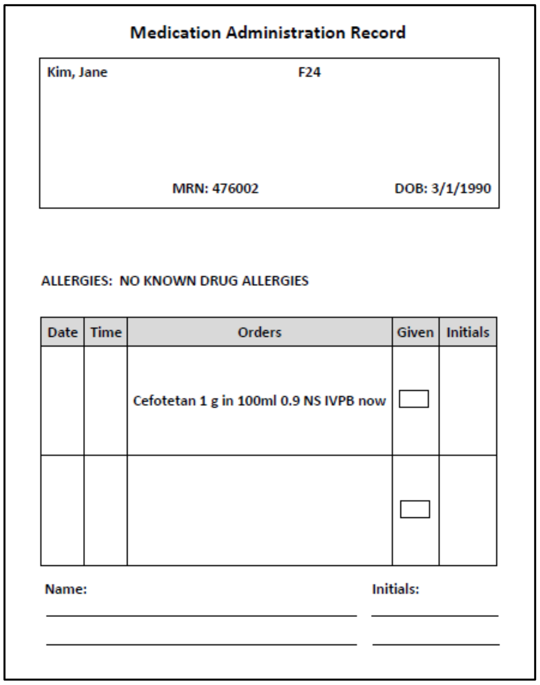

Pre-test
Intervention
Simple VPI task
Complex VPI task
Control group
Treatment group
Provide current training for VPI
Provide definitive procedure-based training for VPI
Control group
Treatment group
Control group
Treatment group
Time

Figure 5.4. Experimental design

During all tasks, the participants wore an eye-tracking device, and a camera on the device recorded a video of each participant's view. After placing and calibrating the eye-tracking device (Appendix D), a researcher led the participant to the simulated patient room where a student acting as a patient was waiting. Each patient had an ID band secured to their wrist. The researcher gave the participant a clipboard with a MAR and asked the participant to pick out the medications for the patient from the medication station (a table placing several patients' medications) and to administrate the picked medications to the patient. In the simple task, the participant is supposed to administrate IV bag; during the complex task, the participant supposed to administrate both IV bag and Tylenol bag.

As shown in Figure 5.5, we labeled all artifacts with patient identifiers in exactly the same way. We designed the labels to look realistic yet but with the patient identifiers more spread out. We placed the patient identifiers on different vertical and/or horizontal axes on the labels to make it easier to distinguish which specific patient identifier the participant was looking at. The MAR, ID band, and the medication bags were labeled with a patient's name, gender/age, MRN, and DOB; the medication bags were labeled with the medication name and dose along with the patient identifiers.



Medication Administration Record

Kim, Jane F24

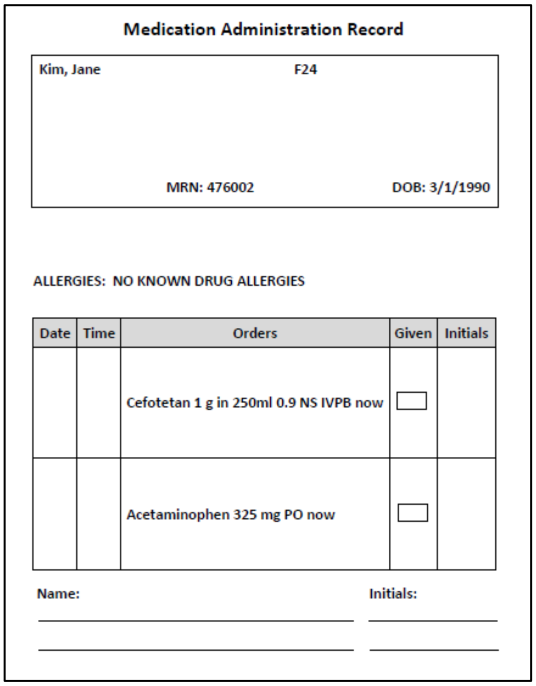
MRN: 476002 DOB: 3/1/1990

ALLERGIES: NO KNOWN DRUG ALLERGIES

Date	Time	Orders	Given	Initials
		Cefotetan 1 g in 100ml 0.9 NS IVPB now	☐	
			☐	

Name: Initials:

A MAR for the simple task



Medication Administration Record

Kim, Jane F24

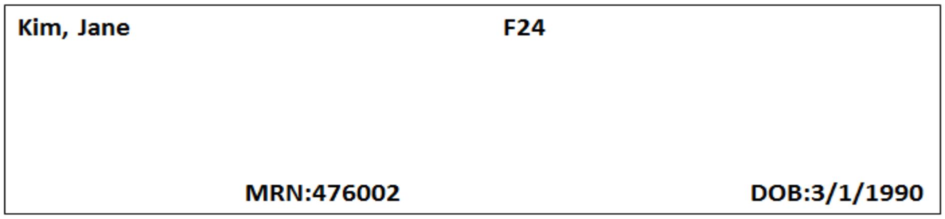
MRN: 476002 DOB: 3/1/1990

ALLERGIES: NO KNOWN DRUG ALLERGIES

Date	Time	Orders	Given	Initials
		Cefotetan 1 g in 250ml 0.9 NS IVPB now	☐	
		Acetaminophen 325 mg PO now	☐	

Name: Initials:

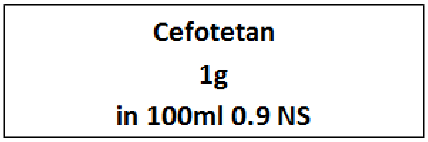
A MAR for the complex task



Kim, Jane **F24**

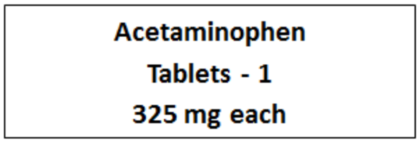
MRN:476002 **DOB:3/1/1990**

A label for the ID band, IV bag, and Tylenol bag



Cefotetan
1g
in 100ml 0.9 NS

A label for IV bag



Acetaminophen
Tablets - 1
325 mg each

A label for Tylenol bag

Figure 5.5. Experiment artifacts

5.5 Analysis approach

After completing the experiments, we reviewed the eye-tracking videos for quality. Of the 53 videos created during the experiments, we discarded 5 (9%) videos because of insufficient video quality, leaving 48 (91%) videos for our analysis. Of the 48 videos, half of the videos (n=24) belong to the control group associated with the current training; the other half of the videos (n=24), to the treatment group associated with the definitive procedure-based training.

We carefully translated the videos into traces. We defined event names based on a set of predefined activities associated with VPI during medication administration (Appendix E) and developed guidelines for generating a trace from a video (Appendix F). Given the standardized set of event names and the guidelines, two volunteers independently reviewed the videos and created the event sequences. The inter-rater agreement between the two volunteers generating traces regarding all events (n=71) was 76% (k=0.76) and the percentage agreement was 90%; regarding only events related with compliance with the Joint Commission guidelines (n=18), the inter-rater agreement was 72% (k=0.72) and the percentage agreement was 88% (Appendix G).

In those cases when there was disagreement between the two coders over an event assignment, a third volunteer reviewed the video and resolved the conflict. One experienced researcher reviewed the reconciled traces by focusing on the participants' verbal steps (e.g., ask patient's name, ask patient's DOB, and ask allergies) and made the final decision on the event assignment. Those videos failing to synchronize between the participant's voice and image on the video required special attention for encoding the associated verbal steps.

The finalized traces were analyzed to evaluate whether the participants complied with the artifact-explicit guidelines. As we did in our previous study, we analyzed the traces by considering the acceptable number of intermediate events between the first and the second part of a match. Figure 5.6 shows one example of such a case where the Dist of the match between the ID Band and MAR to confirm a patient's name is 2 because there are two intermediate events (i.e., Looked at DOB on ID Band and Stated DOB by Patient) between the first and second part of the match; the Dist of the match between the ID Band and MAR to confirm a patient's DOB is 2 because there are two intermediate events (i.e., Stated DOB by Patient and Looked at Name on MAR) between the first and second part of the match.

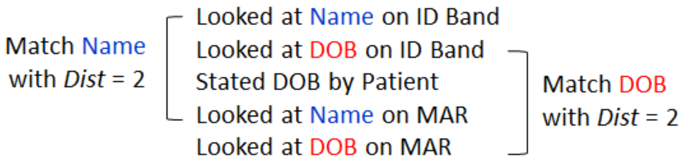
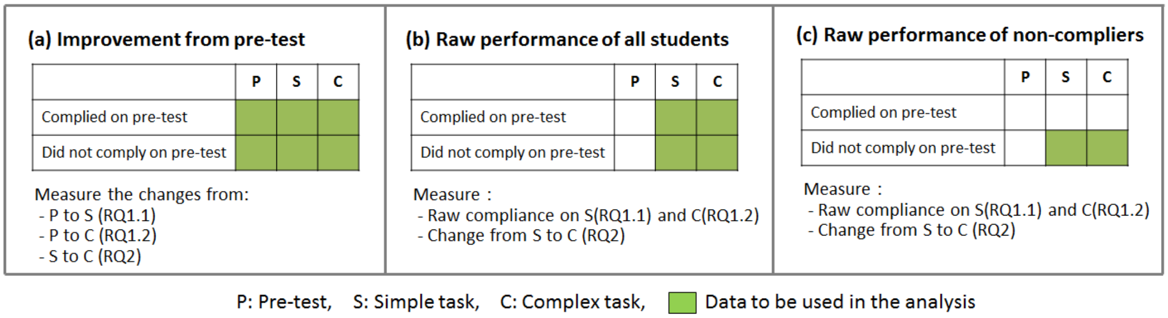


Figure 5.6. An example of a shortened trace from nursing students showing matching two patient identifiers between the ID Band and MAR

When we analyzed traces to determine compliance, we considered what we deemed a *realistic* set of assumptions: the ID band is not trusted, requiring its verification before being used and Dist ≤ 2. Studies have shown that some patients' ID bands contain incorrect information (Dhatt et al., 2011; Sevdalis et al., 2009; Snyder et al., 2010) and so considering the ID band not to be trusted would be a more realistic consideration than trusting the ID band. In Chapter 5.7, we discuss the limitations of choosing the value of the Dist.

We analyzed our data in several ways. In Figure 5.7 (a), we used the data from all participants and measured the compliance changes from the pre-test. Figure 5.7 (b) describes the analysis involving the data from all participants' performance in the simple and complex tasks (not from the pre-test) since it is unknown why some participants complied in the pre-test. Figure 5.7 (c) describes the analysis involving the data from only the participants who did not comply in the pre-test. For those participants who did comply in the pre-test, we could not be sure that their subsequent compliance resulted from previous experience or our training. Thus, we used data only for those non-complying participants' performance in in the simple and complex tasks. In Figure 5.7 (b) and 5.7 (c), raw compliance in the simple task and complex task is used to address RQ 1.1 and RQ 1.2, respectively. Compliance change from the simple to the complex task is used to address RQ2.


(a) Improvement from pre-test

	P	S	C
Complied on pre-test	🟩	🟩	🟩
Did not comply on pre-test	🟩	🟩	🟩

Measure the changes from:
- P to S (RQ1.1)
- P to C (RQ1.2)
- S to C (RQ2)

(b) Raw performance of all students

	P	S	C
Complied on pre-test		🟩	🟩
Did not comply on pre-test		🟩	🟩

Measure :
- Raw compliance on S(RQ1.1) and C(RQ1.2)
- Change from S to C (RQ2)

(c) Raw performance of non-compliers

	P	S	C
Complied on pre-test			
Did not comply on pre-test		🟩	🟩

Measure :
- Raw compliance on S(RQ1.1) and C(RQ1.2)
- Change from S to C (RQ2)

P: Pre-test, S: Simple task, C: Complex task, 🟩 Data to be used in the analysis

Figure 5.7. Three different methods of analysis

We conducted the aforementioned analyses assuming the ID Band was not trusted, but considering both Dist ≤ 2, and a more stringent Dist ≤ 1, meaning only 0 or 1 number of intermediate events are allowed between the first and the second part of a match. Under the more stringent assumptions, for all three of the aforementioned analysis approaches, we found that those students who received the definitive procedure-based training showed an increase in compliance, but this was not statically significant.

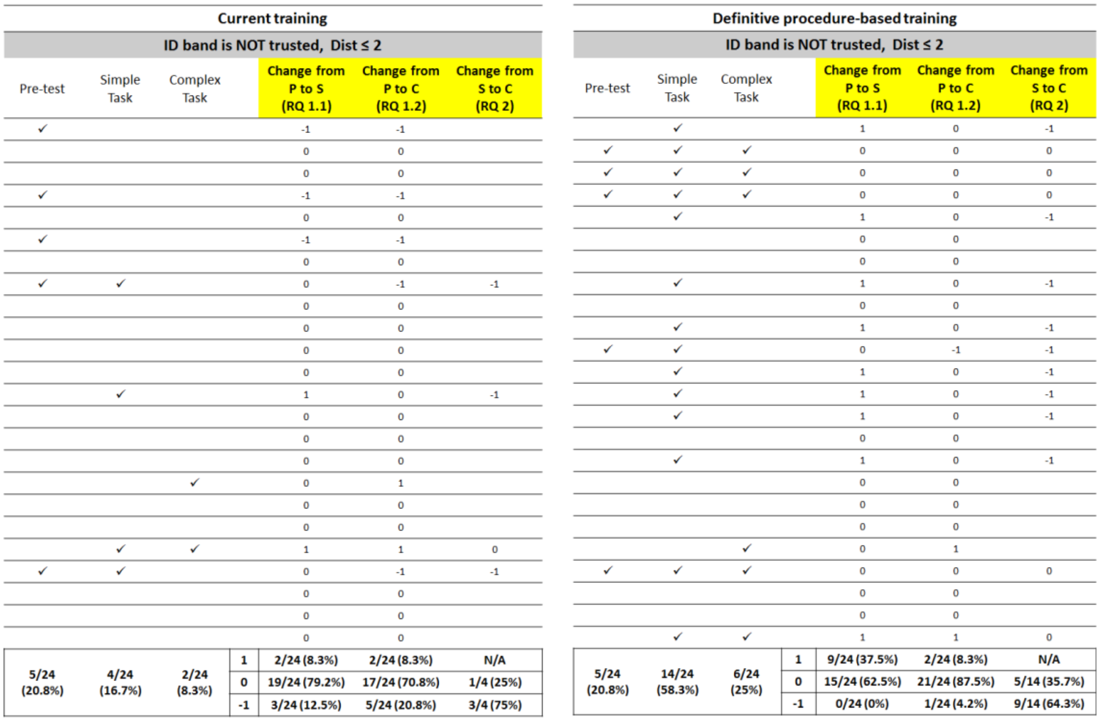
Among these six different analyses – three analyses under realistic assumptions and another three analyses using more stringent assumptions – we present one below, consisting of the data and approach shown in 20(a), and assumed assuming the ID Band was not trusted and Dist ≤ 2. The results of the other five analyses are reported in Appendix H.

5.6 Results

Of the 24 participants given the definitive procedure-based training, the number of participants who complied with the artifact-explicit guidelines was: 5 (20.8%) in the pre-test, 14 (58.3%) in the simple task, and 6 (25%) in the complex task.

Table 5.1 shows these results; the left table is for the current training and the other is for the definitive procedure-based training. The first three columns of each table show the compliance for each task. The remaining three columns show the compliance change from one task to another task. Specifically, the fourth column indicates compliance change when each participant moved from the pre-test to the simple task. The compliance change is classified using three values, -1, 0, and 1; where -1 indicates compliance "got worse" implying that the participant did comply in the pretest but not in the complex task; 0 indicates compliance "did not change" implying that the participant did (did not) comply in the pretest and also did (did not) comply in the complex task; 1 indicates compliance "improved" implying that the participant did not comply in the pretest but did comply in the complex task. Similarly, the fifth column indicates compliance change when each participant moved from the pre-test to the complex task, and the sixth column indicates compliance change when each participant moved from the simple to the complex task. Of these results, the percentage of participants whose compliance "improved" from the pre-test to the simple task is used to address RQ 1.1; from the pre-test to the complex task is used to address RQ 1.2; and from the simple task to the complex task is used to address RQ 2.

Table 5.1. Compliance results



Current training						
ID band is NOT trusted, Dist ≤ 2						
Pre-test	Simple Task	Complex Task		Change from P to S (RQ 1.1)	Change from P to C (RQ 1.2)	Change from S to C (RQ 2)
✓				-1	-1	
				0	0	
				0	0	
✓				-1	-1	
				0	0	
✓				-1	-1	
				0	0	
✓	✓			0	-1	-1
				0	0	
				0	0	
				0	0	
				0	0	
	✓			1	0	-1
				0	0	
				0	0	
				0	0	
		✓		0	1	
				0	0	
				0	0	
	✓	✓		1	1	0
✓	✓			0	-1	-1
				0	0	
				0	0	
				0	0	
5/24 (20.8%)	**4/24 (16.7%)**	**2/24 (8.3%)**	**1**	**2/24 (8.3%)**	**2/24 (8.3%)**	**N/A**
			0	**19/24 (79.2%)**	**17/24 (70.8%)**	**1/4 (25%)**
			-1	**3/24 (12.5%)**	**5/24 (20.8%)**	**3/4 (75%)**

Definitive procedure-based training						
ID band is NOT trusted, Dist ≤ 2						
Pre-test	Simple Task	Complex Task		Change from P to S (RQ 1.1)	Change from P to C (RQ 1.2)	Change from S to C (RQ 2)
	✓			1	0	-1
✓	✓	✓		0	0	0
✓	✓	✓		0	0	0
✓	✓	✓		0	0	0
	✓			1	0	-1
				0	0	
				0	0	
	✓			1	0	-1
				0	0	
	✓			1	0	-1
✓	✓			0	-1	-1
	✓			1	0	-1
	✓			1	0	-1
	✓			1	0	-1
				0	0	
	✓			1	0	-1
				0	0	
				0	0	
				0	0	
		✓		0	1	
✓	✓	✓		0	0	0
				0	0	
				0	0	
	✓	✓		1	1	0
5/24 (20.8%)	**14/24 (58.3%)**	**6/24 (25%)**	**1**	**9/24 (37.5%)**	**2/24 (8.3%)**	**N/A**
			0	**15/24 (62.5%)**	**21/24 (87.5%)**	**5/14 (35.7%)**
			-1	**0/24 (0%)**	**1/24 (4.2%)**	**9/14 (64.3%)**

✓: Comply, **1**: Improved, **0**: Did not change, -**1**: Got worse

Change from P to S: Compliance when moving from the **P**re-test to a **S**imple task
Change from P to C: Compliance when moving from the **P**re-test to a **C**omplex task
Change from S to C: Compliance when moving from a **S**imple task to a **C**omplex task

The compliance change between the two groups of the participants is shown in Figure 5.8. Those participants who received the definitive procedure-based training showed an increase in compliance from the pre-test to the simple task (see Figure 5.8 (a)): 8.3% of participants who received the current training improved compliance; 37.5% of participants who received the definitive procedure-based training improved compliance. The increase in the percentages was statistically significant (p=0.012; Fisher exact test). Those students who received the definitive procedure-based training showed no change in compliance from the pre-test to the complex task (see Figure 5.8 (b)): 8.3% of participants who received the current training improved compliance;

8.3% of participants who received the definitive procedure-based training improved compliance. Those students who received the definitive procedure-based training showed an increase in compliance when moving from the simple task to the complex task (see Figure 5.8 (c)): 25% of participants who received the current training improved compliance; 35.7% of participants who received the definitive procedure-based training improved compliance.

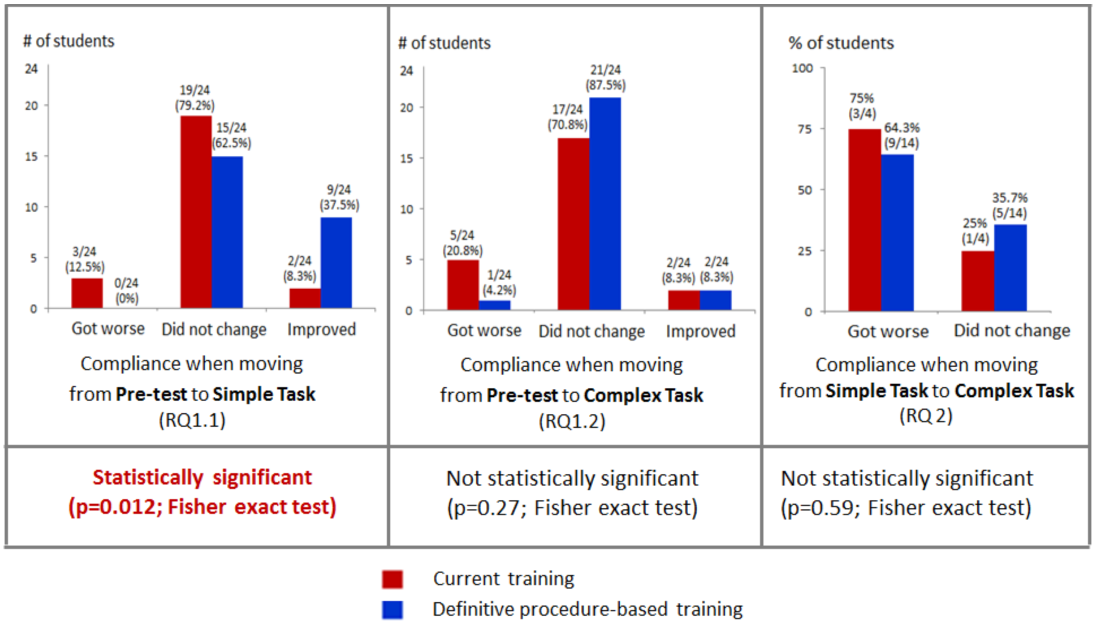
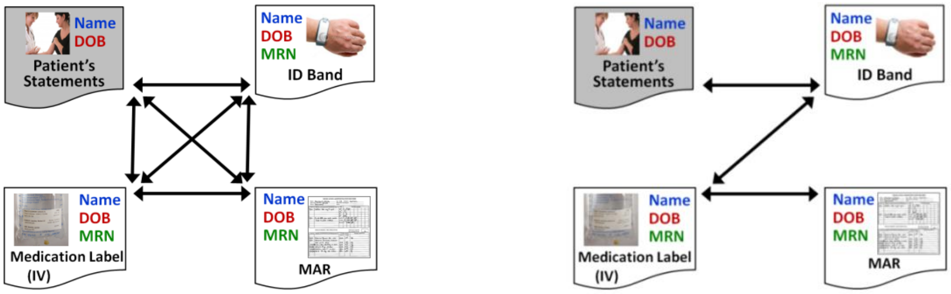


Figure 5.8. Difference in compliance between two groups

For each of the complying participants who were given the definitive procedure-based training, we identified which ISAPs were used for VPI. This analysis is valuable for investigating whether the participants used the ISAP advocated by the training. In the simple task, as shown in Figure 5.9 (a), the four artifacts resulted in six artifact pairs potentially available for VPI, where the total number of possible minimal ISAPs is 16. Among these 16, the minimal ISAP advocated by the definitive procedure-based training is shown in Figure 5.9 (b).


Name
DOB
Patient's Statements
Name
DOB
MRN
ID Band
Name
DOB
MRN
Medication Label (IV)
Name
DOB
MRN
MAR

(a) 6 APs potentially available for VPI

(b) The minimal ISAP advocated by the definitive procedure-based training

Figure 5.9. The advocated minimal ISAP in the Simple Task

Figure 5.10 shows all of the ISAPs used by participants who complied with the artifact-explicit guidelines during the simple task (n=14). The percentage of complying students who used an ISAP recommended by the definitive procedure-based training is 28.6% (4 out of 14).

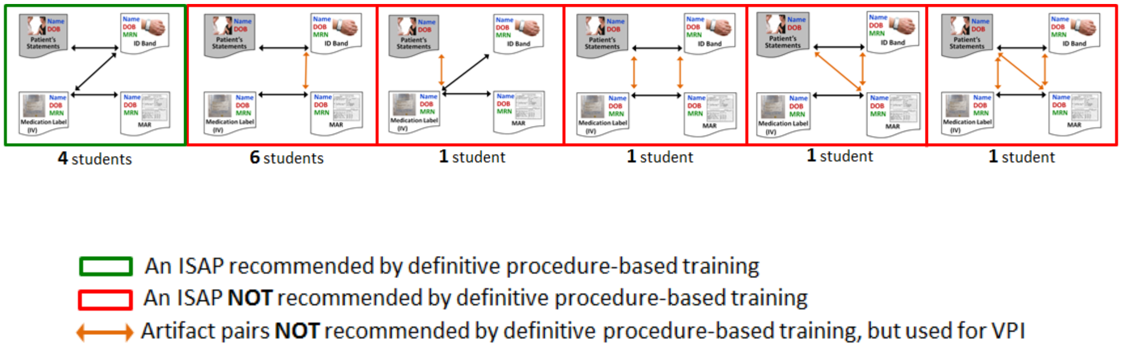

4 students
6 students
1 student
1 student
1 student
1 student
An ISAP recommended by definitive procedure-based training
An ISAP NOT recommended by definitive procedure-based training
Artifact pairs NOT recommended by definitive procedure-based training, but used for VPI

Figure 5.10. ISAPs used by students who complied in the Simple Task (n=14)

Among the four participants who used an ISAP recommended by the definitive procedure-based training (i.e., the ISAP in the green box in Figure 5.10), we examined how many of them followed the order of matching (i.e., MAR and each of the medications → Patient's statements and ID band → ID band and at least one of the medications) as well as the type of patient identifiers recommended by the training (i.e., name and DOB). We found that 50% of the participants (2 out of 4) followed both of them; 25% of the participants (1 out of 4) followed the order of matching but not the type of identifiers; 25% of the participants (1 out of 4) followed neither the order nor choice of identifiers. Figure 5.11 shows an example performed by one participant following the recommended order of matching, but not the types of identifiers - instead of name and DOB, the participant used name and MRN between the medication label and MAR.

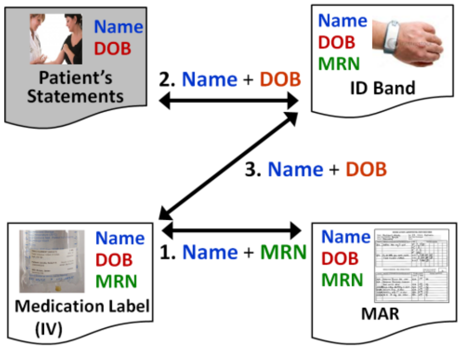


Figure 5.11. An example following the recommended order of matching, but not the type of the patient identifiers in the Simple Task

Next, we investigated which artifact pairs were used for VPI for each of the participants (n=24), regardless of compliance. As shown in Figure 5.12, for each artifact pair, we represented the frequency of use by the thickness of the edge, e.g., 45.8% (in the current training in Figure 5.12) indicates the percentage of the participants who used an artifact pair of the patient's statements and ID band. In the simple task, the students who were given the definitive procedure-based training performed more matches, and thus had a higher percentage for all artifact pair except two. For either of the training types, students tended to use the same three artifact pairs the most: Patient’s statements and ID band (45.5% for the current training; 87.5% for the definitive procedure-based training), ID band and MAR (41.7% for the current training; 41.7% for the definitive procedure-based training), MAR and medication label on the IV bag (45.8% for the current training; 87.5% for the definitive procedure-based training).

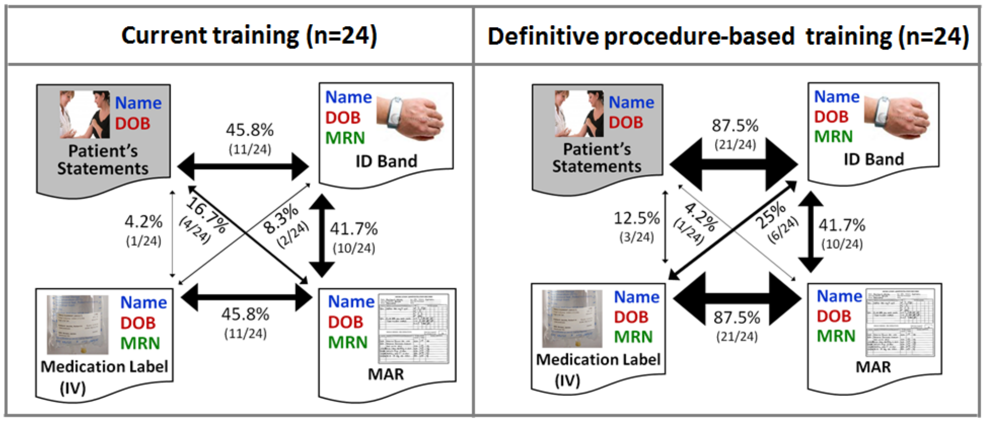
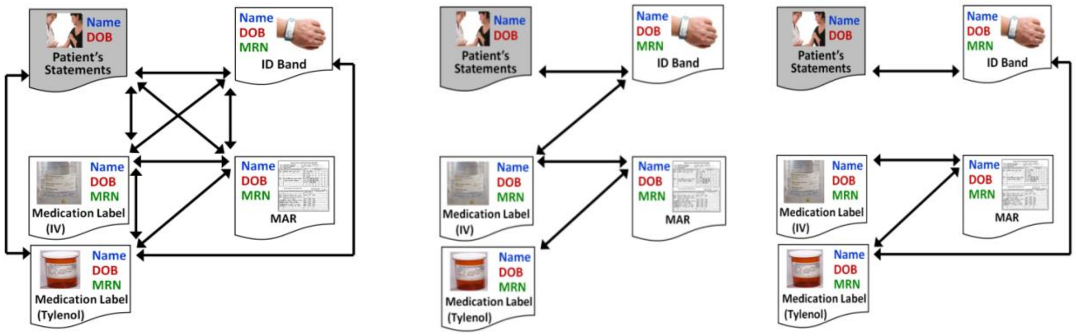

Current training (n=24)
Definitive procedure-based training (n=24)
Name
DOB
Patient’s Statements
Name
DOB
MRN
ID Band
45.8%
(11/24)
4.2%
(1/24)
16.7%
(4/24)
8.3%
(2/24)
41.7%
(10/24)
Name
DOB
MRN
Medication Label (IV)
45.8%
(11/24)
Name
DOB
MRN
MAR
Name
DOB
Patient’s Statements
87.5%
(21/24)
Name
DOB
MRN
ID Band
12.5%
(3/24)
4.2%
(1/24)
25%
(6/24)
41.7%
(10/24)
Name
DOB
MRN
Medication Label (IV)
87.5%
(21/24)
Name
DOB
MRN
MAR

Figure 5.12. The percentage of students who used the artifact pair in the Simple Task

In the same way, we also investigated which ISAPs and artifact pairs were used for VPI in the complex task. As shown in Figure 5.13 (a), the five artifacts resulted in ten artifact pairs potentially available for VPI, where the total number of possible minimal ISAPs is 125. In the training material, as part of the VPI process, we instructed “For each medication, match patient’s name and DOB between the MAR and the Medication Label” and then “Match patient’s name and DOB between the ID Band and the Medication Label on at least one of the medications”. Since the patient’s name and DOB on each medication label is already matched with the corresponding information on the MAR, matching at least one of the medication labels with the ID band also verifies other medication labels. Depending on which medication is selected by the student to match with the ID band, there are two possible minimal ISAPs. Among 125 possible minimal ISAPs, the two minimal ISAPs advocated by the definitive procedure-based training are shown in Figure 5.13 (b).


Name
DOB
Patient's Statements
Name
DOB
MRN
ID Band
Name
DOB
MRN
Medication Label (IV)
Name
DOB
MRN
MAR
Name
DOB
MRN
Medication Label (Tylenol)

(a) 10 APs potentially available for VPI

(b) Two minimal ISAPs advocated by the definitive procedure-based training

Figure 5.13. The advocated minimal ISAPs in the Complex Task

Figure 5.14 shows all of the ISAPs used by the participants who complied with the artifact-explicit guidelines during the complex task (n=6). The percentage of the complying students who used an ISAP recommended by the definitive procedure-based training is 16.7% (1 out of 6); who used an ISAP recommended by definitive procedure-based training along with the additional selected artifact pairs (shown as yellow edges) is 33.3% (2 out of 6); who used an ISAP not recommended by definitive procedure-based training is 50% (3 out of 6).

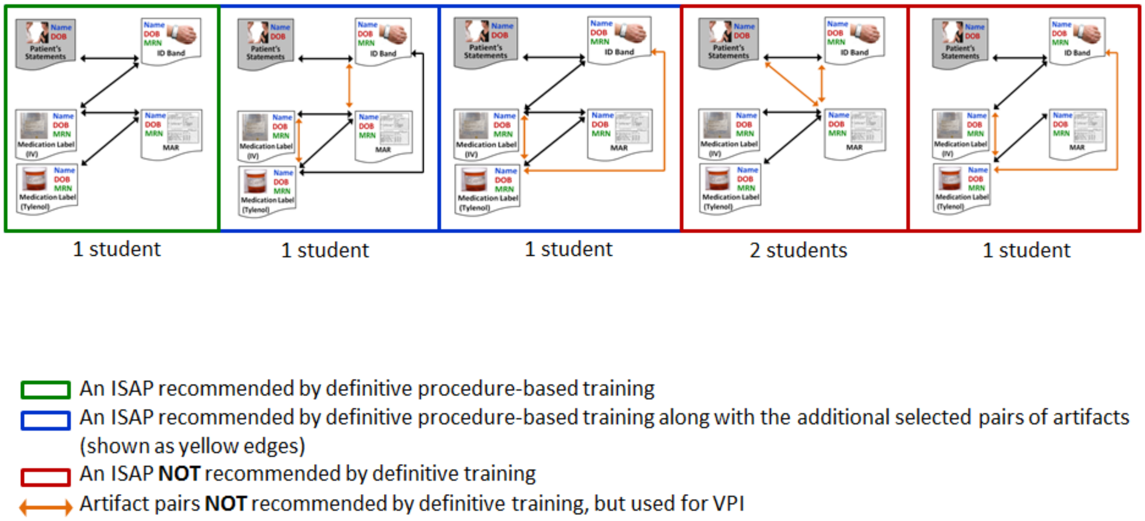

Name
DOB
MRN
Patient's Statements
ID Band
Medication Label (IV)
MAR
Medication Label (Tylenol)
1 student
1 student
1 student
2 students
1 student
🟩 An ISAP recommended by definitive procedure-based training
🟦 An ISAP recommended by definitive procedure-based training along with the additional selected pairs of artifacts (shown as yellow edges)
🟥 An ISAP **NOT** recommended by definitive training
⟷ Artifact pairs **NOT** recommended by definitive training, but used for VPI

Figure 5.14. ISAPs used by students who complied in the Complex Task (n=6)

Among the three participants who used an ISAP recommended by the definitive procedure-based training (i.e., the ISAP in the green box in Figure 5.14), or those including additional artifact pairs (i.e., the ISAP in the blue box in Figure 5.14), we examined how many followed the order of matching as well as the type of patient identifiers recommended by the training. We found that none of the participants (0 out of 3) followed both the ordering and types of artifact-pairs; 33.3% of the participants (1 out of 3) followed the order of matching but not the types of identifiers; 66.6% of the participants (2 out of 3) followed neither the ordering and types of artifact-pairs. Figure 5.15 shows an example performed by one participant following the recommended order of matching, but not the types of identifiers - instead of name and DOB, the participant used name and MRN between the ID band and medication label and between the medication label and MAR.

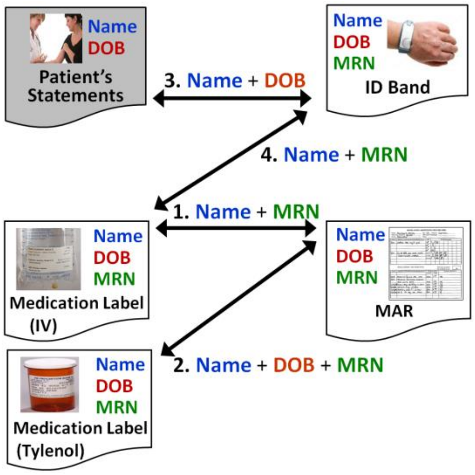

Name
DOB
Patient's Statements
Name
DOB
MRN
ID Band
3. Name + DOB
4. Name + MRN
1. Name + MRN
Name
DOB
MRN
Medication Label (IV)
Name
DOB
MRN
MAR
2. Name + DOB + MRN
Name
DOB
MRN
Medication Label (Tylenol)

Figure 5.15. An example following the recommended order of matching, but not the type of the patient identifiers in the Complex Task

Figure 5.16 shows the usage of artifact pairs in the complex task. Between the two groups, we could not find significant differences in the percentages of the participants using any artifact pairs. For example, in the current training, 9 participants used an artifact pair of the ID band and MAR, but in the definitive procedure-based training, similarly 6 participants used the same pair. For either of training, students tended to use the same three artifact pairs the most; Patient's statements and ID band (62.5% for the current training; 91.7% for the definitive procedure-based training), ID band and MAR (37.5% for the current training; 25% for the definitive procedure-based training), MAR and medication label on the IV bag (41.7% for the current training; 33.3% for the definitive procedure-based training) and on the Tylenol bag (37.5% for the current training; 37.5% for the definitive procedure-based training).

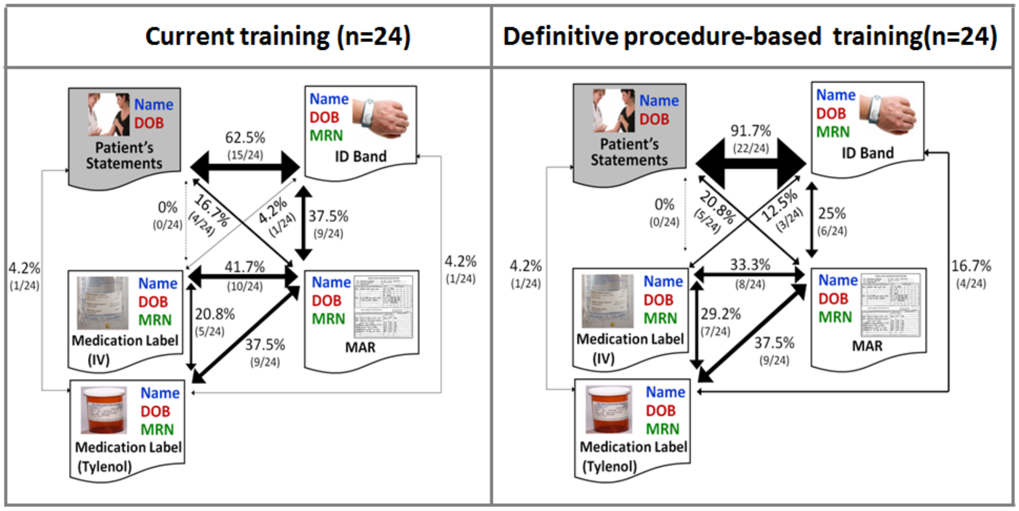

Current training (n=24)
Definitive procedure-based training(n=24)
Name
DOB
Patient's Statements
Name
DOB
MRN
ID Band
62.5% (15/24)
0% (0/24)
16.7% (4/24)
4.2% (1/24)
37.5% (9/24)
4.2% (1/24)
4.2% (1/24)
41.7% (10/24)
Name
DOB
MRN
Medication Label (IV)
Name
DOB
MRN
MAR
20.8% (5/24)
37.5% (9/24)
Name
DOB
MRN
Medication Label (Tylenol)
91.7% (22/24)
0% (0/24)
20.8% (5/24)
12.5% (3/24)
25% (6/24)
4.2% (1/24)
33.3% (8/24)
16.7% (4/24)
29.2% (7/24)
37.5% (9/24)

Figure 5.16. The percentage of students who used the artifact pair in the Complex Task

We investigated whether the amount of time spent reviewing the training material had relevance to compliance. We measured the average time spent on the training material by complying and non-complying participants. As shown in Table 5.2, in the simple task, for either of the training types, complying students tended to spend more time reviewing the training materials than non-complying students - the time increased by 28% for the current training and 17% for the definitive procedure-based training. This increase was not statistically significant, however. In the complex task, it seems there was no relationship between compliance and the time spent reviewing the training materials.

Table 5.2. Time spent reviewing the training material

Simple Task	**Average time spent reviewing the training material (minutes)**	
	Non-complying students	**Complying students**
Current training	0.88	1.13
Definitive procedure-based training	1.69	1.98

Complex Task	**Average time spent reviewing the training material (minutes)**	
	Non-complying students	**Complying students**
Current training	0.93	0.78
Definitive procedure-based training	1.86	1.86

Next, we examined whether there were other impacts of the training on participants' behaviors. To do this, we measured the percentage of the participants who washed their hands and asked the patient about known allergies during the process, respectively (Appendix I). Table 5.3 shows that a few students tended to perform these two actions in the pre-test, but after both types of training, the percentage of the participants performing these actions dramatically increased.

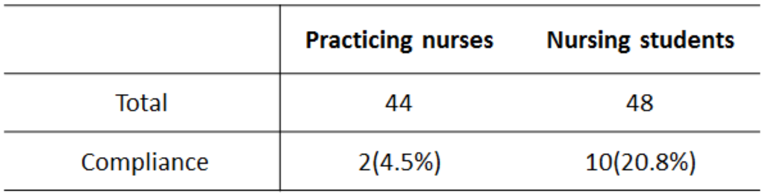
Table 5.3. Other impacts of the training

Wash hands	**Pre-test**	**Simple Task**	**Complex Task**
Current training	16.7%	95.8%	95.8%
Definitive procedure-based training	12.5%	100%	100%

Ask the patient about known allergies	**Pre-test**	**Simple Task**	**Complex Task**
Current training	16.7%	95.8%	83.3%
Definitive procedure-based training	33.3%	87.5%	70.8%

As the last analysis, we examined whether practicing nurses in the clinical simulation (see Chapter 4 and Henemman et al., 2010, 2012) performed VPI better than nursing students during the medication administration process. For nursing students, we used the data from the pre-test. Since both practicing nurses and nursing students performed the same process using the same sets of artifacts in a simulated setting, this comparison could be reasonable. As shown in Table 5.4, nursing students tended to comply significantly more often than practicing nurses (p=0.02; Fisher exact test).

Table 5.4. Comparing compliance of Practicing Nurses to Student Nurses



	Practicing nurses	**Nursing students**
Total	44	48
Compliance	2(4.5%)	10(20.8%)

5.7 Limitations

This study has several limitations in terms of the setting, intervention, analysis, and findings. As to the setting, the simulated clinical setting may not accurately reflect actual clinical settings because the simulated clinical setting may involve time pressures, noises, and interruptions different from those in actual clinical settings. The students' schedules limited the amount of time available for their participation in the study. This meant that they may have felt rushed and therefore did not perform optimally. Also, this time limitation meant the length of time between reviewing the training materials and carrying out the medication administration was short. The students may have performed better if they were given more time to absorb the material. In addition, because the students are aware that their clinical performance was being evaluated, they may have performed the process differently than they would in an actual clinical setting.

Pertaining to the intervention, the materials we used to provide current training for VPI may not be generalizable across nursing schools. In addition, we did not perform a preliminary study evaluating compliance which might have exposed weaknesses in the material for the definitive procedure-based training. If the training material had improved based on the initial compliance results, compliance may have improved. The interval between receiving a training intervention and performing the process may also affect compliance. Compliance in our study may be higher than usual because the training intervention occurs immediately before the students perform the process.

In terms of our analysis, the number of intermediate events between the first and the second part of a match we used in this study is only an estimate based on the participants in our study and so may not be appropriate for other participants. Also, the interpretation of the eye-tracking videos is affected by the distance between the cross-hairs and the students' actual eye position. To address this limitation, we had two volunteers independently review the videos, with one volunteer reconciling discrepancies between the initial volunteers' traces, and one experienced researcher reviewing the reconciled traces to make a final decision on the event assignment. The experienced researcher knew which group the student was associated with and this may have had an inadvertent effect on determining the final event assignment. In addition, students' fixations may not necessarily signify where they direct their attention. Eye-tracking videos show only students' fixation points but does not reveal any information about their mental processes (e.g., understanding). Thus, we cannot conclusively state that if a student looked at two identifiers on two artifacts that they completed a match. This may mean our compliance levels were even lower than those shown in the Results section.

With regard to our findings, the result of this study may not be applicable to other populations or settings since this study is conducted at a single university with nursing students. Most of all, we did not evaluate whether improving compliance led to improved patient safety; that research needs to be conducted in future work once approaches for improving compliance have been found.

5.8 Discussion

Our analyses revealed several findings about how our training strategy may affect nursing students' compliance with the artifact-explicit guidelines.

With regard to RQ1, we found that those students who received the definitive procedure-based training showed a significant increase in compliance on the simple task (8.3% on the current training; 37.5% on the definitive procedure-based training; p=0.012; Fisher exact test), but not on the complex task (8.3% on the current training; 8.3% on the definitive procedure-based training). The training material for the definitive procedure was developed considering general situations and so the material should be applicable to simple and complex tasks; however, the descriptions for the rules in the material may not be explicit enough to provide guidance for complex tasks. This implies, perhaps, that training has to explicitly show complicated scenarios. It also appears that spending more time reviewing the training material has no effects on improving compliance in the complex task. Research suggests that performance on complex processes by nurses improves with well-developed debriefing procedures (Henneman et al., 2014). If we had performed such debriefing sessions, it might have helped to increase compliance on the complex task as well as on the simple task.

Although those students who received the definitive procedure-based training showed a significant increase in compliance on the simple task, we found that only a few complying students chose the ISAP recommended by the training (including those that selected additional artifact pairs) - 28.6% (4 out of 14) in the simple task and 50% (3 out of 6) in the complex task. Among these complying students, selecting the recommended ISAP (including those that selected additional artifact pairs), half of these students (2 out of 4) followed the order of matching as well as the types of patient identifiers recommended by the training in the simple task. None of the complying students (0 out of 3) in the complex task followed both the order of matching and the types of patient identifiers recommended by the training.

Regarding RQ 2, we found that of those students who received the current training, the percentage of students who complied in the pretest but not in the complex task is 75.3%; and of those students who received the definitive procedure-based training, the percentage of students who complied in the pretest but not in the complex task is 64.3%. This implies that definitive procedure-based training reduced the decrement in compliance when moving from the simple task to the complex task more than current training did (from 75.3% to 64.3%). This decrease was not statistically significant, however.

In both types of training, students tended to match the ID band and MAR, instead of the ID band and medication label recommended by the definitive-based training. Of all students who received the current training, 41.7% of students matched the ID band and MAR and 8.3% matched the ID band and medication label; and of all students who received the definitive procedure-based training, 41.7% matched the ID band and MAR and 25% matched the ID band and medication label. This implies that matching the ID band and MAR may be easier or more natural for students to select. We observed that students tended to hold the MAR during the process and so it might be easier to refer to the information on it. Therefore, compliance may be improved if the ISAP suggested by the training advocates matching the ID band and MAR.

We also found that more nursing students (20.8%) complied with the artifact-explicit guidelines than practicing nurses (2%); this difference is statically significant (p=0.02; Fisher exact test). This may be because students were less confident, i.e., they were more careful and performed more matches in the medication administration process while practicing nurses are more confident and less careful in completing the process. Research suggests that experts do not always perform better than novices, and sometimes perform worse. (Ericsson et al., 2007).

In addition, we found other impacts of the training not pertaining to the compliance with the artifact-explicit guidelines. Both current and definitive procedure-based training resulted in considerably increased numbers of the students who “washed their hands” and “asked the patient about known allergies”. These actions would be quite important and can significantly influence patient safety, and the training may help remind the students to perform such important actions - supports previous evidence of the positive influence of checklists on behavior (Pronovost et al., 2006).

Our findings suggest the necessity of investigating more effective approaches for performing the VPI process or providing training. One possible way to improve the process is involving the barcode technology. Since using the barcode scanning can reduce the number of required manual matches, the healthcare workers could concentrate more on performing necessary matches to complete the VPI process. In order to provide better training, we can design the training based on the artifact pairs more frequently used in VPI.

CHAPTER 6

CONCLUSION

Patient identification errors are one of the major causes of medication errors. Previous studies have focused on reporting patient misidentification statistics from case studies, on classifying types of patient identification errors, or on evaluating the impact of technology on the VPI process. However, few studies have attempted to understand the VPI process by analyzing its complexity in order to develop better guidelines or strategies for VPI. In our work, we obtained three major findings that contribute to the patient identification literature. Based on these findings, we provide directions for future work.

6.1 Major findings

First, there are a considerable number of ways to conduct the VPI process that comply with our artifact-explicit guidelines. In particular, these alternatives vary depending on whether at least one of the process artifacts can be trusted prior to the start of the VPI process (from 16 to 8 for MMA; from 8 to 1 for BCMA). If BCMA technology is used in the process, the information encoded on the barcode affects the number and types of alternatives available for VPI (from 3 to 1 when the ID band is initially considered a trusted artifact; from 8 to 3 when the ID band is not initially considered a trusted artifact) (see Chapter 3).

Second, under most conditions, students' compliance with the artifact-explicit guidelines was low. A small percentage of students complied with the guidelines, whether performing MMA or BCMA (2% - 5% for MMA and 12% - 88% for BCMA); whether the ID band was assumed to be trusted or not (for MMA, 5% when the ID band is initially considered a trusted artifact and 2% - 5% when the ID band is not initially considered a trusted artifact; for BCMA, 32% - 88% when the ID band is initially considered a trusted artifact and 12% - 32% when the ID band is not initially considered a trusted artifact); and what information was assumed to be encoded in the barcode for BCMA (12% - 88%) (see Chapter 4).

Third, our guideline-based training strategy was less effective for improving VPI compliance than anticipated. Nursing students who received the definitive procedure-based training showed a significant increase in compliance on a simple task involving administering one medication, but not for a more complex task involving administering two medications. Additionally, very few of the students who complied with the Guidelines followed the specific steps outlined in the training (see Chapter 5).

6.2 Future work

Our findings suggest several research avenues that may improve VPI compliance. One possible reason for low nurse compliance with the artifact-explicit guidelines could be that there are a considerable number of alternatives for VPI, thereby increasing nurses' cognitive burden in choosing (perhaps unconsciously) among them. Our training suggested one alternative for VPI as a means to reduce this cognitive burden. Although our results showed that the definitive procedure-based training was not entirely effective, the concept of reducing the number of alternatives may still be beneficial.

We may be able to design more effective training that reduces the cognitive burden associated with choosing an alternative for VPI. One potential strategy would be to more carefully select the set of artifact pairs advocated by the training. In our study, we did not perform a preliminary experiment to determine if there are artifact pairs that may be easier or more natural for individuals to select. We might also provide individuals with information about why some sets of artifact pairs are acceptable, while others are not.

In contrast to revising the VPI training for MMA, the number of manual matches could be decreased (our training required 6) by using barcode technology. Individuals would still need training on VPI, however, because the appropriate VPI process depends on what information is encoded on the barcodes.

Subsequent studies should also determine if improving compliance with the artifact-explicit guidelines reduces the number of errors that occur, especially those that reach the patient, since that is the ultimate goal of VPI.

APPENDIX A

BAYSTATE MEDICAL CENTER'S PATIENT IDENTIFICATION GUIDELINES

CO 2.100 PATIENT IDENTIFICATION POLICY

POLICY

To provide system-wide structure and guidance in patient identification.

PURPOSE

Establish a process for accurate patient identification, thus ensuring that procedures and treatments are performed on the intended patient.

SCOPE

This policy applies to all Baystate Medical Center employees identifying patients who are to receive a service or treatment. Different identifiers may be used in different settings as long as their use is consistent within the clinical area and is specified in an area specific policy or guideline. Where feasible the use of two distinct patient specific identifiers is required.

PROCEDURE

A. **Patient who can communicate**

1. **The person performing the initial identification does the following.**

For the initial identification of a patient, request picture identification, if picture identification is not available request the patient to state and spell their full name (first and last) and their birth date. Where two persons are known to have the same name and birth date, request the patient to state his/her social security number. Compare this information with the medical record information. Any discrepancy noted when comparing the information requires immediate resolution.

2. **Prior to performance of a treatment or procedure, the person performing the treatment or procedure does the following.**

a) Match two patient specific identifiers directly associated with the individual and the same two identifiers associated with the medication, blood product, specimen (such as an attached label). In addition, the service or treatment must be matched to the individual patient. PPID barcode technology will be used in those areas that have this capability to properly identify the patient prior to medication administration and phlebotomy procedures.

b) The two patient specific identifiers are: 1.) the patient's stated full name (first and last) and 2.) The medical record number on his/her ID band.

c) In the outpatient setting the two patient specific identifiers are: 1.) the patient's full name (first and last) stated and spelled correctly and 2.) The patient's birth date.

B. **Patient who is unconscious, mentally incompetent or who lacks intellectual capacity or who does not speak the language of the person performing the identification.**

1. **Initial Identification**

a) For the initial identification of the patient, request the person accompanying the patient to identify the patient as described in section A.

b) If the patient is not accompanied, a photo ID should be requested to identify the patient's name.

c) If the patient is not accompanied, the following process is followed:

> (1) John or Jane Does' are given a medical record that begins with 08. When the patient's name is determined, the patient information is updated and added to the hospital registration system. The J. Doe's maintain the 08 medical record until discharge at which time the health information department will merge the 08 with the patient's actual medical record.
>
> (2) For identification of infants delivered in the LDRP and in the NICU/CCN refer to Children's Hospital Policy/Procedure: **Identification, Security and Transport: Newborn/Infant/Child).**
>
> (3) For the trauma patient, the two patient identifiers are: 1.) the medical record number 099 and 2.)The trauma E number TR E 1234. When the patient is positively identified, the account number is updated with the patient's correct information. An updated ID band will be printed and placed on the patient in addition to the initial trauma ID band.

2. **Prior to performance of a treatment or procedure, the person performing the treatment or procedure must do the following**:

a) Matching of two patient specific identifiers directly associated with the individual and the same two identifiers associated with the medication, blood product, specimen (such as a specimen label) must occur. In addition, the service or treatment must be matched to the individual patient.

b) The two patient specific identifiers are: 1.) The patient's first and last name 2.)The medical record number on his/her ID band.

c) In the outpatient setting the two patient specific identifiers are: 1. The patient's full name (first and last name) and 2. The patient's birth date.

APPENDIX B

BETH ISRAEL DEACONESS MEDICAL CENTER'S PATIENT IDENTIFICATION GUIDELINES

Beth Israel Deaconess Medical Center
BIDMC Manual

Title: **Patient Identification Policy**

Number: **CP-21**

Purpose: **(1) To ensure reliable identification of each patient prior to the delivery of medical care; (2) to match the intended medical care to each patient (3) to outline the needed interdepartmental steps in order to provide timely resolution of incorrect inpatient identity or medical record demographic information.**

Policy Statement

Patients (population defined below) shall be identified using at least two identifiers prior to receiving medical care (defined below).

Active communication techniques (defined below) shall be used in the verification process whenever possible.

The intended medical care shall be matched to each patient using the two patient identifiers.

Policy for Implementation

A. Who

This policy applies, but is not limited, to the following inpatient and outpatient populations:

1. **All inpatients, including mothers admitted for labor and delivery, newborns delivered at BIDMC, and newborns admitted to but not delivered at BIDMC**
2. **Emergency Department patients**
3. **Patients receiving medications administered by clinical staff**
4. **Patients receiving other therapeutics such as radiation, radioisotopes, etc.**
5. **Patients receiving blood products**
6. **Patients undergoing phlebotomy**
7. **Patients undergoing tissue biopsy or specimen collection**
8. **Patients receiving general, regional, or local anesthesia or conscious sedation**
9. **Patients undergoing invasive procedures**
10. **Patients undergoing Radiology or other diagnostic studies**

B. When

The procedures in this policy must be performed immediately prior to:

1. **Admission to the hospital or admission to the Emergency Department**
2. **The medical interventions listed in #3 – 10 in Section A in both inpatient and outpatient settings**
3. **Application of identification wristbands**
4. **Handing newborns to mothers for breastfeeding or other care**
5. **Administration of expressed breast milk to newborns.**

C. How

Two Patient Identifiers

Two patient identifiers shall be used to verify each patient's identity. Examples of patient identifiers include:

1. **Name**
2. **Date of birth**
3. **Medical record number**
4. **Social security number**

Active Communication Techniques

Active communication techniques shall be used to elicit the patient identifiers whenever possible. In general, this means the avoidance of questions that can be answered with "yes" or "no." For example:

Do not **ask, "Are you Jane Doe?"**

Rather, do **ask, "What is your name?"**

Matching Patients and Medical Care

The two identifiers used to verify a patient's identity must be matched to the same two identifiers displayed on medication packaging, automatic medication dispensing machines (e.g. Omnicell machines), blood product containers, order sheets, test requisitions, etc.

This matching process must occur immediately prior to the provision of the intended medical care.

Whenever possible, the patient should participate in this matching process. If the patient is unable to participate (e.g. during a pre-procedure "time-out" when the patient is anesthetized), clinicians conducting the matching process must still use two patient identifiers and active communication techniques among themselves to match the patient to the intended medical care.

D. Special Circumstances

Patients Admitted for Medical Emergency

Patients unable to communicate during a medical emergency (e.g. a trauma patient in the Emergency Department) shall be issued temporary names and medical record numbers. These temporary identifiers shall be used to identify patients until their identities can be established.

Admission of Patients Unable to Speak for Themselves
Patients unable to communicate for other reasons (e.g. adults with dementia or degenerative diseases, newborns, etc) may be identified during the admission process using information taken from (1) family members or personal caregivers who know the patient well or (2) documentation from other health care facilities.

Information from police, fire, emergency medical services, or correctional facility personnel or from picture identification cards may be used for identification purposes according to local departmental policy.

Patients Transferred Internally Without Appropriate Identification
In the event that (1) a patient is transferred from one BIDMC unit to another, (2) and such patient is unable to participate in the identification process (e.g. due to sedation or critical illness), and (3) such patient does not have an identification band appropriately secured to his or her person, then the transferring licensed practitioner must report in person to the receiving unit to identify the patient prior to any medical intervention.

E. Correcting Misidentified Patients

When staff identify any portion of patient identification as incorrect or duplicated in system, they are to escalate the findings for resolution to their immediate supervisor. Elements requiring immediate correction attention include:

- Name
- Date of Birth
- Gender
- Social Security Number
- Patient Medical Record Number

1. Staff member who discovers incorrect identity information informs:

   a. Manager or designee
   b. Administrative Clinical Supervisor (if applicable)

2. Manager or designee verifies correct information with patient or guardian. All elements of demographic information should be confirmed.

3. Manager or designee contacts Bed Placement (Ext 4-2219) with correct patient identification. Bed Placement makes determination of whether change needed is demographic change, merge or re-registration.

   a. If demographic change, bed placement will immediately update patient demographics.

4. Upon successful change of correct patient record, new Wristband is placed on patient and new Blue Card is made available for use through Bed Placement.

If re-registration or merge needed, proceed to step 5, otherwise continue to step 12.

5. For Merges and Re-Registrations

a. If merge is needed due to:

  I. Patient misidentification
  II. Duplicate medical record
  III. EU critical with ***previous admission**

***Please Note**

An update to an EU Critical record with **NO** previous admission is considered a demographic change and does not require a merge. **It is not necessary to print POE orders for EU critical demographic changes.**

b. If re-registration is needed due to wrong identification of patient, Bed Placement will inform caller that incorrect patient will be un-admitted and correct patient medical record will be admitted. After this occurs, all care should be documented in correctly admitted medical record.

For scenarios a and b, Bed Placement will notify the caller that a merge or re-admission will be performed within 15 minutes and that all POE orders need to be printed (see step 7).

6. If merge or re-registration of patient is needed, Bed Placement will contact Health Information Management to perform the merge.

   a. All Merge requests will be processed within 15 minutes of Notification to Health Information Management.

7. If merge or re-registration is needed, Manager or designee ensures that all pertinent medical information is **printed** and placed in correct patient's medical record including:

   a. POE orders
   b. Radiology results
   c. Labs
   d. New ID labels placed on all Medical Record documents. *This is to be completed to ensure accuracy and availability of orders and results during the record merge/correction process.*

All patient care will continue in corrected medical record in conjunction with printed material from incorrect medical record until all pending orders are re-stored.

8. Manager or designee determines all pending orders and places page to each corresponding department where order was placed.

   a) Laboratory Services – Beeper 31503
   b) Radiology – General Diagnostic Supervisor – Beeper33119

Determination/notification to additional departments to notify is on a patient specific basis (informing specialties, consults, procedure/care areas as necessary)

9. For all pending orders, inpatient unit must cancel old orders and re-enter them using correct patient information.

10. Upon successful merge, new Wristband is placed on patient and new Blue Card is made available for use through Bed Placement.

11. Bed Placement will complete a *_**Patient Information Registration Error Alert**_* e-mail to the registration error distribution group informing them of patient medical record issue and expected resolution.

*The email address for this distribution list is:

VitalInformationRegistrationErrorAllert@bidmc.harvard.edu.

It can also be found in outlook under "*Patient Information Registration Error Alert*".

The content of the Patient Information Registration Error Alert E-Mail will include:

Content of *Vital Information Registration Error Alert E-Mail*

	Incorrect Info	**Correct Info**
Patient Name		
MRN		
Fiscal # (Encounter)		
Date/Time Admitted		
Date/Time Discharged		
Brief Description of situation: (i.e. Demographic Change, Duplicate Medical Record, Merge, EU Critical Update,)		

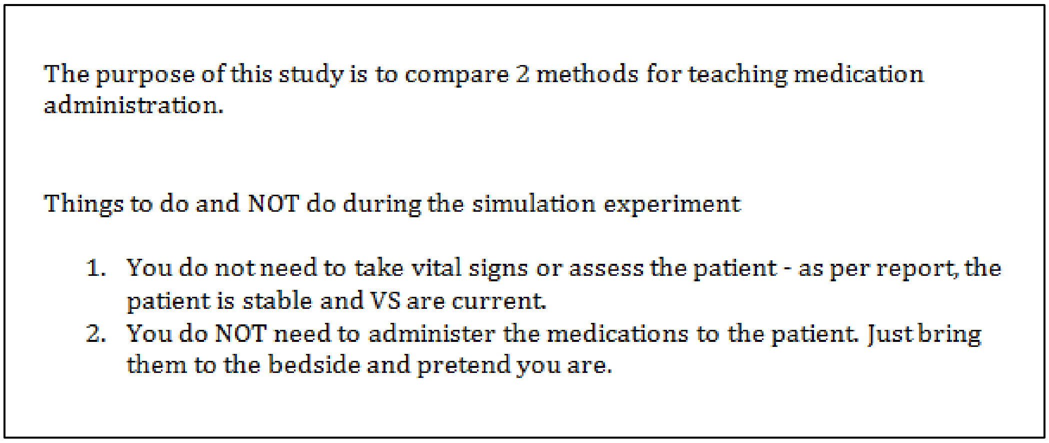
12. Manager notifies patient of error and of resolution of the issue.

13. Manager or designee fills out Incident Report in Patient Safety Reporting System.

APPENDIX C

MATERIALS INVOLVED IN THE EXPERIMENT

A. Experiment script

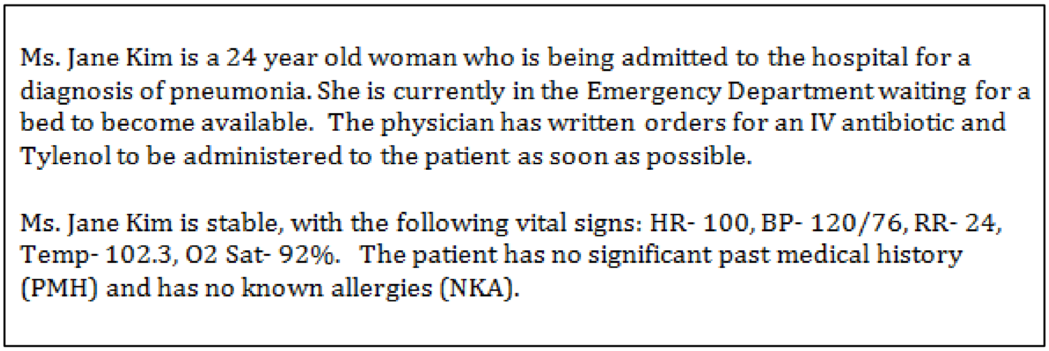


The purpose of this study is to compare 2 methods for teaching medication administration.

Things to do and NOT do during the simulation experiment

1. You do not need to take vital signs or assess the patient - as per report, the patient is stable and VS are current.
2. You do NOT need to administer the medications to the patient. Just bring them to the bedside and pretend you are.

B. Nursing report



Ms. Jane Kim is a 24 year old woman who is being admitted to the hospital for a diagnosis of pneumonia. She is currently in the Emergency Department waiting for a bed to become available. The physician has written orders for an IV antibiotic and Tylenol to be administered to the patient as soon as possible.

Ms. Jane Kim is stable, with the following vital signs: HR- 100, BP- 120/76, RR- 24, Temp- 102.3, O2 Sat- 92%. The patient has no significant past medical history (PMH) and has no known allergies (NKA).

C. Consent form

Consent Form for Participation in a Research Study
University of Massachusetts Amherst

Researcher(s):	Junghee Jo (graduate student researcher), Jenna L. Marquard (faculty sponsor), Elizabeth Henneman (faculty sponsor), Lori A. Clarke (faculty sponsor)
Study Title:	**Nurse decision making during routine procedures**

---

1. What is this form?
This form is called a Consent Form. It will give you information about the study so you can make an informed decision about participation in this research.

2. WHO IS ELIGIBLE TO PARTICIPATE?
Students from the School of Nursing at the University of Massachusetts Amherst

3. WHAT IS THE PURPOSE OF THIS STUDY?
The purpose of this study is to better understand how nursing students make decisions during routine procedures.

4. WHERE WILL THE STUDY TAKE PLACE AND HOW LONG WILL IT LAST?
The study will take place in the University of Massachusetts Amherst School of Nursing Simulation Laboratory. Participation in this study will take approximately 45 minutes. After you have participated in the study, you will not be contacted regarding this study.

5. WHAT WILL I BE ASKED TO DO?
If you agree to take part in this study, you will be asked to perform routine procedures on mock patients in a simulated setting. You will be asked to wear an eye-tracking device while performing the procedures.

6. What are my benefits of being in this study?
You may not directly benefit from this research; however, we hope that the knowledge acquired from this study will be useful for you in thinking about how you perform routine procedures.

7. WHAT ARE my RISKS OF being in THIS STUDY?
There are minimal risks associated with a possible breach of confidentiality of your research data.

8. How will my personal information be protected?
The following procedures will be used to protect the confidentiality of your study records. The researchers will keep all study data in a secure location. Research records will be labeled with a code. A master key that links names and codes will be maintained in a separate and secure location. De-identified data will be kept to possibly use later for secondary analysis. All electronic files containing identifiable information will be password protected. Any computer hosting such files will also have password protection to prevent access by unauthorized users. Only the members of the research staff will have access to passwords. At the

conclusion of the study, the researchers may publish their findings. Information will be presented in summary format and you will not be identified in any publications or presentations.

9. WILL I RECEIVE ANY PAYMENT FOR TAKING PART IN THE STUDY?
You will receive $20 cash after participating in the study.

10. WHAT IF I HAVE QUESTIONS?
We will be happy to answer any questions you have about this study. If you have further questions about this project or if you have a research-related problem, you may contact the student researcher, Junghee Jo at junghee@cs.umass.edu. You may also contact the faculty sponsor, Professor Elizabeth Henneman at Henneman@nursing.umass.edu, or Professor Jenna L. Marquard, at jlmarquard@ecs.umass.edu. If you have any questions concerning your rights as a research subject, you may contact the University of Massachusetts Amherst Human Research Protection Office (HRPO) at (413) 545-3428 or humansubjects@ora.umass.edu.”

11. CAN I STOP BEING IN THE STUDY?
You do not have to be in this study if you do not want to. If you agree to be in the study, but later change your mind, you may drop out at any time. There are no penalties or consequences of any kind if you decide that you do not want to participate.

12. WHAT IF I AM INJURED?
The University of Massachusetts does not have a program for compensating subjects for injury or complications related to human subjects research, but the study personnel will assist you in getting treatment.

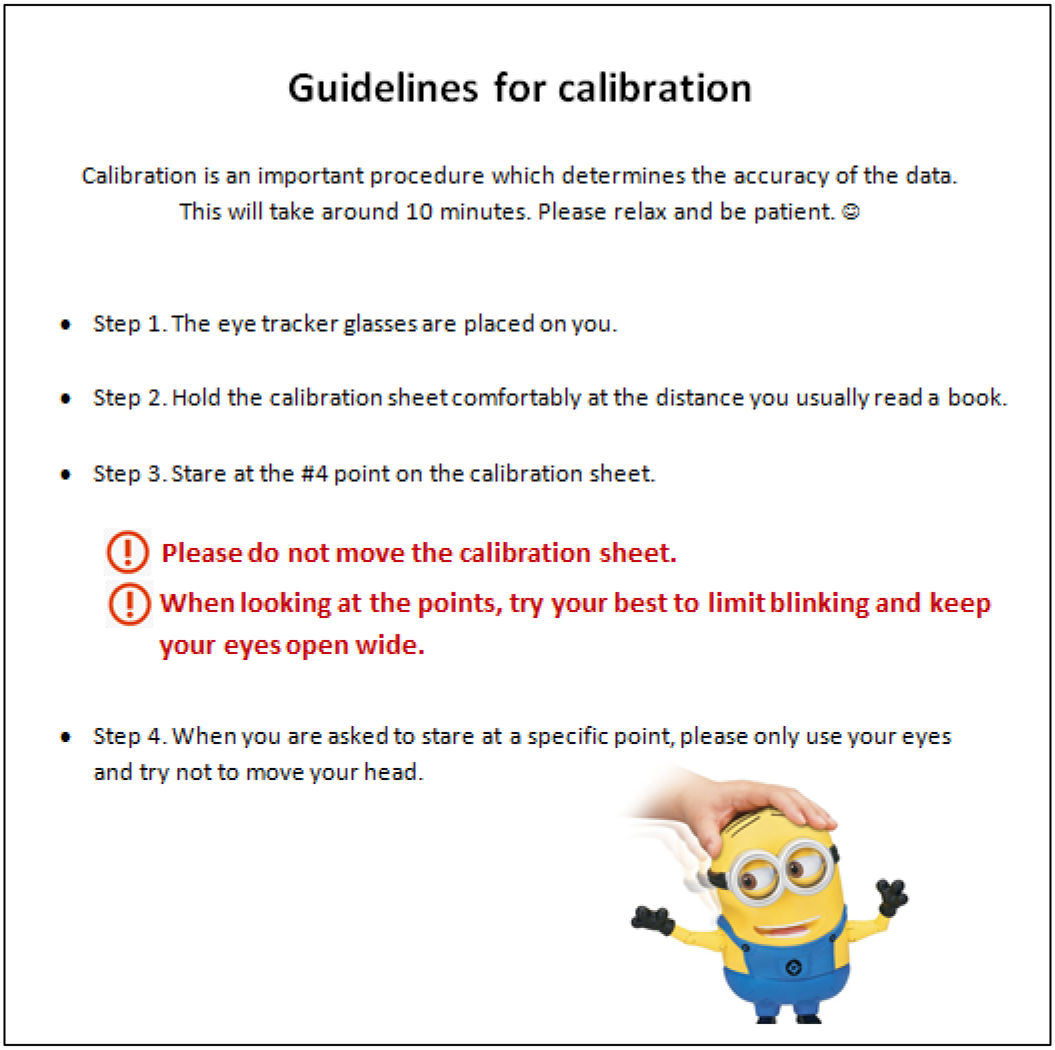
13. SUBJECT STATEMENT OF VOLUNTARY CONSENT
When signing this form I am agreeing to voluntarily enter this study. I have had a chance to read this consent form, and it was explained to me in a language that I use and understand. I have had the opportunity to ask questions and have received satisfactory answers. I understand that I can withdraw at any time. A copy of this signed Informed Consent Form has been given to me.

______________________	______________________	__________
Participant Signature:	Print Name:	Date:

By signing below I indicate that the participant has read and, to the best of my knowledge, understands the details contained in this document and has been given a copy.

______________________	______________________	__________
Signature of Person Obtaining Consent	Print Name:	Date:

D. Guidelines of calibration for nursing students



Guidelines for calibration

Calibration is an important procedure which determines the accuracy of the data.
This will take around 10 minutes. Please relax and be patient. ☺

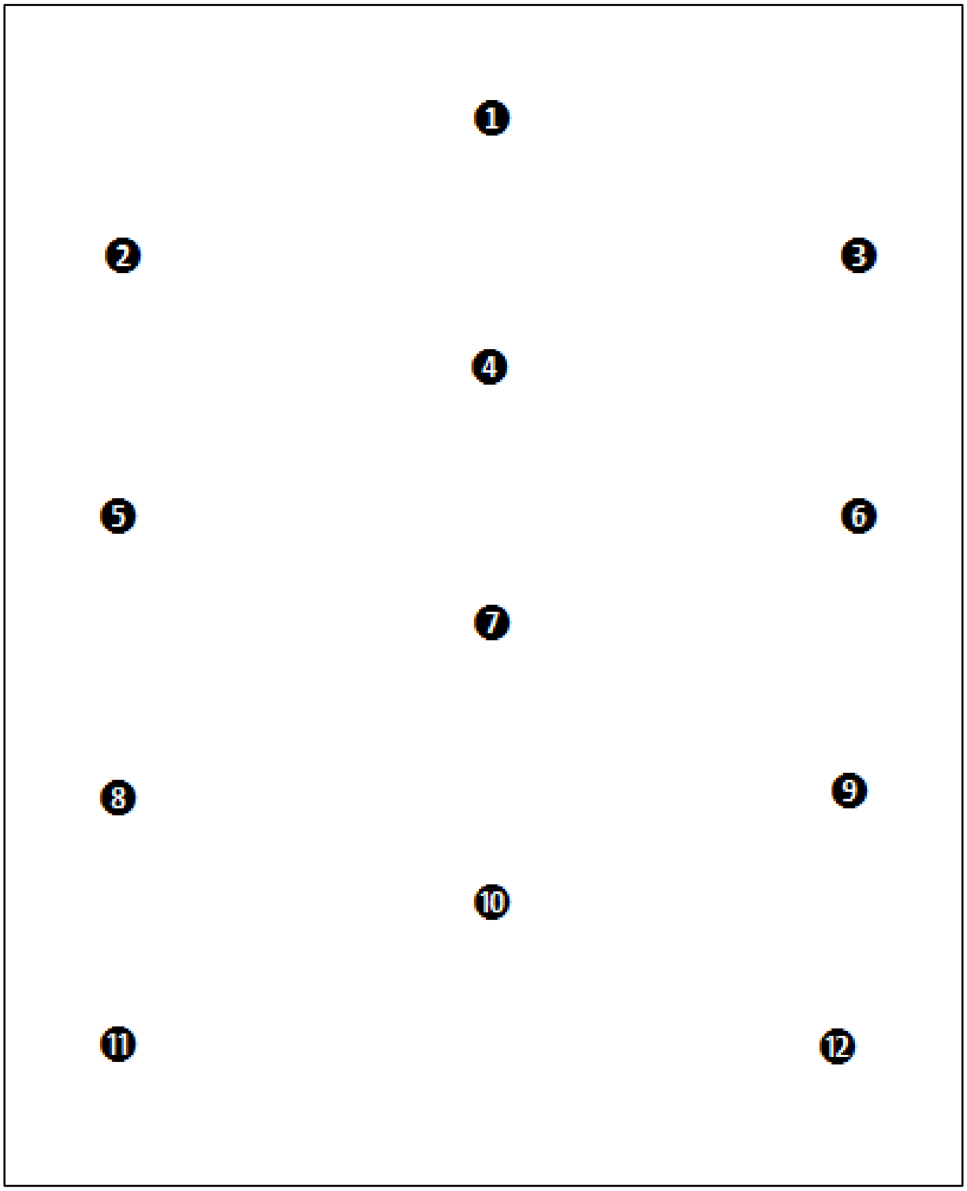
- Step 1. The eye tracker glasses are placed on you.
- Step 2. Hold the calibration sheet comfortably at the distance you usually read a book.
- Step 3. Stare at the #4 point on the calibration sheet.

  ⚠ **Please do not move the calibration sheet.**

  ⚠ **When looking at the points, try your best to limit blinking and keep your eyes open wide.**

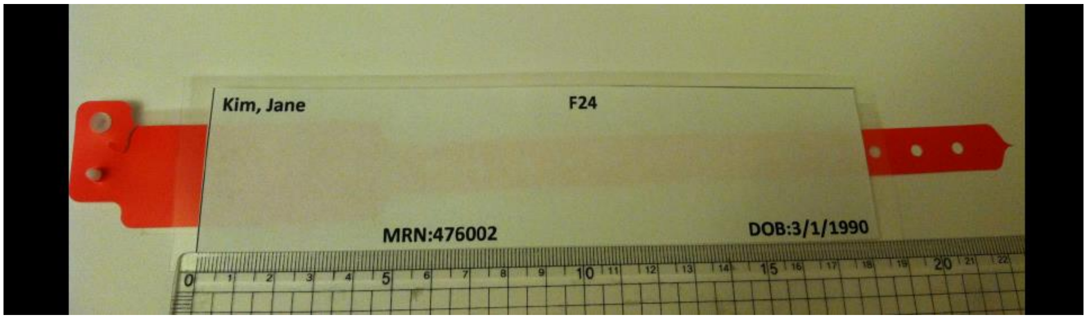
- Step 4. When you are asked to stare at a specific point, please only use your eyes and try not to move your head.

E. 12 reference points used for calibration


1
2
3
4
5
6
7
8
9
10
11
12

F. Artifacts

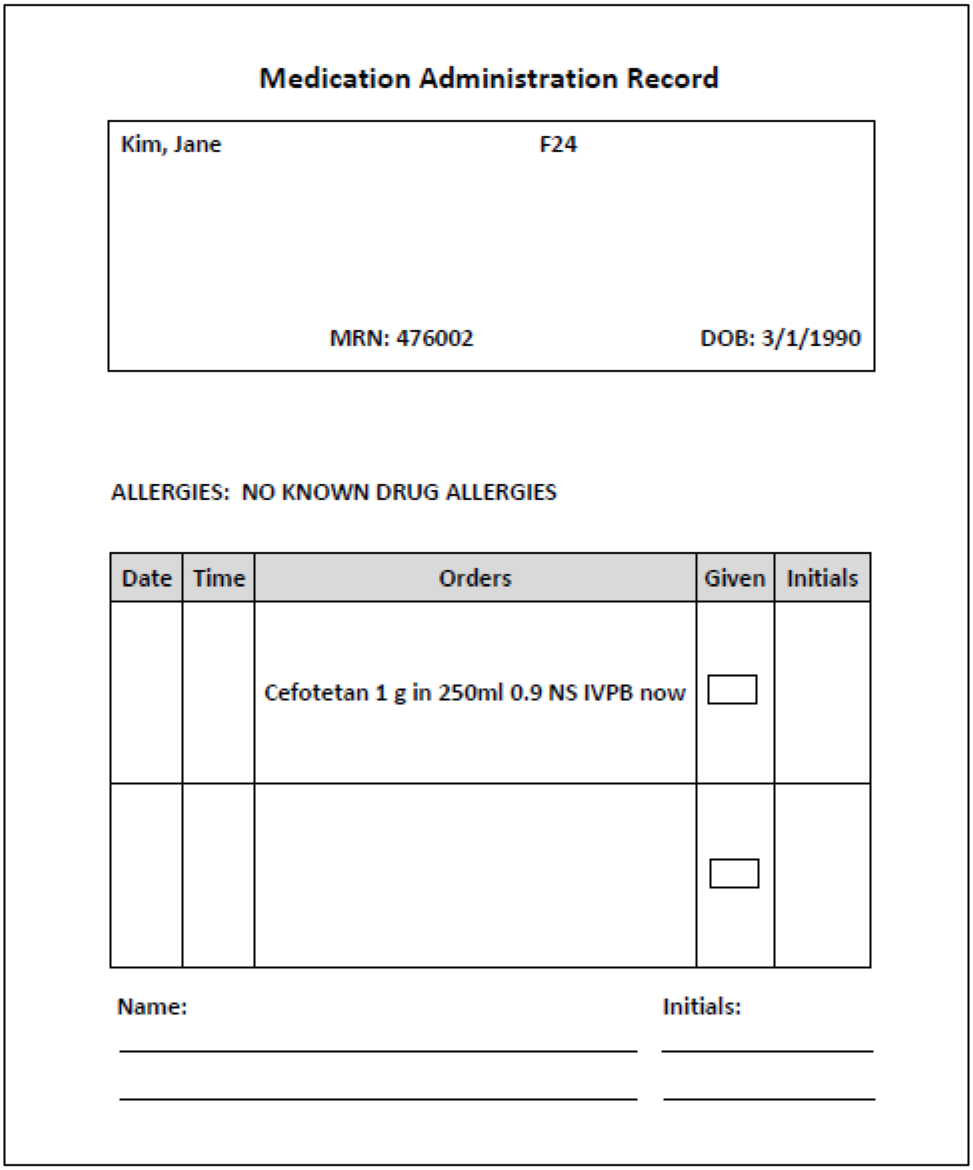
- ID Band


Kim, Jane
F24
MRN:476002
DOB:3/1/1990

- Medications in the simple task (4 IV bags)

- Medications in the complex task (4 IV bags and 1 Tylenol bag)

- MAR in the simple task



Medication Administration Record

Kim, Jane F24

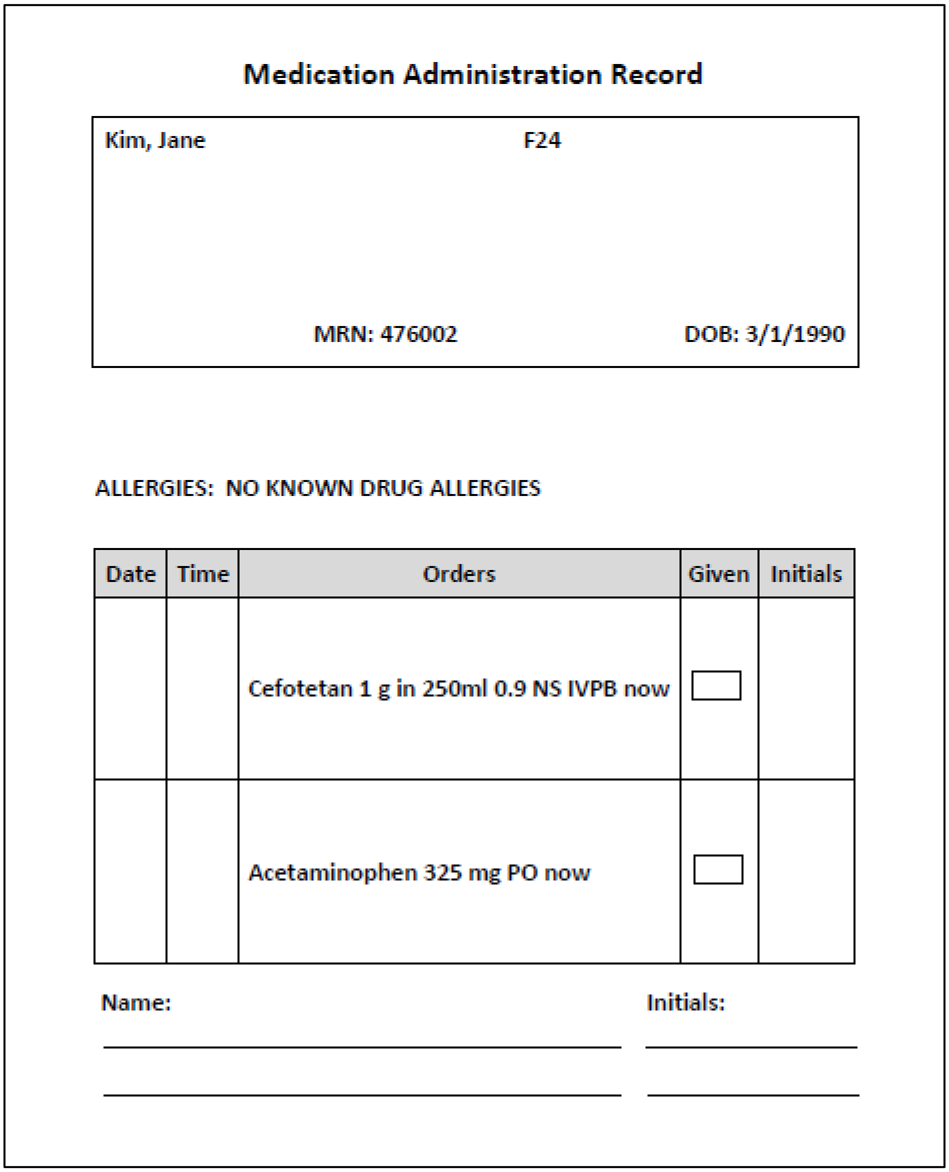
MRN: 476002 DOB: 3/1/1990

ALLERGIES: NO KNOWN DRUG ALLERGIES

Date	Time	Orders	Given	Initials
		Cefotetan 1 g in 250ml 0.9 NS IVPB now	☐	
			☐	

Name: Initials:

- MAR in the complex task



Medication Administration Record

Kim, Jane F24

MRN: 476002 DOB: 3/1/1990

ALLERGIES: NO KNOWN DRUG ALLERGIES

Date	Time	Orders	Given	Initials
		Cefotetan 1 g in 250ml 0.9 NS IVPB now	☐	
		Acetaminophen 325 mg PO now	☐	

Name: Initials:

APPENDIX D

EYE TRACKER CALIBRATION PROCEDURE

Preparation materials for Eye-Tracking

---

1. Glasses set with cables attached

2. Data Tracking Units (DTU) with charger

ASL
Mobile Eye XG

3. SD card inserted into the DTU

Extreme
30MB/s
16GB
SanDisk

4. ASL Laptop that comes with eye tracker software, “Mobile Eye XG” with Green USB, Black USB, and Charger

Calibration procedure

---

1. Plug Green USB into the left side of the ASL laptop.

2. Plug Black USB into the right side of the ASL laptop.

3. Plug the SD card into the DTU.

4. Plug glasses into the DTU.

5. Plug in the ASL laptop to an outlet.

6. Plug in the DTU to an outlet.

7. Insert battery into the DTU.

8. Turn on the DTU.

9. Turn on the ASL laptop.

10. Click Eye Vision XG on the ASL laptop screen.

11. Put the DTU in the pocket and have the subject wear the DTU pocket.

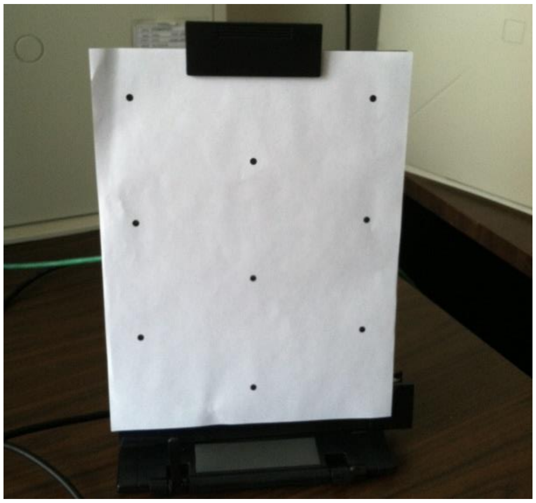
12. Ask the subject to sit.

13. If the subject wears glasses, ask them to remove glasses. If they cannot read the letters without glasses, allow them to wear their glasses.

14. Place the glasses on the subject.

15. Adjust the bead in the back until the unit is tight around the subject’s head.

16. Put the calibration sheet in front of the subject.



17. Advise the subject that once the calibration is done, he/she cannot move the glasses so make sure he/she is comfortable at this point.

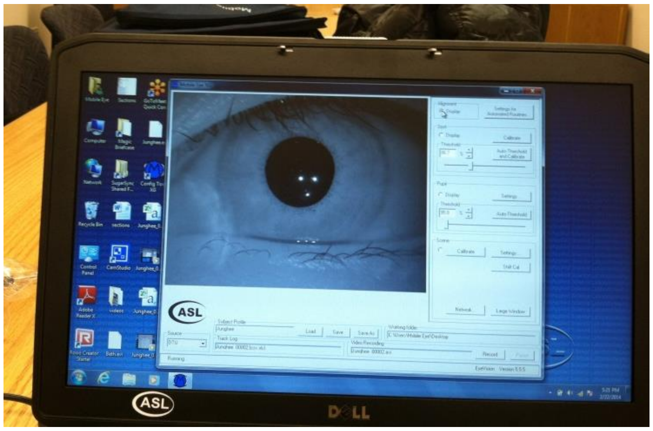
18. Ask the subject to stare at the middle point in the calibration sheet.

19. Adjust the camera (up and down) to include all reference points in the calibration sheet.

20. Adjust monocle to locate the pupil in the center of the screen.

21. Slide the camera until 3 dots are shown.

22. Adjust the knob around the camera until the 3 dots are dense and smaller.



23. Go to “Spot” and click: “Display” → “Auto-Threshold” and “Calibrate”.

24. Go to “Pupil” and click: “Display” → “Auto-Threshold”.

25. Check if the threshold value is around 90%. Otherwise, adjust the focus knobs and monocle until ideal conditions are met.

26. Advise them not to move their head but only their eyes during the calibration.

27. Guide the numbers for each point.

28. Go to “Scene” and click “Calibrate”.

29. Test from 1 to 9. Make sure to wait to click the reference point until the cross-hairs arrives at the point.

30. Click “Finish” button.

31. Test the calibration results by asking the subject to stare a one specific point at a time.

32. Click “Record” to make the video file.

33. After ending, click “Stop” and turn off the Eye Vision XG software.

34. Carefully take the glasses off of the subject.

35. Switch out the batteries in the DTUs and charge the ones just used.

36. Copy the video file to an external hard drive.

APPENDIX E

EVENT NAMES USED IN GENERATING TRACES

- Verbal
    - Introduced self
      (E.g., my name is Kally. I will be your nurse today etc.)
    - Asked patient to state full name
      (E.g., what’s your full name?)
    - Asked patient to state their first name
      (E.g., what’s your first name?)
    - Asked patient to state their last name
      (E.g., what’s your last name?)
    - Asked patient to spell first name
      (E.g., what’s the spelling of your first name?)
    - Asked patient to spell last name
      (E.g., what’s the spelling of your last name?)
    - Stated the patients full name
      (E.g., your full name is Jane Kim, is that right?)
    - Stated patient first name
      (E.g., your first name is Jane, is that right?)
    - Stated patient last name
      (E.g., your last name is Kim, is that right?)
    - Asked patient to state Age
      (E.g., what’s your age?)
    - Stated patient Age
      (E.g., your age is 24, is that right?)
    - Asked patient to state DOB
      (E.g., what’s your DOB?)
    - Stated patient DOB
      (E.g., your DOB is 3/1/1990, is that right?)
    - Asked patient to state Name and DOB
      (E.g., what’s your name and DOB?)
    - Stated patient Name and DOB
      (E.g., your name Jane Kim and your DOB is 3/1/1990. Is that right?)
    - Asked Allergies
      (E.g., what’s your allergies?)
    - Asked if allergies
      (E.g., do you have any allergies?)
    - Q A
      (E.g., how is your pain? Are you all right? How is the weather today? etc.)

- Visual
  - Looked at Name on ID Band
  - Looked at Name on MAR
  - Looked at Name on Med Label (T)
  - Looked at DOB on ID Band
  - Looked at DOB on MAR
  - Looked at DOB on Med Label (T)
  - Looked at MRN on ID Band
  - Looked at MRN on MAR
  - Looked at MRN on Med Label (T)
  - Looked at Age on ID Band
  - Looked at Age on MAR
  - Looked at Age on Med Label (T)
  - Looked at Med info on Med Label (T)
  - Looked at Cefotetan info on MAR
  - Looked at Acetaminophen info on MAR
  - Looked at Allergy info on MAR
  - Looked at Med admin guidelines
  - Looked at Name on Med Label #1 (IV)
  - Looked at Name on Med Label #2 (IV)
  - Looked at Name on Med Label #3 (IV)
  - Looked at Name on Med Label #4 (IV)
  - Looked at Name on Med Label (T)
  - Looked at DOB on Med Label #1 (IV)
  - Looked at DOB on Med Label #2 (IV)
  - Looked at DOB on Med Label #3 (IV)
  - Looked at DOB on Med Label #4 (IV)
  - Looked at DOB on Med Label (T)
  - Looked at Age on Med Label #1 (IV)
  - Looked at Age on Med Label #2 (IV)
  - Looked at Age on Med Label #3 (IV)
  - Looked at Age on Med Label #4 (IV)
  - Looked at Age on Med Label (T)
  - Looked at MRN on Med Label #1 (IV)
  - Looked at MRN on Med Label #2 (IV)
  - Looked at MRN on Med Label #3 (IV)
  - Looked at MRN on Med Label #4 (IV)
  - Looked at MRN on Med Label (T)

  - Looked at Med info on Med Label #1 (IV)

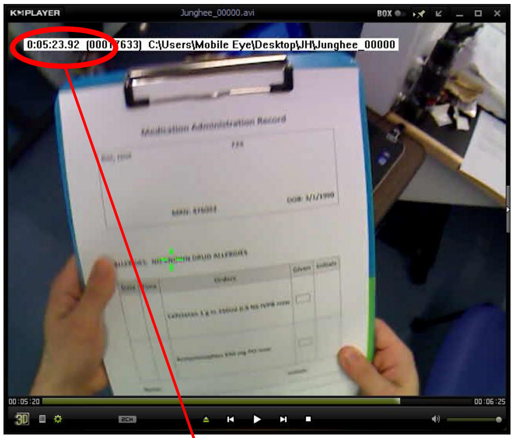
  - Looked at Med info on Med Label #2 (IV)
  - Looked at Med info on Med Label #3 (IV)
  - Looked at Med info on Med Label #4 (IV)
  - Looked at Med info on Med Label (T)
  - Looked at MAR (General)
  - Looked at ID Band (General)
  - Looked at Med Label #1 (IV) (General)
  - Looked at Med Label #2 (IV) (General)
  - Looked at Med Label #3 (IV) (General)
  - Looked at Med Label #4 (IV) (General)
  - Looked at Med Label (T) (General)

- Action
  - Washed hands
  - Picked up Med #1 (IV)
  - Picked up Med #2 (IV)
  - Picked up Med #3 (IV)
  - Picked up Med #4 (IV)
  - Picked up T
  - Gave medication to patient
  - Filled out or signed MAR

APPENDIX F

GUIDELINES FOR GENERATING A TRACE FROM A VIDEO

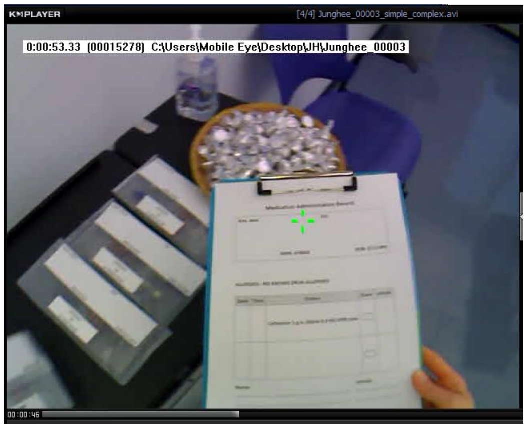
1. Download and Install KM player (http://www.kmplayer.com/)
2. Press “F” for frame step forward, “Shift +F” for frame step backward
3. Track the location of the green cross-hairs and write the event name & time


KMPLAYER
Junghee_00000.avi
BOX
0:05:23.92 (0001 7633) C:\Users\Mobile Eye\Desktop\JH\Junghee_00000
Medication Administration Record
00:05:20
00:06:25

Event name: “Looked at Allergy info on MAR”
Time: 0:05:23.92

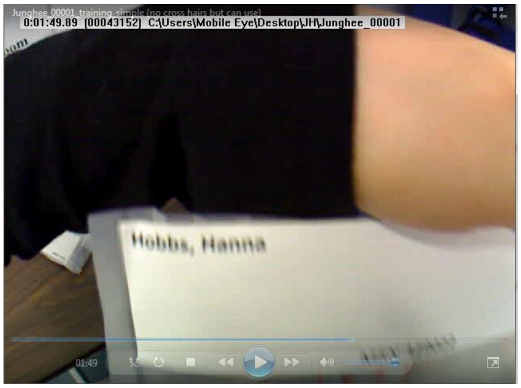
Note:

- Use only pre-defined event names. While you are reviewing the video, if some event names are not defined and need to be defined, please email me
- The minimum time the cross-hairs must remain on an identifier to be considered a fixation is “120ms” which implies time for “3” consecutive frames. In other words, if the cross-hairs did not remain on an identifier while you press the “F” key 3 times, it is not a fixation
- The cross-hairs are sometimes not located right above the identifier, but the location of the cross-hairs can be estimated based on the context of the video


KMPLAYER
[4/4] Junghee_00003_simple_complex.avi
0:00:53.33 (00015278) C:\Users\Mobile Eye\Desktop\JH\Junghee_00003
Medication Administration Record
00:00:46

Example: “Looked at Age on MAR”

- Sometimes the cross-hairs cannot be seen. The location of the eye fixation can be estimated based on the context of the video


Junghee_00001_training_simple (no cross hairs but can use)
0:01:49.89 (00043152) C:\Users\Mobile Eye\Desktop\JH\Junghee_00001
Hobbs, Hanna
01:49

Example: “Looked at Name on Med Label”

- Sometimes the synchronization between the participant’s voice and the image on the video is faulty, but the location of the eye fixation can be estimated based on the context of the video

APPENDIX G

AGREEMENT RATE BETWEEN THE TWO VIDEO CODERS

A. All events (n=71)

Contingency Table		**Coder B**		Total
		YES	NO	
Coder A	YES	**2665**	**500**	3165
	NO	**565**	**6782**	7347
Total		3230	7282	10512

- Kappa value: 0.76 (substantial agreement)
- Percentage agreement: 90%

B. Events related to compliance with Joint Commission guidelines (n=18)

Contingency Table		**Coder B**		Total
		YES	NO	
Coder A	YES	**1288**	**81**	1369
	NO	**114**	**245**	359
Total		1402	326	1728

- Kappa value: 0.72 (substantial agreement)
- Percentage agreement: 88%

APPENDIX H

THE RESULTS OF THE OTHER ANALYSES

A. ID band is NOT trusted & Dist ≤ 2

- Raw performance of all students (Figure 5.7 (b))
    - Compliance results

Current training

ID band is NOT trusted, Dist ≤ 2

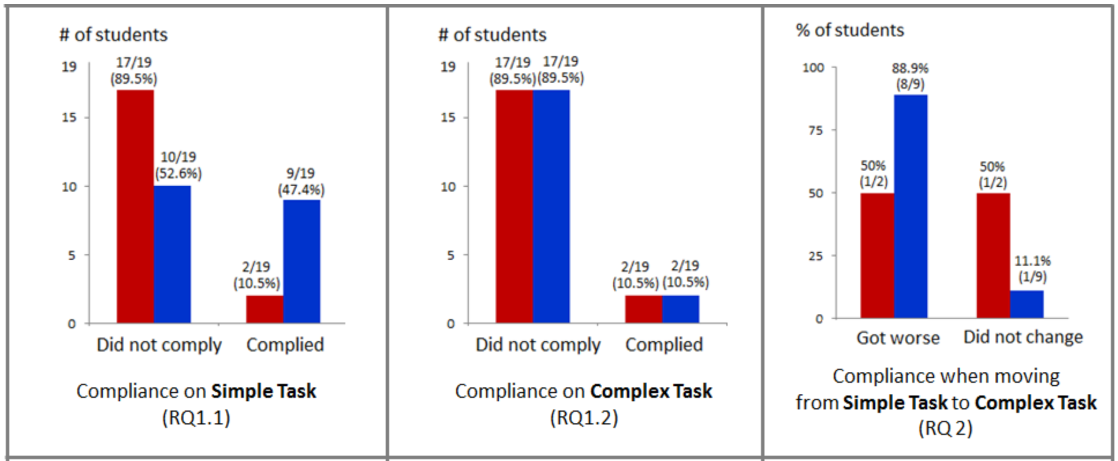
Pre-test	Simple Task	Complex Task		**Compliance on S (RQ 1.1)**	**Compliance on C (RQ 1.2)**	**Change from S to C (RQ 2)**
✓						
✓						
✓						
✓	✓			✓		-1
	✓			✓		-1
		✓			✓	
	✓	✓		✓	✓	0
✓	✓			✓		-1
0/19 (0%)	**2/19 (10.5%)**	**2/19 (10.5%)**	**1**	**2/19 (10.5%)**	**2/19 (10.5%)**	**N/A**
			0	**17/19 (89.5%)**	**17/19 (89.5%)**	**1/2(50%)**
			-1	**N/A**	**N/A**	**1/2(50%)**

Definitive procedure-based training

ID band is NOT trusted, Dist ≤ 2

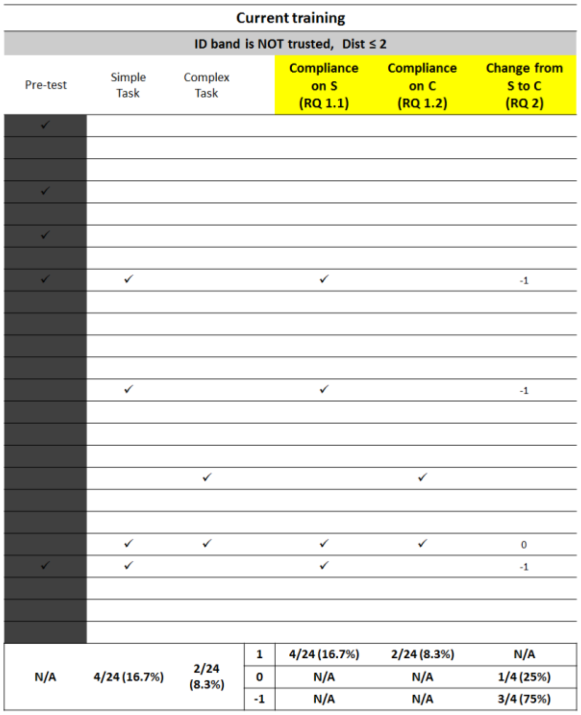
Pre-test	Simple Task	Complex Task		**Compliance on S (RQ 1.1)**	**Compliance on C (RQ 1.2)**	**Change from S to C (RQ 2)**
	✓			✓		-1
✓	✓	✓		✓	✓	0
✓	✓	✓		✓	✓	0
✓	✓	✓		✓	✓	0
	✓			✓		-1
	✓			✓		-1
	✓			✓		-1
✓	✓			✓		-1
	✓			✓		-1
	✓			✓		-1
	✓			✓		-1
	✓			✓		-1
		✓			✓	
✓	✓	✓		✓	✓	0
	✓	✓		✓	✓	0
0/19 (0%)	**9/19 (47.4%)**	**2/19 (10.5%)**	**1**	**9/19 (47.4%)**	**2/19 (10.5%)**	**N/A**
			0	**10/19 (52.6%)**	**17/19 (89.5%)**	**1/9 (11.1%)**
			-1	**N/A**	**N/A**	**8/9 (88.9%)**

- Difference in compliance between two groups



Compliance on Simple Task (RQ1.1)	Compliance on Complex Task (RQ1.2)	Compliance when moving from Simple Task to Complex Task (RQ 2)
Statistically significant (p=0.015; Fisher exact test)	Not statistically significant (p=1.0; Fisher exact test)	Not statistically significant (p=0.34; Fisher exact test)

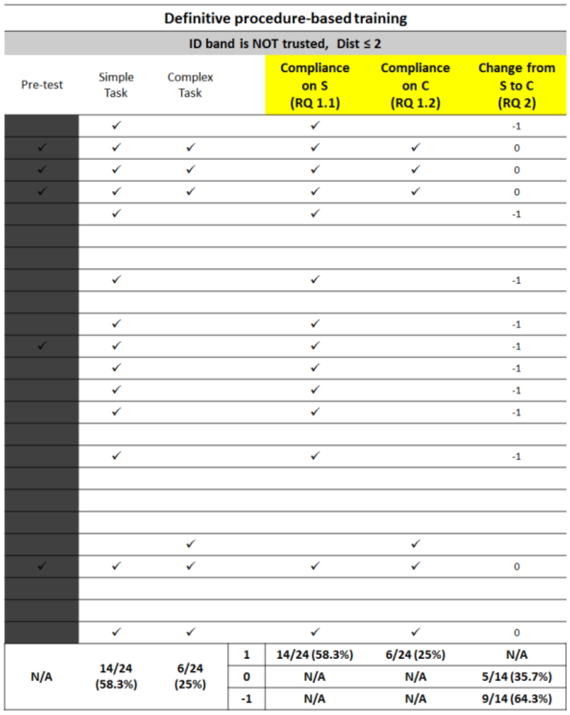
- Raw performance of non-compliers (Figure 5.7 (c))
  - Compliance results



Current training

ID band is NOT trusted, Dist ≤ 2

Pre-test	Simple Task	Complex Task		**Compliance on S (RQ 1.1)**	**Compliance on C (RQ 1.2)**	**Change from S to C (RQ 2)**
✓						
✓						
✓						
✓	✓			✓		-1
	✓			✓		-1
		✓			✓	
	✓	✓		✓	✓	0
✓	✓			✓		-1
N/A	**4/24 (16.7%)**	**2/24 (8.3%)**	**1**	**4/24 (16.7%)**	**2/24 (8.3%)**	**N/A**
			0	**N/A**	**N/A**	**1/4 (25%)**
			-1	**N/A**	**N/A**	**3/4 (75%)**

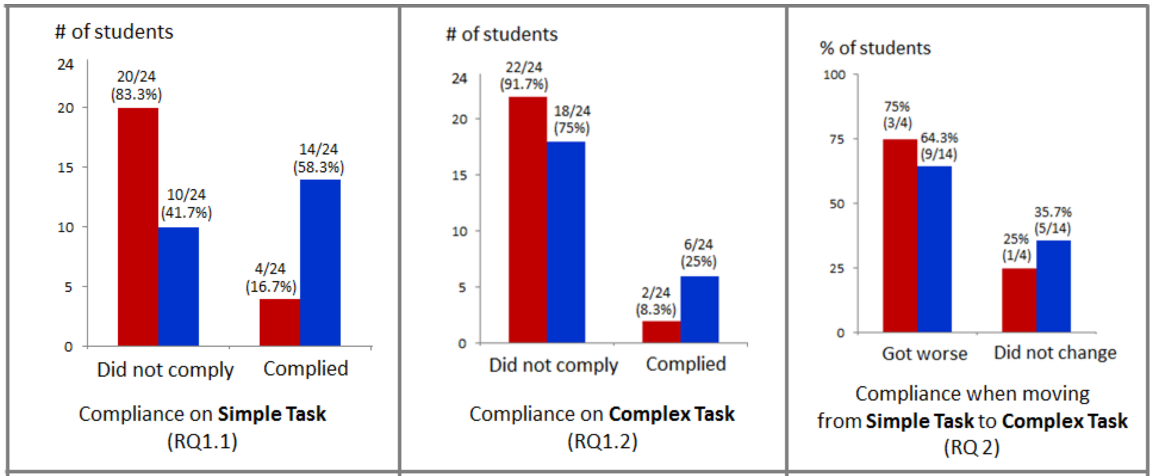


Definitive procedure-based training

ID band is NOT trusted, Dist ≤ 2

Pre-test	Simple Task	Complex Task		**Compliance on S (RQ 1.1)**	**Compliance on C (RQ 1.2)**	**Change from S to C (RQ 2)**
	✓			✓		-1
✓	✓	✓		✓	✓	0
✓	✓	✓		✓	✓	0
✓	✓	✓		✓	✓	0
	✓			✓		-1
	✓			✓		-1
	✓			✓		-1
✓	✓			✓		-1
	✓			✓		-1
	✓			✓		-1
	✓			✓		-1
	✓			✓		-1
		✓			✓	
✓	✓	✓		✓	✓	0
	✓	✓		✓	✓	0
N/A	**14/24 (58.3%)**	**6/24 (25%)**	**1**	**14/24 (58.3%)**	**6/24 (25%)**	**N/A**
			0	**N/A**	**N/A**	**5/14 (35.7%)**
			-1	**N/A**	**N/A**	**9/14 (64.3%)**

  - Difference in compliance between two groups



Compliance on Simple Task (RQ1.1)	Compliance on Complex Task (RQ1.2)	Compliance when moving from Simple Task to Complex Task (RQ 2)
Statistically significant (p=0.003; Fisher exact test)	Not statistically significant (p=0.122; Fisher exact test)	Not statistically significant (p=0.34; Fisher exact test)

B. ID band is NOT trusted & Dist ≤ 1

- Improvement from pre-test (Figure 5.7 (a))
  - Compliance results

Current training

ID band is NOT trusted, Dist ≤ 1

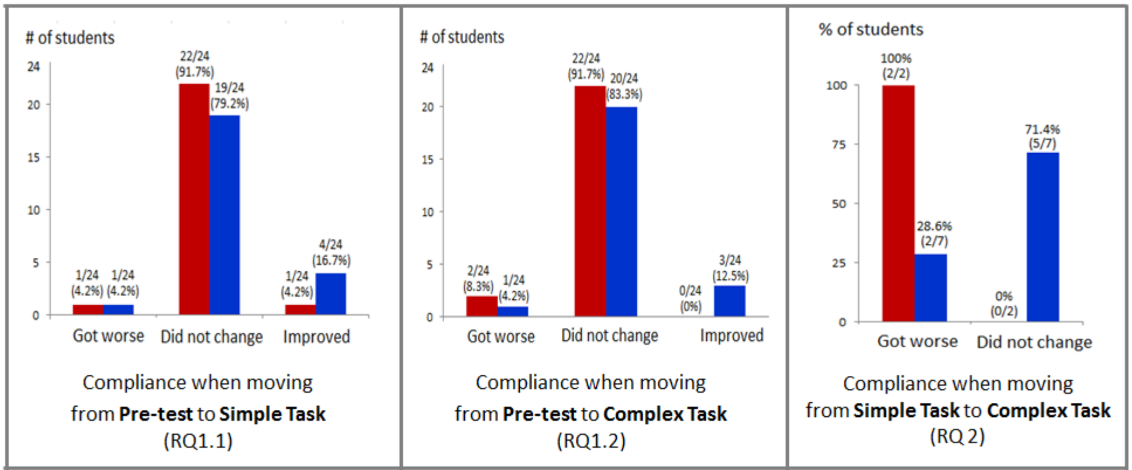
Pre-test	Simple Task	Complex Task		Change from P to S (RQ 1.1)	Change from P to C (RQ 1.2)	Change from S to C (RQ 2)
				0	0	
				0	0	
				0	0	
✓				-1	-1	
				0	0	
				0	0	
				0	0	
	✓			1	0	-1
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
✓	✓			0	-1	-1
				0	0	
				0	0	
				0	0	
2/24 (8.3%)	2/24 (8.3%)	0/24 (0%)	1	1/24(4.2%)	0/24(0%)	N/A
			0	22/24(91.7%)	22/24(91.7%)	0/24(0%)
			-1	1/24(4.2%)	2/24(8.3%)	2/24(100%)

Definitive procedure-based training

ID band is NOT trusted, Dist ≤ 1

Pre-test	Simple Task	Complex Task		Change from P to S (RQ 1.1)	Change from P to C (RQ 1.2)	Change from S to C (RQ 2)
	✓			1	0	-1
	✓	✓		1	1	0
✓	✓	✓		0	0	0
✓	✓	✓		0	0	0
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
				0	0	
✓				-1	-1	
				0	0	
				0	0	
				0	0	
				0	0	
	✓			1	0	-1
				0	0	
				0	0	
				0	0	
		✓		0	1	
✓	✓	✓		0	0	0
				0	0	
				0	0	
	✓	✓		1	1	0
4/24 (16.7%)	7/24 (29.2%)	6/24 (25%)	1	4/24(16.7%)	3/24(12.5%)	N/A
			0	19/24(79.2%)	20/24(83.3%)	5/24(71.4%)
			-1	1/24(4.2%)	1/24(4.2%)	2/24(28.6%)

  - Difference in compliance between two groups



Compliance when moving from **Pre-test** to **Simple Task** (RQ1.1)

Compliance when moving from **Pre-test** to **Complex Task** (RQ1.2)

Compliance when moving from **Simple Task** to **Complex Task** (RQ 2)

Not statistically significant (p=0.348; Fisher exact test)	Not statistically significant (p=0.413; Fisher exact test)	Not statistically significant (p=0.167; Fisher exact test)

- Raw performance of all students (Figure 5.7 (b))
  - Compliance results

Current training

ID band is NOT trusted, Dist ≤ 1

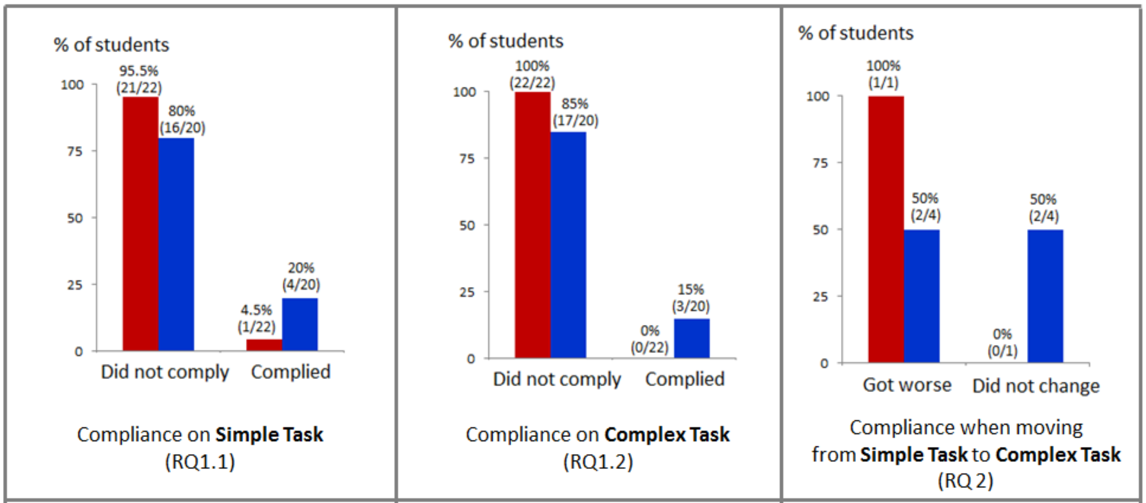
Pre-test	Simple Task	Complex Task		**Compliance on S (RQ 1.1)**	**Compliance on C (RQ 1.2)**	**Change from S to C (RQ 2)**
✓						
	✓			✓		-1
✓	✓			✓		-1
0/22 (0%)	**1/22 (4.5%)**	**0/22 (0%)**	**1**	**1/22(4.5%)**	**0/22(0%)**	**N/A**
			0	**21/22(95.5%)**	**22/22(100%)**	**0/1(0%)**
			-1	**N/A**	**N/A**	**1/1(100%)**

Definitive procedure-based training

ID band is NOT trusted, Dist ≤ 1

Pre-test	Simple Task	Complex Task		**Compliance on S (RQ 1.1)**	**Compliance on C (RQ 1.2)**	**Change from S to C (RQ 2)**
	✓			✓		-1
	✓	✓		✓	✓	0
✓	✓	✓		✓	✓	0
✓	✓	✓		✓	✓	0
✓						
	✓			✓		-1
		✓			✓	
✓	✓	✓		✓	✓	0
	✓	✓		✓	✓	0
0/20 (0%)	**4/20 (20%)**	**3/20 (15%)**	**1**	**4/20(20%)**	**3/20(15%)**	**N/A**
			0	**16/20(80%)**	**17/20(85%)**	**2/4(50%)**
			-1	**N/A**	**N/A**	**2/4(50%)**

  - Difference in compliance between two groups



Compliance on **Simple Task** (RQ1.1)

Compliance on **Complex Task** (RQ1.2)

Compliance when moving from **Simple Task** to **Complex Task** (RQ 2)

Not statistically significant (p=0.144; Fisher exact test)	Not statistically significant (p=0.099; Fisher exact test)	Not statistically significant (p=0.599; Fisher exact test)

- Raw performance of non-compliers (Figure 5.7 (c))
    - Compliance results

Current training

ID band is NOT trusted, Dist ≤ 1

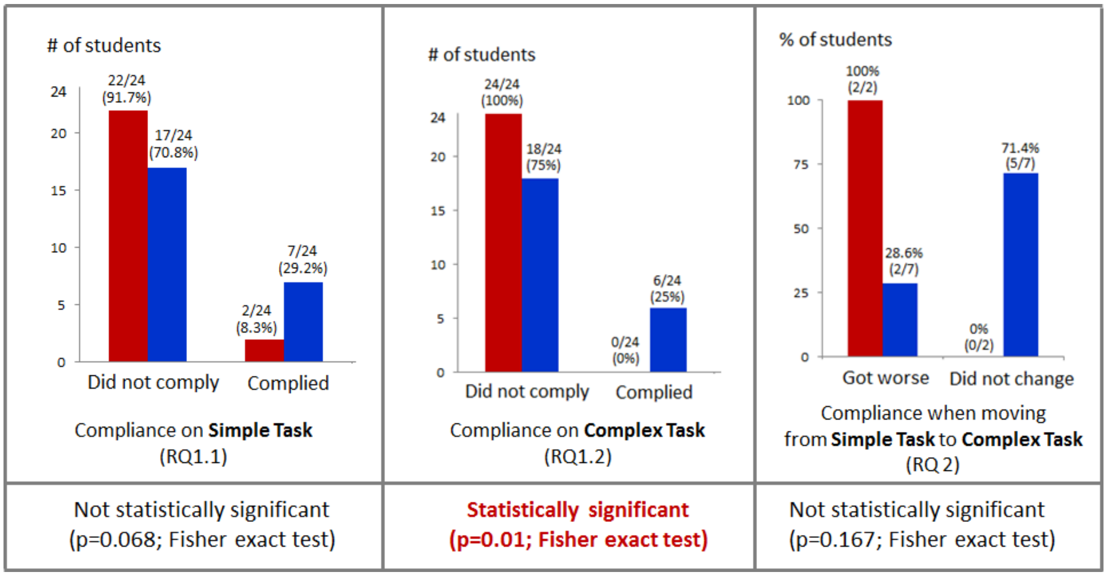
Pre-test	Simple Task	Complex Task		**Compliance on S (RQ 1.1)**	**Compliance on C (RQ 1.2)**	**Change from S to C (RQ 2)**
✓						
	✓			✓		-1
✓	✓			✓		-1
N/A	**2/24 (8.3%)**	**0/24 (0%)**	**1**	**2/24(8.3%)**	**0/24(0%)**	**N/A**
			0	**N/A**	**N/A**	**0/2(0%)**
			-1	**N/A**	**N/A**	**2/2(100%)**

Definitive procedure-based training

ID band is NOT trusted, Dist ≤ 1

Pre-test	Simple Task	Complex Task		**Compliance on S (RQ 1.1)**	**Compliance on C (RQ 1.2)**	**Change from S to C (RQ 2)**
	✓			✓		-1
	✓	✓		✓	✓	0
✓	✓	✓		✓	✓	0
✓	✓	✓		✓	✓	0
✓						
	✓			✓		-1
		✓			✓	
✓	✓	✓		✓	✓	0
	✓	✓		✓	✓	0
N/A	**7/24 (29.2%)**	**6/24 (25%)**	**1**	**7/24(29.2%)**	**6/24(25%)**	**N/A**
			0	**N/A**	**N/A**	**5/7(71.4%)**
			-1	**N/A**	**N/A**	**2/7(28.6%)**

- Difference in compliance between two groups

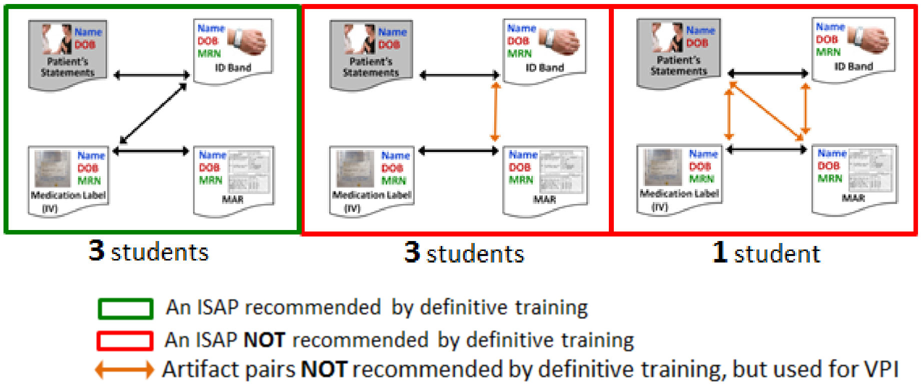


Not statistically significant (p=0.068; Fisher exact test)

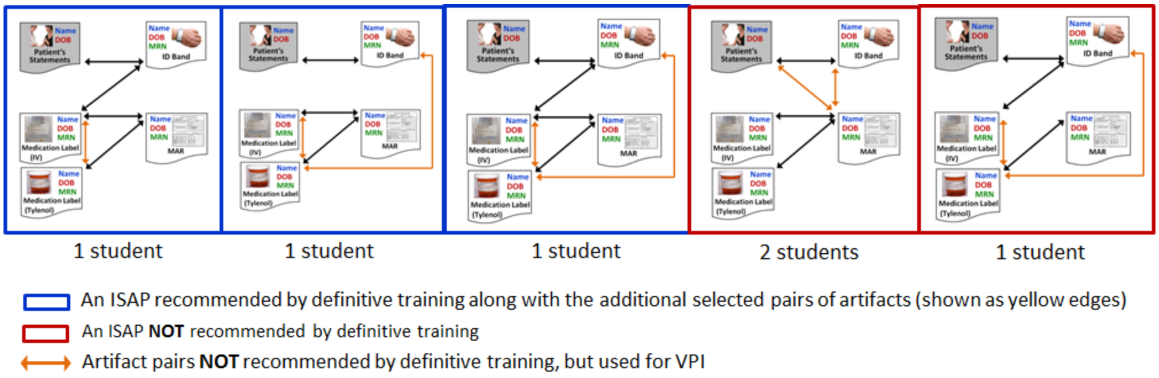
Statistically significant (p=0.01; Fisher exact test)

Not statistically significant (p=0.167; Fisher exact test)

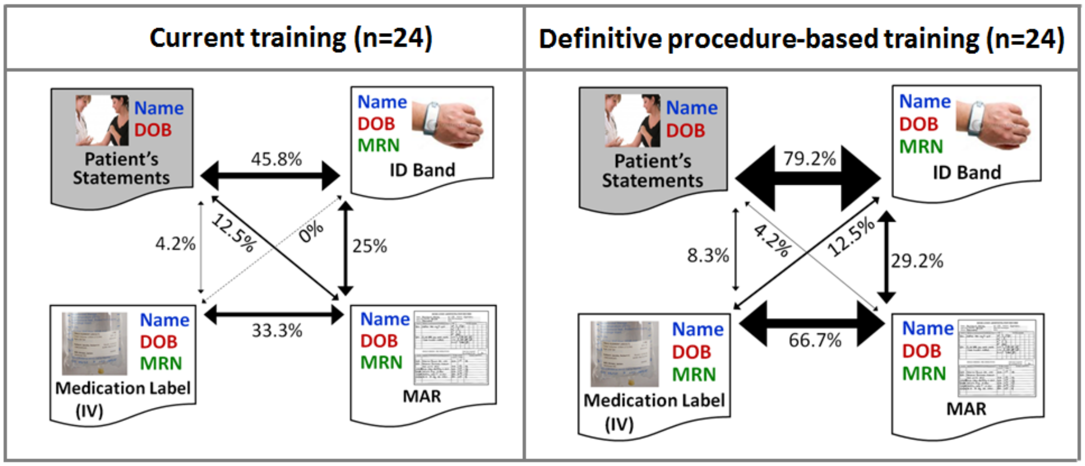
- ISAPs used by students who complied in the Simple Task (n=7)


Name
DOB
Patient's Statements
Name
DOB
MRN
ID Band
Name
DOB
MRN
Medication Label (IV)
Name
DOB
MRN
MAR
3 students
3 students
1 student
🟩 An ISAP recommended by definitive training
🟥 An ISAP NOT recommended by definitive training
⟷ Artifact pairs NOT recommended by definitive training, but used for VPI

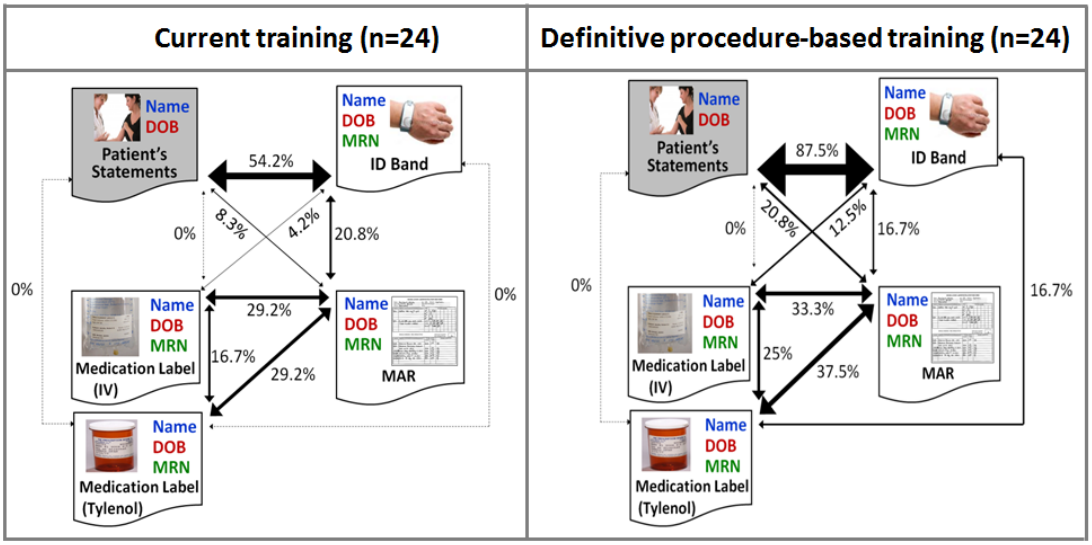
- ISAPs used by students who complied in the Complex Task (n=6)


Name
DOB
Patient's Statements
Name
DOB
MRN
ID Band
Name
DOB
MRN
Medication Label (IV)
Name
DOB
MRN
MAR
Name
DOB
MRN
Medication Label (Tylenol)
1 student
1 student
1 student
2 students
1 student
An ISAP recommended by definitive training along with the additional selected pairs of artifacts (shown as yellow edges)
An ISAP NOT recommended by definitive training
⟷ Artifact pairs NOT recommended by definitive training, but used for VPI

- The percentage of students who used the artifact pair in the Simple Task


Current training (n=24)
Definitive procedure-based training (n=24)
Name
DOB
Patient's Statements
Name
DOB
MRN
ID Band
Name
DOB
MRN
Medication Label (IV)
Name
DOB
MRN
MAR
45.8%
12.5%
0%
4.2%
25%
33.3%
79.2%
4.2%
12.5%
8.3%
29.2%
66.7%

- The percentage of students who used the artifact pair in the Complex Task


Current training (n=24)
Definitive procedure-based training (n=24)
Name
DOB
Patient's Statements
Name
DOB
MRN
ID Band
54.2%
0%
8.3%
4.2%
20.8%
0%
0%
Name
DOB
MRN
Medication Label (IV)
29.2%
16.7%
29.2%
Name
DOB
MRN
MAR
Name
DOB
MRN
Medication Label (Tylenol)
87.5%
0%
20.8%
12.5%
16.7%
0%
16.7%
33.3%
25%
37.5%

APPENDIX I

RAW COMPLIANCE OF “WASH HANDS” AND “ASK THE PATIENT ABOUT KNOWN ALLERGIES”

Current training		
Wash hands		
Pre-test	Simple Task	Complex Task
✓	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
✓	✓	✓
	✓	✓
	✓	✓
	✓	✓
✓	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
✓	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
4/24 (16.7%)	**23/24 (95.8%)**	**23/24 (95.8%)**

Definitive procedure-based training		
Wash hands		
Pre-test	Simple Task	Complex Task
	✓	✓
✓	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
✓	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
✓	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
3/24 (12.5%)	**24/24 (100%)**	**24/24 (100%)**

Current training		
Ask the patient about known allergies		
Pre-test	Simple Task	Complex Task
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	
	✓	✓
	✓	✓
	✓	
	✓	✓
	✓	✓
	✓	✓
	✓	✓
✓	✓	
	✓	✓
	✓	✓
✓	✓	✓
	✓	✓
✓	✓	✓
	✓	✓
✓	✓	✓
	✓	✓
	✓	✓
	✓	✓
4 (16.7%)	**23 (95.8%)**	**20 (83.3%)**

Definitive procedure-based training		
Ask the patient about known allergies		
Pre-test	Simple Task	Complex Task
	✓	✓
✓	✓	
	✓	✓
		✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	
✓	✓	✓
✓	✓	✓
	✓	✓
✓		
	✓	
	✓	✓
	✓	✓
	✓	✓
	✓	✓
	✓	✓
✓		
✓	✓	✓
	✓	
✓	✓	
✓	✓	✓
8 (33.3%)	**21 (87.5%)**	**17 (70.8%)**

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