# PATIENT ROOM HANDEDNESS
## An Empirical Examination

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# PATIENT ROOM HANDEDNESS: AN EMPIRICAL EXAMINATION

## EXECUTIVE SUMMARY


### Objective

The study objective was to examine how physical design configurations impact care processes. An intermediate objective was to examine patterns of care giving behavior in nurses of different characteristics, in acute medical-surgical care.

### Background

Patient room handedness has emerged as an important issue in inpatient unit design with many hospitals adopting the same-handed room concept at all levels of patient acuity. While it is argued that same-handed rooms improve patient safety and staff efficiency (drawing the arguments from aerospace industry), there is little empirical evidence to either support or oppose the contention. Moreover, the same-handed concept assumes that a particular physical design configuration optimizes care behavior, where as there is a lack of knowledge on how nurses behave during care giving.

### Method

An experimental setting was developed where elements of the physical environment and approach related to the caregiver zone was systematically manipulated. Twenty RNs (10 left-handed and 10 right-handed) provided three types of care to a patient-actor across the nine configurations, which were videotaped in 540 separate segments. A structured interview of the subjects was conducted at the end of the individual simulation runs to obtain triangulating data. Video segments were coded by experts in nursing and kinesiology. Statistical and content analysis of the data was conducted.

### Results

Study data show that standardization of processes and workflow to the extent of force functioning staff location on the right side of the patient, in acute medical-surgical settings, may not be achievable owing to numerous factors. Thus, designing same-handed environments may not contribute to process and workflow standardization. However, physical design standardization (as a construct distinct from environmental handedness), leading to familiarity with the physical work environment, is a desirable attribute in acute medical-surgical settings.

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## Introduction and Problem Definition

The dawn of the twenty first century witnessed an unprecedented rise in concerns related to patient safety and efficiency in American healthcare. The wide range of concerns primarily emerged from reports produced by the Institute of Medicine (Institute of Medicine, 2001; Kohn, Corrigan, & Donaldson, 2000; Page, 2004) and the Agency for Healthcare Research and Quality (2001, 2003). The Institute of Medicine report highlighted the large number of preventable deaths and injuries occurring in American hospitals, making it unsafe for the patients. Medical errors, hospital acquired infections, patient falls, and other safety issues emerged as the top concerns in patient care delivery. Among other factors, the AHRQ report pointed out the physical condition of the clinicians' work environment as an area warranting improvement in order to render patient care delivery safer and more efficient.

While numerous clinical and process interventions were examined and implemented in the succeeding years, the architectural design industry also responded with a number of design concepts that could contribute to safer and more efficient patient care. One of the physical design concepts proposed, and subsequently adopted in an increasing number of hospitals, is the concept of "same-handed" patient rooms (Cahnman, 2006; McCullough, 2006; Schneider, 2007).

Figure 1 illustrates an example of tradition mirror-image patient rooms. Figure 2 illustrates an example of a right-handed patient room (one type of same-handed configuration, the other type being left-handed patient room). In traditional hospital bed units, patient rooms are configured in a mirrored arrangement. The mirrored configuration enables sharing of medical gas lines and bathroom plumbing chases and lines. These avenues for sharing are perceived to result in lower initial capital cost of construction as compared to a same-handed patient room configuration, where medical gases and bathroom plumbing cannot be shared between two rooms. While any empirical evidence of initial premium in capital cost is not available in published literature, there is a general perception of a considerable premium in first cost associated with same-handed room configurations (Schneider, 2007).

Despite the perceived cost premium, the concept of same-handed patient room has maintained its status as the subject matter of intense debate owing to a perception of safer care associated with it (Cahnman, 2006; Reiling, 2007; Schneider, 2007). However, little empirical evidence exists to support or refute any of the contentions made pertaining to the same-handed room concept.

The frequently raised issue, as a result, is whether and to what extent same-handed configurations contributes to safety and efficiency.

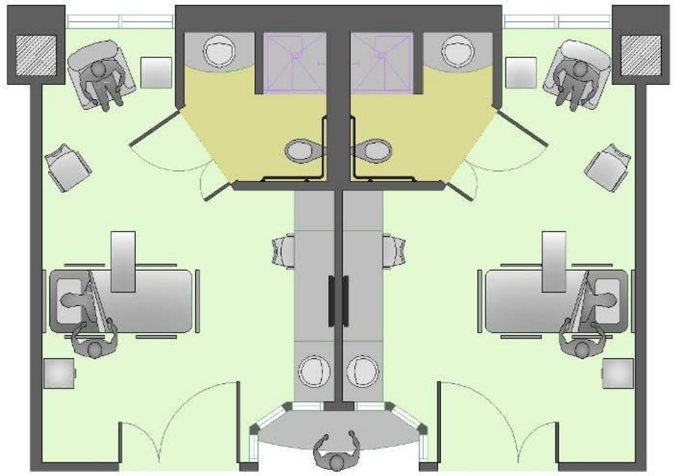


*Figure 1: An example of a traditional mirror-image patient room configuration.*

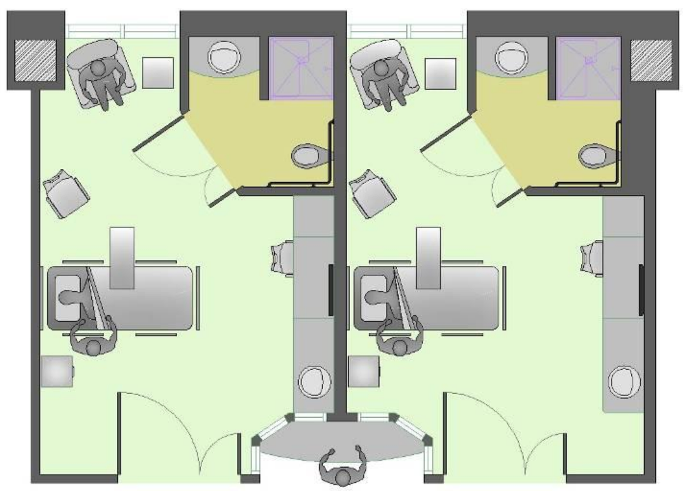


*Figure 2: An example of a right-handed patient room configuration.*

## The Safety Argument

The notion of safety associated with attributes of the physical environment was mapped from the experience in other high risk sectors including aviation and nuclear industries (see Reiling, 2007, for instance).

In aerospace, standardization of processes and environments gained currency owing to substantial evidence that human factors are the underlying cause of errors (Jorna & Hoogeboom, 2004; Schutte & Willshire, 1997). There is a significant body of literature on standardization of flight decks. Human errors have been shown to be associated with 80% of fatal accidents in aviation, and records of worldwide accidents involving commercial jet aircrafts between 1959 and 1995 show that flight crew error was the primary cause in 64.4% of the accidents (Noyes, Starr, & Kazem, 2004). Factors associated with human errors in aviation are multiple. Those include procedural (as in training) and those associated with the physical environment. One of the factors highlighted in literature pertains to the location and design of controls and flight deck interfaces, where continuously changing technology and variations between aircraft equipments are discussed as major challenges (Lande, 1997; Singer, 2004; Spitzer, 2006). This is especially important since crew members typically fly more than a single airplane, even within the same company. The benefits of flight deck standardization was examined and codified in standards decades back (Department of Transportation, 2004; Lande, 1997;  Sulzer, 1981).

Challenges associated with human-machine interactions that involve negative transfer of learning while switching aircrafts (Lande, 1997; Spitzer, 2006) and unnatural or non-intuitive interfaces (Schutte & Willshire, 1997) constitute one area of focus. Advancements in technology contribute considerably to this challenge (Lande, 1997, Spitzer, 2006). Such factors introduce cognitive challenges in pilot decision-making, leading to potential errors. Identical argument drives the concept of same-handed patient rooms, asserting that standardization reduces cognitive demand and help automate several cognitive processes, leading to lesser demand on short-term memory (Reiling, 2007). Standardization of equipment, procedures, actions, system layout, displays and color philosophy, among others, are recommended to enhance safety in the aviation industry (Spitzer, 2006).

Another safety issue highlighted in aviation literature is ergonomics (Seifert & Brauser, 1983). If ergonomic design represents a key factor in aviation safety, it could also play a role in patient safety. Arguably, actions that could hurt caregivers may contribute indirectly to unsafe care. Impacts of inappropriate body mechanics on staff while reaching, lifting, and conducting other physically demanding activities have been well documented in occupational safety literature (Bashir, 2002; Benyon & Reilly, 2002; Smedlay et al., 2003; Trinkoff, Lipscomb, Geiger-Brown, & Brady, 2002). Such activities could include inappropriate body postures (reaching out, pulling, lifting, etc.) and transferring patients (Bashir, 2002). Caregivers' characteristics could have an impact on the manner a particular task is conducted. It is well documented in literature that individuals have a stronger side and preferred posture (Ozcan, Tulum, Pinar & Baskurt, 2004; Turkan, 2003). In that context, the body mechanics that nurses use could vary from person to person based on individual characteristics: 1) height, 2) weight, and 3) handedness (left versus right handed). At the very basic level, the act of compensating for restrictions imposed by the immediate physical environment could impact the efficiency of patient care delivery. Repetitive, inappropriate movements also lead to detrimental physical stresses and strains. Thus, in the worst case scenario, inappropriate body mechanics could not only harm caregivers, but compromise care delivery.

A more important issue pertaining to ergonomics, however, relates to laterality and handedness of people. It has been shown that poor ergonomics could worsen problems associated with laterality - a person's internal awareness of up and down and left and right - and handedness -one's ability to distinguish between left and right, and coordinate one's eyes and hands in response to that knowledge

(Whittingham, 2004). Thus, poor ergonomics could directly impair functional performance, and hence safety and efficiency.

## A Standardization Framework

Experiences in the aviation industry offer a framework to organize the study questions and data analysis in the context of healthcare design. The framework is illustrated in Figure 3. It shows that the primary target of standardization is the standardization of processes. If processes that have safety or efficiency implications are standardized, there should be a corresponding reduction in cognitive demand and fewer incidences in cognitive failure during emergencies.

Standardization of processes includes standardization of procedures and actions performed by the staff. The handedness and laterality of staff do have an implication on standardization of procedures and actions.

The other aspect of standardization involves elements of the physical environment. Procedure and action standardization cannot be implemented successfully without standardizing the physical environment in which tasks are performed. Physical environment factors essential for standardization efforts include the layout and location of elements, the design of the individual elements, and the human-machine interaction involving equipment and healthcare information technology (HIT) such as computerized physician order entry system or electronic medical records. Handedness of the physical environment (note the distinction being drawn here between handedness of people and handedness of the physical environment) constitutes one option in physical environment standardization.

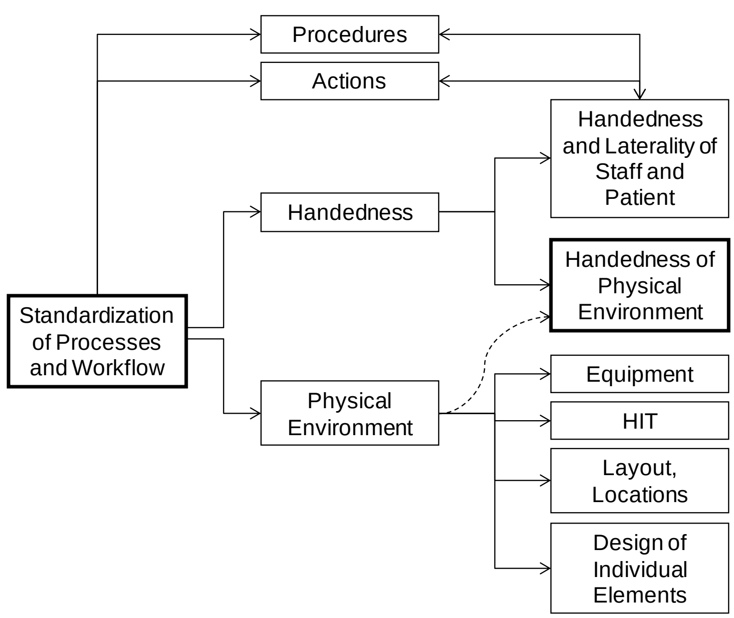



*Figure 3: A framework articulating the different aspects of standardization discussed in literature*

**Standardization versus Handedness**

A key issue in the standardization debate is the handedness of the layout of the physical configuration. It is noteworthy that discussions on same-handed rooms in design literature use the terms standardization and same-handedness interchangeably, suggesting the two as identical concepts. A key distinction made in this study is the one between handedness and the standardization. As illustrated in Figure 3, handedness of the physical environment is only one optional component of standardization.

Further, same-handedness as a standardization measure have been discussed typically at the patient room level; that is, all aspects of the patient room, including handedness, is replicated without any variations throughout a bed unit. Standardization of care environment, however, could be conceived of at five different levels. The lowest two levels pertain to headwall standardization. The third level expands to the care giver zone (the zone around the patient bed reserved for the caregivers and equipment). The fourth level constitutes the standardization of the entire patient room. The highest level of standardization is at the unit level, where all inpatient units in a hospital are built identical. Table 1 articulates the attributes of each level of standardization.

Two pertinent issues warrant considerations within the context of patient safety through standardization. First is the level of standardization that actually contributes to safe patient care. The second issue is the relationship between standardization and handedness. It is noteworthy that all levels of standardization could be achieved without creating patient care room configurations that are same-handed. That would involve standardization of the procedures and actions and those supporting the procedures including design of individual elements involved in the care process, their locations, equipment, and HIT. On the other hand, one could design handedness into care environments without standardizing the physical elements within those environments. Both standardization and same-handedness could be achieved, too. The importance of articulating this distinction is owing to the variable impact standardization with and without handedness could have on cost and patient care delivery.

*Table 1: Five levels of standardization in inpatient care*

| Level of Standardization | Details |
|---|---|
| Level 1 – Headwall | Identical array of utilities is always provided on the corridor side of each room (irrespective of patient side) |
| Level 2 - Headwall | Consistent placement of a certain array of utilities on the patient's left, and another on the right |
| Level 3 – Caregiver Zone | Design and relative locations of all elements provided to support the care process within the caregiver zone are standardized across all patient rooms (e.g., including work surfaces, supply storage, hand washing sink, etc. |

| Level of Standardization | Details |
|---|---|
| Level 4 – Patient Room | Patient rooms (pairs in case of mirrored configurations) are designed identical, in that all elements in the patient rooms are located and oriented in the same position and direction |
| Level 5 – Inpatient Unit | Patient rooms and all support spaces are standardized across all units in a hospital |

## Procedures and Actions: Pattern of Nursing Behavior

As the framework suggests, a crucial component of standardizing processes is standardizing procedures and actions. In the ongoing standardization and handedness debate in healthcare design, the primary difficulty is in the fact that little is available in documented literature regarding the behaviors and actions of caregivers while delivering patient care. The concept of same-handed rooms is predicated on the assumption that there exists a thorough understanding of the way nurses behave naturally during care delivery, and common patterns of behavior are known that could be best supported by one physical design configuration. Neither of these assumptions, however, have evidence to support or refute them. In essence, the increasing focus on same-handed inpatient rooms is emphasizing a knowledge gap pertaining to procedures and actions associated with natural care giving behavior, with the variations in body mechanics and with possible constraints imposed by the physical environment. Without understanding care behavior, it is difficult to assert that a certain physical configuration will optimize standardization of care process or promote efficiency and safety.

## Study Objective and Question

In the absence of any literature on nursing behavior or handedness of physical configuration, the study was designed with two main questions:

1. Are there natural patterns of care behavior?
   *This was intended to address the procedures and actions components of the framework.*
2. Would standardization and/or handedness facilitate or impede care process?
   *This was intended to address the physical environment standardization components of the framework.*

The objective of the study was to create a preliminary foundation to examine potential associations between handedness of the care setting, and safety and efficiency of patient care delivery. The study intended to address the simplest question pertaining to environmental handedness and nursing care, with the aim to generate the preliminary evidence needed to support more complex empirical examination of the handedness issue. Since handedness is discussed within the standardization framework, standardization, by default, constituted an area of examination.

Finally, two types of room configuration handedness have been designed in hospitals – the right-handed patient room and the left-handed patient room. Typically, however, it is the right-handed patient room that has been show-cased in printed literature (Reiling, 2007), based on a traditional perception that the right side of the patient constitutes the best location for the caregiver. Throughout the remainder of this report, right-handedness will be the default in the discussion of handedness. The issues, however, are identical in left-handedness, and any inferences on right-handedness should be treated as one befitting left-handed configurations too.

## Research Design

### Study Setting

The study was conducted at the University of Texas Arlington School of Nursing. The recently opened Smart Hospital™ at UTA School of Nursing is a state-of-science facility that is designed to operate as a fully functioning hospital. Units in the hospital are fitted with the latest headwalls for (working) medical gases and beds manufactured by Hill-Rom. Other equipment that is typically found in hospital rooms are also provided at the bed side. The large Team Training Room focuses on the development and assessment of in-hospital rescue, stabilization, and resuscitation skills. Video cameras located in the ceiling of each patient care training space capture activities around the bed, for subsequent play-back and use during training.

The 23'x24' Team Training Room was used as the study site (Figures 4, 5 and 6). The headwall in the room had an identical array of redundant medical gases, provision for suction, and power outlets on both side of the patient bed. The adjoining control room is linked through a one-way mirror to unobtrusively observe, record and monitor activities in the Team Training Room. Video and audio feed from the ceiling-mounted cameras are received and processed by custom made software installed on computers inside the control room.

### Subjects and Sample

Subjects were recruited from the nursing students and faculty at the School of Nursing, responding to an internal e-mail solicitation. In total, 10 right-handed nurses and 10 left-handed nurses participated in the study. Only female subjects were recruited in this phase since female caregivers constitute the majority of nurses in hospital inpatient units. Since this was a repeated measures study design and the study was exploratory in nature, a sample size of 20 was considered appropriate.

The nurses participating in the study fairly represented attributes of typical nurses working in U.S. hospitals. The age of the nurses ranged between 21 and 62 years, with a median age of 53 years. The median age of 53 years is proximal to the mean age of 46.8 years (as of March 2004) of American nurses (American Nurses Association, 2009). Of the 20 subjects, one had a BSN degree with the remaining having at least a master's degree in nursing. Work experience as a nurse ranged between less than a year to more than 30 years, with a median experience of 25 years.

One standardized patient (actor) volunteered to serve as the patient in all care scenarios designed for the study.

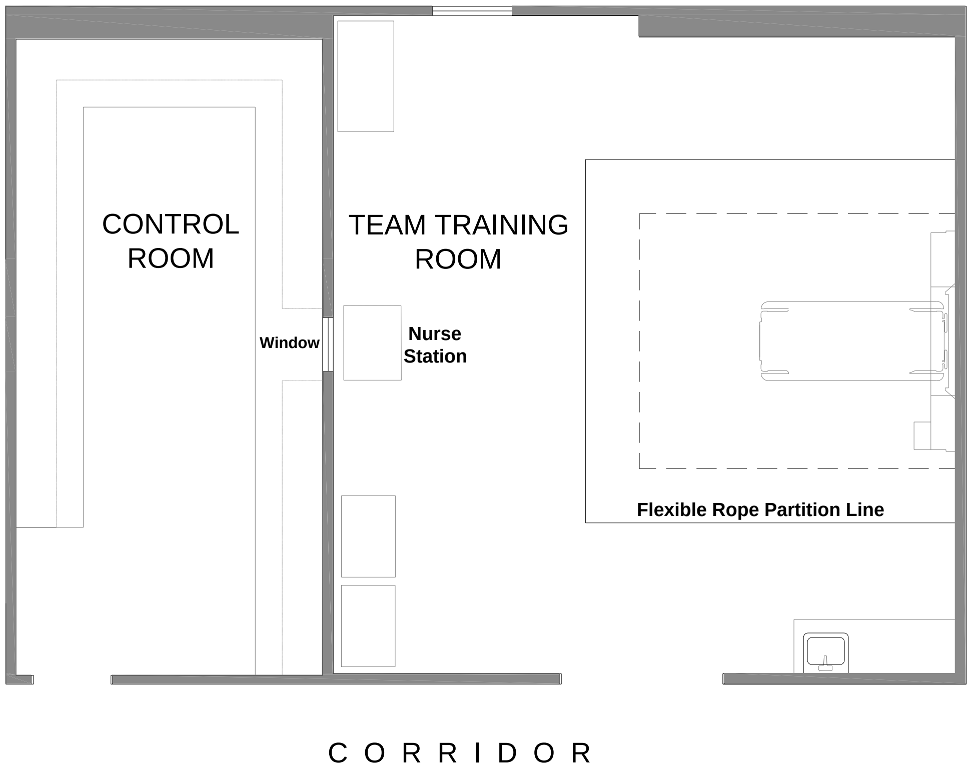



*Figure 4: Floor layout of the Team Training Room and the adjoining Control Room.*

*Figure 5: The bed, headwall and technology features in the Team Training Room.*

*Figure 6: The Control Room with audio visual recording facility.*

**Study Design**

The study protocol was approved by the Institutional Review Board at University of Texas at Arlington. A simulation-based experimental design was adopted for the study where elements of the physical environment were systematically manipulated. As the initial examination of a hitherto unexplored question, the following attributes were considered for the physical environment:

1. A acute medical-surgical unit setting was considered for the study since it represents the predominant care environment in an acute care hospital, both in terms of physical design as well as care procedures. Greater levels of complexities representing higher level of patient acuity were intended to be examined in subsequent studies. Since handedness is often being promoted at all acuity levels in today's hospital design, it represents the most logical and relevant start point.
2. The physical configuration elements that were manipulated included the direction of approach to the patient and the presence or absence of an IV line to the patient using a mobile pole. The patient bed, headwall and a moveable over-bed table represented the common elements across all simulation scenarios. Two classes of physical environment manipulations were conducted:
    a. Right-handed, left-handed and neutral-handed configurations
    b. IV pole on patient's left, IV pole on patients' right, and no-IV pole conditions

These manipulation options resulted in nine physical design configurations. The direction of approach was manipulated using flexible rope partitions as shown in Figure 5. A single panel in the rope partition was left open to represent the patient room door, and hence the direction of approach, when approach was manipulated. The partition was placed five feet away from the bed to allow sufficient space for the subjects to perform their assigned tasks. In the scenarios involving neutral-handedness, the partition was left open to facilitate approach from any direction of the subjects' preference. Table 2 outlines the key attributes of the nine settings. Figure 7 shows diagrams of the nine configurations.

*Table 2: Key attributes of the nine configurations included in the study*

| Scenario Number | Direction of Approach | IV Location |
|---|---|---|
| Scenario 1 | Open | No IV |
| Scenario 2 | Open | IV on patient's left |
| Scenario 3 | Open | IV on patient's right |
| Scenario 4 | Approach from patient's left | No IV |
| Scenario 5 | Approach from patient's right | No IV |
| Scenario 6 | Approach from patient's left | IV on patient's left |
| Scenario 7 | Approach from patient's left | IV on patient's right |
| Scenario 8 | Approach from patient's right | IV on patient's left |
| Scenario 9 | Approach from patient's right | IV on patient's right |

Scenario 1 represents the most unhindered setting without any constraints in the environment related to approach or any obstructions in the immediate care environment. Scenarios 2 and 3 represented obstructions arising from IV location, but no constraints on approach. Scenarios 4 and 5 represented constraints in direction of approach but no obstructions in the care environment. Scenarios 6 through 9 included all possible combinations of constraints in approach and obstructions in the form of IV location vis-à-vis the patient.

**The Simulation Runs**

Each nurse was instructed to conduct three tasks in each of the nine physical configurations. The tasks involved: 1) checking vital signs, 2) suctioning the patient, and 3) sitting up the patient. These three tasks were selected since they represent typical patient care tasks, and could be conducted entirely within the caregiver zone without needing any other part of the patient room. Also, the tasks represented the need of a dominant hand in conducting suctioning (to a greater extent) and sitting up the patient (to a lesser extent).

The three tasks and nine physical configurations totaled to 27 simulation runs for each nurse. With twenty nurses in the sample, a total of 540 simulation runs were conducted for the study. Each nurse completed her 27 simulation runs in a single session. However, the sequence of scenarios and sequence of task in each scenario was presented in a random order. The randomization of scenarios and tasks was conducted using a simple randomization routine available online at http://www.random.org/sequences/.

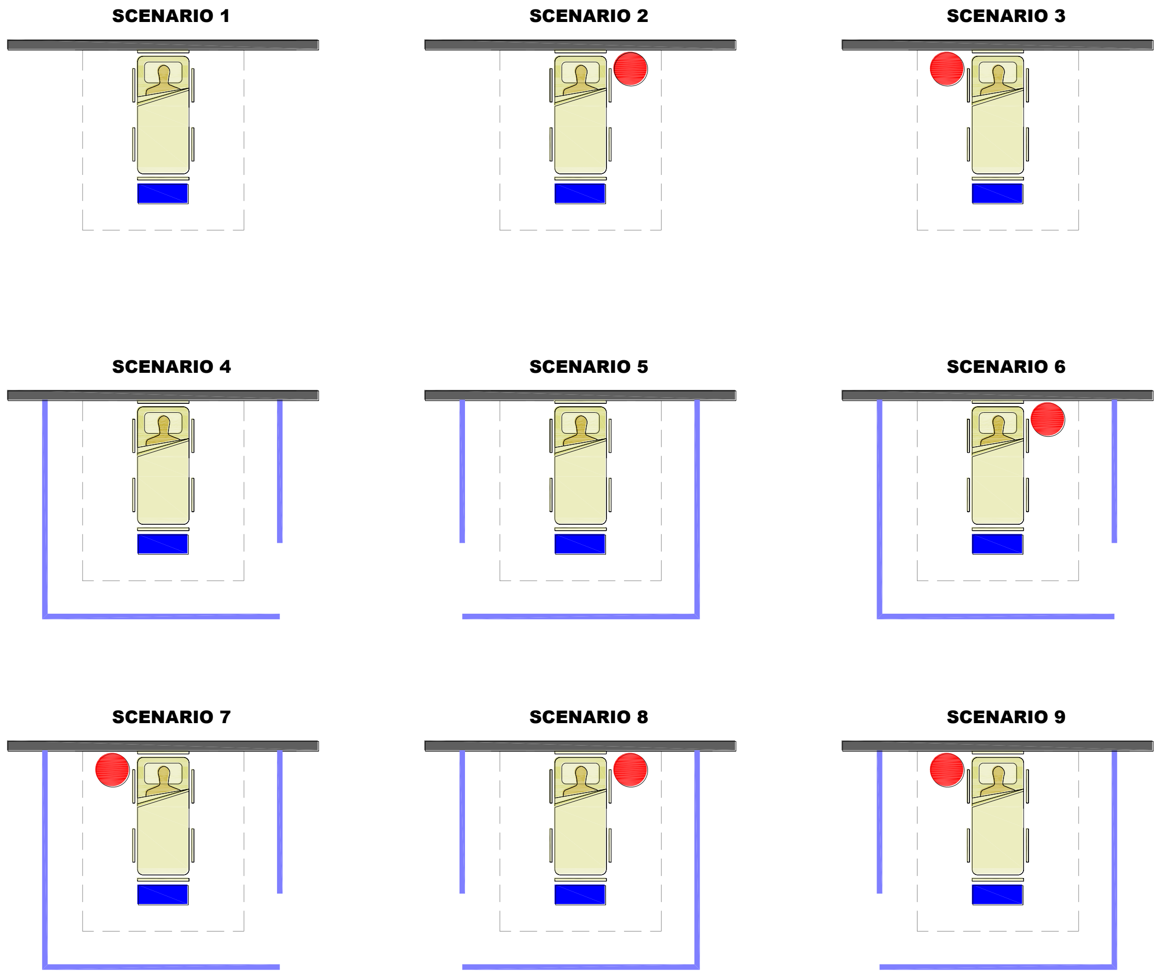



*Figure 7: The nine physical configurations included in the study (circle represents IV pole and rectangle at the foot of the bed represents the over-bed table)*

During the simulation runs, the subjects were stationed outside the Team Training Room, in the corridor. The room door remained closed in order not to provide any advance clue to the subject regarding the scenario to be used. At the beginning of each simulation run the subject's starting point was a make-shift nurse station (Figure 8) that was created inside the Team Training Room. The nurse station was located on the foot wall of the room to provide an unbiased (neutral-handed) starting location. The nurse station was equipped with the two pieces of equipment needed for the study; a DINAMAP on wheels and a hand-held suctioning kit.

*Figure 8: The make shift nurse station used in the simulation runs*

Other than the manipulated variables, all other aspects of the setting was standardized at the beginning of all simulation runs. The aspects of the environment that were standardized included: 1) height of patient bed set at minimum, 2) bed angle set at 30 degrees, 3) bed rails in the up position, 4) over bed table centered at the foot of the bed, 5) suction canister on platform on both sides of the bed, 6) DINAMAP at nurse station, and 7) suctioning kit at nurse station. For each task, a standardized script was read aloud to the subjects by a research team member. Table 3 shows the standard script that was used to assign task to the nurses.

*Table 3: The standardized script that was used to assign tasks to the nurses.*

| Task | Script |
|---|---|
| Vitals | Please take your patient's vital signs and return to the nurse station |
| Suctioning | Your patient is a new admission who has a tracheotomy and will need to be suctioned now.  Please pretend to suction your patient and return to the nurse station. |
| Sitting up | Please sit your patient on the edge of the bed and return to semi fowler's position, and return to the nurse station |

Each simulation run was separately videotaped in the control room. At the end of each set of 27 simulation runs, the subjects were administered a semi-structured interview. The purpose of the interview was to collect any additional data that may enhance understanding of the observational data from the video recordings. The interview questions focused on: 1) work flow, 2) perceived awkward postures or movement, 3) elements of the settings that are perceived as supportive to the tasks conducted, and 4) factors influencing approach decision. The interview plan of inquiry is included in Appendix I. All interviews were also video-recorded separately for subsequent analysis.

**Data Coding**

Two types of coding were conducted on the video segments of the 540 simulation runs. One set of coding was conducted by two registered nurses (RN). The nurses were instructed to watch the video and record a predetermined list of behavior and actions. Those included: 1) direction of approach, 2) any hesitation in approach, 3) over bed table use, 4) bed rail adjustment, 5) bed height adjustment, and 6) bed angle adjustment. In addition, the nurses were instructed to count the number of times the following postures were observed: 1) stretch, 2) bend, 3) unstable, 4) lift, 5) twist, and 7) reposition. The operational definition of these postures were explained to the nurses and a number of mock coding sessions were used for the training purpose, until a 90% agreement rate was achieved. The operational definitions of the posture terms are included in Appendix II. A data coding sheet was created for the nurses to record behavior.

A third RN reviewed the coded data to identify any errors and inconsistencies, and ensure that the coded data is of high quality. The purpose of the RN coding was twofold. First, from a nursing perspective, the coded data was expected to provide some documentation on how nurses behave naturally, from a viewpoint of process standardization. From a design perspective, the coded data was expected to provide the preliminary evidence on any consistency in directionality of approach and factors affecting a nurses' decision to approach a patient from any particular side.

The second type of coding was conducted by an expert in Kinesiology. The Kinesiology expert coded the segments to identify actions that were potentially stressful or harmful, and evaluate the ergonomics of the environment to identify the reasons for such actions. Further elaboration on the ergonomic data coding process is provided in the data analysis section.

Video segments of the interviews were transcribed to text by a professional transcriptionist. Interview transcripts were subjected to content analyses with two main objectives: 1) to identify repeating environmental factors that are perceived by the nurses as determinants of their individual decision to behave in a particular manner, and 2) to identify the relationship between the subjects' decision to act in a particular manner and the configuration of the physical environment. Data analyses followed the steps suggested by Miles and Huberman (1994). The content analysis was conducted using MS Excel software in combination with MS Word. Text chunks from the interview transcripts were encoded and organized to capture recurring factors and interpretations.

## Data Analysis and Findings

Analysis of coded data included five key steps:

1. Within group comparisons of left-handed and right-handed nurses to identify any common pattern of behavior.
2. A between group comparison of left-handed and right-handed nurses to explore any significant differences between the two groups.
3. A factorial design to identify factors influencing potentially harmful actions.
4. An exploratory data analysis to identify factors influencing nurses decision regarding approach direction.
5. Content analysis of the interview transcripts for triangulating study findings.

These steps were designed to systematically proceed through the issues articulated in the standardization framework (Figure 3). The first two analyses were intended to provide information on behavior and actions and the way it relates to handedness of the individual caregivers. The third analysis was designed to explore whether ergonomic issues, physical configuration issues or both introduce any potential safety issues, since poor ergonomics has been linked to safety. The fourth analysis was designed to explore whether force functioning of approach through physical configuration handedness is compatible with process standardization. The analysis of interview transcript was meant to triangulate findings from observation data, and get a deeper insight on physical environment standardization and handedness relationships with process issues. Stress and workload factors were not manipulated in the study, and hence were not examined in the data analysis.

### Pattern of Behavior

#### *Within Left-Handed Nurses*

The primary emphasis in the analysis of data within each group was to examine any contrast in behavior and actions between the first scenario and the remaining eight scenarios. Observation of any significant contrast would suggest the absence of any common pattern of behavior within the group. On the other hand, absence of any significant contrast would provide evidence of a common pattern of behavior within the group.

The contrast analysis (or goodness of fit) was conducted using Logistic regression for dichotomous outcome variables, such as approach from the left or the right. Poisson regression analysis was used where the outcome variables were frequency counts, such as the number of times the subject was observed stretching or bending.

Within the left handed nurse group little evidence was available to suggest any contrast in behavior and actions between the nine physical configurations, for each of the three assigned tasks. Table 4 summarizes the findings from the Logistic and Poisson regression analysis for left-handed nurses.

Expanded summaries of the models for the three tasks are included in Appendix III. The model used for the Logistic and Poisson regressions was (where *ß* represents the predicted coefficient and sets 1-9 represent the nine physical configurations):

Model:

$$behavior = \beta_1 set1 + \beta_2 set2 + \beta_3 set3 + \beta_4 set4 + \beta_5 set5 + \beta_6 set6 + \beta_7 set7 + \beta_8 set8 + \beta_9 set9$$

*Table 4: Summary of statistical significance of the Logistic and Poisson model testing conducted on left-handed subject data.*

| | Approach direction | Hesitation | Over-bed table use | Bed rail adjustment | Bed height adjustment | Bed angle adjustment | Stretch | Bend | Unstable | Lift | Twist | Reposition |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vitals | 0.55 | 0.91 | - | 0.99 | 0.99 | - | 0.79 | 0.99 | 0.91 | 0.91 | 0.86 | 0.99 |
| Suctioning | 0.45 | 0.98 | 0.99 | 0.82 | 0.73 | 0.99 | 0.97 | 0.58 | 0.83 | - | 0.84 | 0.25 |
| Sitting up | 0.03* | 0.90 | - | - | 0.98 | 0.98 | 0.99 | 0.10 | 0.67 | 0.99 | 0.86 | 0.93 |

*Note: *** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1)*
*Blank cells imply that either the model did not converge or zero observations of the behavior*

Table 4 shows that other than in the case of approach direction for the sitting up task, no significant contrast was detected in other behaviors observed in the simulation runs. *The findings suggest that there exists a common pattern of behavior among left-handed nurses for the three tasks employed in the study.*

### *Within Right-Handed Nurses*

Analysis of the right-handed subject data resulted in similar findings. The model and analytical method used were identical to those described in the case of left-handed subjects. Table 5 includes the summary of the findings from the Logistic and Poisson regression analysis of right-handed nurses' data. Expanded summaries of the models for the three tasks are included in Appendix IV.

*Table 5: Summary of statistical significance of the Logistic and Poisson model testing conducted on right-handed subject data.*

| | Approach direction | Hesitation | Over-bed table use | Bed rail adjustment | Bed height adjustment | Bed angle adjustment | Stretch | Bend | Unstable | Lift | Twist | Reposition |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vitals | 0.09+ | 0.98 | - | 0.97 | 0.96 | 0.99 | 0.82 | 0.95 | - | - | 0.38 | 0.98 |
| Suctioning | 0.13 | 0.98 | 0.98 | 0.95 | 0.98 | 0.91 | 0.91 | 0.94 | 0.97 | - | 0.70 | 0.88 |
| Sitting up | 0.13 | 0.99 | - | 0.99 | 0.83 | 0.97 | 0.98 | 0.92 | 0.50 | 0.99 | 0.83 | 0.71 |

*Note: *** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1)*
*Blank cells imply that either the model did not converge or zero observations of the behavior*

Table 5 shows that other than in the case of approach direction for checking vital signs, no significant contrast was observed in other behaviors documented in the simulation runs. Even the single case of significant contrast was at a lower confidence level of 90%. As in the case of left-handed nurses, *the findings suggest that there exists a common pattern of behavior among right-handed nurses for the three tasks employed in the study.*

### *Comparing left-handed and right-handed subject behaviors*

The above analysis provide evidence that within each group (left-handed and right-handed) nurses display a common pattern of behavior while conducting vitals, suctioning and patient sitting up tasks. How similar or different are the two groups in their exhibited behavior? To identify any differences between the two groups a regression analysis was conducted with two sets of categorical variables; one set representing the nine scenarios and the other representing handedness of the subject. The model examined was (where $\beta$ represents the predicted coefficient, sets 1-8 are dummy variables representing the nine physical configurations, and the variable *righthanded* representing handedness of the subject):

Model:

$$behavior = \beta_0 + \beta_1 set1 + \beta_2 set2 + \beta_3 set3 + \beta_4 set4 + \beta_5 set5 + \beta_6 set6 + \beta_7 set7 + \beta_8 set8 + \beta_9 righthanded$$

Table 6 provides the summary of the statistical significance from the regression analysis. A significant estimate indicates a difference in the exhibited behavior between the left-handed and right-handed subjects. Expanded summaries of the models for the three tasks are included in Appendix V.

*Table 6: Summary of statistical significance of the variable 'right-handed' in the models tested to identify differences between the behavior of left-handed and right-handed subjects.*

| | Approach direction | Hesitation | Over-bed table use | Bed rail adjustment | Bed height adjustment | Bed angle adjustment | Stretch | Bend | Unstable | Lift | Twist | Reposition |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vitals | 0.04* | 0.85 | - | 0.05+ | 0.41 | 0.83 | 0.81 | 0.84 | 0.57 | - | 0.49 | 0.0*** |
| Suctioning | 0.0*** | 0.70 | 0.00** | 0.1+ | 0.28 | 0.76 | 0.00** | 0.58 | 0.25 | - | 0.14 | 0.18 |
| Sitting up | 0.07+ | 0.87 | - | 0.83 | 0.01* | 0.96 | 0.96 | 0.02* | 0.40 | 0.60 | 0.01* | 0.77 |

*Note:* **** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1)*
*Blank cells imply zero observations of the behavior*

In contrast to within-group behavior (Tables 4 and 5), Table 6 shows that *left-handed and right-handed subjects differ significantly in a large number of behavior in the three tasks conducted in the study.* Of the 32 behavior category tested, significant differences were observed in 11 exhibited behaviors, amounting to 34% of all behavior categories. *Of particular interest is the direction of approach, where the two groups exhibited significant differences in all three tasks.*

**Potentially Harmful Actions**

The second type of coding was conducted by an expert in Kinesiology. The Kinesiology expert was provided with two sets of video segments for each nurse; one for the suctioning task and one for sitting the patient up. Video segments on checking vital signs were not included in the analysis since those were not considered to be associated with any safety issue arising either from the configuration or from ergonomic factors. Within each set of video segments were two scenarios – the least challenging scenario and the most challenging scenario. The least and most challenging scenarios were identified based on the natural preference of approach of each nurse and the location of the IV pole as a potential obstruction. The natural preference of each nurse was identified from the first scenario (Figure 7) which involved neither a constraint in approach nor any obstruction in the care environment. The least challenging case was the one where the subjects were on their preferred side and the IV pole was located on the opposite side. The most challenging case was the one where the subjects were not located on their preferred side and the IV pole was located on the same side as the subject.

The kinesiology expert was tasked with examining the video segments and for each subject and task provide an assessment of the number of time they were observed stretching, bending, unstable, lifting, twisting and repositioning that, in the expert opinion of the coder, represents a potentially harmful action, either immediately or over time due to repetitions. The assessment was conducted both for the least and the most challenging scenarios. In addition, the expert also provided information on whether the potentially harmful action observed was a result of the physical configuration, of the way the patient bed and the headwall is designed, or both. Results of the Kinesiology data coding for suctioning task is summarized in Table 7, and for sitting up task is summarized in Table 8.

*Table 7: Distribution of potentially harmful actions in the least and most challenging scenarios involving patient suctioning task for left-handed and right-handed subjects.*

| | | STRETCH | | BEND | | UNSTABLE | | LIFT | | TWIST | | REPOSITION | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Headwall/Bed | Configuration | Headwall/Bed | Configuration | Headwall | Configuration | Headwall | Configuration | Headwall/Bed | Configuration | Headwall | Configuration |
| RH | LC | 1 | 0 | 15 | 0 | 3 | 0 | 0 | 0 | 38 | 0 | 0 | 0 |
| RH | MC | 0 | 0 | 17 | 1 | 2 | 2 | 0 | 0 | 36 | 2 | 0 | 1 |
| RH Total | | 1 | 0 | 32 | 1 | 5 | 2 | 0 | 0 | 74 | 2 | 0 | 1 |
| | | | | | | | | | | | | | |
| LH | LC | 0 | 0 | 5 | 0 | 1 | 0 | 0 | 0 | 17 | 0 | 0 | 0 |
| LH | MC | 0 | 0 | 9 | 0 | 0 | 2 | 0 | 0 | 24 | 4 | 0 | 0 |
| LH Total | | 0 | 0 | 14 | 0 | 1 | 2 | 0 | 0 | 41 | 4 | 0 | 0 |
| | | | | | | | | | | | | | |
| Total | | 1 | 0 | 46 | 1 | 6 | 4 | 0 | 0 | 115 | 6 | 0 | 1 |

*Note: RH: Right Handed; LH: Left Handed; LC: Least Challenging; MC: Most Challenging*

*Table 8: Distribution of potentially harmful actions in the least and most challenging scenarios involving patient sitting up task for left-handed and right-handed subjects.*

| | | STRETCH | | BEND | | UNSTABLE | | LIFT | | TWIST | | REPOSITION | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Headwall/Bed | Configuration | Headwall/Bed | Configuration | Headwall | Configuration | Headwall | Configuration | Headwall/Bed | Configuration | Headwall | Configuration |
| RH | LC | 11 | 2 | 40 | 0 | 0 | 0 | 4 | 0 | 46 | 1 | 0 | 0 |
| RH | MC | 11 | 8 | 38 | 10 | 0 | 1 | 0 | 1 | 50 | 7 | 0 | 0 |
| RH Total | | 22 | 10 | 78 | 10 | 0 | 1 | 4 | 1 | 96 | 8 | 0 | 0 |
| | | | | | | | | | | | | | |
| LH | LC | 9 | 0 | 40 | 0 | 0 | 2 | 1 | 0 | 54 | 0 | 4 | 0 |
| LH | MC | 16 | 15 | 42 | 11 | 0 | 1 | 1 | 1 | 47 | 12 | 5 | 3 |
| LH Total | | 25 | 15 | 82 | 11 | 0 | 3 | 2 | 1 | 101 | 12 | 9 | 3 |
| | | | | | | | | | | | | | |
| Total | | 47 | 25 | 160 | 21 | 0 | 4 | 6 | 2 | 197 | 20 | 9 | 3 |

*Note: RH: Right Handed; LH: Left Handed; LC: Least Challenging; MC: Most Challenging*

A key question from the ergonomic data coding was to examine which factors contribute to potentially harmful actions: 1) the level of challenge in the physical environment; 2) the handedness of the caregiver or 3) the use of caregiver's preferred side, or all three. As described in the following section, side preference of the caregiver was not necessarily correlated with their handedness. Hence, side preference was included in the analysis. To examine the question, a 2x2x2 factorial design was adopted, and regression analysis was conducted. The three factors were: challenge (least challenging and most challenging), handedness (left-handed and right-handed), and side preference (left side and right side). The analysis was conducted separately for harmful actions attributable to the headwall or bed design, and those to the physical configuration.

Table 9 and 10 show the statistical significance of the Chi-Square estimate in the analysis involving suctioning and sitting up tasks, respectively. Expanded summaries of the tests are included in Appendix VI. The analysis shows that significant harmful actions in suctioning tasks are mostly associated with the headwall/bed design. Harmful bending and twisting are the most frequently observed actions. Handedness of the subject and preferred side had significant main effects.

On the other hand, potentially harmful actions in sitting up tasks were related to the physical configuration. Significant effects were observed in stretching, bending and twisting. The level of challenge and preferred side had significant main effects. Data shows that in the least challenging scenario – subject on their preferred side and no obstruction – the potential of harmful or stressful actions is less (Appendix VI). This is important since, as is described in the following sections, obstructions in the environment are a major factor that influence the decision of a nurse to position herself vis-à-vis the patient, even though she may not be working from her preferred side.

*Table 9: Significant main effects involving potentially harmful actions associated with suctioning task.*

| | STRETCH | | BEND | | UNSTABLE | | LIFT | | TWIST | | REPOSITION | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Headwall/Bed | Configuration | Headwall/Bed | Configuration | Headwall | Configuration | Headwall | Configuration | Headwall/Bed | Configuration | Headwall | Configuration |
| Challenge (Least vs Most) | - | - | 0.37 | - | - | - | - | - | 0.64 | - | - | - |
| Handedness (Left vs Right) | - | - | 0.000 *** | - | - | - | - | - | 0.000 *** | - | - | - |
| Preferred Side (Left vs Right) | - | - | 0.000 *** | - | - | - | - | - | 0.97 + | - | - | - |

*Note: *** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1)*
*Blank cells denotes not enough frequency of observation to conduct statistical testing*

*Table 10: Significant main effects involving potentially harmful actions associated with sitting up task.*

| | STRETCH | | BEND | | UNSTABLE | | LIFT | | TWIST | | REPOSITION | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Headwall/Bed | Configuration | Headwall/Bed | Configuration | Headwall | Configuration | Headwall | Configuration | Headwall/Bed | Configuration | Headwall | Configuration |
| Challenge (Least vs Most) | 0.30 | 0.000 *** | 1 | 0.99 | - | 1 | - | - | 0.83 | 0.004 ** | - | - |
| Handedness (Left vs Right) | 0.76 | 0.37 | 0.97 | 0.53 | - | 0.33 | - | - | 0.83 | 0.20 | - | - |
| Preferred Side (Left vs Right) | 0.51 | 0.68 | 0.16 | 0.04* | - | 0.83 | - | - | 0.46 | 0.052 + | - | - |

*Note:* **** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1)*
*Blank cells denotes not enough frequency of observation to conduct statistical testing*

**Subjects' Positioning vis-à-vis the Patient**

What factors influenced the subjects' decision to be on the right or the left of a patient. Is it simply a matter of their handedness, or are there other factors involved? In order to examine that question an exploratory data analysis was conducted. In that analysis, left-handed and right-handed nurses were tracked, separately, through each of the nine physical configurations, for each of the three tasks. The changes in percentage of subjects positioning themselves on the left and right side of the patients, as compared to Scenario # 1 (no obstructions), were tracked. The positioning data was then examined along with the physical configuration in which it occurred. *Analysis shows handedness of the subjects was not the only factor influencing their position vis-à-vis the patient.*

Tables 11 and 12 show the percentage of subjects on the left and right side of the patient while checking vital signs across the nine physical configurations, for the left-handed and right-handed nurses respectively.

*Table 11: Vitals - Percentage of left-handed subjects on the left and right side of the patient across the nine physical configurations while checking vital signs.*

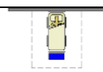
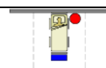
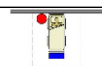
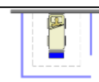
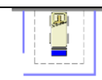
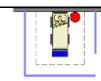
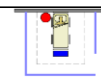
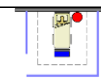
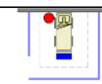
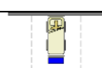
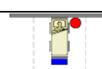
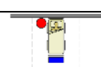
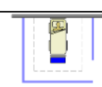
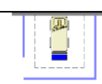
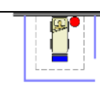
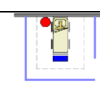
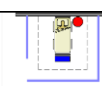
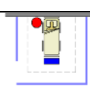
| Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| % on Right | 20 | 100 | 0 | 10 | 50 | 100 | 0 | 100 | 0 |
| % on Left | 80 | 0 | 100 | 90 | 50 | 0 | 100 | 0 | 100 |
| |  |  |  |  |  |  |  |  |  |
| Possible Factors | Natural Pref | | | Natural Pref | | | | | |
| | | IV | IV | | | IV | IV | IV | IV |
| | | | | Walking Distance | | | | | |

*Table 12: Vitals - Percentage of right-handed subjects on the left and right side of the patient across the nine physical configurations while checking vital signs.*

| Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| % on Right | 50 | 100 | 10 | 20 | 80 | 100 | 0 | 100 | 20 |
| % on Left | 50 | 0 | 90 | 80 | 20 | 0 | 100 | 0 | 80 |
| |  |  |  |  |  |  |  |  |  |
| Possible Factor | Natural Pref | | | | | | | | |
| | | IV | IV | | | IV | IV | IV | IV |
| | | | | Walking Distance | Walking Distance | | | | |

It is noteworthy that natural preference did not correspond fully with handedness of the subject. This is evident in the first scenario, since this scenario did not involve any constraint in approach or any obstruction in the form of an IV. While 80% of the left-handed nurses preferred to be on the left side, the right-handed nurses were divided equally in their preference between the two sides. Across the nine configurations, it is evident that at least two other factors, in addition to natural preference, influenced subjects' decision regarding positioning – position of the IV as an obstruction and the walking distance from the doorway.

A specific example will articulate this better. For instance, 80% of the subjects were on the patient's left in Scenario # 1, whereas 100% of the subjects were on the patient's right in Scenario # 2. The reason for this change is the location of the IV pole. It is conventional practice to check vital signs on the arm that does not have an IV line. Since the IV pole was on the patient's left arm in Scenario # 2, all subjects went to the patient's right side. This phenomenon is reinforced in Scenarios # 6, 7, 8, and 9, in both cases of left-handed and right-handed subjects. Irrespective of the door location (hence the forced direction of approach) the subjects positioned themselves on the free arm side of the patient. Scenarios #4 and 5 in Table 12 (right-handed subjects) provide examples of how walking distance may affect their decisions. In both these instances, the subjects overwhelmingly preferred the side closest to the room door, in the absence of an IV as an obstruction.

Similar factors were noted in the analysis of the suctioning and sitting up tasks. Tables 13 and 14 show the percentage of subjects on the left and right side of the patient across the nine physical configurations during the suctioning task, for the left-handed and right-handed nurses respectively.

The suctioning task is different from checking vital signs owing to the need for the use of the dominant hand in the precision work involved. Despite the need of using the dominant hand the subjects' decision to avoid the side with the IV is apparent in the data. Whenever an IV was present in a scenario, a majority of the subjects placed themselves on the opposite side of the IV, whether that side constituted the naturally preferred side or not. Scenario # 9 in the case of right-handed subject is the sole exception. Scenarios #4 and 5 are the best scenarios to examine walking distance as a potential factor in both left-handed and right-handed subjects.

*Table 13: Suctioning - Percentage of left-handed subjects on the left and right side of the patient across the nine physical configurations while suctioning the patient.*

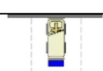
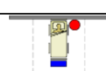
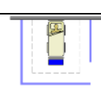
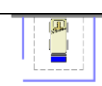
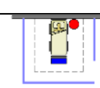
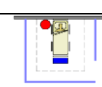
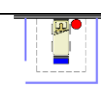
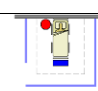
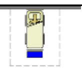
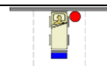
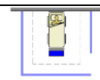
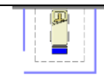
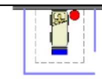
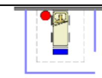
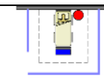
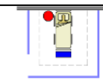
| Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| % on Right | 30 | 60 | 0 | 0 | 40 | 50 | 0 | 60 | 10 |
| % on Left | 70 | 40 | 100 | 100 | 60 | 50 | 100 | 40 | 90 |
| |  |  |  |  |  |  |  |  |  |
| Possible Factors | Natural Pref | | | Natural Pref | Natural Pref | | Natural Pref | | Natural Pref |
| | | IV | IV | | | IV | IV | IV | IV |
| | | | | Walking Distance | Walking Distance | | Walking Distance | Walking Distance | |

*Table 14: Suctioning - Percentage of right-handed subjects on the left and right side of the patient across the nine physical configurations while suctioning the patient.*

| Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| % on Right | 80 | 100 | 40 | 60 | 90 | 90 | 40 | 100 | 80 |
| % on Left | 20 | 0 | 60 | 40 | 10 | 10 | 60 | 0 | 20 |
| |  |  |  |  |  |  |  |  |  |
| Possible Factor | Natural Pref | Natural Pref | | Natural Pref | Natural Pref | Natural Pref | | Natural Pref | Natural Pref |
| | | IV | IV | | | IV | IV | IV | |
| | | | | Walking Distance | Walking Distance | | Walking Distance | Walking Distance | |

IV pole location also influences the decision regarding which side to sit the patient up. Tables 15 and 16 show the percentage of subjects on the left and right side of the patient across the nine physical configurations during the patient sitting up task, for the left-handed and right-handed nurses respectively. Without any additional information regarding the patient room (since only part of the caregiver zone was mocked-up) subjects generally preferred to sit the patient up on the side of the IV. In the absence of an IV, both walking distance and natural preference were potential factors influencing the subjects' decision. An exemplary case of walking distance is scenario #5 in Table 15 and scenario #4 in Table 16, where subjects used their non-preferred side to sit the patient.

*Table 15: Patient Sitting up - Percentage of left-handed subjects on the left and right side of the patient across the nine physical configurations while sitting up the patient.*

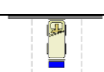
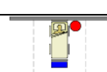
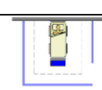
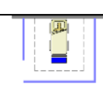
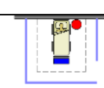
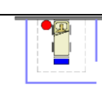
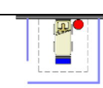
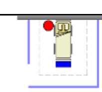
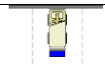
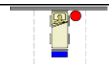
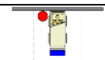
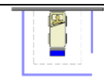
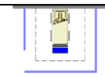
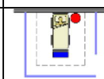
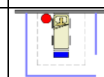
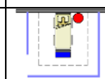
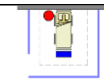
| Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| % on Right | 30 | 10 | 60 | 20 | 70 | 20 | 50 | 40 | 80 |
| % on Left | 70 | 90 | 40 | 80 | 30 | 80 | 50 | 60 | 20 |
| |  |  |  |  |  |  |  |  |  |
| Possible Factors | Natural Pref | | | Natural Pref | | | | | |
| | | IV | IV | | | IV | IV | IV | IV |
| | | | | Walking Distance | Walking Distance | | | Walking Distance | |

*Table 16: Patient Sitting up - Percentage of right-handed subjects on the left and right side of the patient across the nine physical configurations while sitting up the patient.*

| Scenario | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| % on Right | 60 | 40 | 80 | 30 | 90 | 50 | 50 | 30 | 70 |
| % on Left | 40 | 60 | 20 | 70 | 10 | 50 | 50 | 70 | 30 |
| |  |  |  |  |  |  |  |  |  |
| Possible Factor | Natural Pref | | Natural Pref | | Natural Pref | | | | Natural Pref |
| | | IV | IV | | | IV | | IV | IV |
| | | | | Walking Distance | Walking Distance | | | | Walking Distance |

**Interview Data**

The above inferences were reinforced from the analysis of interview transcripts. One hundred percent of the subjects mentioned the location of the IV as a factor affecting their decision to position on a certain side of the bed. Eighty percent of the subjects mentioned the IV as an obstruction, and discussed their preference to be on the side without clutter for tasks that did not involve dealing with an IV. Ten percent of the nurses showed a preference to be on the side with the IV.

The preference for a side, as influenced by hand dominance, was reported as a factor by 65% of the subjects. However, a number of left-handed nurses considered themselves to be comfortable with either hand (mixed-handed). Walking distance as a factor did not turn up as a frequent one from the interview data, with only 20% of the subjects mentioning shorter walking distance as a factor influencing their decision in conducting a task.

A few additional factors came up, although in very small numbers. Not using the dominant arm of the patient to connect an IV was mentioned by two subjects – a standard practice taught in nursing schools. This is a patient-centered variable that was kept outside the study scope, but with considerable implications for the notion of process and workflow standardization.

One subject mentioned her previous back injury from nursing tasks as a factor influencing her decision to be on a certain side of the patient. With the large prevalence of injury among nurses (Institute of Medicine, 1996), this could be an important factor to consider in the assessment of the process and workflow standardization.

An unexpected finding from the interview data has important implications on increasing familiarity with the environment, and hence reducing cognitive demand. When asked to compare the nine physical configurations in terms of initial approach, 70% of the respondents mentioned the layout without partition as the one that supported their task the best. The main benefit of the open configuration, as described by the subjects, was that it provided them with an immediate global view of the caregiver zone condition and equipment layout. This helped the subjects plan out their actions in the most efficient manner, before conducting the assigned tasks. The description of one subject exemplifies this:

> "You can immediately assess where you go in the room. It makes it easier to work. You are more oriented as to what you need to do; saving some steps probably."

The subjects also mentioned the advantages of having redundant medical gases, suction and power connections on both sides of the bed. That enhanced the flexibility of approaching either side of the patient, offered by an initial global view of the caregiver zone.

## Discussions

### Implications of Study Findings

How do these findings relate to the handedness debate? To better understand the implications of the study findings it is necessary to revisit the standardization framework.

Standardization in the aviation industry started from standardization of processes and workflow. Since processes involve physical elements, including the machines and human-machine interfaces, standardization of the machine interfaces, displays, and controls were vital to standardization of any process. The key issue is one of familiarity. The more familiar the environment, fewer are the chances of error during emergency.

Since standardization and handedness are treated as separate constructs in this thesis comparison with the airline industry regarding handedness is warranted. Is handedness a concern in the aviation industry? Handedness could be viewed from two perspectives: 1) handedness of a person, and 2) handedness of a physical environment or equipment. Crew handedness has been extensively studied in the aviation industry. While earlier studies demonstrated some associations between handedness and performance (for instance, Crowley, 1989), it has not been established as a fact (Pipraiya & Chowdhary, 2006). Moreover, Pipraiya and Chowdhary (2006), in their study, found little evidence to support that crew handedness affect flying performance. Indeed, flight decks cannot be designed for a particular handedness since the pilot and co-pilot share the same machine interface from two different sides. Furthermore, handedness is a psychological construct, referring to one's ability to distinguish between left and right, and coordinate one's eyes and hands in response to that knowledge

(Whittingham, 2004). Pipraiya and Chowdhary (2006) found in their study a high degree of mixed-handedness in left-handed crew members. That is also reflected in the interview transcripts that show a number of left-handed subjects considering themselves as mixed-handed.  Thus, handedness of the individual caregiver may not constitute a critical issue in the design of the care environment.

The above inference could be viewed as supporting the notion of handedness of the physical environment. After all, if handedness of the caregiver is not an issue (or left-handed caregivers could be trained to be mixed handed), that would suggest that a right-handed care environment could be designed without any major concerns regarding left-handed staff. The finding that left-handed subjects as a group exhibited several significant differences in behavior from right-handed nurses as a group, amply illustrates the need for training. The fact that within each group of subjects there exists a pattern of behavior across the nine physical configurations (absence of significant contrast) suggests that the exact nature of training required could be systematically designed. However, that issue belongs rightfully to staff teaching and training curriculum, and not a matter of physical design.

On the other hand, the fact that subjects, irrespective of their individual handedness did not position themselves consistently on any particular side of the patient is one of consequence. The identification of recurring factors that affected the subjects' decision on positioning vis-à-vis the patient, including obstructions, walking distance, and use of dominant hand in some tasks, do raise issues pertaining to the handedness of the physical environment. The key question is, will right-handed configurations invariably ensure the positioning of the caregiver on the patient's right side? Can the processes and workflow be standardized to an extent to ensure right side location of the caregiver?

Study data suggests in the negative. For instance, when the patient's right hand is dominant, nurses are taught to use the other side for IV insertion, leading them to the opposite side of the bed. When blood vessels are easier to locate on the left hand, a nurse will insert on the oppostiet side of the bed. In case of a patient with  procedures or treatments involving the right arm, the IV may go into the left side, or opposite side of the bed. When the bathroom is located to the left side of the patient, nurses may prefer to position on the patient's left for easier movement to the toilet.

Further, for hospitals with design maximizing window view or natural light, a right-handed patient room would entail an inboard bathroom location on the patient's right, and hence the preferred IV location on the patient's right, even if they are right-handed. Similarly, for tasks necessitating the use of caregivers' dominant hand, the right side of the patient may not constitute the best in many situations. In other words, force functioning caregiver location may not work. Standardization of processes and workflow observed in the study may not occur to an extent where nurses are forced to position on the right side of the patient. If processes and workflow cannot be standardized to ensure consistent location, designing handedness in the environment to support those processes may not produce desired results.

Aviation literature discusses standardization in the context of emergency situations. Clearly, not all environments in a hospital could be described as designed for high-emergency situations. Medical surgical bed units are designed around basic nursing care, but not particularly for emergency episodes on a frequency or regular basis. Outside of bed units, it may be argued that the operating rooms and some areas in the emergency department involve high-emergency situations. Whether right-handed configurations in such settings do actually help improve safety was not within the scope of this phase of the study and constitutes a pertinent question for further research.

To summarize, *there is little evidence to suggest that force functioning of approach built into right-handed rooms will consistently result in positioning the caregivers on the patients' right (a position driven by the argument that the patients' right side is the most appropriate for the caregiver).* While performance impacts originating from handedness of nurses could be addressed through training, force functioning of bedside location through designed handedness of the environment will not produce the desired behavior.

The second concept in this study pertains to standardization (without handedness). The necessity of standardization arises from the need to render the environment familiar to the staff, which, in case of emergency situations, will not create additional cognitive burden. Several data in this study support that notion. The fact that subjects preferred the open layout since it provided an unobstructed, global view of the caregiver zone falls within the boundaries of this discussion. The advantages offered by the global view is directly linked to the notion of familiarity with the environment – since the physical configurations and tasks were randomly sequenced, the global view offered an instantaneous advantage in terms of improved familiarity. The fact that subjects referred to the redundancy in medical gases, suction and power outlets on both side of the bed as a positive feature deals directly with the notion of familiarity. The familiarly with the fact that the medical utilities are available on both sides of the bed improved the flexibility and perceived efficiency of the subjects. In ICU where beds are positioned perpendicular to the corridor, the global view of the caregiver zone is optimized, by default. However, a beds perpendicular to the corridor do not represent the desired configuration in all circumstances. In other configuration, study findings support the notion of door placement closer to the footwall as opposed to the headwall side of the corridor wall, since door location closer to the footwall would render a better and clearer view of the patient and caregiver zone. Thus, standardization of the care environment, as in the aviation, nuclear and other high-risk industries, does enhance the staff's familiarity with the physical environment in which they perform.

The pertinent question, however, is the level at which standardization will deliver performance improvement. In aviation, the entire cockpit is considered for standardization, since processes involve locations beyond the flight control instruments and display. What is the appropriate level of standardization in patient care settings, from the five levels of standardization articulated in the introduction? The study scope essentially involved the caregiver zone. It, however, did not include all components many times located in the caregiver zone, such as the hand-washing sink, the supply cabinet, a medication drawer, or a documentation area.

Within the study scope, data does support the standardization of the caregiver zone. Pending further studies, it could be argued that standardization of the headwall, the location and design of the supply cabinet (including the design of the drawers and shelves), the location and design of the secure medication drawer (if one is included), the sharps container, and the hand-washing sink would indeed contribute to enhanced efficiency and safety. This argument is posited on the fact that the above elements are intricately linked to care processes. Standardization of processes and the immediate environment within which the processes take place could significantly enhance efficiency and safety.

An issue of perhaps greater importance is one of ergonomics. The problems associated with laterality and handedness of people could worsen owing to poor ergonomics (Whittingham, 2004). This information is particularly relevant when viewed in conjunction with the kinesiology data analysis. The fact that a large number of potentially harmful and stressful actions are linked to the design of the headwall or the bed (Tables 7 and 8), do suggest that additional attention needs to be accorded to the ergonomics of the care environment. In the suctioning task, the total number of potentially harmful actions attributable to the design of headwall or bed was 168, compared to only 12 attributable to the physical configuration. Similarly, in the patient sitting up task, the corresponding numbers for headwall or bed design was 419 as compared to 75 attributable to the physical configuration. Ergonomics as opposed to handedness of the environment warrants greater attention to enhance efficiency and safety, since poor ergonomics could lead to performance failure associated with laterality and handedness of the caregivers. Poor ergonomics could work against any advantages associated with training to reduce performance failures from individual handedness.

Aviation literature also states that problems with laterality could accentuate in high-stress and high-workload environment (Whittingham, 2004), thereby compromising one's internal awareness of up and down and right and left. Decision-making related to standardization or handedness need to include this potential problem area concurrently. Physical design factors (light, sound, ergonomics, air quality, hassles) and operational factors (work load, shift length, and similar issues) are known to influence stress and alertness levels in caregivers, and warrant appropriate consideration in the examination of standardization in patient care processes.

For instance, if the process of creating standardized (or same-handed) rooms increase the walking distance for nurses (a known stressor), or increase the isolation of the documentation area (another known stressor), the potential positive impact of the standardization could be negated by the negative impact of stress on staff laterality. Similarly, large units could introduce stress through noise, crowding, and distractions, which could partially negate the positive contributions of standardization to care quality.

The findings of this study do suggest answers to some critical questions pertaining to care process and environment standardization in non-critical medical-surgical patient care settings. Notably, *study data did not provide any evidence in support of room handedness in such areas. It did provide evidence in favor of standardization of the caregiver zone within such areas. Finally on the question of right-handed rooms (or same-handed physical configuration) the study data provided little in supporting evidence.*, On the other hand, the study leaves several important questions for future examination of these same issues relative to critical care settings such as ICU, Surgery and ED.

**Could Same-Handed Environment be Detrimental?**

**Future Efforts**

Regarding the appropriate level of patient care environment standardization, this study scope did not include the entire patient room. Future studies should examine efficiency and safety implications of room level standardization, particularly the impact of bathroom location on safety and efficiency since this continues to be an area of design laden with anecdotal perceptions absent good quality research. Also, considering the influence of ergonomics on laterality and handedness, future studies should examine safety impacts of poor ergonomics, mediated through laterality and handedness of staff.

The goal of this study was to create the foundation in an area lacking any empirical evidence. Should hospitals reject any notion of same-handedness in physical design? The answer is negative. The stakeholders in a specific context should make that decision. However, until now the decisions were made within an informational vacuum. This study creates the basic empirical information to support the decision-making process pertaining to standardization and handedness. To that extent, the study makes a critical contribution to an area of extensive debate in healthcare design, and now sets the satge for more specific study of behavior within purposefully designed environments.

## Implications for Hospital Administrators and Designers

What do these findings mean to hospital administrators and designers? Owing to the complex nature of the standardization framework, it will be best to address specific questions in isolation, without any intent behind the order in which the issues are addressed below.

### Standardization of Procedures and Actions

*Is handedness and laterality of caregivers an issue?* Yes, data shows that left-handed and right-handed caregivers have significantly different patterns of behavior. Although study data was limited to acute medical-surgical settings, it would be imprudent to assume that there are no differences among critical care clinicians. However, there appear to be a solutions to the problems associated with staff handedness and laterality. Aviation industry studies show that staff handedness may not affect performance in any major way. Data from this study show that within each group (left-handed and right-handed, separately) there are consistent patterns of behavior. That signifies that appropriate training programs could be developed to overcome any potential performance issues. Moreover, study data show that left-handed nurses (like crew members in the aviation industry) develop the ability to be ambidextrous or mixed-handed, something not observed in right-handed subjects. Hospitals and academic settings could develop appropriate training program for nurses and other caregivers to address safety issues related to laterality and handedness.

### Physical Environment Standardization

*Is there evidence to suggest that physical environment standardization will produce positive outcomes?* Yes, study data show that standardization (familiarity with the physical work environment) is a desirable attribute in acute medical-surgical settings. Standardization should include, among others, location and design of elements in the caregiver zone that are crucial to care processes in the caregiver zone – headwall, bed, hand washing sink, sharps container, supply cabinet/cart, and medicine drawers.

*Will handedness of the environment produce positive outcomes?* Study data show that standardization to the extent of force functioning staff location on the right side of the patient, in acute medical-surgical settings, may not be achievable owing to numerous factors. Thus, designing same-handed environments may not contribute to process and workflow standardization. Pending studies on settings exposed to emergency situations, such as in ICUs, ORs and sections of the emergency department, other areas in a hospital may not derive any predictable positive outcomes from same-handedness in the physical environment.

*Finally, what level of standardization is desirable?* Study data support Headwall Level standardization - data support standardization of headwall, with redundant medical utilities on both sides of the patient bed. Data also support Caregiver Zone Level standardization - data suggest that standardization of the Caregiver Zone improves familiarity with the physical care environment, with efficiency implications in acute care settings, and efficiency and safety implications in emergency situations. Safety and efficiency implications of Room-Level standardization are unknown, and this study was not designed to provide any evidence. Patient Room Level standardization (such as in universal rooms) could contribute to long-term operational flexibility, based on other studies (Pati, Harvey, & Cason, 2008). It is noteworthy, however, that study data did not provide evidence to support room-level handedness to enhance safety or efficiency. At the inpatient unit level, based on other studies, Unit-Level standardization could contribute to long-term operational flexibility (Pati, Harvey, & Cason, 2008). Further, in case of successful implementation of the acuity-adaptable nursing model, Unit Level standardization could contribute to safer patient care and reduced length of stay resulting from reduced patient transfer (Hendrich, Fay, & Sorrels, 2004).

### Ergonomics of the Work Environment

Studies show that poor ergonomics accentuate problems associated with handedness and laterality. This study data show that a substantially greater number of potentially harmful or stressful actions were associated with the design of the headwall and bed, and fewer with the physical configuration. Poor ergonomics not only contribute to staff injury (and indirectly care efficiency and safety) but also directly contribute to safety through its impact on handedness and laterality. Benefits from staff handedness training could be diluted while working in a poor ergonomics environment. Ergonomics should be considered concurrently with decisions pertaining to standardization.

### Stress and Workload

Similarly, studies show that high-stress and high-workload environments adversely impact laterality. Physical and operational factors affecting stress and alertness are known. Benefits from staff handedness training could be diluted while working in high-stress or high-workload environment. Factors affecting stress and alertness should be an integral part of any decision-making pertaining to standardization of the physical environment.

### Equipment and HIT

As in the aviation industry, clinicians deal with equipment interfaces and healthcare information technology as an integral part of the care process. Issues pertaining to equipment interfaces and interfacing with HIT need to be considered concurrently in any standardization dialogue. HIT assimilation and adaptation continues to be slow due principally to cost. Unintended consequences of HIT have been widely reported in recent literature (Harrison, Koppel, & Bar-Lev, 2007). Process maps built into HIT systems could conflict with process standardization goals. Standardization of HIT interfaces (in addition to other issues) should be considered.

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## APPENDIX I
## Subject Interview Plan of Inquiry

To be conducted at the end of all simulation scenarios.

1. In these scenarios, please describe the situations where you felt the smoothness of workflow was affected?
2. Were there any situations where you felt you had to engage in unnecessary stretching, bending, leaning or reaching? Any awkward movement or posture?
3. (On a drawing showing the four scenarios with partitions and IV) Please rank order the four settings from the most to least supportive setting for the tasks you conducted.
4. Is there a particular feature of the setting that is optimum to include in all scenarios?
5. (For some specific things we observe during the simulation we may ask one or all of the following questions):
    a. What factors made you decide to go to "that" particular side of the bed? Was it the location of the Dynamap, the IV?
    b. What factors made you decide to get the patient up on "that" particular side of the bed?
    c. Was there anything that would have made you choose a different side of the bed for either the VS or sitting up up on the side of the bed?
6. What was the difference to you between the room without the partitions and the rooms with the partitions?

Final note to each subject: Please do not discuss this study with your colleagues until the data collection is complete to avoid biasing the data.

## APPENDIX II
## Operational Definition of Posture Terms

Source:
Definitions are based on (with modifications) descriptions provided in "A back injury prevention guide for health care providers", CAL/OSHA, 1997.

For the following definitions "applying force" means: 1) lifting an object or person, and/or 2) pushing or pulling an object or person.

**Stretch**:
Perform tasks outside a 30" radius from one's neutral position (erect position) without bending, and applying force.

**Bend**:
Moving the spine (lower back) away from the erect position and applying force. Includes all directions.

**Unstable**:
Bending or stretching while standing on one leg, and applying force.

**Lift:**
Lifting patient from a height outside the range of one's waist to shoulder area.

**Twist**:
Twisting any part of the body or the entire body to accomplish a task, with or without applying force.

**Reposition**:
Changing one's physical location (distinctly) once a task is in progress, to achieve better body posture or control.

## APPENDIX III
## Summary of Logistic and Poisson Regression of Left-Handed Subject Data

Table III.1: Model summaries pertaining to dichotomous outcome variables for **LEFT HANDED** Nurses for task category **VITALS**

| Behavior Type | Contrast | DF | Chi-Square | Significance | Observations |
|---|---|---|---|---|---|
| | | | | | |
| Approach | Set IDs 2-9 all same as Set ID 1 | 8 | 6.79 | 0.5590 | 90 |
| Hesitation | Set IDs 2-9 all same as Set ID 1 | 8 | 3.33 | 0.9118 | 90 |
| Over-bed table use | Set IDs 2-9 all same as Set ID 1 | 8 | Zero subjects used over-bed table – hence no output<br>NO DIFFERENCE | Zero subjects used over-bed table – hence no output | 90 |
| Bed rail adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 0.66 | 0.9996 | 90 |
| Bed height adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 1.5 | 0.9927 | 90 |
| Bed angle adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | *Model did not converge* | *Model did not converge* | 90 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table III.2: Model summaries pertaining to variables measured as frequency counts for **LEFT HANDED** Nurses for task category **VITALS**

| **Behavior Type** | **Contrast** | **DF** | **Chi-Square** | **Significance** | **Observations** |
|---|---|---|---|---|---|
| | | | | | |
| Stretch | Set IDs 2-9 all same as Set ID 1 | 8 | 4.63 | 0.7963 | 90 |
| Bend | Set IDs 2-9 all same as Set ID 1 | 8 | 0.62 | 0.9997 | 90 |
| Unstable | Set IDs 2-9 all same as Set ID 1 | 8 | 3.24 | 0.9181 | 90 |
| Lift | Set IDs 2-9 all same as Set ID 1 | 8 | 3.24 | 0.9181 | 90 |
| Twist | Set IDs 2-9 all same as Set ID 1 | 8 | 3.86 | 0.8694 | 90 |
| Reposition | Set IDs 2-9 all same as Set ID 1 | 8 | 1.13 | 0.9973 | 90 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table III.3: Model summaries pertaining to dichotomous outcome variables for **LEFT HANDED** Nurses for task category **SUCTIONING**

| **Behavior Type** | **Contrast** | **DF** | **Chi-Square** | **Significance** | **Observations** |
|---|---|---|---|---|---|
| | | | | | |
| Approach | Set IDs 2-9 all same as Set ID 1 | 8 | 7.76 | 0.4572 | 90 |
| Hesitation | Set IDs 2-9 all same as Set ID 1 | 8 | 1.7 | 0.9888 | 90 |
| Over-bed table use | Set IDs 2-9 all same as Set ID 1 | 8 | 0.89 | 0.9988 | 90 |
| Bed rail adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 4.37 | 0.8222 | 90 |
| Bed height adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 5.24 | 0.7313 | 90 |
| Bed angle adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 1.6 | 0.9908 | 90 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table III.4: Model summaries pertaining to variables measured as frequency counts for **LEFT HANDED** Nurses for task category **SUCTIONING**

| **Behavior Type** | **Contrast** | **DF** | **Chi-Square** | **Significance** | **Observations** |
|---|---|---|---|---|---|
| | | | | | |
| Stretch | Set IDs 2-9 all same as Set ID 1 | 8 | 2.14 | 0.9766 | 90 |
| Bend | Set IDs 2-9 all same as Set ID 1 | 8 | 6.58 | 0.5822 | 89 |
| Unstable | Set IDs 2-9 all same as Set ID 1 | 8 | 4.24 | 0.8350 | 90 |
| Lift | Set IDs 2-9 all same as Set ID 1 | 8 | *Model did not converge* | *Model did not converge* | 90 |
| Twist | Set IDs 2-9 all same as Set ID 1 | 8 | 4.09 | 0.8492 | 90 |
| Reposition | Set IDs 2-9 all same as Set ID 1 | 8 | 10.19 | 0.2519 | 90 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table III.5: Model summaries pertaining to dichotomous outcome variables for **LEFT HANDED** Nurses for task category **SITTING UP**

| **Behavior Type** | **Contrast** | **DF** | **Chi-Square** | **Significance** | **Observations** |
|---|---|---|---|---|---|
| | | | | | |
| Approach | Set IDs 2-9 all same as Set ID 1 | 8 | 16.33 | **0.0378*** | 90 |
| Hesitation | Set IDs 2-9 all same as Set ID 1 | 8 | 3.48 | 0.9005 | 90 |
| Over-bed table use | Set IDs 2-9 all same as Set ID 1 | 8 | Zero subjects used over-bed table – hence no output NO DIFFERENCE | Zero subjects used over-bed table – hence no output | 90 |
| Bed rail adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | *Model did not converge* | *Model did not converge* | 90 |
| Bed height adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 1.88 | 0.9844 | 90 |
| Bed angle adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 1.9 | 0.9839 | 90 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table III.6: Model summaries pertaining to variables measured as frequency counts for **LEFT HANDED** Nurses for task category **SITTING UP**

| **Behavior Type** | **Contrast** | **DF** | **Chi-Square** | **Significance** | **Observations** |
|---|---|---|---|---|---|
| | | | | | |
| Stretch | Set IDs 2-9 all same as Set ID 1 | 8 | 1.24 | 0.9962 | 90 |
| Bend | Set IDs 2-9 all same as Set ID 1 | 8 | 13.25 | 0.1034 | 90 |
| Unstable | Set IDs 2-9 all same as Set ID 1 | 8 | 5.76 | 0.6746 | 90 |
| Lift | Set IDs 2-9 all same as Set ID 1 | 8 | 1.13 | 0.9973 | 90 |
| Twist | Set IDs 2-9 all same as Set ID 1 | 8 | 3.87 | 0.8690 | 90 |
| Reposition | Set IDs 2-9 all same as Set ID 1 | 8 | 3.04 | 0.9320 | 90 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

**APPENDIX IV**
**Summary of Logistic and Poisson Regression of Right-Handed Subject Data**

Table IV.1: Model summaries pertaining to dichotomous outcome variables for **RIGHT HANDED** Nurses for task category **VITALS**

| **Behavior Type** | **Contrast** | **DF** | **Chi-Square** | **Significance** | **Observations** |
|---|---|---|---|---|---|
| | | | | | |
| Approach | Set IDs 2-9 all same as Set ID 1 | 8 | 13.47 | 0.0967+ | 90 |
| Hesitation | Set IDs 2-9 all same as Set ID 1 | 8 | 1.7 | 0.9888 | 90 |
| Over-bed table use | Set IDs 2-9 all same as Set ID 1 | 8 | Zero subjects used over-bed table – hence no output NO DIFFERENCE | Zero subjects used over-bed table – hence no output | 90 |
| Bed rail adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 2.14 | 0.9765 | 90 |
| Bed height adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 2.35 | 0.9684 | 90 |
| Bed angle adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 1.64 | 0.9902 | 90 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table IV.2: Model summaries pertaining to variables measured as frequency counts for **RIGHT HANDED** Nurses for task category **VITALS**

| **Behavior Type** | **Contrast** | **DF** | **Chi-Square** | **Significance** | **Observations** |
|---|---|---|---|---|---|
| | | | | | |
| Stretch | Set IDs 2-9 all same as Set ID 1 | 8 | 4.33 | 0.8267 | 90 |
| Bend | Set IDs 2-9 all same as Set ID 1 | 8 | 2.64 | 0.9547 | 90 |
| Unstable | Set IDs 2-9 all same as Set ID 1 | 8 | *Model did not converge* | *Model did not converge* | 90 |
| Lift | Set IDs 2-9 all same as Set ID 1 | 8 | *Model did not converge* | *Model did not converge* | 90 |
| Twist | Set IDs 2-9 all same as Set ID 1 | 8 | 8.84 | 0.3884 | 90 |
| Reposition | Set IDs 2-9 all same as Set ID 1 | 8 | 1.95 | 0.9826 | 89 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table IV.3: Model summaries pertaining to dichotomous outcome variables for **RIGHT HANDED** Nurses for task category **SUCTIONING**

| **Behavior Type** | **Contrast** | **DF** | **Chi-Square** | **Significance** | **Observations** |
|---|---|---|---|---|---|
| | | | | | |
| Approach | Set IDs 2-9 all same as Set ID 1 | 8 | 12.29 | 0.1388 | 90 |
| Hesitation | Set IDs 2-9 all same as Set ID 1 | 8 | 2.01 | 0.9806 | 90 |
| Over-bed table use | Set IDs 2-9 all same as Set ID 1 | 8 | 1.66 | 0.9897 | 90 |
| Bed rail adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 2.62 | 0.9561 | 90 |
| Bed height adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 1.99 | 0.9813 | 90 |
| No difference Bed angle adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 3.33 | 0.9123 | 90 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table IV.4: Model summaries pertaining to variables measured as frequency counts for **RIGHT HANDED** Nurses for task category **SUCTIONING**

| **Behavior Type** | **Contrast** | **DF** | **Chi-Square** | **Significance** | **Observations** |
|---|---|---|---|---|---|
| | | | | | |
| Stretch | Set IDs 2-9 all same as Set ID 1 | 8 | 3.24 | 0.9188 | 90 |
| Bend | Set IDs 2-9 all same as Set ID 1 | 8 | 2.83 | 0.9449 | 90 |
| Unstable | Set IDs 2-9 all same as Set ID 1 | 8 | 2.07 | 0.9789 | 90 |
| Lift | Set IDs 2-9 all same as Set ID 1 | 8 | *Model did not converge* | *Model did not converge* | 90 |
| Twist | Set IDs 2-9 all same as Set ID 1 | 8 | 5.44 | 0.7096 | 90 |
| Reposition | Set IDs 2-9 all same as Set ID 1 | 8 | 3.64 | 0.8882 | 90 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table IV.5: Model summaries pertaining to dichotomous outcome variables for **RIGHT HANDED** Nurses for task category **SITTING UP**

| **Behavior Type** | **Contrast** | **DF** | **Chi-Square** | **Significance** | **Observations** |
|---|---|---|---|---|---|
| | | | | | |
| Approach | Set IDs 2-9 all same as Set ID 1 | 8 | 12.41 | 0.1339 | 90 |
| Hesitation | Set IDs 2-9 all same as Set ID 1 | 8 | 1.56 | 0.9916 | 90 |
| Over-bed table use | Set IDs 2-9 all same as Set ID 1 | 8 | Zero subjects used over-bed table – hence no output NO DIFFERENCE | Zero subjects used over-bed table – hence no output | |
| Bed rail adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 1.64 | 0.9902 | 90 |
| Bed height adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 4.19 | 0.8394 | 90 |
| No difference Bed angle adjustment | Set IDs 2-9 all same as Set ID 1 | 8 | 2.09 | 0.9783 | 90 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table IV.6: Model summaries pertaining to variables measured as frequency counts for **RIGHT HANDED** Nurses for task category **SITTING UP**

| **Behavior Type** | **Contrast** | **DF** | **Chi-Square** | **Significance** | **Observations** |
|---|---|---|---|---|---|
| | | | | | |
| Stretch | Set IDs 2-9 all same as Set ID 1 | 8 | 1.9 | 0.9840 | 90 |
| Bend | Set IDs 2-9 all same as Set ID 1 | 8 | 3.17 | 0.9234 | 90 |
| Unstable | Set IDs 2-9 all same as Set ID 1 | 8 | 7.34 | 0.5007 | 90 |
| Lift | Set IDs 2-9 all same as Set ID 1 | 8 | 0.93 | 0.9987 | 90 |
| Twist | Set IDs 2-9 all same as Set ID 1 | 8 | 4.21 | 0.8377 | 90 |
| Reposition | Set IDs 2-9 all same as Set ID 1 | 8 | 5.41 | 0.7134 | 90 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

## APPENDIX V
## Summary of Model Testing for Between Group Differences

Table V.1: Model Summary for APPROACH – **Vitals Task**
Observations = 180

| Parameter | Estimate | Chi-Square | Significance |
|---|---|---|---|
| | | | |
| Intercept | 2.6796 | 7.17 | 0.0074 |
| Set ID 1 | -1.3652 | 2.03 | 0.1544 |
| Set ID 2 | -8.9530 | 1.58 | 0.2089 |
| Set ID 3 | 0.8171 | 0.39 | 0.5318 |
| Set ID 4 | -0.1942 | 0.04 | 0.8507 |
| Set ID 5 | -2.7233 | 7.4 | **0.0065**** |
| Set ID 6 | -8.9530 | 1.58 | 0.2089 |
| Set ID 7 | 4.8645 | 0.47 | 0.4948 |
| Set ID 8 | -8.9530 | 1.58 | 0.2089 |
| Right-Handed | -1.2708 | 4.16 | **0.0413*** |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.2: Model Summary for HESITATION – **Vitals Task**
Observations = 180

| Parameter | Estimate | Chi-Square | Significance |
|---|---|---|---|
| | | | |
| Intercept | 1.6745 | 1.11 | 0.2918 |
| Set ID 1 | 0.6436 | 0.25 | 0.6152 |
| Set ID 2 | 0.8218 | 0.4 | 0.5294 |
| Set ID 3 | 0.8218 | 0.4 | 0.5294 |
| Set ID 4 | 5.3640 | 0.56 | 0.4532 |
| Set ID 5 | -0.7992 | 0.21 | 0.6432 |
| Set ID 6 | 0.8218 | 0.4 | 0.5294 |
| Set ID 7 | 5.3640 | 0.56 | 0.4532 |
| Set ID 8 | 5.3640 | 0.56 | 0.4532 |
| Right-Handed | -0.2594 | 0.03 | 0.8518 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.3: Model Summary for OVER-BED TABLE USE – **Vitals Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | | | |
| Set ID 1 | | | |
| Set ID 2 | | | |
| Set ID 3 | | | |
| Set ID 4 | | | |
| Set ID 5 | | | |
| Set ID 6 | | | |
| Set ID 7 | | | |
| Set ID 8 | | | |
| Right-Handed | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
Zero subjects used over-bed table – hence no output

Table V.4: Model Summary for BED RAIL ADJUSTMENT – **Vitals Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | 1.9722 | 8.29 | 0.0040 |
| Set ID 1 | -0.0695 | 0.01 | 0.9392 |
| Set ID 2 | 0.4717 | 0.23 | 0.6328 |
| Set ID 3 | -959E-18 | 0 | 1 |
| Set ID 4 | 0.3617 | 0.18 | 0.6721 |
| Set ID 5 | 0.3617 | 0.18 | 0.6721 |
| Set ID 6 | -0.0695 | 0.01 | 0.9392 |
| Set ID 7 | 0.7330 | 0.60 | 0.4381 |
| Set ID 8 | -963E-18 | 0 | 1 |
| Right-Handed | -1.0336 | 3.79 | **0.0516**$^{+}$ |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.5: Model Summary for BED HEIGHT ADJUSTMENT – **Vitals Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | 2.5753 | 8.54 | 0.0035 |
| Set ID 1 | -0.3895 | 0.11 | 0.7411 |
| Set ID 2 | -0.4073 | 0.17 | 0.6785 |
| Set ID 3 | -0.3895 | 0.11 | 0.7411 |
| Set ID 4 | -0.9311 | 0.70 | 0.4041 |
| Set ID 5 | -0.9311 | 0.70 | 0.4041 |
| Set ID 6 | -0.3895 | 0.11 | 0.7411 |
| Set ID 7 | -0.3895 | 0.11 | 0.7411 |
| Set ID 8 | 0.4299 | 0.1 | 0.7524 |
| Right-Handed | -0.7739 | 0.66 | 0.4162 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.6: Model Summary for BED ANGLE ADJUSTMENT – **Vitals Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | 7.3736 | 0.99 | 0.3202 |
| Set ID 1 | 1.01E-14 | 0 | 1 |
| Set ID 2 | 1.01E-14 | 0 | 1 |
| Set ID 3 | 9.66E-15 | 0 | 1 |
| Set ID 4 | 9.61E-15 | 0 | 1 |
| Set ID 5 | 9.66E-15 | 0 | 1 |
| Set ID 6 | 1.06E-14 | 0 | 1 |
| Set ID 7 | 1.01E-14 | 0 | 1 |
| Set ID 8 | -4.2133 | 0.32 | 0.5734 |
| Right-Handed | -0.9358 | 0.04 | 0.8345 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.7: Model Summary for STRETCH – **Vitals Task**
Observations = 180

| Parameter | Estimate | Chi-Square | Significance |
|---|---|---|---|
| | | | |
| Intercept | -3.8067 | 6.36 | 0.0117 |
| Set ID 1 | 0 | 0 | 1 |
| Set ID 2 | -25.0028 | 0 | 0.9999 |
| Set ID 3 | -25.0028 | 0 | 0.9999 |
| Set ID 4 | 1.0986 | 0.45 | 0.5011 |
| Set ID 5 | 0.6931 | 0.16 | 0.6890 |
| Set ID 6 | 0 | 0 | 1 |
| Set ID 7 | 0 | 0 | 1 |
| Set ID 8 | -25.0027 | 0 | 0.9999 |
| Right-Handed | 0.2231 | 0.06 | 0.8140 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.8: Model Summary for BEND – **Vitals Task**
Observations = 180

| Parameter | Estimate | Chi-Square | Significance |
|---|---|---|---|
| | | | |
| Intercept | 0.0389 | 0.03 | 0.8674 |
| Set ID 1 | 0.0476 | 0.02 | 0.8774 |
| Set ID 2 | -0.3124 | 0.85 | 0.3579 |
| Set ID 3 | -0.0247 | 0.01 | 0.9374 |
| Set ID 4 | -0.05 | 0.02 | 0.8744 |
| Set ID 5 | -0.05 | 0.02 | 0.8744 |
| Set ID 6 | -0.076 | 0.06 | 0.8114 |
| Set ID 7 | -0.05 | 0.02 | 0.8744 |
| Set ID 8 | -0.0247 | 0.01 | 0.9374 |
| Right-Handed | -0.0287 | 0.04 | 0.8499 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.9: Model Summary for UNSTABLE – **Vitals Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | -28.3911 | 372.03 | 0.0001 |
| Set ID 1 | 25.6831 | 219.87 | 0.0001*** |
| Set ID 2 | 24.9899 | 156.12 | 0.0001*** |
| Set ID 3 | 24.9899 | 156.12 | 0.0001*** |
| Set ID 4 | -0.0012 | 0 | 1 |
| Set ID 5 | -0.0009 | 0 | 1 |
| Set ID 6 | 24.9899 | 156.12 | 0.0001*** |
| Set ID 7 | 24.9899 | | |
| Set ID 8 | -0.0009 | 0 | 1 |
| Right-Handed | -0.6931 | 0.32 | 0.5714 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.10: Model Summary for LIFT – **Vitals Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | -2.9957 | 4.49 | 0.0341 |
| Set ID 1 | -26.8237 | 0 | 1 |
| Set ID 2 | 0 | 0 | 1 |
| Set ID 3 | -26.8237 | 0 | 1 |
| Set ID 4 | -26.8237 | 0 | 1 |
| Set ID 5 | 0 | 0 | 1 |
| Set ID 6 | -26.8237 | 0 | 1 |
| Set ID 7 | 0 | 0 | 1 |
| Set ID 8 | -26.8237 | 0 | 1 |
| Right-Handed | -26.6787 | 0 | 1 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.11: Model Summary for TWIST – **Vitals Task**
Observations = 180

| Parameter | Estimate | Chi-Square | Significance |
|---|---|---|---|
| | | | |
| Intercept | -2.2842 | 10.28 | 0.0013 |
| Set ID 1 | -0.2231 | 0.06 | 0.8140 |
| Set ID 2 | -1.6094 | 1.08 | 0.2989 |
| Set ID 3 | -1.6094 | 1.08 | 0.2989 |
| Set ID 4 | -0.5108 | 0.24 | 0.6209 |
| Set ID 5 | -0.5108 | 0.24 | 0.6209 |
| Set ID 6 | 0 | 0 | 1 |
| Set ID 7 | 0 | 0 | 1 |
| Set ID 8 | -24.61 | 0 | 0.9999 |
| Right-Handed | 0.3747 | 0.46 | 0.4988 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.12: Model Summary for REPOSITION – **Vitals Task**
Observations = 180

| Parameter | Estimate | Chi-Square | Significance |
|---|---|---|---|
| | | | |
| Intercept | 0.6318 | 11.45 | 0.0007 |
| Set ID 1 | 0.1232 | 0.25 | 0.62 |
| Set ID 2 | 0.2066 | 0.72 | 0.3968 |
| Set ID 3 | 0.0938 | 0.14 | 0.7078 |
| Set ID 4 | 0.4080 | 0.04 | 0.8495 |
| Set ID 5 | 0.1232 | 0.25 | 0.6200 |
| Set ID 6 | 0.1086 | 0.19 | 0.6631 |
| Set ID 7 | 0.1026 | 0.17 | 0.6841 |
| Set ID 8 | 0 | 0 | 1 |
| Right-Handed | -0.4756 | 15.96 | 0.0001*** |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.13: Model Summary for APPROACH – **Suctioning task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | 1.6010 | 4.75 | 0.0294 |
| Set ID 1 | -0.5723 | 0.48 | 0.4883 |
| Set ID 2 | -2.0215 | 4.29 | **0.0383*** |
| Set ID 3 | 1.4711 | 2.53 | 0.1119 |
| Set ID 4 | 0.6652 | 0.52 | 0.4722 |
| Set ID 5 | -1.1803 | 1.87 | 0.1717 |
| Set ID 6 | -1.4777 | 2.95 | **0.0856+** |
| Set ID 7 | 1.4711 | 2.53 | 0.1119 |
| Set ID 8 | -2.0215 | 4.29 | **0.0383*** |
| Right-Handed | -2.6515 | 20.16 | **0.0001***** |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.14: Model Summary for HESITATION – **Suctioning task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | 1.4186 | 3.25 | 0.0713 |
| Set ID 1 | 0.8245 | 0.4 | 0.5281 |
| Set ID 2 | 0.9218 | 0.64 | 0.4237 |
| Set ID 3 | 1.1219 | 0.54 | 0.4629 |
| Set ID 4 | 5.6422 | 0.63 | 0.4287 |
| Set ID 5 | 5.6422 | 0.63 | 0.4287 |
| Set ID 6 | 0.9218 | 0.64 | 0.4237 |
| Set ID 7 | 0.3002 | 0.05 | 0.8263 |
| Set ID 8 | 0.4492 | 0.16 | 0.6909 |
| Right-Handed | -0.3040 | 0.14 | 0.7062 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.15: Model Summary for OVER-BED TABLE USE – **Suctioning Task**
Observations = 180

| Parameter | Estimate | Chi-Square | Significance |
|---|---|---|---|
| | | | |
| Intercept | -0.9016 | 2.35 | 0.1250 |
| Set ID 1 | 0.3250 | 0.17 | 0.6831 |
| Set ID 2 | 7.43E-17 | 0 | 1 |
| Set ID 3 | 0.325 | 0.17 | 0.6831 |
| Set ID 4 | 0.3242 | 0.17 | 0.6765 |
| Set ID 5 | 0.3242 | 0.17 | 0.6765 |
| Set ID 6 | 2.68E-17 | 0 | 1 |
| Set ID 7 | 0.5685 | 0.55 | 0.4564 |
| Set ID 8 | 5.52E-17 | 0 | 1 |
| Right-Handed | -1.1564 | 8.88 | 0.0029** |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.16: Model Summary for BED RAIL ADJUSTMENT – **Suctioning Task**
Observations = 180

| Parameter | Estimate | Chi-Square | Significance |
|---|---|---|---|
| | | | |
| Intercept | 0.6775 | 0.83 | 0.3626 |
| Set ID 1 | 0.6898 | 0.67 | 0.4133 |
| Set ID 2 | 0.4942 | 0.36 | 0.5471 |
| Set ID 3 | 0.0535 | 0 | 0.9469 |
| Set ID 4 | 1.413 | 2.45 | 0.1176 |
| Set ID 5 | 0.7706 | 0.85 | 0.3556 |
| Set ID 6 | 0.5101 | 0.39 | 0.5337 |
| Set ID 7 | 0.8461 | 0.82 | 0.3644 |
| Set ID 8 | 0.5101 | 0.39 | 0.5337 |
| Right-Handed | -0.6526 | 2.71 | 0.1000+ |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.17: Model Summary for BED HEIGHT ADJUSTMENT – **Suctioning Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | 1.5324 | 5.86 | 0.0155 |
| Set ID 1 | -0.2796 | 0.13 | 0.7206 |
| Set ID 2 | 0.0522 | 0 | 0.9483 |
| Set ID 3 | -0.2253 | 0.08 | 0.7718 |
| Set ID 4 | 1.79E-15 | 0 | 1 |
| Set ID 5 | -0.3455 | 0.19 | 0.6643 |
| Set ID 6 | 0.3993 | 0.22 | 0.6402 |
| Set ID 7 | 0.0522 | 0 | 0.9483 |
| Set ID 8 | -0.7334 | 0.96 | 0.3275 |
| Right-Handed | -0.4041 | 1.15 | 0.2830 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.18: Model Summary for BED ANGLE ADJUSTMENT – **Suctioning Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | 1.6190 | 6.09 | 0.0136 |
| Set ID 1 | 6.7E-16 | 0 | 1 |
| Set ID 2 | 0.4938 | 0.26 | 0.6129 |
| Set ID 3 | -0.2032 | 0.04 | 0.8426 |
| Set ID 4 | 6.84E-16 | 0 | 1 |
| Set ID 5 | -0.4745 | 0.30 | 0.5857 |
| Set ID 6 | 5.2142 | 0.54 | 0.46 |
| Set ID 7 | -0.042 | 0 | 0.9629 |
| Set ID 8 | 6.7E-16 | 0 | 1 |
| Right-Handed | 0.1512 | 0.09 | 0.7623 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.19: Model Summary for STRETCH – **Suctioning Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | -1.8453 | 14.51 | 0.0001 |
| Set ID 1 | 0.087 | 0.02 | 0.8828 |
| Set ID 2 | 0.087 | 0.02 | 0.8828 |
| Set ID 3 | -0.0953 | 0.02 | 0.8774 |
| Set ID 4 | 0.0870 | 0.02 | 0.8828 |
| Set ID 5 | -1.2993 | 1.99 | 0.1584 |
| Set ID 6 | -0.0953 | 0.02 | 0.8774 |
| Set ID 7 | 0.2412 | 0.18 | 0.6721 |
| Set ID 8 | -0.0953 | 0.02 | 0.8774 |
| Right-Handed | 0.9089 | 7.95 | **0.0048**** |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.20: Model Summary for BEND – **Suctioning Task**
Observations = 179

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | 0.8434 | 28.38 | 0.0001 |
| Set ID 1 | -0.371 | 2.63 | 0.1047 |
| Set ID 2 | -0.2169 | 0.98 | 0.3220 |
| Set ID 3 | 0.0037 | 0 | 0.9859 |
| Set ID 4 | -0.0609 | 0.08 | 0.7722 |
| Set ID 5 | -0.1063 | 0.25 | 0.6171 |
| Set ID 6 | -0.1912 | 0.77 | 0.3793 |
| Set ID 7 | -0.1063 | 0.25 | 0.6171 |
| Set ID 8 | -0.0948 | 0.20 | 0.665 |
| Right-Handed | 0.0560 | 0.30 | 0.5859 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.21: Model Summary for UNSTABLE – **Suctioning Task**
Observations = 180

| Parameter | Estimate | Chi-Square | Significance |
|---|---|---|---|
| | | | |
| Intercept | -4.0943 | 7.74 | 0.0054 |
| Set ID 1 | 1.3863 | 0.77 | 0.3806 |
| Set ID 2 | 1.0986 | 0.45 | 0.5011 |
| Set ID 3 | 1.3863 | 0.77 | 0.3806 |
| Set ID 4 | 1.0986 | 0.45 | 0.5011 |
| Set ID 5 | 0.6931 | 0.16 | 0.6890 |
| Set ID 6 | 0.6931 | 0.16 | 0.6890 |
| Set ID 7 | 0.6931 | 0.16 | 0.6890 |
| Set ID 8 | 1.0986 | 0.45 | 0.5011 |
| Right-Handed | 0.6931 | 1.28 | 0.2577 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.22: Model Summary for LIFT – **Suctioning Task**
Observations = 180

| Parameter | Estimate | Chi-Square | Significance |
|---|---|---|---|
| | | | |
| Intercept | -50.6931 | 0 | 1 |
| Set ID 1 | 0 | 0 | 1 |
| Set ID 2 | 0 | 0 | 1 |
| Set ID 3 | 0 | 0 | 1 |
| Set ID 4 | 0 | 0 | 1 |
| Set ID 5 | 0 | 0 | 1 |
| Set ID 6 | 0 | 0 | 1 |
| Set ID 7 | 0 | 0 | 1 |
| Set ID 8 | 0 | 0 | 1 |
| Right-Handed | 0 | 0 | 1 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.23: Model Summary for TWIST – **Suctioning Task**
Observations = 180

| Parameter | Estimate | Chi-Square | Significance |
|---|---|---|---|
| | | | |
| Intercept | -1.6964 | 11.17 | 0.0008 |
| Set ID 1 | -0.9163 | 1.2 | 0.2734 |
| Set ID 2 | -0.1054 | 0.03 | 0.8712 |
| Set ID 3 | -0.6931 | 0.8 | 0.3709 |
| Set ID 4 | -0.1054 | 0.03 | 0.8712 |
| Set ID 5 | -0.2231 | 0.11 | 0.7394 |
| Set ID 6 | -0.6931 | 0.8 | 0.3709 |
| Set ID 7 | -0.9163 | 1.2 | 0.2734 |
| Set ID 8 | -0.5108 | 0.49 | 0.4843 |
| Right-Handed | 0.5465 | 2.08 | 0.1491 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.24: Model Summary for REPOSITION – **Suctioning Task**
Observations = 180

| Parameter | Estimate | Chi-Square | Significance |
|---|---|---|---|
| | | | |
| Intercept | 0.7543 | 23.05 | 0.0001 |
| Set ID 1 | -0.1164 | 0.29 | 0.5900 |
| Set ID 2 | 0.3094 | 2.51 | 0.1130 |
| Set ID 3 | 0.1713 | 0.72 | 0.3947 |
| Set ID 4 | -0.0110 | 0 | 0.9581 |
| Set ID 5 | -0.0800 | 0.14 | 0.7084 |
| Set ID 6 | 0.1335 | 0.43 | 0.5107 |
| Set ID 7 | -0.1414 | 0.42 | 0.5155 |
| Set ID 8 | -0.1288 | 0.35 | 0.5522 |
| Right-Handed | 0.131 | 1.8 | 0.1802 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.25: Model Summary for APPROACH – Sitting up Task
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | -0.7311 | 1.74 | 0.1870 |
| Set ID 1 | 1.2360 | 3.11 | 0.0778+ |
| Set ID 2 | 2.0685 | 7.45 | 0.0063** |
| Set ID 3 | 0.1797 | 0.06 | 0.8036 |
| Set ID 4 | 2.1558 | 8.63 | 0.0033** |
| Set ID 5 | -0.3348 | 0.18 | 0.6680 |
| Set ID 6 | 1.6438 | 5.27 | 0.0217* |
| Set ID 7 | 1.0368 | 2.29 | 0.1302 |
| Set ID 8 | 1.6269 | 5.38 | 0.0204* |
| Right-Handed | -0.6115 | 3.20 | 0.0737+ |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.26: Model Summary for HESITATION – **Sitting up Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | 1.3085 | 1.60 | 0.2065 |
| Set ID 1 | 0.8236 | 0.40 | 0.5285 |
| Set ID 2 | 0.9300 | 0.40 | 0.5261 |
| Set ID 3 | 0.2955 | 0.08 | 0.7756 |
| Set ID 4 | 0.8254 | 0.53 | 0.4659 |
| Set ID 5 | 0.8254 | 0.53 | 0.4659 |
| Set ID 6 | 0.8236 | 0.40 | 0.5285 |
| Set ID 7 | -0.0913 | 0.01 | 0.9328 |
| Set ID 8 | 0.8236 | 0.40 | 0.5285 |
| Right-Handed | 0.1088 | 0.03 | 0.8725 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.27: Model Summary for OVER-BED TABLE USE – **Sitting up Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | | | |
| Set ID 1 | | | |
| Set ID 2 | | | |
| Set ID 3 | | | |
| Set ID 4 | | | |
| Set ID 5 | | | |
| Set ID 6 | | | |
| Set ID 7 | | | |
| Set ID 8 | | | |
| Right-Handed | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
Zero subjects used over-bed table – hence no output

Table V.28: Model Summary for BED RAIL ADJUSTMENT – **Sitting up Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | -3.1654 | 0.48 | 0.4868 |
| Set ID 1 | -4.2113 | 0.32 | 0.5734 |
| Set ID 2 | -4.2113 | 0.32 | 0.5734 |
| Set ID 3 | -4.2113 | 0.32 | 0.5734 |
| Set ID 4 | -4.2113 | 0.32 | 0.5734 |
| Set ID 5 | -4.2113 | 0.32 | 0.5734 |
| Set ID 6 | -4.2113 | 0.32 | 0.5734 |
| Set ID 7 | -4.2113 | 0.32 | 0.5734 |
| Set ID 8 | -4.2113 | 0.32 | 0.5734 |
| Right-Handed | 0.9358 | 0.04 | 0.8345 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.29: Model Summary - BED HEIGHT ADJUSTMENT – **Sitting up Task**
Observations = 180

| Parameter | Estimate | Chi-Square | Significance |
|---|---|---|---|
| | | | |
| Intercept | 1.7290 | 8.69 | 0.0032 |
| Set ID 1 | -0.00214 | 0 | 0.9977 |
| Set ID 2 | -0.3042 | 0.16 | 0.6867 |
| Set ID 3 | 0.6780 | 0.69 | 0.4069 |
| Set ID 4 | -0.00214 | 0 | 0.9977 |
| Set ID 5 | 0.2275 | 0.09 | 0.7654 |
| Set ID 6 | 0.8286 | 0.74 | 0.3903 |
| Set ID 7 | 0.2876 | 0.11 | 0.7454 |
| Set ID 8 | -0.1543 | 0.03 | 0.8563 |
| Right-Handed | -1.1479 | 5.68 | **0.0172*** |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.30: Model Summary for BED ANGLE ADJUSTMENT – **Sitting up Task**
Observations = 180

| Parameter | Estimate | Chi-Square | Significance |
|---|---|---|---|
| | | | |
| Intercept | -1.6489 | 3.70 | 0.0544 |
| Set ID 1 | -5.2406 | 0.54 | 0.4607 |
| Set ID 2 | -5.2406 | 0.54 | 0.4607 |
| Set ID 3 | -0.5904 | 0.19 | 0.6610 |
| Set ID 4 | -0.5904 | 0.19 | 0.6610 |
| Set ID 5 | -5.2406 | 0.54 | 0.4607 |
| Set ID 6 | -0.5527 | 0.19 | 0.6610 |
| Set ID 7 | -0.0107 | 0 | 0.9908 |
| Set ID 8 | -5.2406 | 0.54 | 0.4607 |
| Right-Handed | -0.0385 | 0 | 0.9662 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.31: Model Summary for STRETCH – **Sitting up Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | -0.0283 | 0.01 | 0.9059 |
| Set ID 1 | -0.1082 | 0.11 | 0.7424 |
| Set ID 2 | -0.1671 | 0.25 | 0.6175 |
| Set ID 3 | 0.0253 | 0.01 | 0.9366 |
| Set ID 4 | -0.0526 | 0.03 | 0.8711 |
| Set ID 5 | -0.1082 | 0.11 | 0.7424 |
| Set ID 6 | 0.0253 | 0.01 | 0.9366 |
| Set ID 7 | 0.2283 | 0.57 | 0.4520 |
| Set ID 8 | -0.1671 | 0.25 | 0.6175 |
| Right-Handed | 0.0059 | 0 | 0.9695 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.32: Model Summary for BEND – **Sitting up Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | 1.7173 | 279.93 | 0.0001 |
| Set ID 1 | -0.0697 | 0.24 | 0.6216 |
| Set ID 2 | -0.0594 | 0.18 | 0.6730 |
| Set ID 3 | 0.0696 | 0.26 | 0.6095 |
| Set ID 4 | -0.0800 | 0.32 | 0.5717 |
| Set ID 5 | -0.0748 | 0.28 | 0.5964 |
| Set ID 6 | 0.0143 | 0.01 | 0.9175 |
| Set ID 7 | 0.2497 | 3.65 | **0.0562+** |
| Set ID 8 | -0.0293 | 0.04 | 0.8340 |
| Right-Handed | -0.1423 | 4.75 | **0.0293*** |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.33: Model Summary for UNSTABLE – **Sitting up Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | -2.8134 | 7.62 | 0.0058 |
| Set ID 1 | 0.4055 | 0.10 | 0.7535 |
| Set ID 2 | 0.9163 | 0.60 | 0.4387 |
| Set ID 3 | 1.3863 | 1.54 | 0.2150 |
| Set ID 4 | 0.9163 | 0.60 | 0.4387 |
| Set ID 5 | -0.6931 | 0.16 | 0.6890 |
| Set ID 6 | -0.6931 | 0.16 | 0.6890 |
| Set ID 7 | 0.4055 | 0.10 | 0.7535 |
| Set ID 8 | 1.2528 | 1.22 | 0.2692 |
| Right-Handed | -0.4055 | 0.69 | 0.4060 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.34: Model Summary for LIFT – **Sitting up Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | 0.3723 | 3.68 | 0.0552 |
| Set ID 1 | -0.1241 | 0.22 | 0.6417 |
| Set ID 2 | -0.2231 | 0.66 | 0.4152 |
| Set ID 3 | -0.1054 | 0.16 | 0.6912 |
| Set ID 4 | -0.1241 | 0.22 | 0.6417 |
| Set ID 5 | -0.1054 | 0.16 | 0.6912 |
| Set ID 6 | -0.1054 | 0.16 | 0.6912 |
| Set ID 7 | -0.0513 | 0.04 | 0.8445 |
| Set ID 8 | -0.0513 | 0.04 | 0.8445 |
| Right-Handed | 0.0653 | 0.26 | 0.6093 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.35: Model Summary for TWIST – **Sitting up Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | -0.1023 | 0.19 | 0.6588 |
| Set ID 1 | -0.3727 | 1.27 | 0.2589 |
| Set ID 2 | -0.4394 | 1.70 | 0.1920 |
| Set ID 3 | -0.1691 | 0.29 | 0.5874 |
| Set ID 4 | -0.2231 | 0.50 | 0.4804 |
| Set ID 5 | -0.1431 | 0.21 | 0.6437 |
| Set ID 6 | -0.4055 | 1.48 | 0.2238 |
| Set ID 7 | 0.0220 | 0.01 | 0.9409 |
| Set ID 8 | -0.4055 | 1.48 | 0.2238 |
| Right-Handed | 0.4003 | 6.24 | **0.0125*** |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table V.36: Model Summary for Reposition – **Sitting up Task**
Observations = 180

| **Parameter** | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|
| | | | |
| Intercept | 1.2969 | 110.80 | 0.0001 |
| Set ID 1 | -0.1144 | 0.46 | 0.4992 |
| Set ID 2 | -0.0274 | 0.03 | 0.8685 |
| Set ID 3 | -0.0414 | 0.06 | 0.8033 |
| Set ID 4 | -0.1689 | 0.97 | 0.3255 |
| Set ID 5 | -0.2787 | 2.48 | 0.1156 |
| Set ID 6 | -0.0274 | 0.03 | 0.8685 |
| Set ID 7 | -0.1220 | 0.52 | 0.4720 |
| Set ID 8 | 0.0134 | 0.01 | 0.9347 |
| Right-Handed | 0.0228 | 0.08 | 0.7776 |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

## APPENDIX VI
## Summary of Model Testing Ergonomic Data

Table VI.1a: Model Summary for STRETCH (TOTAL) – **Suctioning Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -58.6312 | 3437.61 | 0.0001 |
| Challenge | Least Challenging | | 28.2197 | . | . |
| | Most Challenging | | | | |
| Handedness | Left | | -29.6692 | 0 | 1 |
| | Right | | | | |
| Preferred Side | Left | | 29.7183 | . | . |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
**[NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE]**
**[Not sufficient variability in data. Only 1 stretch observation; 39 no stretch observations]**

Table VI.1b: Model Summary for STRETCH (HEADWALL) – **Suctioning Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -58.6312 | 3437.61 | 0.0001 |
| Challenge | Least Challenging | | 28.2197 | . | . |
| | Most Challenging | | | | |
| Handedness | Left | | -29.6692 | 0 | 1 |
| | Right | | | | |
| Preferred Side | Left | | 29.7183 | . | . |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
**[NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE]**
**[Not sufficient variability in data. Only 1 stretch observation; 39 no stretch observations]**
**[The only stretch observation attributed to headwall]**

Table VI.1c: Model Summary for STRETCH (CONFIGURATION) – **Suctioning Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -50.6931 | 0 | 1 |
| Challenge | Least Challenging | | 0 | 0 | 1 |
| | Most Challenging | | | | |
| Handedness | Left | | 0 | 0 | 1 |
| | Right | | | | |
| Preferred Side | Left | | 0 | 0 | 1 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[Not sufficient variability in data. Zero total stretch observations]**

Table VI.2a: Model Summary for BEND (TOTAL) – **Suctioning Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -0.1535 | 0.25 | 0.6168 |
| Challenge | Least Challenging | | -0.2624 | 0.78 | 0.3777 |
| | Most Challenging | | | | |
| Handedness | Left | | -1.6659 | 24.18 | 0.0001*** |
| | Right | | | | |
| Preferred Side | Left | | 1.8786 | 29.44 | 0.0001*** |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.2b: Model Summary for BEND (HEADWALL) – **Suctioning Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -0.1535 | 0.25 | 0.6168 |
| Challenge | Least Challenging | | -0.2624 | 0.78 | 0.3777 |
| | Most Challenging | | | | |
| Handedness | Left | | -1.6659 | 24.18 | 0.0001*** |
| | Right | | | | |
| Preferred Side | Left | | 1.8786 | 29.44 | 0.0001*** |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.2c: Model Summary for BEND (CONFIGURATION) – **Suctioning Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -2.0794 | 4.32 | 0.0376 |
| Challenge | Least Challenging | | -27.4554 | 0 | 1 |
| | Most Challenging | | | | |
| Handedness | Left | | -26.3112 | 0 | 1 |
| | Right | | | | |
| Preferred Side | Left | | -25.9715 | 0 | 1 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[Not sufficient variability in data. Only 1 bend observation; 39 no bend observations]**
**[Most risky bending attributed to headwall design. Few bending occurred owing to configuration issues]**

Table VI.3a: Model Summary for UNSTABLE (TOTAL) – **Suctioning Task**
Observations = 40

| Parameter | | | Estimate | Chi-Square | Significance |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -1.5606 | 6.05 | 0.0139 |
| Challenge | Least Challenging | | -0.4055 | 0.39 | 0.5299 |
| | Most Challenging | | | | |
| Handedness | Left | | -1.6582 | 5.13 | 0.0235* |
| | Right | | | | |
| Preferred Side | Left | | 1.7918 | 5.99 | 0.0144* |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.3b: Model Summary for UNSTABLE (HEADWALL) – **Suctioning Task**
Observations = 40

| Parameter | | | Estimate | Chi-Square | Significance |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -28.7011 | 1544.54 | 0.0001 |
| Challenge | Least Challenging | | 0.6931 | 0.64 | 0.4235 |
| | Most Challenging | | | | |
| Handedness | Left | | -2.8622 | 6.83 | 0.0090** |
| | Right | | | | |
| Preferred Side | Left | | 28.5188 | . | . |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[Not sufficient variability in data. Zero frequency in 87.50 percent of the observations]**

Table VI.3c: Model Summary for UNSTABLE (CONFIGURATION) – **Suctioning Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -1.4629 | 4.21 | 0.0403 |
| Challenge | Least Challenging | | -26.0577 | 0 | 0.9999 |
| | Most Challenging | | | | |
| Handedness | Left | | 0.5018 | 0.21 | 0.6467 |
| | Right | | | | |
| Preferred Side | Left | | -1.1444 | 0.82 | 0.3653 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[Not sufficient variability in data. Zero frequency in 90.0 percent of the observations]**

Table VI.4a: Model Summary for LIFT (TOTAL) – **Suctioning Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -50.6931 | 0 | 1 |
| Challenge | Least Challenging | | 0 | 0 | 1 |
| | Most Challenging | | | | |
| Handedness | Left | | 0 | 0 | 1 |
| | Right | | | | |
| Preferred Side | Left | | 0 | 0 | 1 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
**[NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE]**
**[No lifting was involved in suctioning task]**

Table VI.4b: Model Summary for LIFT (HEADWALL) – **Suctioning Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -50.6931 | 0 | 1 |
| Challenge | Least Challenging | | 0 | 0 | 1 |
| | Most Challenging | | | | |
| Handedness | Left | | 0 | 0 | 1 |
| | Right | | | | |
| Preferred Side | Left | | 0 | 0 | 1 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
**[NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE]**
**[No lifting was involved in suction task]**

Table VI.4c: Model Summary for LIFT (CONFIGURATION) – **Suctioning Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -50.6931 | 0 | 1 |
| Challenge | Least Challenging | | 0 | 0 | 1 |
| | Most Challenging | | | | |
| Handedness | Left | | 0 | 0 | 1 |
| | Right | | | | |
| Preferred Side | Left | | 0 | 0 | 1 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[No lifting was involved in suction task]**

Table VI.5a: Model Summary for TWIST (TOTAL) – Suctioning Task
Observations = 40

| Parameter | | | Estimate | Chi-Square | Significance |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | 1.2881 | 69.10 | 0.0001 |
| Challenge | Least Challenging | | -0.1515 | 0.68 | 0.4098 |
| | Most Challenging | | | | |
| Handedness | Left | | -0.6981 | 10.34 | **0.0013**** |
| | Right | | | | |
| Preferred Side | Left | | 0.3974 | 3.54 | **0.0598**+ |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.5b: Model Summary for TWIST (HEADWALL) – **Suctioning Task**
Observations = 40

| Parameter | | | Estimate | Chi-Square | Significance |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | 1.2688 | 65.22 | 0.0001 |
| Challenge | Least Challenging | | -0.0870 | 0.22 | 0.6411 |
| | Most Challenging | | | | |
| Handedness | Left | | -0.7703 | 11.93 | **0.0006***** |
| | Right | | | | |
| Preferred Side | Left | | 0.3561 | 2.74 | **0.0977**+ |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.5c: Model Summary for TWIST (CONFIGURATION) – **Suctioning Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -1.8047 | 5.30 | 0.0214 |
| Challenge | Least Challenging | | -26.4655 | 0 | 0.9999 |
| | Most Challenging | | | | |
| Handedness | Left | | 0.3261 | 0.11 | 0.7423 |
| | Right | | | | |
| Preferred Side | Left | | 0.7315 | 0.54 | 0.4607 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[Not sufficient variability in data. Zero frequency in 92.50 percent of the observations]**

Table VI.6a: Model Summary: REPOSITION (TOTAL) – **Suctioning Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -2.0794 | 4.32 | 0.0376 |
| Challenge | Least Challenging | | -27.4554 | 0 | 1 |
| | Most Challenging | | | | |
| Handedness | Left | | -26.3112 | 0 | 1 |
| | Right | | | | |
| Preferred Side | Left | | -25.9715 | 0 | 1 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[Not sufficient variability in data. Zero frequency in 97.50 percent of the observations]**

Table VI.6b: Model Summary: REPOSITION (HEADWALL) – **Suctioning Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -50.6931 | 0 | 1 |
| Challenge | Least Challenging | | 0 | 0 | 1 |
| | Most Challenging | | | | |
| Handedness | Left | | 0 | 0 | 1 |
| | Right | | | | |
| Preferred Side | Left | | 0 | 0 | 1 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[Not sufficient variability in data. Zero frequency in 100.0 percent of the observations]**

Table VI.6c: Model Summary for REPOSITION (CONFIGURATION) – **Suctioning Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -2.0794 | 4.32 | 0.0376 |
| Challenge | Least Challenging | | -27.4554 | 0 | 1 |
| | Most Challenging | | | | |
| Handedness | Left | | -26.3112 | 0 | 1 |
| | Right | | | | |
| Preferred Side | Left | | -25.9715 | 0 | 1 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[Not sufficient variability in data. Zero frequency in 97.5 percent of the observations]**

Table VI.7a: Model Summary for STRETCH (TOTAL) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | 0.5532 | 5.24 | 0.0221 |
| Challenge | Least Challenging | | -0.3610 | 0.1714 | 0.1838 |
| | Most Challenging | | | | |
| Handedness | Left | | -0.2389 | 0.76 | 0.3837 |
| | Right | | | | |
| Preferred Side | Left | | 0.1190 | 0.19 | 0.6627 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.7b: Model Summary for STRETCH (HEADWALL) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | 0.1512 | 0.29 | 0.5911 |
| Challenge | Least Challenging | | -0.3001 | 1.03 | 0.3090 |
| | Most Challenging | | | | |
| Handedness | Left | | 0.0888 | 0.09 | 0.7660 |
| | Right | | | | |
| Preferred Side | Left | | 0.1958 | 0.43 | 0.5130 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.7c: Model Summary for STRETCH (CONFIGURATION) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -0.1538 | 0.17 | 0.6769 |
| Challenge | Least Challenging | | -2.4423 | 10.98 | 0.0009*** |
| | Most Challenging | | | | |
| Handedness | Left | | 0.3720 | 0.08 | 0.3715 |
| | Right | | | | |
| Preferred Side | Left | | 0.1676 | 0.17 | 0.6834 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.8a: Model Summary for BEND (TOTAL) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | 1.5007 | 109.48 | 0.0001 |
| Challenge | Least Challenging | | -0.1576 | 1.10 | 0.2945 |
| | Most Challenging | | | | |
| Handedness | Left | | -0.0047 | 0.00 | 0.9756 |
| | Right | | | | |
| Preferred Side | Left | | 0.1360 | 0.79 | 0.3752 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.8b: Model Summary for BEND (HEADWALL) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | 1.2649 | 65.23 | 0.0001 |
| Challenge | Least Challenging | | 0 | 0 | 1 |
| | Most Challenging | | | | |
| Handedness | Left | | 0.0052 | 0 | 0.9743 |
| | Right | | | | |
| Preferred Side | Left | | 0.2249 | 1.92 | 0.1660 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.8c: Model Summary for BEND (CONFIGURATION) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | 0.2857 | 0.74 | 0.3885 |
| Challenge | Least Challenging | | -27.7103 | 0 | 0.9999 |
| | Most Challenging | | | | |
| Handedness | Left | | 0.2761 | 0.39 | 0.5341 |
| | Right | | | | |
| Preferred Side | Left | | -0.9712 | 3.91 | 0.0479* |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]

Table VI.9a: Model Summary: UNSTABLE (TOTAL) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -2.9180 | 6.18 | 0.0129 |
| Challenge | Least Challenging | | 0 | 0 | 1 |
| | Most Challenging | | | | |
| Handedness | Left | | 1.1398 | 0.95 | 0.3308 |
| | Right | | | | |
| Preferred Side | Left | | -0.2069 | 0.04 | 0.8385 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.9b: Model Summary for UNSTABLE (HEADWALL) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -50.6931 | 0 | 1 |
| Challenge | Least Challenging | | 0 | 0 | 1 |
| | Most Challenging | | | | |
| Handedness | Left | | 0 | 0 | 1 |
| | Right | | | | |
| Preferred Side | Left | | 0 | 0 | 1 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[Insufficient variability in data. Zero frequency count for 100.0 percent of the observations]**

Table VI.9c: Model Summary for UNSTABLE (CONFIGURATION) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -2.9180 | 6.18 | 0.0129 |
| Challenge | Least Challenging | | 0 | 0 | 1 |
| | Most Challenging | | | | |
| Handedness | Left | | 1.1398 | 0.95 | 0.3308 |
| | Right | | | | |
| Preferred Side | Left | | -0.2069 | 0.04 | 0.8385 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.10a: Model Summary for LIFT (TOTAL) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -1.8997 | 5.63 | 0.0176 |
| Challenge | Least Challenging | | 0.9163 | 1.2 | 0.2734 |
| | Most Challenging | | | | |
| Handedness | Left | | -0.8924 | 1.1 | 0.2943 |
| | Right | | | | |
| Preferred Side | Left | | -0.1198 | 0.02 | 0.8774 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.10b: Model Summary for LIFT (HEADWALL) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -2.5144 | 5.54 | 0.0186 |
| Challenge | Least Challenging | | 1.6094 | 2.16 | 0.1418 |
| | Most Challenging | | | | |
| Handedness | Left | | -0.5801 | 0.43 | 0.5103 |
| | Right | | | | |
| Preferred Side | Left | | -0.5801 | 0.43 | 0.5103 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[Insufficient variability in data. Zero frequency count for 85.0 percent of the observations]**

Table VI.10c: Model Summary for LIFT (CONFIGURATION) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -28.6743 | 822.21 | 0.0001 |
| Challenge | Least Challenging | | -27.2076 | 0 | 1 |
| | Most Challenging | | | | |
| Handedness | Left | | -0.4055 | 0.08 | 0.7743 |
| | Right | | | | |
| Preferred Side | Left | | 27.2888 | . | . |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[Insufficient variability in data. Zero frequency count for 95.0 percent of the observations]**

Table VI.11a: Model Summary for TWIST (TOTAL) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | 1.16815 | 167.36 | 0.0001 |
| Challenge | Least Challenging | | -0.0182 | 0.02 | 0.8927 |
| | Most Challenging | | | | |
| Handedness | Left | | -0.0606 | 0.19 | 0.6597 |
| | Right | | | | |
| Preferred Side | Left | | 0.1213 | 0.77 | 0.3787 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.11b: Model Summary for TWIST (HEADWALL) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | 1.5096 | 116.90 | 0.0001 |
| Challenge | Least Challenging | | 0.0305 | 0.05 | 0.8308 |
| | Most Challenging | | | | |
| Handedness | Left | | 0.0296 | 0.04 | 0.8387 |
| | Right | | | | |
| Preferred Side | Left | | 0.1059 | 0.53 | 0.4673 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.11c: Model Summary for TWIST (CONFIGURATION) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | 0.0093 | 0 | 0.9801 |
| Challenge | Least Challenging | | -2.9444 | 8.24 | **0.0041**** |
| | Most Challenging | | | | |
| Handedness | Left | | 0.5846 | 1.59 | 0.2071 |
| | Right | | | | |
| Preferred Side | Left | | -0.9611 | 3.76 | **0.0524**+ |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))

Table VI.12a: Model Summary for REPOSITION (TOTAL) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -27.7082 | 1818.35 | 0.0001 |
| Challenge | Least Challenging | | -0.2231 | 0.11 | 0.7394 |
| | Most Challenging | | | | |
| Handedness | Left | | 26.8328 | . | . |
| | Right | | | | |
| Preferred Side | Left | | 0.2877 | 0.17 | 0.6841 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[Insufficient variability in data. Zero frequency count for 82.5 percent of the observations]**

Table VI.12b: Model Summary for REPOSITION (HEADWALL) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -27.7082 | 1818.35 | 0.0001 |
| Challenge | Least Challenging | | -0.2231 | 0.11 | 0.7394 |
| | Most Challenging | | | | |
| Handedness | Left | | 26.8328 | . | . |
| | Right | | | | |
| Preferred Side | Left | | 0.2877 | 0.17 | 0.6841 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[Insufficient variability in data. Zero frequency count for 82.5 percent of the observations]**

Table VI.12c: Model Summary for REPOSITION (CONFIGURATION) – **Sitting up Task**
Observations = 40

| **Parameter** | | | **Estimate** | **Chi-Square** | **Significance** |
|---|---|---|---|---|---|
| | | | | | |
| Intercept | | | -28.4918 | 1623.57 | 0.0001 |
| Challenge | Least Challenging | | -27.5941 | 0 | 1 |
| | Most Challenging | | | | |
| Handedness | Left | | 27.7987 | . | . |
| | Right | | | | |
| Preferred Side | Left | | -1.0986 | 0.8 | 0.3697 |
| | Right | | | | |

(*** (significant at .001), ** (significant at 0.01), * (significant at 0.05), + (significant at 0.1))
[**NOTE: VALIDITY OF THIS MODEL FIT IS QUESTIONABLE**]
**[Insufficient variability in data. Zero frequency count for 95.0 percent of the observations]**