Identification of factors affecting EMS workers adoption of MSD interventions

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List of Terms and Abbreviations

EMS – Emergency Medical Services

MSDs – Musculoskeletal Disorders

Abstract

The long-term goal of this project is to prevent musculoskeletal injuries in Emergency Medical Service (EMS) workers. Prior work by our group and others had shown that EMS tasks contain many risk factors that have been associated with musculoskeletal disorders (MSDs) in the literature. This work investigated the adoption of a folding transfer-board that reduces friction and therein promotes sliding patients, as opposed to lifting patients, between surfaces during lateral transfers. This device was developed through a participatory process in a prior NIOSH funded project. The primary purpose of the current project was to further our understanding of the issues surrounding the adoption and sustained use of voluntary interventions aimed at preventing MSDs. The project aims were to: 1. Use the framework of the integrated technology acceptance model and task technology fit model as a starting point, to identify and quantify the degree to which specific perceptual and attitudinal factors contribute to the adoption and sustained use of a previously validated musculoskeletal disorder (MSD) intervention; 2. Quantify the degree to which individuals who step up and "champion" an intervention affect the adoption and sustained use of the intervention and to determine the nature of the successful efforts; 3. Characterize, both quantitatively and geographically, the diffusion of a specific musculoskeletal interventions within and between EMS organizations.

Methods. We recruited 324 professional EMS workers for a 2-month longitudinal study. At baseline, upon receiving the interventions and monthly thereafter, the participants were surveyed to assess attitudes and perceptions about the transfer board (Aim 1). In addition, participants were asked to report their actual use of the intervention for the first 5 weeks of the study. Complete and usable data for all analyses were obtained from 187 participants.

Results. After the completion of the two-month study period, the multivariate stepwise regression indicated only two factors were predictive of "intention to use": the perceived "ergonomics advantage," and the degree to which the transfer-board was "endorsed by champions" (r^2=.58). Actual use was predicted by: "ergonomics advantage" and "previous tool experience." The structural equation model developed in this study, which builds upon the factor analysis and regression models, identified that the perceived ergonomics advantage (comprised of the following dimensions: "easy to use," "easier on the back," "easier on the shoulder," "compatible with current equipment", and allowing "smoother transfers") was influenced by access and storage convenience, and to a lesser degree previous experience with the specific intervention. The perceived ergonomics advantage also further influenced the endorsement of the intervention by individual champions, which, in turn, moderately impacts one's intention to use the intervention. The organizational climate factor had only a weak indirect effect through its influence on the endorsement by champions. The theoretical model developed and tested in this study should be further tested with other types of equipment and in other healthcare settings to expand its applicability.

Section 1

Significant (Key) Findings.

1. The most important factor affecting an EMS worker's intention to use or actual use of the transfer board intervention was the perceived ergonomics advantage. Survey questions comprising this factor included items assessing the usability and usefulness of the tested intervention. With regards to usability, the survey questions assessed whether the transfer board was easy to use, whether the transfer board allows for smooth transfers for the patient, and the degree to which the transfer board works well with the current equipment (i.e. ambulance cots). With regards to usefulness, the survey questions items addressed whether the transfer board made lateral transfers easier on the back and on the shoulders. All of these questions strongly contributed to the perceived ergonomics advantage, indicating that all were important considerations. It should also be noted that the modeling process indicated that the perception of an ergonomics advantage could be affected by access and storage issues.

2. Having Individuals that championed the transfer board, for example by encouraging its use, significantly affected others intention to use the intervention. The modeling process showed that the degree to which an intervention is endorsed by champions is strongly influenced by the perceived ergonomics advantage and weakly influenced by whether the organizational climate is supportive of innovation.

3. Actual use of the transfer board intervention was, in addition to being dependent upon perceived ergonomics advantage, was also dependent on previous tool experience. In the case of EMS workers, prior tool experience was comprised of prior use of transfer boards at medical facilities.

Translation of Findings.

It is very important to effectively introduce an ergonomics intervention by communicating the anticipated usefulness of the intervention to the affected employees. The recipients of the intervention need to clearly understand the ergonomics advantage during this initial exposure to the intervention. In some environment where there are multiple shift schedules this can be particularly challenging. However, failure to communicate with all affected individuals results in some individuals asking "why" an intervention is being made available or being left to figure out the usefulness of an intervention for themselves. We had instances where the folding transfer board intervention was removed from the ambulance cot and placed in a storage cabinet by individuals who were not informed of the utility of the intervention. The fire service personnel who participated in this study provided anecdotal examples of other potential ergonomics interventions that just "showed-up" on the emergency response vehicles, taking up valuable space as they were typically not used.

This work stresses the need to clearly identify and address usability issues before and during the implementation of a new ergonomics intervention. While many usability issues are readily apparent early in the implement process, usability evaluations need to be a continuous process in that many of the usability issues may not be readily apparent early in the implementation process. This can occur due to ergonomic interventions being used in unforeseen ways, even though they are beneficial, or due to wider acceptance which yields variations in the interactions between the intervention and other variations in the targeted work systems including access and storage issues.

Recognizing that champions play an important role in the adoption of an ergonomics intervention highlights the needs to encourage and support the efforts of these individuals. If it is known who the likely champions may be, it may be worthwhile to be sure that they are engaged early in the implementation process and perhaps involved in training others to use the intervention. When usability issues are encountered, our experience with this project shows that the intervention champions may be very good people to recruit when attempting to resolve these issues.

Outcomes / Impact

The potential outcomes from this project are ways to better ensure the adoption of viable voluntarily-used ergonomics interventions. While this work is limited in that it was done with fire service personnel using a specific intervention aimed at aiding lateral transfers of patients, the work has the potential to affect occupational safety and health of many workers who may be provided with voluntarily-used ergonomics interventions. Understanding the key factors driving one's intention to use and actual use can direct implementation efforts towards more successful strategies. This work stresses the importance of communicating the ergonomics advantage of an intervention, making sure access and storage issues are adequately resolved, building off employee's previous experiences with similar types of interventions if they exist, and nurturing the efforts of those workers who promote the intervention amongst their peers. This research also showed that while having an organizational climate supportive of innovation may be nice, it is not necessary for promoting intervention adoption. In essence, if the advantages of the intervention are perceived and there is peer encouragement, the adoption of the voluntarily used intervention can be successful, which in the case of the transfer board, reduces the overall physical demands on the EMS providers, and therefore reduces the potential for injury.

2. Scientific Report.

2.1 Specific Aims

The overall goal of this R21 proposal was to further our understanding of research to practice (r2p) issues surrounding the adoption and sustainability of interventions aimed at preventing musculoskeletal disorders. Unfortunately, interventions that are designed and validated through laboratory testing often fail to be adopted and put into use. In some cases the use of the intervention is mandatory, either by directives from management or by the fact that tools or equipment are replaced with the newly engineered intervention. But in many cases, the decision to use an intervention is a voluntary one. This is particularly true for EMS workers who encounter a wide range of situations and must make decisions as to what tools and equipment to use while balancing the needs of the patient and their own personal health and safety.

Models of intervention adoption suggest the users must first perceive the interventions fit the task for which they are designed, and then must perceive the interventions to be both useful and easy to use (Dishaw & Strong, 1999). All of these characteristics affect user attitudes towards the intervention, which, in turn, affect the intent to use and subsequent use. Moreover, one must consider whether the use of the intervention is sustained once there has been some actual experience using the intervention.

Therefore, the primary aim of this R21 application was to explore the adoption process and to identify the modifiable factors that could be addressed during the introduction of a new, voluntarily used, musculoskeletal disorder intervention that will potentially facilitate decisions regarding intervention adoption and sustained use. We studied this adoption process within the context of EMS workers because we have identified through a prior R01 project a relatively low-cost, biomechanically validated, and usability evaluated intervention that can potentially address some of the significant musculoskeletal concerns faced by this population of workers.

Our preliminary work has indicated that word-of-mouth is perhaps one of the strongest factors affecting the diffusion of interventions into the EMS worker population (Conrad, Reichelt, Lavender, & Gacki-Smith, 2008). Within a single organization, this diffusion is often facilitated by an individual who steps-up and champions an innovation such as a musculoskeletal disorder intervention (Rogers, 2003). We wanted to understand the factors that allow a champion to be effective as this component of the intervention diffusion process is closely tied to individual decisions regarding intervention adoption. Moreover, by looking at diffusion patterns both within and between departments as the new interventions are adopted and accepted as tools that are regularly used, we sought to gain new insights into how this process can be facilitated.

This application was been designed to address the following **aims**:

1. *Using the framework of the integrated technology acceptance model and task technology fit model as a starting point, we aimed to identify and quantify the degree to which specific perceptual and attitudinal factors contribute to the adoption and sustained use of a previously validated musculoskeletal disorder (MSD) intervention.*

2. *To quantify the degree to which individuals who step up and "champion" an intervention affect the adoption and sustained use of the intervention and to determine the nature of the successful efforts.*

3. *To characterize, both quantitatively and geographically, the diffusion of a specific musculoskeletal intervention within and between EMS organizations.*

2.2 Background

Sprains, strains, and muscular pain account for over half of the injuries suffered by firefighter/ paramedics while performing non-fire emergency tasks, such as emergency medical services (EMS). This is not unexpected given that today, the majority of fire department calls are for EMS rather than fire suppression. In 2005, 62% of fire department calls were for medical aid with the numbers increasing steadily over time from about 6 million EMS calls in 1986 to over 14 million in 2005 (Karter & Molis, 2010). These EMS calls represent a significant risk for musculoskeletal injury. The same injury profile holds true for EMS workers in the private sector, such as paramedics working for ambulance companies where in 2004, of the 5170 injuries reported, 3410 of them (67%) were sprain/strain injuries (United States Bureau of Labor Statistics, 2006). These injuries are typically due to overexertion type activities with the back being the major body part affected (Maguire, Hunting, Guidotti, & Smith, 2005; United States Bureau of Labor Statistics, 2006; Walton, Conrad, Furner, & Samo, 2003).

These injuries are both costly economically due to high worker compensation costs (Boatright, 2002; Walton et al., 2003) and personally due to permanent disability and premature retirement (Conrad, Balch, Reichelt, Muran, & Oh, 1994). In our analysis of firefighter injuries we found that the overexertion related injuries were associated with high worker compensation costs. More specifically, the overall average claim for worker compensation cost of injury to firefighters was $5,168 while the mean cost for overexertion related injuries was $9,715. In medical costs alone, the per-claim average was $1,973 overall compared to $3,458 for overexertion related injuries. This same analysis showed that 42% of the overexertion injuries affected the lower back. Thus, the prevalence, costs, and disability associated with work-related musculoskeletal injuries among EMS workers, particularly to the back, support the need for analysis and control measures.

While EMS workers do a variety of tasks, a survey by Conrad, Reichelt, Lavender, and Meyer (2000) indicated that the most frequently performed strenuous work tasks entail either lifting and carrying patients down stairs or performing lateral transfers of patients at the emergency location and at the hospital. In addition to the authors (Lavender, Conrad, Reichelt, Johnson, & Meyer, 2000a; Lavender, Conrad, Reichelt, Meyer, & Johnson, 2000b), others have described the physical demands required by these tasks (Doormaal, Driessen, Landeweerd, & Drost, 1995; Furber, Moore, Williamson, & Barry, 1997; Massad, Gambin, & Duval, 2000). The physical demands continue to increase as the degree of obesity in the population grows. This is especially an issue at the scene of an emergency where often only 2 or 3 EMS workers are available to move a patient (Boatright, 2002). In summary, EMS workers' tasks involve lifting and carrying heavy loads and assuming awkward body postures while bending and twisting.

There is a need for effective interventions to improve and protect the musculoskeletal health of EMS workers (Westgaard & Winkel, 1997). Engineering changes, such as the design of new EMS assistive devices, and task method redesign are two potential intervention avenues for combating musculoskeletal injuries among EMS workers. Engaging the end-users, who are the experts on their job experience, throughout all phases of an intervention process helps increase the likelihood of program effectiveness (Kogi, 2006; Zalk, 2001). Our previous NIOSH-funded R01 research project, which is described in the preliminary studies section below, employed this participatory approach to both generate and evaluate musculoskeletal disorder intervention ideas for EMS equipment and task redesign (Conrad, et al.,2008)

The purpose of that research project was to take the next step in the intervention development process. We utilized a user-centered design process, much like what has been advocated by NIOSH (Cohen, Gjessing, Fine, Bernard, & McGlothin, 1997). In this effort we involved the end-users of the interventions, the EMS workers, throughout the process. This allowed us to complete the intervention process that was initiated with our previous research. But we recognize that even though we have developed biomechanically and physiologically valid interventions, there are likely to be usability issues. In the final phase of our prior work we conducted focus groups to address usability issues, and brought the interventions to the point of commercial production. Even though the interventions are now becoming available in the marketplace, the factors affecting the actual adoption and use of the interventions in the workplace are still poorly understood.

Karsh (2004) identifies several organizational, individual, and technological factors that are believed to influence the adoption of new technologies in the health care arena. Karsh (2004) also makes the point that the specific factors that affect adoption and use may vary depending upon whether actual use of the intervention is voluntary or not. In the case of EMS workers, who are relatively autonomous, the decision to use an intervention aimed at preventing musculoskeletal disorders (MSDs) is largely voluntary. Having the equipment on the truck in no way ensures that it will be used. Others have noted that the major obstacles to adoption of equipment designed to prevent MSDs in the construction industry included a lack of management commitment, the low amount of power within the organization possessed by those in an occupational safety role, the lack of communication about the benefits of an intervention, and not trying to overcome the resistance to change (Fulmer, Azaroff, & Moir, 2006). These same investigators realized that the adoption of the intervention in their study resulted from the direct involvement of the researchers themselves (Fulmer et al., 2006).

This observation suggests how important it is for the process to have someone, or perhaps a group of individuals, "champion" an intervention so that others are encouraged to initially adopt and continue its use until the benefits are self-evident. We believe that incorporating some of the ideas from studies of technology acceptance in the information technology literature may yield some new insights about the MSD intervention adoption process. Dishaw and Strong (1999) proposed combining the technology acceptance model with the task-technology fit model. Both models were developed to predict users' acceptance of new software tools applied to information technology problems. While in both models the outcome variable is the use of a tool, the basis for prediction is quite different, yet at the same time complimentary. In the *technology acceptance model,* tool use behavior is predicted from intention to use, which is in turn predicted from the attitudes toward using the tool and the perceived usefulness of the tool. Both of these quantities are dependent upon the tool's perceived ease of use. In the *task-technology-fit model* of tool use, the task requirements, combined with the tool functionality, determine the fit between the task and the tool. Where the fit is good, rational experienced users will choose to use the tool. However, the individual's experiences with the tool or similar tools are also theorized to directly impact tool use in this model. In Dishaw and Strong's (1999) integrated model (Figure 1) the hypothesized paths are shown.

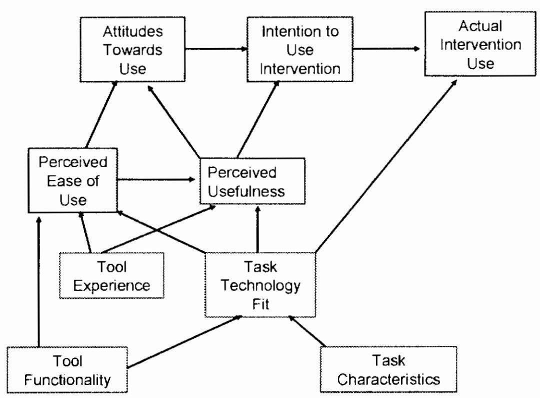

Figure 1. The integrated technology acceptance model and the task-technology fit model as proposed by Dishaw and Strong (1999).

One could expect very similar constructs to apply to the voluntary use of interventions designed to prevent MSDs in EMS workers. Structural equation modeling can be applied to these data to quantify the relative weights of the links, thereby identifying the factors positively and perhaps negatively impacting intervention adoption and use. Others have proposed that moderators, for example organizational and individual factors, impact this model and should also be considered (Sun and Zhang, 2006). However, the primary aim of this application is to use this type of approach to study the intervention adoption process in

EMS workers so that future studies looking to facilitate intervention adoption can be directed at the most critical factors determining musculoskeletal disorder intervention use.

Champions serve as advocates for a new technology in that they not only recognize the value of the innovation but they work to convince others in their organization of its value (Mullins, Kozlowski, Schmitt, & Howell, 2008). "Champions are heralded as the heroes of product innovation in organizations" (Howell & Shea, 2001, p. 15). There is little empirical research reported on the role of champions in occupational health (Backer & Rogers, 1998), with a modest amount of research in other fields, most notably, in the management, product innovation, and information technology literature (e.g., Barczak, Sultan, & Hultink, 2007; Markham, 1998; Shane, 1995). Two studies in particular illustrate work that is relevant to our proposed research.

In the first study, rather than using a dichotomous measure of the champion role, which is typically the case, Howell and Shea (2001) developed a psychometrically sound multi-item champion behavior scale and found that champion's behavior positively influenced product use over a one-year time interval. In the second study, Mullins et al. (2008) tested a causal model that included some elements of the Task Acceptance Model with the goal of learning how the presence of a champion may influence the frequency of innovation use. In the final model (chi square > .05; RMSEA = .53; goodness of fit index = .85; normed fit index = .95), the presence of a champion had a significant direct effect on perceived ease of use at Time 1. Fifteen months later, the presence of a champion had significant direct effects on prior exposure to the innovation and frequency of use as well as a significant indirect effect on frequency of use via prior exposure. The champion did not influence judgments of perceived usefulness. The results suggest that champions may be powerful both in their influence on usage and also in their effect on attitude and behavior of co-workers as they relate to use of the innovation (Mullins et al., 2008). As we ramp up our efforts to translate research findings into practice, it seems worthy of our efforts to examine the role of the champion and explore how the champion's behavior influences the adoption and use of innovations that promote worker safety and health.

2.3 Methods

Approach: This research was a longitudinal study over a period of two months. In this longitudinal-sequential design (MacCallum and Austin, 2000) where different variables were measured at successive occasions. One baseline survey was administeed immediately following the introduction of the intervention. Two follow-up surveys were administered during the study period after the first and second months of potential intervention use. Data collected from multiple sites were treated as one group for the final analysis.

Subjects: Participants were recruited from three private (ambulance companies) and four public (paramedics from three city-wide fire departments and one suburban fire department) EMS services. Inclusion criteria included (a) having a minimum of basic-EMT training; (b) were over the age of 18 and under the age of 65; and (c) that the potential participant was not likely to be on vacation for more than a week during the study period. All participants singed an IRB approved consent document. Of the 324 participants who were recruited from seven different organizations, 223 participants provided complete data wherein each of the three surveys was completed. Some participants were removed from the analysis given they did not view the transfer board as an intervention suitable for them as they worked in four-person teams, or because the run volume over the period where actual use was sampled indicated there were very few opportunities to use the intervention. Therefore, depending on the analysis, final sample size used in the analyses were either 187 or 190.

<u>*The Intervention:*</u> The intervention was a foldable transfer-board (a.k.a slideboard) with two hinges to make it foldable and compact. As shown in figure 2, the board is designed to bridge the gap between the cot and the bed and reduce the friction between the sheet and the cot mattress, therein facilitating sliding, as opposed to lifting, of the patient during lateral transfers. In EMS, lateral transfers occur when patients are moved from their bed to the ambulance cot and when moving the patients from the ambulance cot to a hospital or a nursing home bed.

The intervention was selected for the adoption study because: (1) It had been previously tested and validated in a lab-based study and shown to have positive biomechanical benefits (Lavender et al., 2007), (2) it represents a relatively low cost intervention that could be used along with existing equipment, and (3) it is an intervention that each individual EMS worker must *choose* to use.

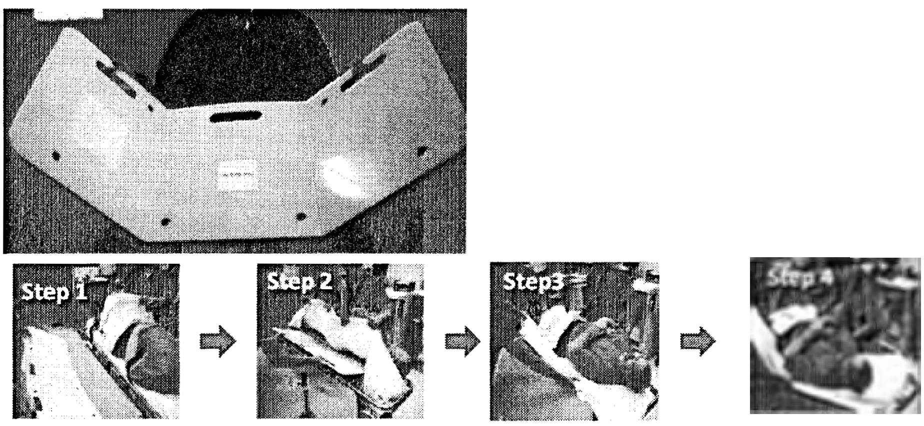

Figure 2: The transfer-board and how it can be used for performing lateral transfers.

<u>*Data collection procedure:*</u> The training process of each organization was intentionally not disturbed for the sake of preserving the applicability of the study's findings. The intervention was given to the respective EMS coordinators, who in turn introduced it to their crews at each station by giving a short training session. Each coordinator used a different method for training. The methods used for training

included video provided by the manufacturer, power point presentation with a sequence of pictures that presented how the transfer-board may be used, live demonstration, and some hands on practice.

When the training period was completed EMS personnel were recruited into the study and the transfer-board was placed on the cots on-board each medic truck that was operated by the participating stations. At this point the recruited EMS workers were given the baseline survey (Figure 3). The first monthly survey was distributed at the end of four weeks and the second monthly survey was distributed by the researcher at the end of eight weeks. The content of the three surveys is shown if Table 1. The daily run use form (figure 4) was a simple checkbox form on which the participants could record if they used the transfer-board for each run. The content of the daily run

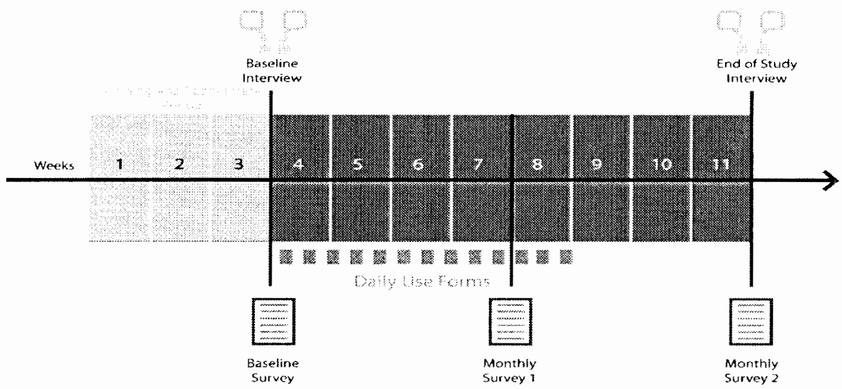

Figure 3: Data collection process showing the timing of each survey.

Table 1: The survey items included in the three surveys.

Baseline Survey	Monthly survey 1	Monthly survey 2

• Demographics
  • Age
  • Gender
  • Ht/wt
  • Work experience
  • Education
  • Shift duration/frequency
• Previous experience
• Previous injury
• Organization climate supportive of innovation
	• Adequacy of training
	• Voluntariness
	• Ease of use
	• Usefulness
	• Task compatibility
	• Accessibility
	• Partner support
	• Attitude towards use
	• Intention to use
	• Actual use-over past seven day(study equipment and other similar equipment)
		• Champion effect
		• Optimistic bias
		• Partner support
		• diffusion – recommending purchase
		• Effect of patient weight
		• Attitude towards use
		• Intention to use
		• Actual use-over past seven day(study equipment and other similar equipment)

use form was also inserted into an electronic reporting system used by some of the fire department to do their routine run reports. With both the paper and electronic

Run Use Form

Subject ID __________ Date ______________

Run #	Patient handling Tasks	Equipment	Used	Could have used but didn't	Inappropriate situation	Used other similar equipment	Comments
1	Moving pt at pick up	Study transfer board	☐	☐	☐	☐	
		Study carry-strap	☐	☐	☐	☐	
	transferring at hospital	Study transfer board	☐	☐	☐	☐	
		Study carry-strap	☐	☐	☐	☐	
2	Moving pt at pick up	Study transfer board	☐	☐	☐	☐	
		Study carry-strap	☐	☐	☐	☐	
	transferring at hospital	Study transfer board	☐	☐	☐	☐	
		Study carry-strap	☐	☐	☐	☐	

Figure 4: The partial daily run use form. The full form could provide information printed on two sides.

reporting, the actual-use data were collected only for the first five weeks of the study to minimize survey burden on the participants.

For those stations using the electronic reporting system, the content of the daily run use form was inserted into an electronic reporting system used by the fire department to do their routine run reports. The use data collected using the electronic reporting system had a limitation, in that, the data was no longer individual reporting. This was because only one participant technically reported the run details on the electronic system even though there was more than one paramedic assigned to that run. The actual-use data was collected only for the first five weeks of the study to minimize survey burden on the participants.

Data Analysis. An exploratory factor analysis was carried out to investigate the interdependence structure of the items used in the survey. The Comprehensive Exploratory Factor Analysis (CEFA) computer program (Browne et al. , 2010) was employed. Maximum likelihood estimates of factor loadings were obtained and oblique CF-Varimax employed for rotation to simple structure. The CF-Varimax criterion for simple structure yields the same solution as the usual Varimax solution in orthogonal rotation where factors are constrained to be uncorrelated. In oblique rotation where factors are allowed to be correlated the CF-Varimax criterion has no difficulty whereas the standard Varimax criterion breaks down. In general oblique rotation provides clearer simple structures than orthogonal rotation. Additional information about the rotation facilities of CEFA may be found in Browne (2001). The number of factors to be used to adequately represent the structure of the data was chosen by examining the rotated factor matrices for 3, 4 and 5 factors and choosing the number of factors that yielded the clearest simple structure.

Regression models predicting intention to use and actual use at the end of month 1 and the end of month 2 were developed using a stepwise process that included the variables for which there were data available at the end of month 1 and month 2, respectively. Because the data were not all collected at the same time, not all subscales identified by the factor analysis could be included in the analysis of the month-1 data.

An additional subscale not related to the factor analysis was also defined. This was for measuring "intention to use" and was defined as the sum of scores on the following three items:

1. When performing lateral transfer tasks, I would rather use the transfer-board than use the usual method.
2. I like the idea of using the transfer-board.
3. I intend to use the transfer-board where appropriate.

Additional scores were also considered in the regression analyses. A "patient advantage" score was included in the regression model as a separate variable based on previous literature (Nelson, 2008). A "previous tool experience" score was included based in part on the work of Rogers (2003), and in part due to initial analyses of correlations between previous experience and the outcome variables "intention to use" and "actual use."

The response rate was low for the daily run use form (less than 30%), therefore actual use was quantified by using the reported use data from the run use forms and data from the monthly surveys which included a question about the frequency of use over the prior seven days. This composite measure was calculated according to equation 1 below and it was this composite measure of actual use that was used as the outcome variable in the logistic regression and the structural equation models relating the identified factors to actual use. This approach enabled us to include participants who reported use in either or both of these means in the overall analysis.

Actual use = sqrt((use frequency from monthly surveys)^2 + (use frequency from run use forms)^2) (Eq. 1)

Structural Equation Modeling. The input correlation matrix for structural equation modeling was generated using the SAS 9.2 system. Where there were missing data in the data set, SAS uses list-wise deletion as a default in which respondent is completely removed from the analysis even if only one data point is missing from the data set. There are two concerns; first, this may lead to selection bias where the data that remains may be biased and second, there is a loss of power as the number of observations is reduced. The percentage of missing data in the data matrix for each variable was between 2-5%. Since an examination of the pattern of missing data points suggests a random process, a multiple imputation procedure on SAS was used to get parameter estimates by a maximum likelihood method.

A structural equation model was developed to specify the mathematical relationship between the latent variables. The analysis is initiated by generating the sample correlation matrix from the survey data. Based on the sample correlation

matrix, path coefficients were calculated to indicate the level of dependence between two variables in the model. These path coefficients, represented by single-headed arrows in the model, are linear regression coefficients. Thus, each path coefficient represents the predictive strength of the link between the two variables.
The hypothesized relationships, as indicated by the path coefficients (β_i), were tested using the RAMONA application within the SYSTAT 12 software (Browne, M.W., and Mels G., 2005). RAMONA has a facility for constraining variances of endogenous latent variables to unity, a procedure used throughout for identification purpose. The latent variables were evaluated using a hypothesized structural equation model. In the current study, the root mean square error of approximation (RMSEA) was used to evaluate the solution. The model explains the sample data as best as it can; however, the hypothesized model will not fit the sample correlation matrix exactly.
The goodness of fit of the structural equation model was measured by the root mean square error of approximation (RMSEA) index.

McDonald and Ho (2002) explained, "All structural equation modeling are simplified approximations to reality and hypotheses that might possibly be true." In the current study, the root mean square error of approximation (RMSEA) that originated from Steiger and Lind (1980) was used to assess the goodness of fit. Rough guidelines given by Browne and Cudeck (1993), suggest that an RMSEA less than 0.05 correspond to a "good fit" and an RMSEA less than 0.08 corresponds to an "acceptable fit." The RMSEA for the proposed model was 0.06 with a confidence interval of 0.04-0.07, which is within the acceptable fit range.

2.4 Results

The factor loading matrix with four factors after oblique CF-Varimax rotation and the corresponding factor inter-correlation matrix are shown in Table 2. In Table 2 shows that the factor loading matrix was clear and unambiguous, which made it relatively straight-forward to identify which items loaded on whch factor. The first factor, "Ergonomics Advantage," has high factor loadings for the survey items assessing ease of use and subjective assessments of physical demands on the back and shoulder. The second factor, "Endorsed by Champions," has high factor loadings for the three items indicating whether there were individuals in their workplace that promoted the use of the transfer-boards. Three items assessing the innovativeness of EMS workers' organizations with regards to their approach for dealing with musculoskeletal disorders define the third factor labeled "Climate Supportive of Innovation." The fourth "Access and Storage" factor is comprised of two items focused on ease of storage and accessibility.

Table 2. CF-VARIMAX Rotated Factor Matrix for four factors; items that are shaded in each column indicate that they load on the same factor. The matrix at the bottom of the table shows the inter-correlations between the factors.

Survey items	Ergonomics Advantage (Factor 1)	Endorsed by Champions (Factor 2)	Climate Supportive of Innovation (Factor 3)	Access and Storage (Factor 4)
My org innovative with investing resources to reduce MSDs	0.01	-0.04	0.87	0.02
My org encourages creativity in ways to reduce MSDs	0.01	0.06	0.94	-0.02
My org stresses that EMS workers should be on the cutting edge of our field	-0.03	0.03	0.75	-0.02
Overall, the transfer-board (TB) is easy to use	0.74	0.04	0.02	0.03
Transfer is smoother	0.81	0.1	0.03	0.03
Easier on my shoulder	0.62	0.18	-0.04	0.09
Easier on my back	0.77	0.13	-0.06	0.04
Works well with current equipment	0.72	-0.01	0.02	0.2
Stored conveniently	0.07	-0.05	-0.01	0.76
Easily accessible	-0.05	0.03	0	0.97
"role of champions" - Others I know have endorsed	0.13	0.8	0.04	0.06
"role of champions" - Others I know have recommended	0.03	0.94	0.02	0.04
"role of champions" - Others I know have spread word	-0.02	0.9	0.02	-0.01

Factor inter-correlation matrix

Factors	Ergonomics Advantage	Endorsed by Champions	Climate Supportive of Innovation	Access and Storage
Ergonomics Advantage	1			
Endorsed by Champions	0.43	1		
Climate Supportive of Innovation	-0.01	0.16	1	
Access and Storage	0.34	0.21	-0.05	1

Examination of the factor inter-correlation matrix in Table 2 shows that the "Ergonomics Advantage" factor is moderately correlated with the "Endorsed by Champions" and "Access and Storage" factors. This is to be expected because perceived access and storage convenience impacts if the EMS worker will use the transfer-board. This consequently affects how they perceive its ergonomics advantage. Similarly, it is possible that perceived ergonomics advantage influences the endorsement by champions who believe in the benefits by using the transfer-board and tell other about it.

2.4.1 Regression Models Predicting Intention to Use.

The stepwise regression analysis performed with the data available at the completion of month 1 indicates that 78% of the variance in "intention to use" was explained by two variables: "Ergonomics Advantage," and "Patient Advantage." The regression equation for the final model for intention to use at month 1 is:

*Intention to use at month 1=2.31+0.44*Ergonomics_Advantage+0.32*Patient_Advantage (Eq. 2)*

The stepwise regression analysis performed with the data available at the completion of month 2 (which includes the surveyed intention to use at the end of month 2 as well as the champion effect) produced a model that explained 58% of the variance. This stepwise process only included two factors: "Ergonomics Advantage" and "Endorsed by Champions." The regression equation for the final model for intention to use at month 2 is:

*Intention to use at month 2=2.37+0.38*Ergonomics_Advantage+0.21*Endorsed by Champion (Eq. 3)*

2.4.2 Logistic Regression Model Predicting Adoption.

The actual use function was dichotomized into two groups: adopters (participants who reported using the transfer-board 5 or more times in the 8-week study period) and non-adopters (participants who reported no uses and those who used it just once and never used it again). A total of 126 observations were used for model building. There were 66 participants who fell in the non-adopter category and 60 who fell in the adopter category.

The stepwise selection method was employed to find the model in which each variable in the model produces an F statistic significant at the 0.05 level. Stepwise selection method was specifically used for this analysis because of the exploratory nature of the study. Perceived "Ergonomics Advantage" (p=0.01) and "Previous Tool Experience" (p=0.002) were both found to be statistically significant predictors of adoption. The resulting odds ratios for "Ergonomics Advantage" and "Previous Tool Experience" were 1.23 (C.I. 1.10 – 1.38) and 5.96 (C.I. 2.72 – 13.08), respectively. The sensitivity and the specificity for this model were each 80%.

2.4.3. Structural Equation Modeling

The structural equation model is shown in figure 4. Actual frequency of use was predicted by intention to use at month 1 (β=0.32) and previous tool experience (β=0.26). Further, intention to use at month 1 was predicted by the EMS worker's perceived ergonomics advantage of using the transfer-board (β=0.87). Intention to use at month 2 was predicted by whether it was endorsed by champions in their organization (β=0.27). Perceived ergonomics advantage was predicted by the access and storage convenience (β=0.46). Having a climate supportive of innovation was, at best, a weak predictor of endorsement by champions (β=0.18), but was an indirect predictor of intention to use at month 2.

The strongest relationship in the model was between perceived ergonomics advantage and intention to use assessed at the end of month 1. Other strong relationships in the model included the path between ergonomics advantage and the presence of champions and the path between the access and storage variable and perceived ergonomics advantage. The weakest paths in model were between previous tool experience and ergonomics advantage and the path between climate supportive of innovation and endorsement by champions. It is important to note that the lower limit of that confidence interval is very close to zero for these relationships, which indicates a weak relationship.

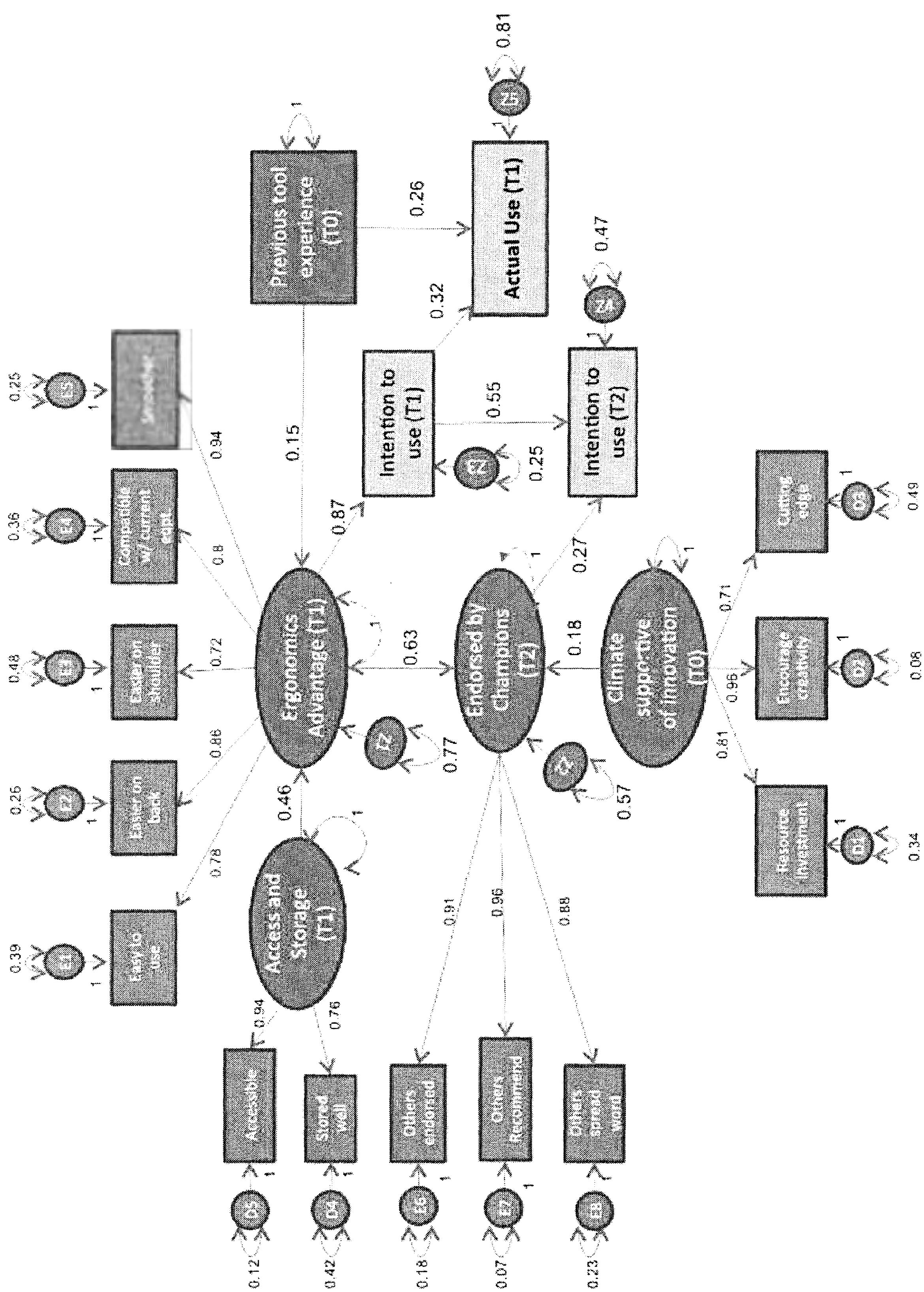

Figure 4. The structural equation model with the path weights indicating the strength of the relationship between model factors. All relationships shown were statistically significant at alpha=0.1.

2.5 Discussion

This project sought to evaluate the following specific aims:

1. *Using the framework of the integrated technology acceptance model and task technology fit model as a starting point, we aimed to identify and quantify the degree to which specific perceptual and attitudinal factors contribute to the adoption and sustained use of a previously validated musculoskeletal disorder (MSD) intervention.*

2. *To quantify the degree to which individuals who step up and "champion" an intervention affect the adoption and sustained use of the intervention and to determine the nature of the successful efforts.*

3. *To characterize, both quantitatively and geographically, the diffusion of a specific musculoskeletal intervention within and between EMS organizations.*

Analysis of Aim 1

The structural equation model developed in this study showed that the adoption of a specific ergonomics intervention by EMS personnel was strongly dependent upon the perceived ergonomics advantage, which in turn was dependent upon access and storage convenience, and to a lesser degree previous experience with the specific intervention. Moreover, the perceived ergonomics advantage further influenced the endorsement of the intervention by individual champions, which moderately impacts one's intention to use the intervention. Having an organizational climate supportive of innovation was found to have a relatively weak influence on the endorsement by champions and no direct affect on the outcome measures of intention to use and actual use.

The perceived ergonomics advantage term developed through the factor analysis was based on assessment of 5 key variables: "easy to use", "easier on the back", "easier on the shoulder", "compatible with current equipment", and "smoother". These terms comprise a range of usability and usefulness measures. Specifically, the ease of use, the compatibility, and the transfer smoothness measures addressed key usability dimensions. The perceptions regarding the task being easier on the back and shoulders comprise usefulness measures. One usability issue, "access and storage", is particularly notable as this emerged as a separate factor in the factor analysis and contributed to the perceived ergonomics advantage in the structural equation model.

It is notable that the perceived ergonomics advantage had the strongest link to "Intention to use" in the structural equation model and emerged as the strongest factor predicting intention to use as both time points. This finding emphasizes the need to:

1) Clearly identify and address usability issues before and during the implementation of a new ergonomics intervention. While many usability issues are readily apparent early in the implement process, usability evaluations need to be a continuous process in that many of the usability issues may not be readily apparent early in the implementation process. This can occur due to interventions being used in unforeseen ways, even though they are beneficial, or due to wider acceptance which yields interactions between the intervention and other variations in the targeted work systems including access and storage issues.

2) Effectively introduce an ergonomics intervention by communicating the anticipated usefulness of the intervention to the affected employees. The recipients of the intervention should not be left asking "why" an intervention is being made available or being left to figure out the usefulness of an intervention. We heard anecdotally of examples of other potential ergonomics interventions that just "showed-up" on the emergency response vehicles. These pieces of equipment take up valuable space and were typically not used.

Analysis of Aim 2

This aim was designed to explore how strong an impact peer champions could have in adoption of ergonomics interventions. This was assessed using three items in the survey that assessed the degree to which others endorsed, recommended, and or spread word about the intervention. The literature suggests that the endorsement by champions plays a key role in the success of an innovation (adoption) in an organization (Chrusciel, 2008; Jenssen and Jorgensen, 2004). Jensen and Jorgensen (2004) describe champions emerging through an interaction of organizational, environmental, personal, and social characteristics that provide context and affect the tactics individuals use to promote their cause. Rogers (2003) suggests that the champion is also someone who is convinced of the benefits of using the innovation and is a "charismatic individual who throws their weight behind an innovation, thus overcoming indifference or resistance that the new idea may provoke in an organization." The literature indicates that these champions need to be politically astute (Markham and Aiman-Smith; 2001, Schon, 1963), motivating (Howell and Higgens, 1990), and persistent (Jenson and Jorgensen, 2004). The endorsement by champions in the current study emerged as a significant predictor of the participant's intention to use and showed a modest path coefficient (0.27) in the structural equation model. Because the presence of a champion was not addressed until later in the study, so as to give time for champions to emerge, and the limitation that actual use measurements were only obtained for the first 5 weeks, the direct relationship between the presence of a champion and actual use could not be determined. Nevertheless, the participants did indicate that champions were present and this did at least influence their intentions.

In the Theory of Planned Behavior, Fishbein and Azjen (1975) identified subjective norm as one of the components to influence behavioral intentions. The subjective norm, which is how he/she thinks other people view them if they performed the behavior, is altered if others are modeling and promoting the behavior of interest, in this case use of the ergonomics intervention. Moreover, the emergence of the champions was strongly influenced by the perceived ergonomics advantage of the intervention and, to a lesser degree, being in a climate supportive of innovation.

Casual observations and discussions with EMS personnel suggested that the champions tended to be users, although in some cases they were the EMS coordinators who were responsible for training. In both cases they were vocalized their support of the intervention to others. It should be noted that the movement of patients is typically a team lifting situation in which decisions to use the transfer boards intervention would also be affected by the specific individuals a participant was working with during a shift. Where the champions were users, they modeled the use behavior with their run partners. In addition, where there were access and storage issues, the champions often took the lead in resolving these issues such that usable solutions were identified and implemented.

Analysis of Aim 3

The third aim was focused on describing the diffusion and dissemination process within and between organizations. We intended to study how rapidly others, outside the initial study group, became aware of the interventions and made purchasing decisions. We received sales data from the manufacturer of the interventions within two months of the inception of the study and continued through the end of 14 months of the project (the last sales data we received was as of 29 September, 2011). However, very few sales occurred throughout the follow-up period. Data obtained from the manufacturer included the entity's name, city, state, and the type and number of intervention devices purchased.

We expected communication between medics, both between and within stations, to lead to increased sales and diffusion of the intervention. *It was hypothesized that more devices would be sold in areas adjacent to and in close proximity to stations we supplied with intervention devices than in other areas.* Sales of the transfer board have been meager; other than the boards sold to Ohio State University, 15 were sold to the Tucson fire Department (Tucson was a secondary study site); and 12 were sold to various municipalities in Illinois (11 of them in suburban Chicago). It was hypothesized that in places where spontaneous sales would occur, dissemination would have a more random appearance and would be separated in space to a greater degree than sales surrounding our distribution sites. Sales were too sparse to adequately evaluate dissemination, but more devices were sold in study locations than outside of those locations. The devices sold in the Chicago area do not support or weaken evidence in favor of the hypothesized patterns – it seems that the manufacturer, Livingston Products based in Wheeling, Illinois, has simply supplied local customers with some of its products.

Limitations

The eight-week study period did not allow for a long-term evaluation of the adoption process or any change in injuries associated with lateral transfers. However, since the intervention introduced was simple and aids in one of the frequently performed tasks among EMS personnel, 8 weeks seemed sufficient to study the perceptions, attitudes, intentions, and behaviors related to the transfer-board's adoption. While it would have been useful to assess the same perception variables at baseline and with each follow up survey, therein making it possible to analyze the change in these variables over time, pilot testing indicated that the additional response burden would have been a significant constraint and limited the number of completed surveys. It was necessary to keep the questionnaires short because of the nature of emergency response tasks. Another limitation of this study is that actual use data were not collected at the end of the second month. This is a limitation because this does not allow us to determine the relationship between intention to use at month 2 with actual use. We found that having participants provide daily use information, even with incentives in place to encourage reporting, was extremely challenging and pilot testing indicated we would likely have very incomplete data after 5 weeks.

2.6 Conclusions

The structural equation model developed in this study, which builds upon the factor analysis and regression analyses, identified that the perceived ergonomics advantage (comprised of the following dimensions: "easy to use," "easier on the back," "easier on the shoulder," "compatible with current equipment", and allowing "smoother transfers") was influenced by access and storage convenience, and to a lesser degree previous experience with the specific intervention. The perceived ergonomics advantage also further influenced the endorsement of the intervention by individual champions, which, in turn, moderately impacts one's intention to use the intervention. The organizational climate factor had only a weak indirect effect through its influence on the endorsement by champions. The theoretical model developed and tested in this study should be further tested with other types of equipment and in other healthcare settings to expand its applicability.

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3. Enrollment Inclusion Report

Inclusion Enrollment Report

Study Title: Identification of factors affecting EMS workers adoption of MSD interventions

Total Enrollment: 322 **Protocol Number:** 2008B0319

Grant Number: 5 R21 OH009378-02

PART A. TOTAL ENROLLMENT REPORT: Number of Subjects Enrolled to Date (Cumulative) by Ethnicity and Race

Ethnic Category	Females	Males	Sex/Gender Unknown or Not Reported	Total
Hispanic or Latino	1	10		11 **
Not Hispanic or Latino	28	259		287
Unknown (individuals not reporting ethnicity)		24		24
Ethnic Category: Total of All Subjects*	29	293		322 *
Racial Categories				
American Indian/Alaska Native				
Asian				
Native Hawaiian or Other Pacific Islander				
Black or African American	1	12		13
White	29	254		283
More Than One Race		1		1
Unknown or Not Reported		25		25
Racial Categories: Total of All Subjects*	30	292		322 *

PART B. HISPANIC ENROLLMENT REPORT: Number of Hispanics or Latinos Enrolled (Cumulative)

Racial Categories	Females	Males	Sex/Gender Unknown or Not Reported	Total
American Indian or Alaska Native	0	0	0	1
Asian				
Native Hawaiian or Other Pacific Islander				
Black or African American				
White	1	10		11
More Than One Race				
Unknown or Not Reported				
Racial Categories: Total of Hispanics or Latinos**				11 **

* These totals must agree. ** These totals must agree.

4. Publications.

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