

Novel Approaches to Increasing
Stair Use in a University Population

by

Marley Ford

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Graduate Supervisory Committee:

Marc Adams, Chair
Linda Vaughan
Cheryl Der Ananian

ARIZONA STATE UNIVERSITY

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ABSTRACT

Research indicates that adults are not acquiring enough physical activity. Increasing the use of stairs is an accessible way to weave high intensity physical activity into the daily routine. The purpose of this study is to test the effect of four environmental changes on ascending stair use in a mixed population of college students, faculty, and staff on a southwest college campus. The study design included a 10-week time series design with alternating baseline and intervention phases, including a directional cue represented by footprints on the ground, a positive prompt, a deterrent prompt and a combination phase. Data was collected with both an in-person tally and a video recording device. The study included 6,140 observations and coded variables included stair use, sex, number of bags carried, temperature, and volume. Rater reliability ranged from .81 to 1.0. Multivariate logistic regression was used to perform the statistic analysis. Stair use increased significantly from Washout 1 and the positive prompting phase with a 7% absolute increase and an odds ratio of 1.35 (95% CI 1.080-1.696). Stair use during the footprint phase, deterrent phase and combination phase did not increase significantly compared to the previous baseline or washout phases. Day of the week (Monday=reference, Tuesday CI=1.626, 95% CI 1.298-2.011, Wednesday OR=0.457, 95% CI 0.248-0.841, Thursday OR=1.434, 95% CI 1.164-1.766), sex (OR=1.376, 95% CI 1.173-1.613) and volume (OR=1.007, 95% CI 1.005-1.008) were significantly correlated to stair use. Women used the stairs more than men and higher volume situations were related to increased stair use. Temperature and baggage number were not related to stair use. The results of this study indicate that positive prompting with an

environmental message theme is an effective method to increase stair use in a university setting.

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TABLE OF CONTENTS

	Page
LIST OF TABLES	vi
LIST OF FIGURES	vii
CHAPTER	
1 INTRODUCTION	1
Purpose, Aims, and Hypotheses.....	3
Definition of Terms	5
2 LITERATURE REVIEW	6
Intervention Technique.....	7
Environment	18
Population.....	21
Measurement	23
Health Effects	25
3 METHODS	28
Participants	28
Design and Intervention	29
Measurement and Definitions	36
Statistical Analysis	38
4 RESULTS	43
Visual Analysis.....	44
Regression Modeling.....	46
5 DISCUSSION	54

	Page
Methodological Considerations	59
REFERENCES.....	62
APPENDIX	
A IRB APPROVAL	69
B FACILITIES APPROVAL	71

LIST OF TABLES

Table		Page
1.	Frequencies	48
2.	Descriptive Statistics	48
3.	Logistic Regression by Phase	49
4.	Logistic Regression by Phase with Covariates	49

LIST OF FIGURES

Figure		Page
1.	Study Design	30
2.	Positive Poster (Left) and Study Placement (Right)	34
3.	Deterrent Poster (Left) and Study Placement (Right)	34
4.	Non-Verbal Cue to Action (Footprints).....	35
5.	Combination with All Intervention Techniques Shown.....	35
6.	Example Time-Series Graph.....	40
7.	Raw Counts of Stair Use with Median and IQR Represented Across Phase.....	50
8.	Percentage of Stair Use with Median and IQR Represented Across Phase.....	51
9.	Raw Counts of Stair Use with Trendline Across Phase.	52
10.	Percentage of Stair Use with Trendline Across Phase.	53

CHAPTER 1

INTRODUCTION

Accelerometry data indicate that less than 5% of US adults adhere to the physical activity recommendations of 150 minutes of moderate intensity or 75 minutes of vigorous physical activity per week (US Department of Health and Human Services, 2008; Troiano *et al.*, 2008). Higher levels of physical activity are associated with reduced risk of heart disease (Sattelmair *et al.*, 2011), diabetes (Knowler *et al.*, 2002), and all-cause mortality (Samitz, Egger, & Zwahlen, 2011). In addition, as a result of mechanization and technology improvements, the prevalence of moderate intensity occupations has steadily declined since the 1960's. Low levels of physical activity paired with long duration sitting, as characterized by the increased prevalence of light and sedentary intensity occupations, place the population at a high risk for all-cause mortality (Church *et al.*, 2011; Patel, Slentz, & Kraus, 2011). Based on the risks associated with inactive or sedentary lifestyles, it is prudent to work towards testing novel approaches to weave physical activity back into the daily routine.

Stair use is an appealing way to increase incidental physical activity because stairs are free, readily available, accessible, and provide a high intensity exercise (Ainsworth *et al.*, 2011). Over time, formulating a habit of stair use can positively affect numerous aspects of health including cardiorespiratory fitness (Mair *et al.*, 2014), resting and exercise heart rates, perceived exertion, balance (Donath, Faude, Roth, & Zahner, 2013), and post prandial hyperglycemia (Takaishi, Imaeda, Tanaka, Moritani, & Hayashi, 2012).

Although correlational studies show consistent relations between features of the built environment and physical activity, the effect of environmental change has been

more difficult to test. While environmental changes have been very successful strategies for certain health behaviors (e.g. smoking), the efficacy of environmental changes to promote health enhancing physical activity is still largely unknown (Foster & Hillsdon, 2004). Previous research has investigated a multitude of environmental strategies that nudge individuals to increase their stair use. The most widely tested method of increasing stair use has been point-of-choice prompts (Dolan *et al.*, 2006). The Task Force on Community Preventative Services recommends the point-of-choice intervention method because it is highly effective at producing moderate increases in stair use (Task Force on Community Preventative Services, 2010). However, point-of-decision prompts appear more effective at increasing stair use over escalator compared to elevator use (Nocon, Muller-Riemenschneider, Nitzschke, & Willich, 2010). The efficacy of stair rise banners (i.e. banners located on stair risers), another commonly used intervention method, is debated in the literature. Frank, Kerr & Carroll, 2001, found that banners were more effective than posters in increasing stair use in a shopping mall setting while another group reported the opposite result in a similar setting (Olander, Eves, & Puig-Ribera, 2008). Aesthetic changes in an indoor staircase environment including adding carpet, music, artwork, and changing the color of the walls, are effective; however, more so in combination with point-of-choice prompts (Boutelle, Jeffery, Murray, & Schmitz, 2001). Although a vast array of interventions have been tried, the average increase in persistent stair use is estimated to be 2.4%, which is clinically insignificant (Soler *et al.*, 2010). Further strategies need to be explored to maximize the ubiquitous nature of stairs to enhance the health of the population.

To date, improvements to exercise and health have been the main message themes across all mediums as a reason to take the stairs. Given that individuals are bombarded with vast amounts of health information regularly due to the nature of our society, people might be less responsive to health related messaging. For this reason, the current study developed and evaluated messages focusing on other culturally important themes such as energy conservation (being green/sustainability) that may have a stronger impact on stair use. Additionally, there is sparse research on non-verbal cues to action (i.e. footprints on the ground or other symbols directing individuals to the stairs). This method is highly sustainable and requires a low start up and negligible maintenance cost. This study utilized footprints on the ground to encourage stair use. Finally, only one study has experimented with deterrent signs finding equal effectiveness between motivational and deterrent messaging on stair use. However, there are limited data on the efficacy of deterrent messages in different populations and settings (Russell & Hutchinson, 2000). Therefore, a deterrent poster prompt was evaluated. The current study attempted to illuminate sustainable and efficacious environmental changes that can increase daily incidental physical activity through elevated stair use instead of elevator use.

Purpose, Aims, and Hypotheses

The purpose of this study is to test the effect of four environmental changes on ascending stair use in a mixed population of college students, faculty, and staff on a college campus. The environmental changes that were utilized included (a) point-of-choice messaging with a focus on green living and sustainability, (b) non-verbal cues to action represented by footprints leading to the stairwell, (c) point-of-choice deterrent messaging, and (d) a combination of all three previous changes. Understanding the impact of novel message

themes and non-verbal cueing on behavior change will help to guide future stair use initiatives on efficacious strategies.

Aim 1: To determine the efficacy of point-of-choice poster prompts to increase short-term ascending stair use over elevator use among college students, faculty, and staff on a university campus.

Hypothesis: Point-of-choice poster prompts will increase ascending stair use above baseline levels.

Aim 2: To assess the efficacy of non-verbal cues to action to increase short-term ascending stair use over elevator use among college students, faculty, and staff on a university campus.

Hypothesis: Non-verbal cues to action will increase ascending stair use above baseline levels.

Aim 3: To determine the efficacy of deterrent messaging to increase short-term ascending stair use over elevator use among college students, faculty, and staff on a university campus, as well as compare the efficacy of deterrent messaging to other promotion strategies (point of choice and non-verbal cues).

Hypothesis 1: Deterrent messaging will increase ascending stair use above baseline levels.

Hypothesis 2: Deterrent messaging will be no more effective at increasing stair use than the other promotion strategies.

Aim 4: To determine the efficacy of a combination of all three motivational strategies to promote ascending stair use among college students, faculty and staff, on a university campus.

Hypothesis: The combination of the three strategies will produce a more robust effect on ascending stair use than any one strategy independently.

Definition of Terms

- Point-of-Choice: The physical space where an individual is forced to make a decision between a mode of transportation (elevator or escalator versus stairs).
- Point-of-Choice Prompt: A poster or related article placed just before point-of-choice designed to interrupt habitual behavior and promote a substitution of health-enhancing behavior, i.e. taking the stairs (Nocon *et al.*, 2010).
- Non-Verbal Cues to Action: Suggestive cues, such as arrows or footprints painted on the ground, leading to the stairs to encourage behavior change.
- Deterrent Messaging: “Point-of-decision prompts designed to decrease perceived accessibility and attractiveness of a sedentary option, [elevator]” (Russel & Hutchinson, 2000).
- Promotion Messaging: Increasing the perceived accessibility and attractiveness of the active option, stair use (Russell & Hutchinson, 2000).
- Health Enhancing Physical Activity: Any physical activity that has a beneficial effect on health such as occupational activity, active transportation, planned exercise, etc.

CHAPTER 2

LITERATURE REVIEW

The technology surrounding labor saving devices continues to advance at a rapid pace. As a result, the majority of individuals does not meet the physical activity recommendations outlined to maintain good health and delay or even prevent the onset of costly chronic diseases. Because the requirements of daily physical activity have been altered significantly by the ubiquitous presence of automobiles, elevators, and computers, scientists have turned to alternative measures to increase incidental physical activity during the daily routine. The metabolic benefits of short bouts of high intensity interval training (HIIT) have been shown repeatedly in the literature. Stair climbing represents a very demanding form of physical activity (Ainsworth *et al.*, 2011; Webb & Eves, 2011). It has been posited that increasing levels of daily stair use may impart a positive health effect by helping individuals meet the daily physical activity recommendations. Behavioral researchers have explored different approaches to increase stair use across multiple populations and environments since the 80's. The Task Force on Community Preventative Services indicated that "point-of-choice" prompts have been the most successful initiative to increasing stair use (Task Force on Community Preventative Services, 2010). However, the average increase in stair use by this "best practice" method appeared to only be around 2.4% (Soler *et al.*, 2010). It is evident that additional techniques must be explored to find a method that produces significant and sustained increases in stair use in various communities.

Intervention Technique

Interventions aimed at increasing stair use often intervene at the point-of-choice. The point-of-choice (POC) location is the physical space where an individual is forced to make a decision about their locomotion strategy. As often seen in shopping malls or airports, the POC is located directly before a set of stairs proximal to the escalators. In office buildings, or buildings of increased height, the POC is not always obvious because the stairs are often far removed from the elevators.

Poster Prompt

Poster prompts placed at the point-of-choice have been the most widely utilized intervention technique in the literature. Brownell and colleagues were the first to use the poster prompt idea to increase stair use (Brownell, Stunkard, & Albaum, 1980). The effect of the posters doubled the use of stairs over escalator use and the levels remained elevated for a month after the poster was withdrawn. It was not until three months after the poster was withdrawn that the stair use levels returned to baseline. The results of this study showed a promising future for stair use interventions, specifically by poster prompting. The positive effect of poster use was further touted in a study surveying 1,348 New York City employees. The results of the survey indicated that with a poster prompt present, an individual was 3.2 times more likely to use the stairs compared to no prompt (Ruff *et al.*, 2013). Poster prompts located on the elevator were very effective in a hospital setting, increasing stair use levels 8.5% during the intervention and 9.9% post-intervention (Dorresteijn, van der Graaf, Zheng, Spiering, & Visseren, 2013). Poster prompts were also effective in another worksite setting during a promotional stair climbing contest, however stair use was measured by self-report and was therefore,

subject to misrepresentation of actual flights climbed (Knadler & Rogers, 1987). Poster prompting has demonstrated efficacy in community settings (i.e. shopping centers, airports, train stations) by almost tripling rates of stair use (Andersen, Franckowiak, Snyder, Bartlett, & Fontaine, 1998; Blamey, Mutrie, & Aitchison, 1995).

Unfortunately, not all studies represent the same positive results. Other authors using posters found no difference in stair use levels with the addition of the prompt. One study utilized A1 size posters with varying motivational messaging themes including family, health, and time found that stair use did not increase over a 10 week period (Blake, Lee, Stanton, & Gorely, 2008). A study in Australia actually noted a decline in stair use while a positive prompt was in place and no change in stair use during a deterrent prompting phase (Cooley, Foley, & Magnussen, 2008). A second study from Australia found that poster prompts only increased stair use less than 1% but the levels of stair use during the follow up phase were actually significantly lower than the baseline phase (Marshall, Bauman, Patch, Wilson, & Chen, 2002). The results of this study are alarming and indicate that encouraging stair use via poster actually reduced overall use. In a later review of the efficacy of motivational poster prompts to increase stair use over escalator use, Dolan *et al.* found that poster prompting only increased stair use 2.8% on average (Dolan *et al.*, 2006). Clinically, this result is insignificant, but on a population level, an increase of 2.8% of the population taking the stairs would have a broad effect. Furthermore, Dolan *et al.* may have underestimated the efficacy of poster prompting because the effect of the prompt is not limited to the intervention site and stair use often remains elevated when the prompt is removed (Eves, 2007), which is likely explained by behavioral modeling (Adams *et al.*, 2006).

The ambiguous efficacy results of the studies may be due to the actual poster features. The characteristics of the poster seem to be influential on the effects towards stair use. In this case, bigger is better. An A1 size poster (specifications, 2 feet by 3 feet) had a larger effect than an A2 poster, sized slightly smaller than the A1 size. Both A1 and A2 were significantly more effective than the A3 size (smaller than A2). The A3 size poster actually had equivalent results to having no poster at all (Eves, Olander, Nicoll, Puig-Ribera, & Griffin, 2009). To intervene effectively the poster must be large enough to catch the attention of the travelers.

Banner

Although posters are the most prominent intervention technique, other methods have been tried. The second most utilized technique is messaging on the stair riser, referred to as a “banner.” The banner is painted or adhered to the vertical portion of the step and is therefore only visible from the ascending perspective. The addition of banners to the stairs has shown to be effective at significantly increasing stair usage above baseline levels in a community setting compared to escalator use (Webb, Eves, & Kerr, 2011). In a series of studies by Webb and Eves, they found that bannering increased subsequent stair ascent and descent. The group added stair banner messages at one staircase and monitored stair ascent and descent at an additional staircase, containing no intervention, proximal to the target case. The results indicated that banner messaging may be a useful technique for producing increased stair use in successive stair versus escalator decisions (Webb & Eves, 2007a, 2007b). However, there are some significant limitations to banner efficacy.

The isovist, or level of visibility, of the banner significantly affects the impact of the banner. Eves, *et al.* studied contextual variables that may moderate the efficacy of bannering in a train station. Stair rise banners were installed on two adjacent staircases in a train station and stair use was monitored for three and a half weeks. The group found that only the staircase with the largest isovist produced significant increases in stair use. The results were explained through two key points; “pedestrians minimize horizontal deviation from their path whenever possible,” and “pedestrians are more likely to use stairs that are more visible in their path of travel” (Eves *et al.*, 2009). Therefore, bannering is only as effective as the environmental design in which it is placed. Additionally, stair use, with or without an intervention, is directly related to traffic volume (Webb *et al.*, 2011). During high pedestrian volumes, stair use levels are elevated. This trend may confound the results of studies employing bannering or other techniques.

Both poster prompts and stair rise banners have limitations but there does not appear to be a concrete answer on the superiority of one technique over the other to promote stair use. One study comparing poster prompts to stair rise banners in a mall environment found that banners increased stair use to 6.7% from a baseline level of 2.4% while posters only increased stair use to 4.0%. The results of a visibility survey performed during the intervention showed that 73% of shoppers saw the banner while only 33% recalled seeing the poster (Frank, Kerr, & Carroll, 2001). However, the results from a similar study conducted in a train station provide contrasting results. Olander, *et al.*, reported that the poster significantly increased stair use, while there was no difference between the banner intervention and baseline levels (Olander *et al.*, 2008). The banner

might have been ineffective due to high traffic volumes obscuring the visibility. A limited number of studies have compared the efficacy of stair rise banners on the choice between the stairs and the elevator. Generally, when an elevator is an option, the stairs are the fire escape route and are located in a removed location or behind a door (Bassett *et al.*, 2013). The environmental difference between elevator and escalator settings prevents findings in escalator settings to be presumed true in elevator settings. The studies that do include banners as part of the intervention are coupled with posters or aesthetic changes rendering it difficult to tease out the efficacy of the banner alone. Two research groups implemented poster prompting and aesthetic changes concurrently with the bannering technique (Graham, Linde, Cousins, & Jeffery, 2013; van Nieuw-Amerongen, Kremers, de Vries, & Kok, 2011). The results from both groups produced an increase in stair use, however, due to the research designs, the impact of each technique is unclear. Although bannering and poster prompts dominate the large majority of the experimentation, other more radical approaches have been used.

Aesthetic Approaches

Less popular intervention approaches to increase stair use include aesthetic modifications and environmental changes. Boutelle and colleagues were the first to explore the effect of altering the aesthetics of the staircase on stair use. The intervention was completed in a university building and stair use was competing with the elevator. The group added artwork and music to the stairwell in addition to signs directing individuals to the stairs. Stair use increased significantly with the addition of signs and even more so with all three techniques employed simultaneously (Boutelle *et al.*, 2001). Kerr's 2004 stairwell aesthetic intervention at the Centers for Disease Control and

Prevention (CDC) further supports the use of aesthetic changes. The longitudinal study consisted of four compounding interventions over time. An additional intervention was added after every four-month period. The group began by adding carpet and new paint to the stairwell, followed by artwork, signage, and finally music. Both the signs and the music increased stair use 8.9% above baseline while the carpet, paint, and artwork failed to have a significant effect (Kerr, Yore, Ham, & Dietz, 2004). Aesthetic changes appear to significantly improve stair use when compared to elevator use, however limited research has been performed with this technique. Aesthetic techniques have yet to be tried to increase stair use compared to escalator use.

Alternative Approaches

Titze, *et al.*, utilized a more active intervention approach to increasing stair use. The design included a fruit give-away in the stairwell, games, and knowledge dissemination by the exercise professional on staff as a means to increase stair use in four Swiss federal buildings. The intervention required a significant amount of time and resources yet only one building demonstrated significantly increased stair use. However, the baseline rate of stair use varied from 31% to 85% so there may have been a ceiling effect (Titze, Martin, Seiler, & Marti, 2001). Due to the extremely high baseline in this study, it is difficult to determine if increased resources and more active intervention strategies had a significant effect on stair use.

A final successful yet unconventional approach to increasing stair use utilized the idea of “skip stop” elevators. The elevators only stop every third floor meaning that employees would need to use the stairs to access other floors. The stairs adjacent to the skip stop elevators in the building were used 33 times more than the stairs proximal to the

normal functioning elevators on the opposite of the building. Over time, employee acceptance of the radical intervention increased and 72.8% of employees reported taking the stairs at the end of the six-month study (Nicoll & Zimring, 2009).

Poster prompts and stair rise banners are the most prominent interventions demonstrated in the literature. These noninvasive, low-cost techniques produce an increase in stair use of about 6% (Webb *et al.*, 2011). Other more radical approaches have been tried with mixed efficacy. These approaches tend to require significant resources that may not be practical or available in every situation. Future research needs to further explore efficacious intervention techniques that can produce significant, long lasting effects while requiring only limited resources.

Message Theme

The overall theme or message displayed in the prompt is important to consider before beginning an intervention. The purpose of the message is to convince an individual that taking the stairs over the elevator or escalator is the right choice. Numerous studies have tried varying messages across multiple mediums, however the main message theme focuses on health. Andersen and colleagues completed a study in a shopping center that compared general health posters' and weight control posters' effects on stair use. After each poster was present for one month, the results showed that the weight control poster was marginally more effective than the health promotion signs (Andersen *et al.*, 1998). However, health messaging appears to be just as effective as time saving messages when compared in a similar environment but message efficacy varied by sex. Time saving themes were more effective for women while general health prompts seemed to increase stair use by men more (Kerr, Eves, & Carroll, 2001c). Coleman and

Gonzalez highlight the importance of designing culturally competent messages that cater to the demographics of the research environment. In their study to increase stair use in a US-Mexico border community, the group experimented with individual and family health promotion messages. Although stair use was not significantly different between the two messaging conditions, the results highlight the importance of understanding the target population (Coleman & Gonzalez, 2001).

Researchers have experimented with positive and negative messaging within the health messaging theme. In Cooley *et al.*'s study, the positive messages actually reduced stair use below baseline levels while the negative messages produced no change from baseline. The group noted that behavior change requires eliciting a combination of fear, regret, guilt, or challenge, which one can escape by acting. The theory behind the intervention was that the messaging needed "to take into account the critical role of emotions in persuasion, especially for translating tendencies into action" (Cooley *et al.*, 2008). The results indicated that either their messages elicited heightened emotions or the message was not persuasive enough to encourage individuals to take the stairs over the defaulted option of the elevator or escalator.

Messages that alter the perceived accessibility of the sedentary and active options do have a substantial effect on stair use. There is a significant interaction between the proximity of the physically active and sedentary options and the time spent being physically active. Physical activity rates increase when the sedentary option is less accessible and/or the physically active option is more accessible (Raynor, Coleman, & Epstein, 1998). Russell and colleagues experimented with promotion and deterrent prompts to alter the perceived accessibility of the active and sedentary options. The

health promotion sign was designed to increase the perceived accessibility of the stairs while the deterrent sign was constructed to decrease the perceived accessibility of the elevator/escalator. Both studies -- one focused on deterring escalator use in a community and the other focused on deterring elevator use in a university setting -- showed that decreasing the perceived value and accessibility of the sedentary behavior were effective at increasing lifestyle physical activity (Russell, Dzewaltowski, & Ryan, 1999; Russell & Hutchinson, 2000). In short, dissuading people from taking the elevator appears to be as effective as encouraging people to take the stairs.

Researchers trying to further elucidate the “ideal” message formula to increase stair use experimented with the complexity of the message. Stair rise banners tend to be limited on message complexity due to the nature of the small environmental space. These messages tend to be short and to the point, such as “free exercise,” “take the stairs,” or “keep fit” (Kerr, Eves, & Carroll, 2001). However, to test “complexity” on the stair rise banners, multiple messages are used over the whole case. In one study, 8 banners were placed on every other stair. In the first two weeks of the intervention phase all the banners read the same message, “keep fit.” For the next two weeks, the 8 banners each held a different message, adding to the “complexity” of the intervention. The group hypothesized that the increased complexity and associated knowledge dissemination and awareness would increase stair use significantly more than just the single message approach. In theory, this makes sense, however the results indicate that both message formats performed with equal efficacy in the banner format (Webb & Eves, 2005).

A large-scale survey study was employed to systematically assess the complexity characteristics of poster prompts employed (Webb & Eves, 2006). The group compared

messages describing general descriptions about stair use (“free exercise”) to specific but relatively delayed consequences (“keeps you fit”) through a survey indicating how likely/unlikely the messages were to encourage the individual to use the stairs. Additionally, the group told half the responders in both groups that the messages were true, in order to assess how validating the messages influences their persuasive ability. The survey data revealed that specific consequence messages were more effective than general messaging and the “told true” statements were more persuasive than the non-validated messages. A recent study supported the findings that specific messages may be more effective at increasing stair use than more general messages (Eckhardt, *et al.*, 2014). Lewis and Eves, 2005, tested poster prompt complexity in a community based setting similar to the setting in the banner complexity study. The complex poster reading, “regular stair climbing for *7 minutes per day* protects your heart” was compared to the more general message reading, “regular stair climbing protects your heart” (Lewis & Eves, 2012). When traffic volume was controlled for, both messages produced similar increases in stair use. When pedestrian volume was not controlled for, the complex messages displayed reduced efficacy, probably as a result of visibility issues, lack of time to read the prompt fully, and inability to modify path of travel due to volume. The survey data, measured in theoretical responses, indicated that complex, consequence based messages were more effective at encouraging stair use while intervention based approaches produced contradicting results that supported the use of simple messaging.

Lewis and Eves continued to further the base of knowledge around messaging by examining the effect of motivational versus volitional prompts. A motivational prompt was defined as changing attitudes and intentions regarding stair use. The motivational

prompt was placed inside the elevator and included a long message about stair use burning calories and the potential subsequent total calories burned per year. The volitional prompt was aimed at translating intentions into action (i.e. a point-of-choice prompt). The motivational prompt phase incurred no change on stair use while the volitional prompt phase produced significant increases in stair use. Because the motivational prompt was located inside the elevator, the individual had already made their transportation choice (Lewis & Eves, 2012a). These results illustrate two important points: appropriate intervention timing is crucial to disrupting habits and awareness does not always translate into action (Webb & Eves, 2006).

In theory, more information should produce increased levels of motivation to behave in ways conducive to increased health, however the present data indicate that theory does not always translate into practice. The environment and population have significant interaction effects with the intervention. Positive, negative, simple, and complex messaging have shown to all be effective in varying settings with different populations. Messaging interventions have been most successful when they make the healthy choice the easy choice (Mansi, Mansi, Shaker, & Banks, 2009). Messages should be tailored to the target population and setting and environmental factors should be considered when designing a message (Task Force on Community Preventative Services, 2010). It is important to note that all of the research to date studying varying aspects of messaging has only focused on messages based on the health benefits of stair climbing. Further research needs to determine the efficacy of non-health based messages to encourage stair use.

Time Frame

Studies designed to encourage stair use are generally performed on a short-term timeline. Most studies employ a design that occurs over a four to twelve week timeline, however, studies have been run over a shorter two week period (Dorresteyn *et al.*, 2013) and up to a longitudinal three and a half year period (Kerr *et al.*, 2004). In any intervention study there is always a threat of habituation to the intervention in place. In a relatively short term study, only spanning eight weeks, with three of those weeks designated as a baseline period, the levels of stair use only fell when the poster prompt was removed (Andersen *et al.*, 2006). The risk of habituation in that study was low because the intervention was only present for a short period. The effectiveness of an intervention technique does not appear to dwindle with an increased duration of exposure. In a 22-week project, the levels of stair use remained elevated above baseline levels throughout the entire intervention and again only fell after the prompt was removed (Kerr, Eves, & Carroll, 2001b). Due to the varied time frames and the persistent effects of the intervention, there does not appear to be a critical threshold of effectiveness to encourage stair use through prompting, either with poster or banner.

Environment

The same stair-use intervention employed in two different environments will most likely not produce the same results. Because of this response variability, understanding the interaction effect between the environment and the intervention in previous studies can enhance future intervention designs. The environmental design of a building significantly affects the rate of stair use. Buildings that are designed with a “stair-centric” approach (the stairs are the main focus and most easily accessible) have an average stair

ascent rate of 81.1% and a descent rate of 93.7%. Dissimilarity, “elevator-centric” designs (buildings where the elevator is the default mode of transportation) have an average stair ascent rate of 8.1% and an average stair descent rate of 10.8% (Bassett, Browning, Conger, Wolff, & Flynn, 2013). Based on these results, the ideal intervention to increase stair use would include adding an easily accessible staircase in the atria of every building. Unfortunately, this isn’t feasible. Scientists must work with the current built environment to create a more conducive environment for stair use. Most of the stair-use interventions fall within two main environmental categories: community or worksite. The community environment represents a shopping mall, airport, train station, or any other generally public place. This environment generally represents an escalator versus stair scenario. Taller, high-rise buildings with regularly frequenting individuals and an elevator versus stair scenario generally characterize the worksite environment. When thinking about stair use in a particular environment, stairs are the alternative to one of two options: elevator or escalator. Researchers have performed numerous intervention studies in both situations. However, a recent review of 25 studies found that point-of-decision prompts increased stair use more so when the alternative is the escalator rather than the elevator (Nocon *et al.*, 2010).

Studies aimed at increasing use of stairs over the elevator have been largely unsuccessful to date, only creating small improvements in stair use. Adams and White found no increase in absolute stair use during a poster prompt intervention study in a university setting (Adams & White, 2002). Another study using poster prompts to increase stair use over elevator use in a health care facility found a less than one percent increase in use (Marshall *et al.*, 2002). Characteristics of the building and specifically the

stairs seem to have an impact on the rate of use. The baseline variability of stair use is drastic in elevator versus stair environments. The baseline rates of stair use ranged from 70.1% in a three-story health clinic to 13.0% in an affordable housing complex with ten stories. The height of the building was negatively correlated with stair use (Lee *et al.*, 2012). The number of flights needed to climb to reach the final destination was inversely related to stair use. Additionally, stair cases with natural light and visible from the lobby were associated with higher baseline levels (Ruff *et al.*, 2013). The visibility of the stairs is equally as important as the visibility of the intervention technique. Visible stair cases were 4 times more likely to be used compared to hidden cases (Grimstvedt *et al.*, 2010). Due to the environmental interaction affecting stair use, interventions that have been successful in a community setting (i.e. escalator settings) might not be transferable to the workplace (Eves & Webb, 2006). Successful interventions at improving stair use over elevator use involved designs that made elevator use less accessible while simultaneously making stair use the default decision (Nicoll & Zimring, 2009).

Encouraging individuals to choose to take the stairs as opposed to the escalator tends to be an easier “sell.” The physical space design of the escalator/stair combination is different than that of the elevator/stair combination. The stairs are generally parallel to the escalator making the decision much easier in that it requires significantly less effort to find the stairs. In addition, the stairs will generally fall in the walking path thereby reducing the barrier of horizontal deviation (Eves *et al.*, 2009). The “height of the building” barrier generally does not present as an issue because the escalator is generally utilized to span only one to two floors. If stair use is inversely related to the number of flights needed to travel, individuals should be more likely to opt for the stairs in an

escalator alternative situation. Despite this logic, interventions to increase stair use over escalator use only averaged about 6.0% increase (Webb *et al.*, 2011). Escalator environments are highly susceptible to pedestrian traffic changes. The visibility of poster and banner prompts was reduced in high traffic situations which limits the ability to encourage stair use (Olander *et al.*, 2008). Further studies are warranted to continue to determine best practices to encourage stair use across an array of environments.

Population

Studies have illustrated that understanding the target population is critical to designing an effective intervention. Previous work has elucidated patterning in stair use, specifically characteristics of persons that respond more favorably to interventions. Studies that note the characteristics of participants showed that young, white men often had the highest frequency of stair use compared to all other groups (Kerr *et al.*, 2001). Additional research showed that whites used the stairs more than African Americans, younger individuals more so than older people, and lean more so than overweight (Andersen *et al.*, 2006). Ryan, *et al.* 2011, completed a study examining the levels of stair use across socioeconomic groups. The group found that a high socioeconomic area had a higher baseline rate of stair use, over escalator use, compared to the lower socioeconomic area. The low and high socioeconomic groups both increased their stair use in response to the poster prompting intervention but there was no statistical difference between the groups' improvements (Ryan, Lyon, Webb, Eves, & Ryan, 2011). A similar study examined stair use in blue-collar and white-collar office settings, both stair versus elevator settings. The group found that although both groups increased their stair use to a similar extent, the white-collar group had a higher baseline use and maintained use after

the intervention more so than the blue-collar employees (Kwak, Kremers, van Baak, & Brug, 2007). These two studies show that socioeconomic status (SES) may be an important variable to consider when designing a study and interpreting the results. The pattern of increased stair use for higher SES can be found in both escalator and elevator conditions. Stair use interventions also appeared to be more effective for infrequent stair users (Graham *et al.*, 2013) and in those with lower customary activity levels (Kerr, Eves, & Carroll, 2000). However, these results might occur due to a ceiling effect. Individuals that are more active or take the stairs more frequently may not be able to increase their activity. Planning interventions to target less active groups may show more positive results because these individuals have more room for growth and habit change.

Multiple studies have examined reasons and barriers reported for not taking the stairs. One worksite poster prompt intervention implemented a post intervention questionnaire. Participants cited time, carrying load, and floor worked on as significant barriers to using the stairs. The average number of floors participants were willing to climb was 3.5 therefore employees on lower levels had increased levels of habitual stair use (Kerr, Eves, & Carroll, 2001a). Marshall *et al.* 2002, noted that participants in a health care facility did not take the stairs due to laziness or being too busy, according to self-report data (Marshall *et al.*, 2002). A more in depth analysis of self-reported influences on stair use asserts that the decision is mainly influenced by four reasons: 1) direction of travel, 2) distance travelled, 3) time pressure, 4) how busy the elevators were. Participants reported choosing the elevator over the stairs for convenience, to avoid getting sweaty or out of breath, physical limitations, and the perception that the distance traveled is physically too far to climb. Based on the reported reasoning for taking the

elevator, the group concluded that decreasing the accessibility and convenience of the elevator will have the most profound impact on stair use (Adams & White, 2002).

Measurement

Research groups measuring stair use have employed three predominant techniques to collect data: observation, infrared sensor, and video recording. Each of the techniques is associated with various benefits and drawbacks, which should be considered before implementing the technique in a study.

The infrared sensor, or photoelectric barrier, is a device that is installed on the sides at the base of a staircase. When an object or human interrupts the beam, the device registers a “stair user.” A significant limitation of this method is that if a group of people pass through the barrier simultaneously, there is a possibility of only registering one individual (Titze *et al.*, 2001). Additionally, the infrared sensor is unable to discern between individuals ascending and descending the stairs. The physical exertion requirement of ascending is significantly higher than descending steps. Therefore, if an intervention enhanced ascent more so or equal to descent it would be more successful than an intervention only increasing descent. The infrared sensor is an excellent device to use in long term studies where employing human counters would not be feasible. Once installed, the device requires almost no maintenance, which makes it an ideal collection method for long durations and counting large quantities of data. Over the course of a 10 week intervention, 143,514 counts were registered on the infrared device (Blake *et al.*, 2008), compared to only 6,216 counts collected by human observation over the course of an 11 week study (Russell *et al.*, 1999). The device registers stair users over a 24-hour period allowing for the analysis of daily trends. From a practical perspective, the infrared

beam is more useful in an elevator versus stair scenario. Often the stairs are located in a remote location from the elevator (Bassett *et al.*, 2013). This design requires twice as many individuals to collect data and is often not feasible. The majority of studies that utilize the infrared sensor occur in elevator versus stair designs.

Most studies performed in stair versus escalator settings utilize observation to collect data. The view of both modes of transportation is generally not obstructed by distance, as the two are generally located in parallel. When observation is utilized in a stair versus elevator scenario, the staircase is usually obscured by a fire door. Because of this the observers must assume that when an individual enters the door to the stairway that they are using the stairs (Vanden Auweele, Boen, Schapendonk, & Dornez, 2005). This assumption does leave room for error and limits the number of variables that can be collected, such as number of flights taken. Observation is the most prevalent data collection method in the stair use literature to date. The duration of these studies tend to be shorter but do range from 1 day (Bassett *et al.*, 2013) to 22 weeks (Webb & Eves, 2007b). A significant benefit to the observational technique is that multiple variables can be collected whereas the infrared sensor only registers one variable: total number. Observational data collection can easily discern between ascenders and descenders. This method is the easiest to employ because it does not require any extra time or resources to set up.

The final method utilized by research groups provides the most in depth and complete data. Video recording has only been used in three stair use research studies to date (Kerr *et al.*, 2001a; van Nieuw-Amerongen *et al.*, 2011; Adams *et al.* 2006). Two studies occurred in an elevator versus stair scenario and one in an escalator scenario. One

took place in a worksite office, another at an airport, while the third occurred in a university setting. Video recording allows researchers to code for a significantly higher number of variables than either observation or infrared sensors using direct observation. Variables that have been coded in previous studies include sex, age, crude race/ethnicity, somatotype, clothing type, shoe type, presence of baggage, children, etc. This method also allows researchers to “re-live” the intervention and have an increased ability to identify actions or characteristics that may have been missed in real time. The limiting factor of video recording is that it is often a safety and privacy issue when done in private settings. However, if the risks are mitigated with appropriate action then video offers the most in depth exposure to the effects of the intervention.

The three measurement techniques reviewed each presented their own strengths and weaknesses. The utilization of each method depends on multiple factors such as economic, time, and staffing resources.

Health Effects

Research has indicated that further studies are warranted to determine the most effective method to increase stair use from a health perspective. The literature indicates that increasing stair use provides a health benefit across multiple populations. A 7-week study on the training effects of accumulated daily stair-climbing exercise in previously sedentary young women reported an increase in high-density lipoprotein (HDL) and reduced total cholesterol to HDL ratio. During the post intervention stair-climbing test the women presented with reduced VO_2 , heart rate (HR), and blood lactate, all indicating improved cardiorespiratory fitness (CRF). The progressive program started with one ascent during the first week and ended with six ascents over the course of the day during

week 7. The highest level of the progression only totaled 13.5 minutes of vigorous exercise per day. The results of this study support the notion that vigorous exercise broken up over the course of the day (i.e. habitual stair climbing) can incur positive health benefits (Boreham, Wallace, & Nevill, 2000).

The benefits of stair climbing are also found in middle-aged adults. A program encouraging middle-aged adults to complete 9-minutes of stair climbing on three days of the week reported significant improvements in cardiorespiratory fitness after only four weeks. No changes were detected in body composition or strength, but the individuals were participating in less than 30 minutes of exercise *per week*, a duration well below the recommended levels, and still experienced improvements in cardiorespiratory fitness. Of note is the program produced a 96% adherence rate (Mair *et al.*, 2014). Stair climbing may be a form of vigorous exercise woven into the daily routine for individuals that report “lack of time” as a significant barrier to exercise. Takaishi *et al.* 2012, reported additional benefits of stair climbing in a middle-aged population. Individuals with postprandial hyperglycemia experienced reduced blood sugar levels by performing approximately 6 minutes of stair climbing at 60% heart rate reserve (HRR), a moderate intensity controlled by stepping rate, 90 minutes after a meal. The individuals that performed the stair exercise controlled their blood sugar more so than individuals that only walked on a flat surface after the meal. Both groups performed better than the sedentary group (Takaishi *et al.*, 2012).

A final study examining the effect of a stair use program on seniors also showed favorable results. The 8-week intervention encouraged seniors to either take the stairs one step or two steps at a time. Both groups experienced reduced resting and submaximal

heart rate, decreased perceived exertion, and improved balance. The stair use groups reported significantly less falls risk and strains during activities of daily living compared to the control group. Program attendance was over 80% for both stair use groups (Donath *et al.*, 2013).

Stair use appears to have wide reaching health effects that impact individuals across age groups and even those with chronic conditions. The adherence rate to stair climbing programs is remarkably high and the duration of time spent in activity is small relative to the health benefits achieved. Changing habits during daily life could easily produce 5 to 6 minutes of stair climbing per day. This duration is similar to those in the intervention studies. Without making any drastic life changes, individuals can experience improved cardiorespiratory fitness, balance, and blood glucose control. A significant limitation to extrapolating the results of these studies is that the participants were all “previously sedentary” individuals. There may be a ceiling effect associated with general daily stair use. However, given the prevalent sedentary nature of the majority of the population, widespread increase in stair use has the potential to deliver significant health benefits.

CHAPTER 3

METHODS

This study was conducted during the Fall 2014 academic semester in the area around the outdoor staircase of the NHI-2 building on ASU's Downtown campus. The building housed staff and faculty members as well as classrooms for university students. The design of the building included a staircase located outside and proximal to one of two building entrance doors, which led inside to the elevators, lobby desk, and a few classrooms. Each of the five-stories of the building was accessible by stairs. The nature of the study was to observe the unhindered effects of changes to an area where students, faculty, and staff made a choice regarding their mode of transportation.

Participants

All individuals using the stairs or entering the NHI-2 building were counted by a research assistant. In order to reduce the validity threat of reactivity, the research assistant responsible for counting was located in an inconspicuous location and did not interact with any individuals entering the building or using the stairs. A video recording device was placed in a discrete location and individuals traveling through the study area were counted and scored based on their choice of the stairs or entering the building. Additional characteristics of the individuals were coded using the video technology. During the data collection phase, the research assistant counted all individuals using the stairs and entering the NHI-2 building. During the data analysis phase, individuals who were carrying items larger than a school or workbag, a child, or an item that could not easily be carried up the stairs were noted. In addition, individuals perceived as incapable of taking the stairs, such as individuals using a wheelchair or crutches were also noted. These

individuals were included in the data analysis. Individuals excluded from counting and analysis included those who just descended the stairs and those who descended the stairs and then entered the building. Individuals that exited the building and ascended the stairs were counted.

Design and Intervention

A time series design with repeated measures and alternating intervention and washout phases was utilized to test the effects of multiple environmental changes on stair use. The study duration was ten-weeks during the Fall 2014 semester. *Figure 1* shows the study design contained two baseline weeks, four intervention weeks and four washout weeks across only three washout phases. The first washout phase was extended due to the fall break, which added a second week to this phase. The study was comprised of three independent intervention techniques (positive poster prompt, deterrent poster prompt, and non-verbal cues) and a fourth phase containing a combination of all three techniques. The first two weeks of the study were used to determine baseline stair use levels. Data were collected during this phase, but there was no implementation of an intervention. The following eight weeks were comprised of alternating intervention and washout weeks. Each washout phase included a week of data collection (two weeks during Washout 1) without any intervention present, similar to the baseline phase. By breaking up the intervention phases with washout weeks, there was less chance of a carryover effect on stair use from the previous motivational technique during the following intervention phase.

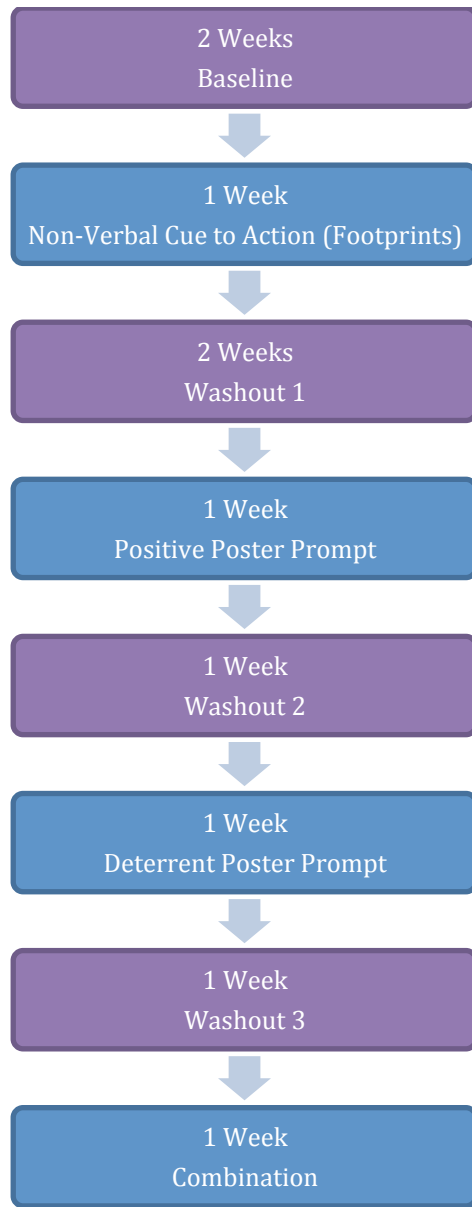


Figure 1. Study Design

Intervention Techniques:

This study examined the impact of three primary intervention techniques and a combination of all three on stair use. Two of the techniques involved poster messaging while the third was a non-verbal cue. All of the techniques were presented at the point-of-choice. This term defines the physical location where an individual chooses the next mode of transportation (i.e. stairs vs. elevator/escalator). This critical environment location selected for the study was located between the outside staircase and the west facing doors entering the NHI-2 building. If an individual desired to use the elevator, they were required to enter the building. However, if they opted for the stairs, they were accessible to them from outside of the building. A description of each of the techniques is located below.

Positive Prompt: The purpose of the positive poster prompt was to directly encourage stair use. The message of the positive prompt focused on sustainable and green living. Using the stairs is one way to reduce the use of electricity and reduce an individual's carbon footprint. The message was printed on A1 size (33.11"x 23.39") poster board. The poster was laminated to prevent any damage or wear and tear. During the intervention phases that utilized poster messaging, the poster was adhered to the building wall before data collection and removed promptly after. Removing the poster each day reduced the effect of habituation and increased the validity of the results. The poster was adhered directly to the building with the use of strong, non-marking Velcro Command strips. An illustration of the positive prompt and the environmental location is represented in *Figure 2*.

Deterrent Prompt: The purpose of the deterrent poster prompt was to indirectly encourage stair use by discouraging elevator use. The poster specifications for the deterrent prompt were exactly the same as the positive prompt for the first day of data collection in the deterrent phase. There was a facilities issue and the poster needed to be relocated. The poster was placed on an easel the last two days of the deterrent phase directly adjacent to the initial placement on the building wall. During the combination phase of the intervention, where both poster prompts were present, the deterrent poster was placed at the forefront of the point-of-choice while the positive prompt was located above the stairs, adjacent to the deterrent prompt. The deterrent prompt design and the environmental location are represented in *Figure 3*.

Non-Verbal Cue to Action: This technique was represented by “footprints” adhered to the ground, leading up to the stairwell. The subtleness of the technique was designed to encourage individuals to follow the path and use the stairs. The footprints were adhered to the ground and led to the stairs from two directions including sets leading from the southeast and southwest sides of the building. 14 footprints were leading to the building from each side with a total of 28 “feet” placed on the ground. Unfortunately, due to the material and the time necessary to adhere the footprints, they were not removed after each data collection session, as the posters were. The labor to remove and replace the footprints was far too great so removing the threat of habituation for the footprints was not feasible. The footprints were made of JessupTM grip tape, a material synonymous to sandpaper. The material was designed to prevent athletes from slipping off their skateboard so the risk of slipping on the footprints was miniscule. The non-verbal cue is shown with the study placement in *Figure 4*.

Combination Phase: The combination phase of the intervention included all three novel approaches to increasing stair use. The deterrent poster was placed proximally while the positive prompt was located next to the staircase. Both posters were visible while approaching the building. The footprints were adhered to the ground in the same fashion that they were during the footprint phase. The posters were put up prior to data collection and removed promptly after the session ended, as they were during their respective intervention phases. The footprints remained adhered to the ground throughout the entire combination phase, again due to the lack of feasibility to adhere and remove with the onset and conclusion of the data collection sessions. The environmental placement of the intervention techniques is illustrated in *Figure 5*.



Figure 2. Positive Poster (left) and study placement (right).



Figure 3. Deterrent Poster (left) and study placement (right).



Figure 4. Non-verbal cue to action (footprints).



Figure 5. Combination phase with all intervention techniques shown.

Measurement and Definitions

Data were collected from an inconspicuous location near the stairwell. During the ten-week time frame, data were collected from 7:40am to 9:40am, every Monday, Tuesday, and Thursday, which totaled six hours of data collection per week. Additionally, data were collected on a Wednesday and a Friday for the same time period during baseline to increase the power of the baseline measure. Data were collected on the same days at the same times over the course of the study to promote consistency. The research assistant participated in two orientation sessions before the start of the project to ensure inter and intra-observer reliability and validity. The traffic volume in a university setting ebbs and flows drastically with the class schedule, consequently, there were times when the traffic volume was quite high. The data recorder was not physically able to count multiple variables at one time; therefore, only total number of people ascending the stairs and entering the building were counted. Data were collected via tally marks in a notebook. To avoid over-burdening the data collector and to increase the number of variables that were analyzed, a video-recording device was used to capture footage of the stairwell area during the data collection times. The camera was placed in an inconspicuous location where the building users did not readily see it. Changing behavior based on awareness of observation is known as reactivity. In order to avoid this phenomenon the camera was properly disguised. The GoPro Hero3+ Black Edition was used in this study. The camera was located next to the observer during the data collection. The camera recorded footage for the entire duration of each data collection session. After the sessions were complete the video footage was reviewed and multiple additional variables were coded.

A list of variables included in the study is as follows:

Independent Variable:

- Positive Prompt
- Deterrent Prompt
- Non-Verbal Cue to Action
- Combination: The combination phase included the presence of the positive prompt, the deterrent prompt and the non-verbal cues to action.

Dependent Variable:

- Stair Use: Individuals that opt to take the stairs were coded as stair users. Only individuals that ascended the stairs were counted. Individuals that descended the stairs were not counted. Individuals that descended the stairs and then entered the building were also not counted. Individuals that entered the building and either took the elevator or remained on the first floor of the building were coded as non-stair users. Stair users were coded when an individual placed their foot on the first step. A non-stair user was coded when the individual placed their first foot across the threshold into the building.

Control Variables:

- Sex: Participants were coded as either male or female.
- Baggage Number: This variable is continuous and represents the number of bags carried by an individual. Each discrete item carried by an individual was considered a bag.

- Volume: The total number of stair and non-stair individuals per every 15-minute period coded for each data session. Each session was made up of 8 individual volume periods.
- Temperature: The temperature was taken using the Wunderground iPhone application at the beginning of each recording session. This application pin points an exact location and provides the temperature for the associated location as opposed to a general temperature for a general area. The ending temperature was at the culmination of each data collection session.
- Day of the week: Days of the week included Monday through Friday however Wednesday and Friday only had one recording session each, captured during the baseline phase.

Statistical Analysis

A repeated measures time series design enabled for further understanding of community practices and behavior change. The design allowed for the ability to understand behavior change over time under various conditions within the same population (Biglan, Ary, & Wagenaar, 2000). The single subject ABACADAE design utilized in the current study was analyzed both visually and statistically. “A” represents the baseline, or *return to baseline* phases, that functioned as a washout period, while the following alphabet characters represent differing intervention phases. “B” represented the first intervention phase, footprints. “C” represented the positive prompting phase. “D” represented the negative prompting phase. “E” represented the combination intervention phase, which was a combination of all previous phases (footprints, positive, and negative).

The dependent variable, stair use, was collected via direct observation and again through video recording. The inter-rater reliability was calculated between the two individuals coding the video footage. Cohen's kappa agreement of 0.8 or above was considered acceptable (Adams *et al.*, 2006). The distribution and order of video coding between raters was randomly selected. There was also a random selection of 12.5% overlap in video coding between raters. These overlapping segments were reviewed for consistency between raters. The inter-rater reliability was perfect for coding sex. Stair use had an agreement of $\kappa=0.92$. Number of bags carried by each individual had an agreement of $\kappa=0.83$; slightly lower than the other two coded variables but still within acceptable limits. Temperature was recorded in real time during data collection and was therefore not coded. Volume was calculated based on the time stamp of each individual. Time stamp had an agreement of $\kappa=0.81$. The majority of disagreement within the time stamp coding was off by generally no more than one second, effecting volume minimally. When there were discrepancies in the data, the coding from rater 1 was used.

Visual Analysis

Data were represented in graphical form for a visual analysis assessment. The graphs simplify the data and allow for trends and changes in the dependent variable to be easily viewed. Components of the visual analysis include the pattern, degree of mean shift, and fluctuation variation within phases (i.e., variability of the data, and overall data trend) (Kinugasa, Cerin, & Hooper, 2004). The x-axis of the graph represents the independent variable; intervention condition represented as time in weeks. The y-axis of the graph represents the dependent variable, stair use. Microsoft Excel was used to formulate a graph that represents stair use across all intervention conditions (Dixon *et al.*,

2009). Each graph also contains the mean, standard deviation, median and interquartile range (IRQ) for each phase. The first washout phase was extended because it was combined with the fall break session. The third washout phase was truncated because one day was a national holiday resulting in nearly zero participants; it was therefore dropped from the data.

Figure 6 illustrates a representative graph of a time series design. The initial baseline data should show consistent stair use patterns. Statistically significant increases in stair use levels during the intervention phase followed by a subsequent decline in stair use after the intervention is withdrawn indicate an efficacious technique. The graph for this study includes all baseline, washout and intervention phases across a ten-week timeline.

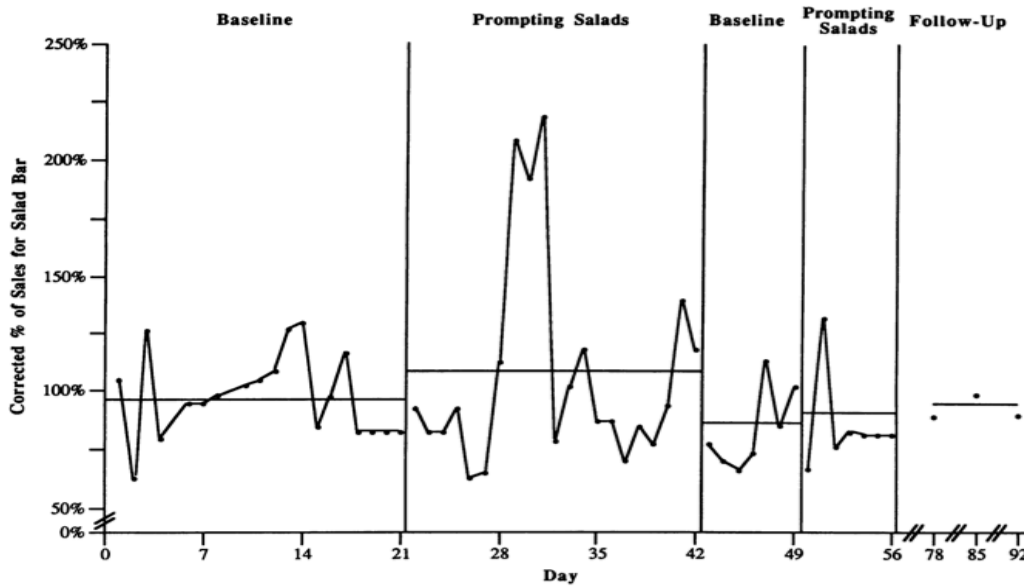


Figure 2. Daily corrected percentage of sales for salad bar across phases of the study with weekly follow-up points.

Figure 6. Example time-series graph. Figure extracted from (Wagner & Winett, 1988)

For visual analysis, stair use was represented as a continuous numerical value of total counts. The counts for stair use were reported over eight time periods, “Baseline,” “Footprints”, “Washout 1,” “Positive prompt,” “Washout 2,” “Deterrent prompt,” “Washout 3,” and “Combination phase.” In the time series graph, each day of observation was represented separately to illustrate trends more accurately.

Regression Modeling

Due to the subjective nature of visual analysis, more objective statistical measures are warranted to analyze the data. Descriptive statistics include percentages, medians and interquartile ranges for each observation day. SPSS (IBM, Version 21.0.0.0) was used to perform statistical analysis. A multivariable logistic regression analysis was utilized to examine the effects of the intervention phases and covariates on stair use. A $p \leq 0.05$ was considered statistically significant. Covariates included sex, number of bags carried per individual, traffic volume per 15-minute interval, day of the week, and temperature on stair use. The predictor variables were coded as the following:

- Condition: Baseline; Footprints, Washout-1, Positive Prompt, Washout-2, Deterrent Prompt, Washout-3, Combination Phase
- Stair Use: Non-stair (0); Stair (1)
- Sex: Male (0); Female (1)
- Baggage Number: Continuous ranging from 0-∞
- Volume: Continuous ranging from 0-∞ (mean centered)
- *Study day: Range from onset of study (Day 0) to culmination of project (Day 66)
- Day of the Week: Monday, Tuesday, Wednesday, Thursday, Friday

– Temperature: Degrees Fahrenheit ranging from $-\infty^{\circ}\text{F}$ to $\infty^{\circ}\text{F}$ (mean centered)

*Study day and temperature had a large and negative correlation ($r = -0.84$).

Multicollinearity across all covariates was examined by tolerance and variance inflation factor (VIF). Tolerance and VIF results supported that study day was collinear with temperature and study day was excluded from further regression models.

CHAPTER 4

RESULTS

Descriptive data are represented in *Tables 1* and *2*. Over the course of the 31 data collection sessions, 6,140 people were observed in the study area. Video footage from the second day in the combination phase was lost therefore the data was not included in the regression modeling. However, the total stair and non-stair users were recorded by hand during data collection. These numbers are presented in the visual analysis graph. In addition, the second day of Washout 3 was dropped due to the national holiday and subsequent reduced participation. Because of this, the trend of stair use and median rates during the third washout phase are difficult to truly determine.

Total stair use across the study averaged 23% with the remaining 77% classified as non-stair users. Data were primarily collected on Mondays, Tuesdays and Thursdays, with two additional baseline days on a Wednesday and a Friday. Tuesdays and Thursdays contained the majority of participants with 32.4% and 43.8%, respectively. Mondays represented 18.7%, Wednesday had 3.1% and Friday had 1.9% of total participants. Tuesdays and Thursdays represented the highest percent of total stair users. Tuesdays and Thursdays comprised 37.7% and 48.5% of total stair use recorded over the duration of the study while Mondays only contained 12.1%. The percent of stair use within the days was comparable between Tuesdays (26.7%) and Thursdays (25.4%). Both days were much greater than Mondays (14.9%).

Females made up a vast majority of the participants at 78.7% while males only represented 21.3% of the population; 24.3% of females and 18.1% of males used the stairs. The number of bags carried ranged from 0-4 bags. The mode of bags carried per

person was 1 bag (71.2%) followed by 2 bags (16.1%), 0 bags (9.6%), 3 bags (2.9%) and 4 bags (0.3%). Individuals carrying 1 bag made up 80.5% of total stair use followed by 2 bag individuals making up 13.1%. Among those with bags, 11.8% of individuals carrying zero bags used the stairs, 26.0% of 1 bag individuals, 18.7% of 2 bag carriers, 11.3% of 3 bag participants, and 0% of 4 bag users.

The study occurred between September 15th and November 20th. The temperature averaged 72.8°F (SD = 9.52°F) with a high of 91°F and a low of 47°F. Volume was determined by the total number of people during a 15 minute period. Daily observations occurred over 2 hours and with 8, 15-minute periods. The average volume was 52.7 individuals per 15-minute period (SD = 38.75). The maximum volume was 133 participants and the minimum was 1 participant in a 15-minute period with a range of 132 people.

Visual Analysis

Figures 7, 8, 9, and 10 illustrate stair use across each phase of the study. Because the data were not normally distributed, the median and the interquartile range represent a more accurate summary. *Figure 7* represents raw counts of stair use by phase. The median values for stair use in each phase were graphed as a horizontal line. *Figure 8* shows percent stair use by phase and also contains median stair use lines. The data have an appreciable amount of variability as Monday sessions always had lower numbers of people and stair use compared to Tuesdays and Thursdays. The median lines more clearly illustrate any changes across phases. The footprint phase has a substantial increase in stair use from baseline (baseline, median=39 people (17% stair use), IQR 53.75 people (13% stair use); footprint, median=72 people (25% stair use), IQR 32 people (8% stair use)).

The positive phase also has a noticeable increase from the first washout phase (Washout 1, median=38 people (21% stair use), IQR 55 people (9% stair use); Positive, median=72 people (28% stair use), IQR 28.5 people (7% stair use)). Stair use decreases slightly during the second washout phase but does not return to baseline levels. Compared to the second washout phase, stair use during the deterrent phase increased only slightly (Washout 2, median=61 people (24% stair use), IQR 31.5 people (7% stair use); Deterrent, median=71 people (26% stair use), IQR 27.5 people (6% stair use)). The third washout phase decreased stair use levels, but again did not return to original baseline levels. The combination phase increased stair use slightly compared to the third washout phase (Washout 3, median=46.5 people (23% stair use), IQR 29.5 people (5% stair use); Combination, median=68 people (27% stair use), IQR 30.5 people (8% stair use)). The combination phase had comparable stair use levels as the deterrent phase. These graphs show a steady increasing trend of stair use across the study. This trend is best illustrated in *Figure 8*. The stair use during the washout phases decreases compared to the prior intervention phase; however, the drop in stair use does not reach original baseline levels.

Figures 9 and 10 are similar to *Figures 7 and 8* respectively, however, they contain phase trendlines as opposed to average lines. Ideally, the trendlines during the intervention phases should have a positive slope while the trendlines in the baseline and washout phases should have a negative or neutral slope. The baseline phase had a slight negative trend, followed by a sharp positive trend during the footprint phase. Similarly, the first washout phase had a negative stair use trend while the subsequent positive prompting phase had a steep positive trend. All of the remaining phases, including the washout phases all had positive stair use trends. The second and third washout phases did

not have a negative trend indicating an absence of reduced stair use when the intervention was removed.

Regression Models

Multivariable regression modeling was used to determine if stair use changed significantly between phases of the intervention, after adjusting for covariates. The intervention phases were compared to the baseline or washout phase directly prior. *Table 3* shows when stair use was analyzed across phases, without the inclusion of covariates, stair use was significantly increased by 26% during the positive prompt phase compared to the Washout 1 phase (OR=1.256, 95% CI, 1.007-1.568). The footprint phase showed a small positive effect compared to baseline, however it was not statistically significant (OR=1.191, 95% CI 0.961-1.476). Stair use during the deterrent (OR=0.977, 95% CI 0.760-1.256) and the combination (OR=0.961, 95% CI 0.685-1.350) phases did not significantly increase compared to Washout 2 and Washout 3, respectively.

Table 4 shows when adjusting for day of the week, sex, bags, temperature, and pedestrian traffic volume, the positive prompt phase still had significantly increased stair use compared to the Washout 1 phase (OR=1.354, 95% CI 1.080-1.696). Stair use during all other phases did not change significantly compared to the previous baseline or washout phase after controlling for covariates; footprint (OR=1.092, 95% CI 0.785-1.519), deterrent (OR=1.056, 95% CI 0.770-1.448), and combination (OR=1.077, 95% CI 0.698-1.661).

Day of the week, sex, and volume all had significant correlations to stair use. Day of the week was divided into Monday through Friday. Monday was the reference category in the regression modeling. Tuesday and Thursday were both significantly

positively correlated with stair use indicating that an individual was more likely to use the stairs on both Tuesdays and Thursdays (Tuesday OR=1.616, 95% CI 1.298-2.011; Thursday OR=1.434, 95% CI 1.164-1.766) compared to Mondays. Both Wednesday (OR=0.457, 95% CI 0.248-0.841) and Friday (OR=0.598 95% CI 0.303-1.180) were negatively associated with stair use compared to Mondays. Data were only collected on one Wednesday and one Friday during the baseline phase. All other data points were collected during Mondays, Tuesdays, and Thursdays. Sex had a significantly positive association with stair use (OR=1.376, 95% CI 1.173-1.613). Females used the stairs significantly more than males. Pedestrian traffic volume was also positively associated with stair use (OR=1.007, 95% CI 1.005-1.008). Stair use increased slightly as number of people per 15-minute period increased. Number of bags carried and temperature were not significantly related to stair use (bags OR=0.976, 95% CI 0.878-1.086; temperature OR=1.007, 95% CI 0.987-1.027).

Table 1

Frequencies

	Stairs	Non-Stairs	Total Counts	Percent of Total Counts
Sex	% within Variable	% within Variable		
Male	18.1%	81.9%	1306	21.3%
Female	24.3%	75.7%	4834	78.7%
Bags				
0	11.8%	88.2%	592	9.6%
1	26.0%	74.0%	4370	71.2%
2	18.7%	81.3%	990	16.1%
3	11.3%	88.7%	177	2.9%
4	0.0%	100.0%	11	0.2%
Day				
Monday	14.9%	85.1%	1149	18.7%
Tuesday	26.7%	73.3%	1992	32.4%
Wednesday	6.8%	93.2%	191	3.1%
Thursday	25.4%	74.6%	2690	43.8%
Friday	8.5%	91.5%	118	1.9%

Table 2

Descriptive Statistics

	Mean	Std. Dev.	Median	Mode	Min	Max	Range
Temperature	72.760	9.52	72.5	72.5	47	91	44
Mean Centered Temperature	0.755	9.52	0.5	0.5	-25	19	44
Volume	52.670	38.75	42	12	1	133	132
Mean Centered Volume	27.070	38.75	16.4	-13.6	-25	107	132

Table 3

Logistic Regression by Phase

	OR	CI	p-value
Baseline vs. Footprint	1.191	0.961-1.476	0.110
Washout 1 vs. Positive	1.256	1.007-1.568	0.043
Washout 2 vs. Deterrent	0.977	0.760-1.256	0.857
Washout 3 vs. Combo	0.961	0.685-1.350	0.820

Table 4

Logistic Regression by Phase with Covariates

	OR	95% CI	p-value
Baseline vs. Footprint	1.092	0.785-1.519	0.600
Washout 1 vs. Positive	1.354	1.080-1.696	0.008
Washout 2 vs. Deterrent	1.056	0.770-1.448	0.737
Washout 3 vs. Combo	1.077	0.698-1.661	0.739
Day of the Week			
Monday	1.000	Reference	
Tuesday	1.616	1.298-2.011	0.000
Wednesday	0.457	0.248-0.841	0.012
Thursday	1.434	1.164-1.766	0.001
Friday	0.598	0.303-1.180	0.138
Sex (reference: males)	1.376	1.173-1.613	0.000
Bags	0.976	0.878-1.086	0.659
Temperature (mean centered)	1.007	0.987-1.027	0.516
Volume (mean centered)	1.007	1.005-1.008	0.000

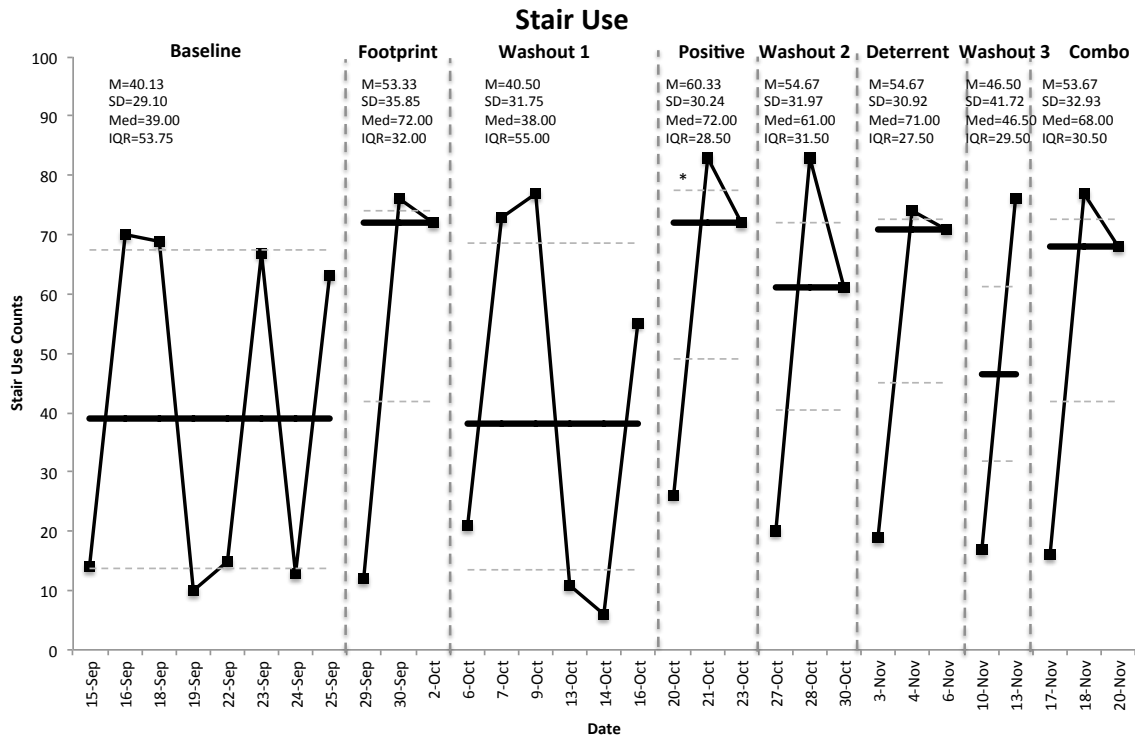


Figure 7. Raw counts of stair use with median and IQR represented across phase. (*) based on logistic regression; indicates significant increase from previous phase, $p < .05$.

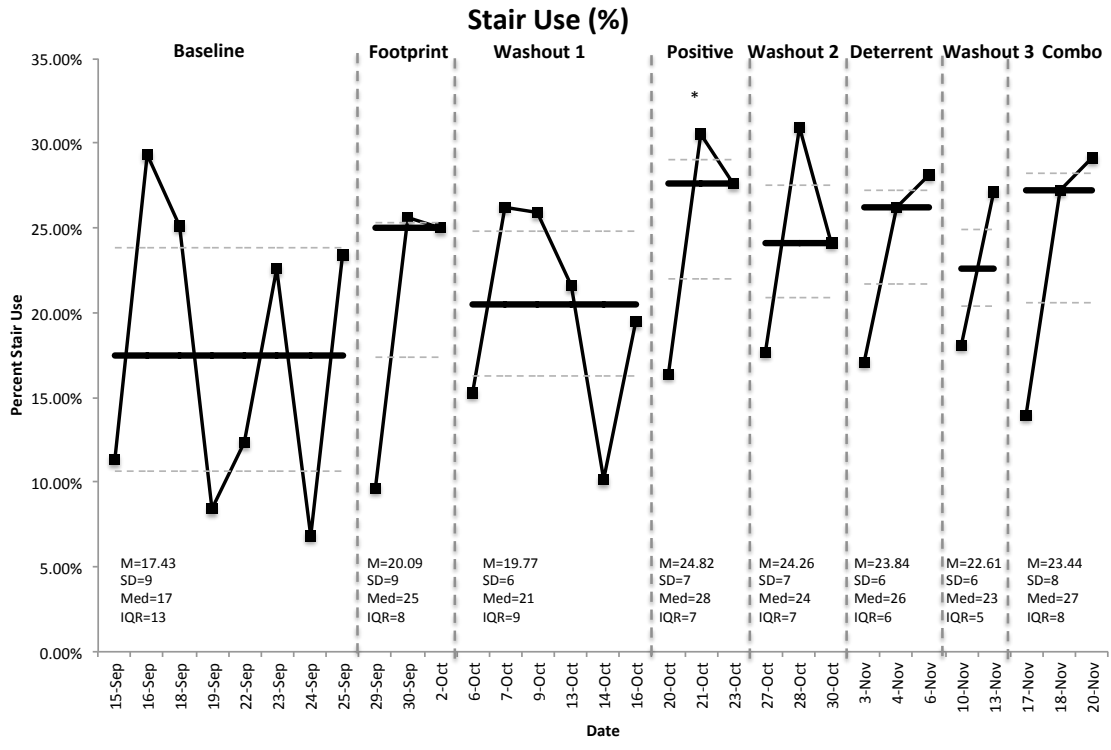


Figure 8. Percentage of stair use with median and IQR represented across phase. (*) based on logistic regression; indicates significant increase from previous phase, $p < .05$.

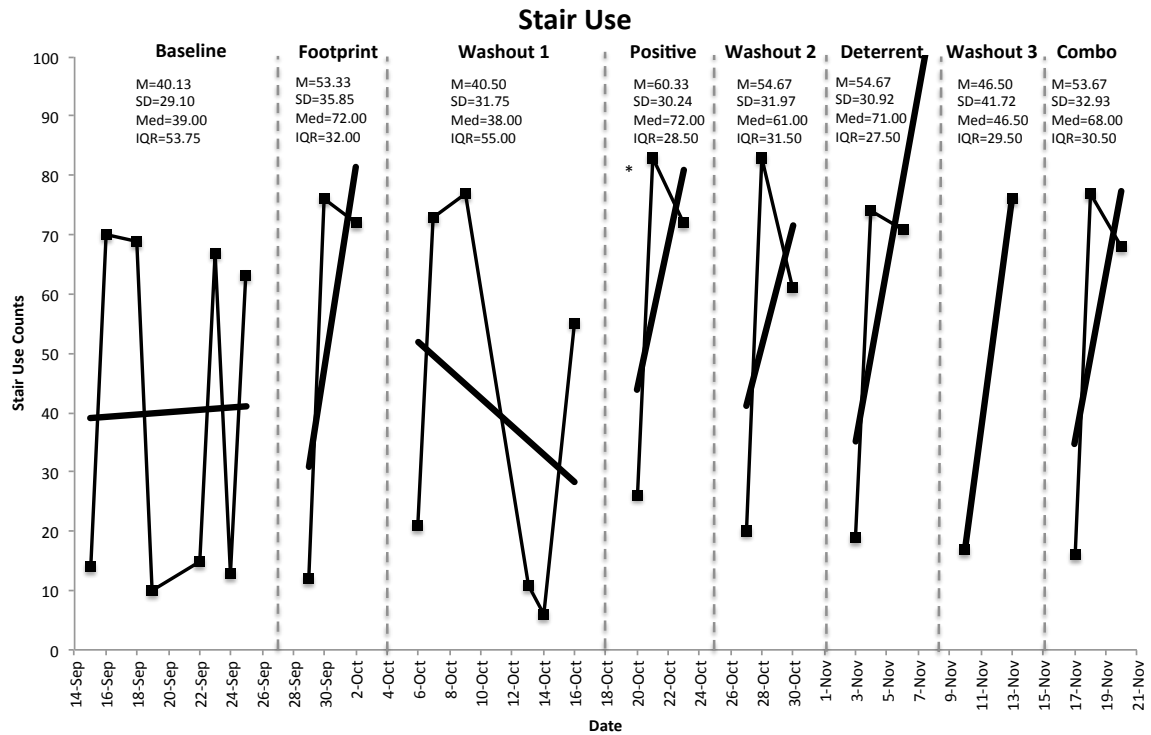


Figure 9. Raw counts of stair use with trendline across phase. (*) based on logistic regression; indicates significant increase from previous phase, $p < .05$.

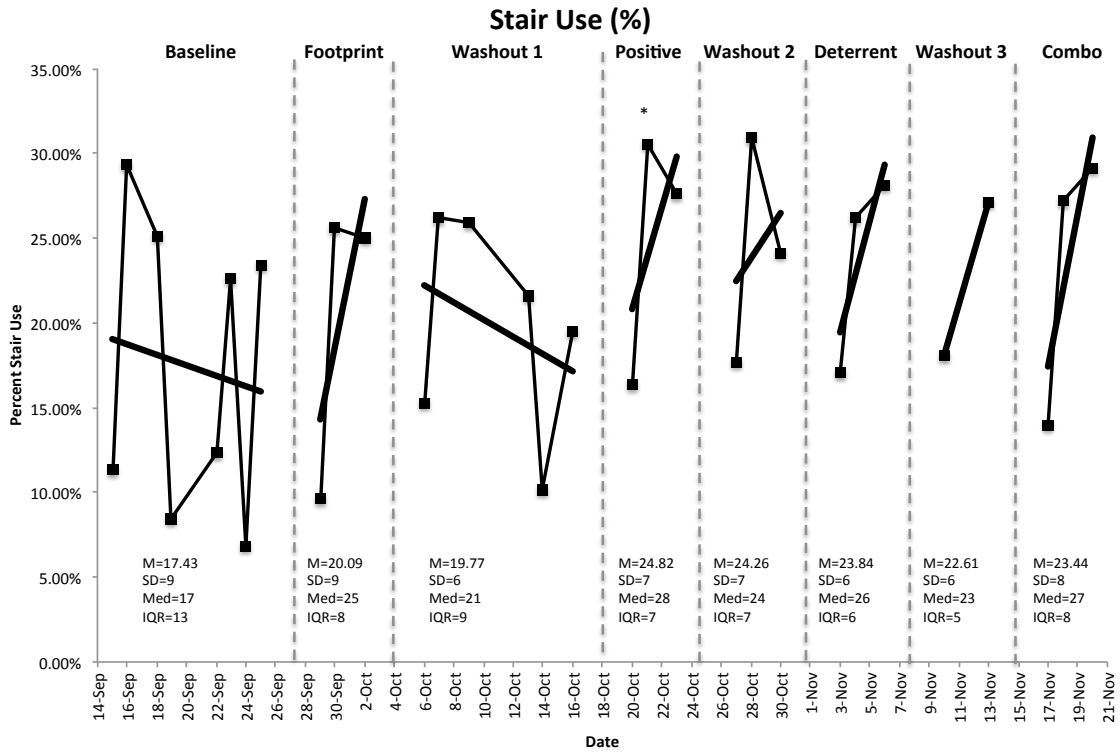


Figure 10. Percentage of stair use with trendline across phase. (*) based on logistic regression; indicates significant increase from previous phase, $p < .05$.

CHAPTER 5

DISCUSSION

The purpose of this study was to test the effect of four environmental changes on ascending stair use in a mixed population of college students, faculty, and staff on a college campus. This study utilized a positive poster prompt that encouraged stair use for an environmental benefit, a deterrent poster prompt that dissuaded elevator use, a non-verbal prompt that consisted of footprints placed on the ground leading to the stairs, and the combination of all three changes. The present study took place during the Fall 2014 semester.

The positive prompting phase increased stair use significantly compared to the previous washout phase while the other novel approaches did not appear to have a significant effect. The positive prompt increased the median stair use 7% (33% relative increase) from Washout 1 based on the visual analysis. After adjusting for covariates, regression modeling showed that an individual was 1.35 times more likely to use the stairs during the positive prompting phase compared to Washout 1. This increase is approximately on par with the results of a previous study out of the Netherlands. Dorresteyn *et al.* that found that a poster prompt increased absolute stair use 8.5% during the intervention and 9.9% post-intervention, when compared to elevator use (Dorresteyn, van der Graaf, Zheng, Spiering, & Visseren, 2013). The results from the current study are also consistent with Blamey's 1995 study which found that motivational prompts increased stair use from 8% at baseline to a 15% use during the intervention phase. However, this study occurred in an environment when stair use was being compared to escalator use (Blamey, 1995). Despite a general positive theme, other studies have found

positive, motivational messages to be ineffective at increasing stair use. A study with a similar time series design, utilizing a range of messaging including an emphasis on family, time, and health, found no significant changes in stair use compared to elevator use (Blake, 2008). The results of the present study are above average when compared to literature reviews that concluded that stair use interventions, to date, only increase absolute use about 2.8%-6.0% (Dolan, 2006; Webb, 2011). However, these reviews primarily assessed studies that occurred in stair versus escalator settings whereas this study occurred in a stair versus elevator setting. The Nocon, 2010 review found that point-of-decision prompts are more effective at increasing stair use when the competing option is an escalator rather than an elevator. Based on the literature review findings, the effect of the point-of-decision prompts in the current study showed above average increase given the elevator alternative. The efficacy of the positive prompt in this intervention is emphasized by having a larger than average effect on stair use.

One limitation in the literature is the efficacy of prompting surrounding environmental concern. To date, health messages have been the most prevalent focus (Andersen *et al.*, 1998). However, time saving (Kerr, Eves, & Carroll, 2001c) and family (Blake, 1995) messaging have been explored. Coleman and Gonzalez 2001, through a study in a border community, noted the importance of culturally competent messaging technique. The positive prompt utilized in the current study tested for the first time the eliciting concern for the environment or “green behavior” by saving electricity via taking the stairs. A pertinent topic globally, and potentially prevalent within the microcosm of environmentally conscious college population, is global warming. Reducing the carbon footprint appeared to be an effective message strategy in this southwest university

population. A focus on the environment may not be relevant to all populations, but a younger population in a university setting seems to be receptive.

The deterrent prompt was designed to elicit fear and a symbol of death or disease associated with inactivity via taking the elevator. Previous studies have reported significant efficacy with deterrent messaging (Russell, 2000). However, Russell used a very direct messaging strategy, specifically reserving escalator use to staff and those that needed it while all others should take the stairs. The deterrent message in this current study was far less pointed. The current study merely suggested that elevator use is related to fear or death through the presence of the “grim reaper” on the poster prompt while encouraging stair use verbally with “try the stairs.” The red font color in the deterrent prompt was also difficult to see from a distance. During the deterrent prompting phase, a facilities issue occurred which necessitated the relocation of the prompt. A new building sign was being erected exactly where the deterrent prompt was placed. The potential negative effect of relocation was mitigated by the replacement on a freestanding easel directly next to the original placement. A more significant effect may have been seen with a more direct deterrent message such as “the elevator is reserved for those who need it only” or “are the stairs broken?”

The footprint phase appears to have significantly improved stair use compared to baseline on the visual analysis graphs. However, any increase in stair use between the baseline and footprints phases was non-significant. This relationship was maintained after controlling for covariates. The lack of significance during the footprints phase may be attributed to the notable variability in people and stair use between Monday and Tuesday

or Thursday. Additional days with the footprints in place may have illuminated an increasing trend in stair use.

Previous studies have supported the theory of “more is better” in terms of prompting for increased stair use. Boutelle *et al.* found that stair use was greater when signs, music, and artwork were all present than any single intervention. The combination phase in the present study was unsuccessful in creating a significant increase in stair use potentially due to the lack of efficacy of two of three interventions (i.e. footprints and deterrent prompt). The positive prompt was the only individual intervention that created a significant increase in stair use. The effect of the positive prompt may have been washed out or mitigated by the presence of the two lesser efficacious approaches.

In addition to stair use, multiple covariates were measured including sex, day of the week, volume, number of bags, and temperature. Sex was significantly correlated with stair use; however, it was opposite to what previous literature has noted. In this study, females were approximately 38% more likely to use the stairs compared to males. Even though females made up about 80% of the study population, 24% of females compared to only 18% of males took the stairs. This result is completely opposite to what previous studies have found which is that white males use the stairs more than any other group (Kerr, 2001).

Day of the week was significantly correlated with stair use. Mondays, Wednesdays, and Fridays had very low counts of stair use while Tuesdays and Thursdays had quite a bit more stair users as well as total participants. After adjusting for other variables, the logistic regression model showed that individuals were significantly more likely to use the stairs on Tuesdays and Thursdays compared to Mondays. Individuals

were less likely to use the stairs on Wednesday and Friday compared to Mondays. However, data were only collected on one Wednesday and Friday during the baseline phase so part of this relationship can be explained by low sample size. Adding more data collection days or collecting only on days with similar traffic, such as only Tuesdays and Thursdays or Mondays, Wednesdays, and Fridays, would reduce the high variability in the data. This approach might eliminate the “Monday effect” seen in this study. Another way to reduce the day effect is to increase the duration of baseline and intervention phases. The huge variability would smooth after additional days and a true baseline would be revealed.

Similar to previous studies, pedestrian traffic volume was significantly and positively related to stair use (OR = 1.007), although the magnitude of the relation was small. When the volume of individuals is larger, waiting for the crowd to move through the door may seem less appealing than using the stairs to arrive at one’s destination. The effect of volume may also be related to behavioral modeling (Adams *et al.*, 2006). With increased volume, there is a subsequent increase in stair use and behavioral modeling allows individuals to simply follow the person in front of them to support an increase in stair use.

The number of bags carried per individual was not significantly correlated with stair use based on the regression analysis. However, the frequencies analysis indicated that individuals that were carrying one bag made up the vast majority of stair users, while those carrying two bags were the second most prevalent, followed by zero bags. This result varies slightly from the literature. According to previous studies, individuals carrying zero bags are more likely to use the stairs (Webb and Eves, 2005; Webb & Eves,

2007a, Adams *et al.*, 2006). Because this study took place on a university campus, the norm is to carry a backpack. This “norm” may be equivalent to zero bags in a mall or shopping center environment. The precipitous decline in stair use by individuals carrying 3 or 4 bags indicates that an increased load may be a deterrent to taking the stairs.

Although temperature was not significantly related to stair use, it is an important variable to consider. There may be a certain threshold in which individuals find that it is too hot or too cold to take the stairs. This variable is important to consider in this particular study because the staircase was outside. Future studies should examine temperatures and/or humidities to determine if they are related to stair use.

Methodological Considerations

The study contained multiple methodological strengths. The time-series design of the study supported the independent evaluation of the four intervention conditions. Additionally, the method of data collection through both in-person tallying and video recording allowed for multiple variables to be coded retrospectively and included in the analysis. Washout periods were included to allow for stair use to return to baseline to prevent any carryover effect from the previous intervention, however, the washout periods may not have been long enough to reduce stair use to the true baseline as stair use levels remained elevated during the washout periods.

The baseline level of stair use in the current study (17%) was higher than most studies previously conducted. Most studies reported a baseline ranging from 1.7%-39.7% with an 8.2% median. This large range can largely be explained by a handful of studies with high baselines of 39.7%, 61.8%, and 36% (Russel *et al.*, 1999; Titze *et al.*, 2001; Lee *et al.*, 2012). The high baseline rate in the current study may be explained by the

study population. The study took place in a building that housed nursing and exercise and health science students and professionals. These individuals are often more health conscious than others and therefore may already habitually take the stairs or may be more susceptible to an intervention encouraging stair use. Additionally, the location of the staircase was outdoors. The southwest climate allows for comfortable outdoor use for most parts of the year. The temperature across the study was ideal for stair use. Additional weather factors such as snow, rain, wind, etc. were not influences during the study.

The design of data collection allowed for only stair use and non-stair use to be recorded. The staircase was located outside of the building so all individuals that used the stairs were coded as such, however, the individuals that entered the building may have taken the elevator or may have entered a classroom on the first floor. Data were not collected inside of the building for two reasons. First, individual's privacy was a consideration. Secondly, the limitation of having only one data collector made it impossible to collect data outside (stair users) and inside (elevator users) simultaneously. Despite these limitations, the change in overall stair use could be identified. Similarly, we were unable to determine to which floor each stair user ascended. Examining the number of flights traveled may reveal a threshold that individuals find accessible to use the stairs.

Additional limitations include lost and dropped data. Due to a national holiday, a day during Washout 3 was dropped from the study because only two individuals were recorded. A video file during the combination phase was lost. Because of this, those data were not included in the regression modeling. However, the observational tally data for that missing day were included in the visual analysis graph. Another limitation in the data

analysis was a lack of time to explore interactions between variables. Future studies should explore any potential interactions between day of the week and intervention phase that might influence stair use. Due to the high variability in stair use across days of the week, future studies should increase the duration of each phase to reduce variability and better identify trends.

In conclusion, this study shows that a positive poster prompt with an environmental theme is an effective means to increase stair use in a university population. This study also cautions the use of multiple prompting methods until the efficacy of each is known to be potent, as ineffective strategies may distract from, or overshadow, effective messaging. The deterrent messaging and point of choice prompts did not appear to be effective in this study however, examining different messaging themes and mediums may increase the effectiveness of these approaches.

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APPENDIX A
IRB APPROVAL



EXEMPTION GRANTED

Marc Adams
SNHP - Exercise and Wellness
602/827-2470
Marc.Adams@asu.edu

Dear Marc Adams:

On 7/22/2014 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Novel Approaches to Increasing Stair Use in a University Population
Investigator:	Marc Adams
IRB ID:	STUDY00001235
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	<ul style="list-style-type: none"> • Appendix B, Category: IRB Protocol; • Appendix A, Category: IRB Protocol; • IRB Social Behavior Application NHI2 Stair 7.16.14.docx, Category: IRB Protocol;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 7/22/2014.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Marley Ford

APPENDIX B
FACILITIES APPROVAL



Date: May 30, 2014
To: Linda Vaughan, Linda Searcy
From: Dominique Laroche, Tiziana Asprella
Re: Master's Thesis Project

We have reviewed the project presented by student Marley Ford and approve the project to go forward with the following stipulations:

- All material used must not create any permanent changes to the stairwell, walkways or walls. No holes can be made in any surface without prior approval from ASU Facilities Management and clearance from the Asbestos Team is received. Any damages will be billed to the College of Nursing.
- The project duration will be 9 weeks – actual dates to be specified at least two weeks before the start of the project. An additional two days is granted prior to the start of the project to install visual cues and posters, and two days following for removal of all material. Any material left after the specified dates will be removed and labor charged to the College of Nursing.
- If the posters or directional cues become a hazard, defaced, or unsightly, they will need to be removed.
- A walk-through of the space will be conducted by a member of the Facilities team after the project.

Please sign below as to your understanding and agreement.

Linda A. Vaughan

Linda A. Vaughan

Linda Searcy

Print Name: LINDA SEARCY

Date: 6.12.14

**Facilities Development and Management
Facilities Management - Downtown Phoenix Campus**

522 N. Central Avenue Suite 201
Phoenix, Arizona 84004
602-496-2500 or 602-496-1502
<https://cfo.asu.edu/fdm-dpc-facman>