# DEVELOPMENT AND EVALUATION OF A MOBILE-BASED WEIGHTED WELL-BEING SCORING FUNCTION FOR TRAUMA AFFECTED COMMUNITIES

by

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Trauma affected communities (TACs) are population groups in which members have experienced chronic traumatic events. This dissertation research defines "trauma informed" communities as services which have been tailored and evaluated specifically for the needs of communities in which trauma and violence have been seen. This dissertation details the process of designing and evaluating a first of a kind intervention via a weighted mobile app with the idea of trauma informed services in mind. This research is part of a larger project known as imHealthy, a comprehensive health status evaluation system, which represents an entire ecosystem of mobile technology coupled with various other software components. My dissertation addresses the feasibility of building a well-being scoring system from the ground up. A preliminary study was conducted to test the usability of a well-being app. The results showed that further attention was needed in addressing various user-interface (UI) sizing issues. Upon modification and a re-test, a positive time on task results was seen. The total time spent logging into the app dropped by 50%; navigation between domains dropped by 43%, navigation within pages dropped 82% and overall total time to logout dropped by 44%.

In addition, a scoring algorithm was devised to weight and score the mobile-based wellbeing survey. A step-by-step approach outlines the process of the scoring function and the calibration of the algorithm. Initial results showed inconsistencies between expert raters vs. the app generated score (intraclass correlation coefficients (ICC) values for five domains were physical = .279, behavioral = .237, relational = .029, spiritual = .497, socio-economic = -.268). Post calibration the ICC results improved significantly (physical = .797, behavioral = .749, relational = .742, spiritual = .905, socio-economic = .286). Lastly, a usability study was conducted to test user satisfaction of an administrative web portal used in conjunction with the mobile app. The low ASQ (Avg. Range 1.00 - 1.52) and CSUQ (Avg. Range 1.00 – 1.95) scores during, and post study suggest highly favorable user satisfaction on the web portal.

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# 1.0 INTRODUCTION

The aim of this dissertation research is to quantify quality of life (QoL) measures through a weighted scale via a mobile app, and present the results via a web portal for healthcare providers to use to assess an individual, family, or community. The methods used will assess five key areas associated with QoL well-being. The five domain areas include: socio-economic, physical, behavioral, relational and spiritual well-being. There are many well-being questionnaires that currently exist. In addition to the standard questionnaire, which simply uses an additive approach, there also exists in this space, preference weighted questionnaires. (Kopec, 2003) These questionnaires begin to formulate a weight by way of gathering basic statistics from the actual patient population's preferred responses, and later by way of a statistical algorithm to assign the final weights. None of the questionnaires mentioned are applied in the mobile space.

Section 9 of this dissertation describes a stepwise scoring algorithm used to derive the well-being score. The scoring function considers both the question weights and the domain weights in deriving the final score. It is made up of a four-step process described below.

1. The process begins by taking the answers submitted by the user. The Likert scale answers are valued, and each value has an exact weight assigned. This value is then multiplied by the question weight as denoted by,

$$D_s = \sum R_w * Q_w$$

$R_w$ is the Likert score value and $Q_w$ is the question weight value. The summation of this builds a unique domain score in each of the five domains. The domain scores, $D_s$ is then normalized. The finalized well-being score (WBS) is derived by taking a summation of $D_s$ multiplied by the domain weights associated with each domain, $D_w$. The finalized score calculation is shown below.

$$WBS = \sum D_s * D_w$$

To test the app with the user population, a usability study was conducted. The usability study, as described in Chapter 9, was broken up into two main phases. Phase 1 consisted of the initial user testing with task scenarios. One of the key takeaways from the phase 1 testing was the UI sizing and font sizes within the app. Many of the app components in the initial design were smaller, making it harder for users to read and interact via finger presses. One of the main issues was the dropdown boxes and the placement of them within the page. In phase 2, all the discovered usability issues were modified, and the same user population was re-tested. Based on the results phase 2 redesign was a success, with many of the users expressing positive feedback on some of the most common changes.

We have designed a well-being questionnaire (Appendix A) that not only fully encompasses the many domains that deal with well-being but is also designed to be one of the first of its kind in the mobile space. In addition, expert and community preference

weighting have been applied to each question to produce a robust scoring algorithm. Our system aims to allow the behavioral health community organizer (BHCO), or any health practitioner to easily assess a patient through a series of wellness assessment questions on a mobile tablet. The mobile app continually talks with the central server in formulating a well-being score real-time. The mobile app works in conjunction with a patient portal, which will allow patients and staff to interact with the patient's information and scoring results.

## 1.1 HYPOTHESIS AND SPECIFIC AIMS

This research hypothesizes that *a mobile-based intervention for well-being can increase efficiency and reliability in determining novel interventions to help trauma informed communities.* To address this hypothesis, this research aims to develop a well-being scoring function to be used in conjunction with a mobile based well-being questionnaire for trauma informed medically underserved populations. In conjunction with Focus Pittsburgh, a user centered design approach was utilized to build the mobile application and web portal. The following specific aims were utilized to achieve the goals of this research:

**Specific Aim 1:** Perform a usability study to determine the barriers and discover issues with the mobile app interface and ease of use.

**Specific Aim 2**: Develop a weighted scoring function, which will score an individual's risk based on five domains of well-being. To address reliability of the app

scoring function ICC statistics were conducted comparing the expert assigned domain values with the domain values generated in the mobile app. The benefit of ICC over the standard Pearson correlation is that Pearson only looks at between variable correlations, whereas ICC looks at both between and within variables and thus yields more information. In addition, from the ICC analysis, standard errors will also be determined. In addition, consistency between the two raters on average between the app and person will also be determined with the ICC. A value greater than .7 is ideal. Optimally, we would like the ICC value to be greater than .80.

**Specific Aim 3**: Design, develop and test a web portal interface, which will present data analytics for reporting to the BHCO and patients.

## 1.2 PROBLEM STATEMENT

David Packard, co-founder of HP once said, "The betterment of our society is not a job to be left to a few; it is a responsibility to be shared by all". This statement is more important today than ever before. One area that is the focus of this research intervention is trauma informed communities. Trauma is defined as a deeply distressing or disturbing experience. This paper defines "trauma informed" communities as services that have been tailored and evaluated specifically for the needs of communities in which trauma and violence have been seen. These services have been evaluated and are sensitive to the role that violence plays in communities and which individuals within these communities seek treatment. (Jennings, 2004) Traumatic events include things like physical and emotional abuse, domestic abuse, community turmoil and violence, witness to natural

disasters, motor vehicle accidents, or witnessing a crime or murder, to name a few. Even more significant is the exposure of toxic stress or stress that is very emotionally taxing toward early child and adolescent brain development. This type of stress can occur when a child is exposed to frequent and on-going episodes of adversity. Increased toxic stress can lead to increased developmental consequences. (Walkely et al., 2013) The results of this type of trauma later manifest into adult depression, social isolation, and socio-economic divisions and ultimately continue the cyclical nature of high crime and drug activity within neighborhoods. The result of childhood toxic stress cannot be more evident than in the research of Felitti et al. in the Adverse Childhood Experiences (ACE) study. For example, Felitti found that individuals who had experienced four or more categories of adverse effects had a four to 12-fold increased health risk for alcoholism, drug abuse, depression, and suicide attempt. (Felitti et al., 1998) Therefore, it is of the utmost importance to address/create prevention and intervention programs to foster individuals and improve their well-being.

## 1.3 SIGNIFICANCE OF STUDY

The goal of this paper is to build a framework, which will address the prevention and intervention toward trauma informed communities. Based on current literature reviews there is no system that incorporates a multi-dimensional view of well-being within a mobile application with the addition of a weighted questionnaire. This research will justify the usability of a mobile application with a newly designed well-being questionnaire with a weighted scoring system. If successful, it will be one of the first of

its kind to deploy a mobile application within the field to determine the well-being of trauma affected communities via a mobile questionnaire utilizing a weighted scoring function. Previous research in well-being has yielded numerous questionnaires that aim to address specific attributes related to well-being. (Bradburn 1969, Bradley 1989, Kaplan 1976, Ware 1992, Furlong 1998, WHOQoL 1993, PROMIS 2007) Some of these questionnaires apply a weighted scoring function.(Kopec, 2003) The creation of the Well-being, Relational, Stability, Competency Index (WRSC-I), which tries to measure the quality of life in five domains: physical, mental/emotional, relationships, spiritual and socioeconomic, is part of a larger project which aims to exhaustively assess well-being. (Peterson, 2017) This dissertation aims to develop a mobile based weighted scoring system to address the WRSC-I questionnaire. The outcomes of this research were used in the larger parent project called imHealthy to assess individuals and help identify interventions within at-risk populations. Furthermore, outside research can then incorporate this new methodology as a standard in quality of life and well-being research across the United States.

# 2.0 WELL-BEING THEORY

The dictionary definition of well-being is defined as the state of being happy, healthy, or prosperous. In this section, we attempt to look back at over a half century of theory and practice. Beginning with well-being theory, moving to adaptation theory, then the revision of it as seen by Diener et al., and lastly psychological well-being theory and subjective well-being theory.

## 2.1.1 Happiness

The area of well-being is complex and multifaceted. There are different viewpoints by many authors on key indicators of happiness, mood and overall well-being. To understand the roots of well-being research we need to go back to earlier work that took root post World War II. Going back to the work by Bradburn and his research on positive and negative affects against internal experiences has shown that happiness is an underlying goal of most people. (Bradburn, 1969) Bradburn's research states that well-being is affected independently between positive and negative effects. (Bradburn, 1969) Happiness is often a key measure of subjective well-being and many authors describe their research based on this term. Wessman's 1956 research on happiness concluded that

the three major effectors of happiness include family life, job satisfaction and social relationships. (Wessman, 1956) Wilson described happiness as "The happy person emerges as a young, healthy, well-educated, well-paid, extroverted, optimistic, worry-free, religious, married person with high self-esteem, high job morale, and modest aspirations, of either sex and of a wide range of intelligence." (Wilson, Pg. 294, 1967)

Bradburn based his research on reports of avowed happiness, summarizing that even though groups of people surveyed differed across time, the groups coming in and the groups going out showed stability in responses of happiness. In addition, he reported gamma coefficients in his reports of avowed happiness that remained steady across different times for the same individuals. (Bradburn, 1969) Diener's analysis of happiness suggests a positive effect over a negative and suggests that individuals may not be in a negative state due to motivational reasons and further states, "Approach tendencies must prevail in behavior for people to obtain food, shelter, social support, sex…". (Diener, Pg.184, 1996)

### 2.1.2 Subjective Well-Being

One of the key points of an individual's view on his or her life is indeed happiness or attaining happiness. The idea of well-being theory is rooted in subjective well-being. Subjective well-being (SWB) deals with individuals' cognitive judgments toward happiness in their lives, or life satisfaction. It is the daily emotional and psychological thoughts of an individual. It is affected by the individual's environment, and the SWB of one individual may be different among others geographically. Therefore, in many ways SWB is a catch all term, which defines the multifaceted cognitive and behavioral aspects

of one's life. In addition, it also deals with the positive and negative effects within an individual's daily life, with many times the positive effects outweighing the negative. (Diener, 2008) Diener also suggests that in assessing SWB one must look at multiple areas including positive effect, negative effect, life satisfaction and satisfaction among various domains such as an individual's health, job and personal relational factors, to name a few. (Diener et al, 1999) In addition, Andrews and Withey suggest that these areas of positive effect, negative effect and life satisfaction should be measured independently. (Andrews et al., 1976) Another view of a form of subjective happiness is that of Kahneman's "objective happiness" theory, or the aggregation of a subjective timeline. Kahneman posits that an outside observer can infer happiness levels by the temporal integral of instant utility (or the happiness level at a moment in time). (Kahneman, 1999)

The authors Bryant and Veroff tested the well-being theories of two populations two decades apart using confirmatory factor analysis with a three-factor model defined by unhappiness, strain, and personal inadequacy, and found that groups between the years 1957 and 1976 had similar defined factor loadings in the areas of general and marital unhappiness. They found that these factors load well to unhappiness and that psychological anxiety along with immobilization load well with strain and that marital inadequacies and self-shortcomings load well with personal inadequacies. Among the factors themselves, the study showed a moderate correlation (.29 to .46) for strain against the other two factors-unhappiness and personal inadequacy. (Bryant & Veroff, 1982)

### 2.1.3 Adaptation Theory

To understand well-being, specifically subjective well-being, we must go back to the work by Harry Helson on adaptation theory, in which he postulated that an individual's judgment toward stimuli are based on past experiences with such stimuli. (Helson 1948) Later, Brickman and Campbell added to adaptation theory by suggesting that individuals will react to good stimuli and bad stimuli for short amounts of time and eventually the individual will go back to neutral. Known as the "hedonic treadmill" Brickman and Campbell suggested that as individuals attain higher levels of success, then future expectations of happiness also rise, which results in a drop back to neutrality in terms of happiness. (Brickman et al., 1971)

### 2.1.4 Revision in Adaptation Theory

In work that is more recent however, Diener et al. explains needed changes to the treadmill model. (Diener, 2006) They suggest five modifications from previous thoughts on adaptation theory. They supplant that most individuals are happy most of the time and that they in fact do not move to a neutral plane because they maintain happiness, and the move down to neutral is not neutral at all, but positive. Secondly, personality correlates much stronger with well-being traits over other factors like demographics; thus, individuals may experience different levels of well-being simply based on personality traits. Third, Diener (Diener, 2006) states that happiness is not a unitary measure with a single set point to which individuals adapt. Rather, well-being can move in different directions and changes in one domain may not affect changes in another domain.

Diener's fourth revision goes against most of Brickman and Campbell's theory that an individual is doomed to never really attain long-term happiness. Rather, happiness does change for some individuals and major life events can improve life satisfaction for individuals in the long term. Lastly, individuals differ in how they adapt. Specifically, individual differences in coping strategies with negative events and an individual's personality affect how he or she adapts.

# 3.0 QUALITY OF LIFE AND WELL-BEING

Almost a half century ago, the World Health Organization (WHO) defined the term health as "a complete state of physical, mental and social well-being, and not merely the absence of disease or infirmity". (WHO, 1995) This definition is still important today as it affirms the notion that overall health and well-being is complex and has many interrelated components. To focus merely on disease is one aspect; however, another component is the mental, social and quality aspect of health. For example, in the RAND medical outcomes study (MOS) it showed relatively poor emotional well-being for patients who suffer from depression at baseline. When tested again two years later, those patients with major depression still showed relatively poor emotional well-being. (Hays et al., 2001) One of the early questionnaires to incorporate a psychological well-being survey was utilized in the Affect Balance Scale assessing happiness, devised by Bradburn. (Bradburn, 1969) Neugarten devised the 20-item Life Satisfaction Index (LSI) to be applied to adult life, which measured mood, life satisfaction and goal setting. (Neugarten et al., 1969) The Self Esteem Scale by Rosenberg consisted of a 10-item scale across a four-point answer selection continuum of *Strongly Agree to Strongly Disagree*. (Rosenberg, 1965) Levenson created the locus of control scales in the early 1970s consisting of an eight-item Likert type format with a six-item continuum of *strongly agree to strongly disagree*. (Levenson, 1974) One of the first modern well-

being questionnaires was created by Bradley, and was originally intended to be used in diabetes research. (Bradley, 1994) The WHO eventually endorsed this questionnaire to branch out to other domains outside of diabetes testing. The questionnaire itself as it pertains to well-being consists of six items related to a persons' positive well-being and utilizes a Likert scale for answers. The questions are limited to a person's outlook on his or her life and asks about a person's mood, daily goals/obstacles, and overall satisfaction with life.

Other questionnaires designed in the early 1990s include the short form survey 20 (SF-20), which includes 20 key items in assessing general well-being. (Stewart et al., 1988) The SF-36 (Ware et al., 1992) is most likely one of the most popular and well-known surveys in functional health and well-being. The SF-36 is a product of the medical outcomes study (MOS) (Tarlov et al., 1989) and measures eight areas of health and well-being. The SF-36 has many variants including the SF-12 and SF-6D. There is also a similar 36-item scale derived from the MOS by RAND. (Hays et al., 2001)

The WHO began designing an instrument to measure quality of life in the early 1990s. The result was the WHO quality of life measurement tool (WHOQOL) and it contained five key areas of focus. Those were: physical health, psychological health, level of independence, social relationships, and environment. (WHOQOL Group, 1993) Aside from the main tool, several modifications exist including the WHOQOL-BREF (WHOQOL Group, 1996), a shorter version of the main tool and the WHOQOL-OLD (Power et al., 2005), aimed at assessing older age groups.

The early pilot study by the WHOQOL Group yielded good item correlations and high Cronbach alphas. In addition to the data analyzed in the first study, a later

publication shed light on some of the most important items within the questionnaire. (Saxena et al., 2001) The WHOQOL questionnaire contains a psychological domain, which focuses on key areas such as positive feelings, self-esteem, bodily image, and negative feelings.

To assess current models and methodologies, attention must be placed on the National Institutes of Health (NIH) in building a comprehensive framework for patient reported outcomes, specifically, using these questionnaires in conjunction with disease research. The result of NIH's effort is the Patient Reported Outcomes Measurement Information System (PROMIS), which aims to address various domains including physical, mental, and social health. (Cella et al., 2007) Spearheaded by the NIH in early 2003, the PROMIS guidelines aim to create a standardized set of patient report outcomes (PRO) that can be used in a large spectrum of disease related to health-related quality of life (HRQL). The PROMIS framework consists of three broad, top-level domains, which are physical, mental and social. Within each of these top-level groupings are subdomains comprised of the PROMIS item bank version 1.0. Based on item bank version 1.0, the physical domain contains criteria for physical function, fatigue, sleep disturbance, and sleep related impairment. The mental health domain contains criteria related to anxiety, depression, and anger. Lastly, the social domain contains criteria for social function, which is broken down further into *ability to participate* and *satisfaction in participation*, which has a lineage to further define participation into *social roles* and *discretionary social activities*, respectively. (Cella, 2010) A thorough investigation by Pilkonis et al. for the calibration and development of three key areas of the emotional/behavioral domain for PROMIS (anger, anxiety and depression) was designed with sample values

for the short form and ordered by their respective slope (discrimination slope). (Pilkonis et al., 2011) Within the PROMIS domain set of mental health, is a subdomain listing of emotional distress, cognitive function, and positive psychological function. Surprisingly, many of the mental health subdomains have similarities to Fisher's spiritual well-being scale.

The surveys and questionnaires discussed in this section comprise some of the most well known and used in the past decade. None of them, however, except for SF-6D, uses a weighted approach.

## 3.1 MODERN INITIATIVES IN WELL-BEING UTILIZING A MOBILE PLATFORM

The past half-decade has seen an increase in mobile-based well-being solutions. Depending on the definition of well-being, a search of Google and Apple app stores will yield a plethora of apps. Most apps are geared toward exercise and stress management; others deal with nutrition; some focus on mental clarity through yoga and meditation; and, a few cater to the idea of well-being encompassed by the domains discussed in this dissertation; but, do not dive into the specificity required to address the individual well-being needs of trauma affected groups. For the purposes of this research, fitness and nutrition apps are not discussed. However, this discussion of well-being will focus on apps in which some of the core areas are included, such as mental or behavioral well-being, emotional well-being, etc. For example, the app BeWell (Lane et al., 2011) monitors various areas of well-being including sleep, physical activity, and social interaction via sensors on the phone. BeWell calculates scores for the different dimensions via a Gaussian function and linear regression. The score in each dimension is based on an exponentially weighted average of daily scores in each dimension.

Rickard et al. discusses the development of a mobile app to assess emotional well-being. (Rickard et al., 2016) The app, MoodPrism, captures a user's mood through various prompts; however, based on the research article, no mention of a weighted approach is given and not much detail is presented on how the app scores a patient. Another app, CopeSmart, was designed to address mood and coping in adolescents. (Kenny et al., 2016) Based on the research article, CopeSmart does not utilize a weighted scoring function and is based on an additive approach.

However, most modern well-being instruments that exist attempt to capture a well-rounded picture of a person's well-being, including the Heathway's Well-Being 5 instrument, which utilizes a survey instrument via mobile tablet/phone that incorporates a front-end reporting portal. (Sears et al., 2014)

# 4.0 WELL-BEING DOMAINS

Chapter 4 provides a brief overview of each domain used in this study. It is also important to examine the interconnected nature of well-being. In this section, the interconnected nature of well-being is demonstrated as different domains can influence other domains and share symbioses. This is important to note as later in this research the use of path analysis and structural equation modeling is discussed as it relates to these latent variables and their effects on one another.

## 4.1 SOCIO-ECONOMIC DOMAIN

Socio-economic status (SES) is an important variable in assessing well-being. For example, higher income and education is correlated with areas of subjective well-being. (Pinquart et al., 2000) (Clark et al., 2008b) SES affects domains of mental and behavioral health. Studies have shown correlations between deteriorating mental health and socio-economic status. (Ostler 2001, Butterworth 2009, Lorant 2003, Gilman et al., 2003, Lorant et al., 2007, Tomarken 2004, Meltzer 2010) Lorant et al. concluded that increased poverty, increased financial strain and ceasing to live with a partner increased the depression score significantly. (Lorant et al., 2007) A study assessing self-reported depression criteria in terms of SES showed that three key measures affect socio-economic

status. Those areas include household income, employment status, and education level. (Talala et al., 2009) Other studies have shown low SES, family disruption and residential instability as indicators of early childhood onset of depression. (Gilman et al., 2003) Economic pressure on families is correlated to problematic social behavior in young children in low-income communities. (Mistry et al,, 2002) In terms of housing instability, Pappa et al. has shown significant association to QoL, alongside increased material deprivation (lack of heating or electricity) and chronic disease, which also are significantly associated with QoL. (Pappa et al., 2015) A systematic review of housing stability in key areas such as warmth and energy efficiency and rehousing has shown improvements in overall health and mental stability. (Thomson et al., 2013) Furthermore, another study examined mortality in survey non-respondents and showed that education level, income status and marital status played a role in increased mortality. (Tolonen et al., 2009) In high-impoverished populations, having access to stable housing was found to be a significant SES in terms of QoL. (Baumstarck, 2015) Housing instability for adults results in increased anxiety and/or depression. (Burgard et al., 2012)

Physical activity is also linked to SES. Lower SES tends to show lower physical activity trends. (Salmon et al., 2005 Drenowatz et al., 2010 Gidlow et al., 2005) Especially children and adolescents in low SES trend lower in physical activity and trend higher in obesity and body mass index (BMI) then higher SES standing groups. (Drenowatz et al., 2010) As a corollary, low SES standing may have less parental involvement in adolescent physical activity (i.e. lack of transportation resources). (Salmon et al., 2005) (Taylor et al., 1994) Parental support seems to have a positive correlation on physical activity patterns in children and adolescents. (Mota, 1999) (Zhao

et al., 2013)

## 4.2 BEHAVIORAL DOMAIN

The behavioral domain, as it pertains to this research, deals with a subject's coping ability toward positive and negative reactions, exposure to traumatic events and the resilience to overcome obstacles in life. Negative thoughts and actions narrow the perceived state of the individual and tend to lower social and intellectual growth. Positive emotions can elicit a compounding effect that stacks over time, leading to increased future positive thinking. (Fredrickson, 2002) Behavioral well-being can also be culture based. Various studies have shown the relationship between cultural norms and the resulting emotional/behavioral characteristics that follow, with the consensus being emotional output varies by culture. (Mesquita, 2002, Diener 2003, Tov 2009) An important area of behavioral domain is child and adolescent development, since much of what happens to us in childhood can ultimately shape our behaviors into adolescence and adulthood. Parental mental health instability can have significant effects to the behavioral development of children. (Kahn et al., 2004) Children of depressed parents are at higher risk for depression, morbidity and mortality. (Weissman et al., 2016) In addition, maternal depression is associated with higher levels of physical symptoms during childhood, higher levels of minor stress, and greater risk of utilizing mental health services. (Lewinsohn et al., 2005)

Having adequate housing is another factor in behavioral well-being. Housing

instability has been shown to be a significant factor in emotional and psychological well-being, specifically in children and adolescents. (Ackerman, 1999) For children, housing instability research is even more important to analyze as it has the chance to impact early cognitive development. (Fowler et al., 2015) Foster care is another area of concern. Placement instability in foster care affects behavioral development. (Rubin et al., 2007) Socio-economic aspects of life do in fact affect post adolescent behavior. For example, housing mobility, or instability in young children and adolescents has a reaching impact into early adulthood function and an increase in risk-taking behavior (i.e. arrests). (Fowler et al., 2015)

## 4.3 SPIRITUAL DOMAIN

It has been shown that spirituality plays a key role in behavioral health (Koenig et al, 2012). Spirituality also plays a role in disease management, and furthermore, in coping with a specific health condition. (Crane 2009, Vachon 2008, Thune´-Boyle et al., 2006, Ahn et al., 2012) Thus, it is important to gather the inputs related to a patient's spiritual beliefs when assessing overall well-being. A study implemented by Kass et al. showed a strong relationship between spiritual domains and positive health outcomes. Specifically, regression analysis utilizing The Index of Core Spiritual Experiences (INSPIRIT) is associated with increased life satisfaction and decreased frequency of medical symptoms. (Kass et al., 1991) Moreover, studies have continued to show strong relationships with spiritual markers and various mental and emotional states; however, no tangible relationship has been seen with actual physical health diagnostics. (Tsuang, 2007)

In addition, spirituality may act as a protective factor against early mortality and coping skills. (Mueller 2001, Powell 2003) As specified by Moriera-Almeida and Koenig, two useful tools exist in capturing a patient's spiritual history.(Moreira-Almeida et al, 2014) The first is the FICA (Faith and Belief, Importance and Influence, Community, Address in care) assessment, which captures some key responses in the areas mentioned above. A few of the questions from each FICA domain are listed below:

*Faith and Belief - "Do you consider yourself spiritual or religious?"*

*Faith and Belief – "Do you have spiritual beliefs that help you cope with stress?"*

*Importance and Influence – "What importance does your faith or belief have in our life?"*

*Community – "Are you part of a spiritual or religious community?"*

*Address in Care – "How would you like me, your healthcare provider, to address these issues in your healthcare?"*

The second beneficial scale is the Royal College of Psychiatrists Assessment. (Culliford et al., 2014) This assessment has similar questions to the FICA assessment, such as, "Is the patient part of any religious community?" However, the main difference in this assessment is the addition of past and future events that may have shaped the spirituality of the patient. For example, a section labeled "The past" asks: "Emotional stress usually involves loss, or the threat of loss. Have you experienced any major losses or bereavements? What has been the effect, and what ways of coping have you tried?"

Fisher's four domain (4D) spirituality model (Fisher, 2011) aims to encompass the key areas of spiritual function. These include four domains with subdomains showing their correlation coefficients and percent favored by respondents.

This 4D model has been extensively used as a basis for multiple studies including the development of the Spiritual Well-Being Questionnaire (SWBQ), which improves on some shortcomings of the original 4D model (Gomez et al., 2002) and the 20 items SHALOM spiritual questionnaire (Fisher, 2010). Furthermore, Rowold's analysis using the Fisher/Gomez model further backs the validity of SWBQ. (Rowald et al., 2011)

Another important scale featuring spiritual well-being is the Daily Spiritual Experience Scale (DSES). (Underwood et al., 2002) This scale tries to attribute faith and spirituality across all religions, and the focus of the scale is the spiritual experience as opposed to a person's beliefs and behaviors. Based on the study conducted by Underwood, it was determined that out of the 16-item spirituality scale a few items had more relevance during implementation across the different sites. For example, two items, "I desire to be close to God or in union with Him" and "I am spiritually touched by the beauty of creation" had higher intra-class correlation coefficients (ICC) than other items on the scale. (Underwood et al., 2002) Other values with relevant ICCs include:

I feel God's presence.

I find strength in my religion or spirituality.

I find comfort in my religion or spirituality.

I feel deep inner peace or harmony.

I feel God's love for me, directly.

However, despite the importance of the spiritual domain in overall health assessments, some clinicians fail to address it. (Hathaway et al., 2004)

## 4.4 PHYSICAL DOMAIN

Physical well-being is an important attribute in every day functioning. Physical function includes every day movements such as walking, running, lifting and general movements. Improving exercise habits can lead to improved health among populations. Numerous studies have shown the effectiveness of increased exercise and its benefits to cardiovascular health, improved behavioral health, and the ability to protect against and/or delay specific health conditions such as, diabetes mellitus and certain cancers. (Hassmen et al., 2000, Eriksson et al., 1991, Schuler et al., 1992, Fox 1999) It is also important to investigate the link between physical well-being and emotional distress. A long history of studies over the past 30+ years have shown the benefits of physical exercise on emotional/mental well-being and the correlative effects cannot be disregarded. The benefits of physical exercise leading to improved mental health have been shown by numerous literatures. (Craft 1998, Farmer 1988, Strohle 2009, Paffenberger, Camacho 1991, Petruzzello 1991, Calfas 1994, Harris et al., 2006) Consequently, the same individuals with depression have higher likelihoods of a sedentary lifestyle. (Hassmen et al., 2000, Scully et al., 1998) Along the lines of psychological health Scheier et al. make the case that optimism in individuals increases their likelihood for improved physical well-being, be it post-surgical recovery or increased physical exercise.(Scheier et al, 1992) It is also important to determine the key attributes in assessing physical well-being. Many modern health surveys like the SF-36, SF-12 and SF-8 are considered short forms, which aid in quick turnaround time with less precision. (Ware, 2008) The SF-36 questionnaire consists of 36 key items with 10 out of 36 relating to physical function (PF). (Ware, 1998)

Similar to the SF-36 survey is the RAND 36-item survey. Gathered from the same longitudinal Medical Outcomes Study (MOS), the RAND 36-item survey is strikingly like the SF-36 with the additions of Energy/Fatigue items and Emotional well-being items. (Hays et al., 2001)

Doll looked at the role of emotional and physical well-being and correlations to obesity. (Doll et al., 2000) Doll used the SF-36 questionnaire, and the following dimensions served as key components to physical well-being: Physical functioning, Role physical, and Bodily pain. The results of the study showed the obvious conclusion of low scores for highly obese individuals in the physical categories. Furthermore, in low SES communities, increases in physical activity programs is shown to significantly benefit both physical and mental health in adolescents. (Bonhauser, 2005)

Another important aspect of physical well-being is the presence of fatigue. Fatigue plays a role in almost every individual's life. Fatigue can be a barrier to the progression of daily living in individuals; or in some cases, may be due to lack of proper sleep/rest; and in more extreme cases, is a direct result of a chronic disease. Therefore, because of the ubiquitous nature of fatigue in the population it is an important trait of physical well-being. Cella et al. looked at fatigue via the Functional Assessment of Chronic Illness Therapy (FACIT) Fatigue Scale, comparing fatigue severity across three domains of anemic cancer patients, non-anemic cancer patients, and the general population. (Cella et al., 2002) The FACIT Fatigue Scale consists of 13 items measuring fatigue in daily activity with a five-point Likert answer scale. As a subdomain in the PROMIS item bank, the fatigue subdomain originated from the FACIT cancer study. Cella et al., 2010)

Consequently, the importance of the FACIT scale has aided in the contribution

toward the PROMIS physical domain research study. (Cella et al., 2007) The PROMIS initiative has far reaching connections to past item banks including fatigue and pain. Another key area of focus for physical function is the occurrence of pain. The Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials (IMMPACT) has yielded numerous researches in pain assessment including a 13-item IMMPACT pain survey. (Turk et al., 2008) In addition, the survey also sheds light on the mental and emotional states of participants living with chronic pain. The web-based survey identified 13 key areas of pain and their average importance ratings. The rating scale is based on a 0-10 scale, where 0 = "not at all important" and 10 = "extremely important."

Chen later adapted the IMMPACT Pain Scale and the Core scales by combining them to help build the initial physical function research in the PROMIS early years design. (Chen et al., 2009)

The WHOQOL groups' effort in building a well-being questionnaire has yielded key attributes in the physical domain. The WHOQOL-100 physical domain consists of twelve questions in the areas of pain and discomfort, energy and fatigue and sleep and rest. (WHOQOL Group, 1998)

Stewart et al. developed the 20-item short form survey (SF-20) which addresses multiple areas in well-being, specifically related to the physical domain. (Stewart et al., 1988)

## 4.5 RELATIONAL DOMAIN

The relational domain is important in overall well-being because it defines the social connections that individuals share with one another but also the intimate relationships with their partners. Furthermore, studies have shown an increased risk of mortality in individuals with low quantity, low quality social relationships. (House et al., 1988, Holt-Lunstadt 2010, Kawachi et al., 1996) Intimate relationships can significantly influence psychological well-being between adult partners. (Khaleque, 2004)

Evidence also suggests an interconnected link between physical pain from social rejection. (MacDonald et al., 2005) Social support has been found to be an important criterion for maintaining interpersonal connections and activities during times of severe chronic illness (i.e. cancer). (Hahn et al., 2005) Positive social support and interpersonal relationships help to foster psychological well-being. (Turner 1981, Seeman 1996, Cohen et al., 1985, Schaefer et al., 1981)

In addition to the link between mortality risk and social relationships, there also exists a link between relational domains and socio-economic standing. Kawachi discusses an increased mortality risk because of the eroding "social capital", or involvement in a social organization, norms of reciprocity, and trust in others as direct results of low socio-economic standing due to income inequality. (Kawachi et al., 1997)

## 5.0 ON WEIGHTED WELL-BEING QUESTIONNAIRES

When assessing overall well-being, a questionnaire can be a valuable tool in gathering data about the individual. A wellness questionnaire serves tremendous purposes in understanding the health lifecycle of an individual and at times can be the prerequisite needed to determine disease and/or a current disease state in an individual. Thus, it is equally important to be able to quantify and gain meaning from the questionnaire being used. For a questionnaire to be concise, thorough and valid, it needs to have a simple, yet well designed scoring system. It needs to be accurate, reliable, and applicable to multiple domains. Most questionnaires use very simple additive models to gather the total score. A simple sum of values can be enough to group an individual into a category. Other questionnaires may employ a slightly more sophisticated method of scoring an individual. Preference weighting is seen in various notable quality of life questionnaires. (Kaplan et al., 1989, Anderson et al 1989, Dolan 1997, Furlong et al., 1998, Brazier et al., 1998, Brazier et al., 2004, Sintonen 2001) The weights are derived from patient sample responses to health-related quality of life (HRQoL) questions. The authors of these questionnaires have applied multivariate statistics in determining the final weights for the scoring functions. Others like Hirsch et al. designed a questionnaire and scoring system to assess asthmatic patients. Regression analysis was conducted to determine weights for the questions that correlated with asthmatic symptoms. (Hirsch et al., 2004) In a 2002

colorectal screening study a questionnaire was used to gather patient information related to symptoms of colorectal cancer. The study used a subjective approach to analyze multiple symptom variables. The weights were determined via a proprietary score based on the clinical experience. "The score is derived subjectively by weighting of symptoms and symptom complexes in relation to the likelihood of cancer outcome." (Selvachandran et al., 2002)

Most designed surveys will differ slightly in how they apply general scoring or weighted scoring across items. However, they most certainly always apply a summation or an average. For example, the patient health questionnaire (PHQ-9) uses a summation score to determine depression severity (with the additional aid of cut-off points to determine major vs. minor depression). (Spitzer et al., 1999) In the domain of pain assessment, one of the major contributions to pain scales is the McGill Pain Questionnaire which defines a patient's pain rating via descriptive words and a score associated with each. (Melzack, 1975) The scoring is simple and is based on a summed total of all values. The RAND 36-item short form and SF-36 surveys are derived from the same source (MOS); however, their scoring methods differ slightly. The RAND version uses a two-step process to generate a score. First, the answers selected are recoded to fall between 0-100. Next, following the 8-scale averaging chart, the response is averaged, respectively.

### 5.1.1 Preference Weights

The process of preference weighting is a mathematical technique in which survey data given to consumers to rank various attributes are converted to weighted values for an

item. A preference weight is a mathematical value derived from the preference of a population and denotes a social judgment of importance. Kaplan (Kaplan et al., 1976) believes in the importance of weighting to achieve content validity and states, "A measure that distinguishes 'better' from 'worse' is impossible to create without using weights, at least implicitly. Use of any scales of dysfunction without measures of relative importance omits a critical element of content validity and introduces substantial bias by assuming equal weights among the items." A few takeaways that Kaplan's research has established are:

It has been shown that preferences can be measured reliably (r = .91) and that preferences are generalizable across different social groups. (Kaplan et al., 1976)

### 5.1.2 Quality Well-being Questionnaire (QWB)

The QWB is one of the most well-known well-being scales. Its weighting technique goes back to a prior study (Kaplan et al., 1976) and the designing of the Index of Well-being (IWB), whereby function levels and preference weighting for assessing well-being were defined. The IWB was based on a weighted average function to determine well-being for a given population. Shown in Figure 1 below:

$$W = \frac{1}{N}\sum_{j=1}^{J} W_j N_j \qquad (2)$$

where $N$ is the total number of persons in a population
$N_j$ is the number of persons in each function level $j$, $j = 1, \ldots, J$
$W_j$ is the social preference weight for each function level $j$, $j = 1, \ldots, J$
$J$ is the total number of function levels

**Figure 1.** IWB symptom-standardized function for population well-being

One such preference-weighted questionnaire is the Quality Well-being Questionnaire (QWB-SA). (Anderson et al., 1989) The weights were created via preference weighting on a cohort of individuals within the population. The weighting is comprised of four areas: a mobility scale, physical activity scale, social scale and problem complexes.

The general formula follows an additive approach for the final calculation. The top weighted question from each section is selected and inputted into the formula below:

$$W = 1 + (CPXwt) + (MOBwt) + (PACwt) + (SACwt)$$

The scale severity levels (Appendix B) and scale weights and definitions for the QWB questionnaire were taken from (Anderson et al., 1989) and are shown in Appendix C.

### 5.1.3 Health Utility Index Third Iteration (HUI3)

Like the QWB (in terms of preference weighting) and the QoL questionnaire is the HUI3. (Furlong, 1998) The number 3 in HUI3 denoting the third iteration from the first two counter parts. The HUI3 captures QoL components that include vision, hearing, speech, ambulation, dexterity, emotion, cognition and pain. Each component has a level description with the max in each category being a level 5 or level 6, denoting complete loss of function in relation to the domains previously mentioned. In relation to this research, three of the eight values are most significant in terms of QoL comparison. They are shown in Table 1 below.

**Table 1.** HUI3 Severity Levels

| **Emotion** | |
|---|---|
| 1 | Happy and interested in life |
| 2 | Somewhat happy |
| 3 | Somewhat unhappy |
| 4 | Very unhappy |
| 5 | So unhappy that life is not worthwhile |
| | |
| **Cognition** | |
| 1 | Able to remember most things, think clearly and solve day-to-day problems. |
| 2 | Able to remember most things, but have a little difficulty when trying to think and solve day to day problems |
| 3 | Somewhat forgetful, but able to think clearly and solve day to day problems |
| 4 | Somewhat forgetful, and have a little difficulty when trying to think or solve day to day problems |
| 5 | Very forgetful, and have great difficulty when trying to think or solve day to day problems |
| 6 | Unable to remember anything at all, and unable to think or solve day to day problems |
| | |
| **Pain** | |
| 1 | Free of pain and discomfort |
| 2 | Mild to moderate pain that prevents no activities |
| 3 | Moderate pain that prevents a few activities |
| 4 | Moderate to severe pain that prevents some activities |
| 5 | Severe pain that prevents most activities. |

The HUI3 is based on a multiplicative multi-attribute utility function shown below. Once a patient selects an attribute level within each of the eight domains, then the score for that attribute level is substituted into the function here. $\mathbf{u^* = 1.371 (b_1 \times b_3 \times b_3 \times b_4 \times b_5 \times b_6 \times b_7 \times b_8) - 0.371.}$ An example of HUI3 scoring method taken from Furlong et al. is shown in Appendix F.

The HUI3 falls into the category of multi-attribute utility theory (MAUT). The importance of the HUI3 scoring function is seen in the use of MAUT, specifically in conjunction with the standard gamble (SG) application. SG is known to be a good analog to health utilities (interrater=.77, test-retest=.80) (Garza et al., 2003).

### 5.1.4 EQ-5D

The EQ-5D is a tool to measure health related quality of life (HRQoL)(EuroQol Group, 1990). It consists of five dimensions: mobility, self-care, usual activities, pain, and anxiety/depression, each of which has three levels of severity. Each severity level has a weight assigned to it. The EQ-5D's scoring function follows an additive approach such that there are two constants within the formula and five weighted values, as shown below. Unlike the HUI3, EQ-5D uses

$$\mathbf{1 + C_1 + C_2 + W_1 + W_2 + W_3 + W_4 + W_5}$$

The EQ-5D domains and weights are listed below:

**Table 2.** EQ-5D Domains and Weights

| | Mobility | Self-care | Usual Activities | Pain | Anxiety/Depression |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | -0.069 | -0.104 | -0.036 | -0.123 | -0.071 |
| 3 | -0.314 | -0.214 | -0.094 | -0.386 | -0.236 |
| | | | | | |
| Constant 1 | -.081 or 0 (full health) | | | | |
| Constant 2 | -.269 or 0 (if the state does not contain level 3) | | | | |

### 5.1.5 15D

The 15D is a self-administered 15-dimensional measure of health-related quality of life. (Sintonen, 2001) It is on par with most of the weighted questionnaires discussed in this section. The 15D score represents overall HRQoL on a scale of 0-1 (0 = death and 1 = no problems found) and is calculated by using population preference weighting. The valuation of the 15D is based on multi-attribute utility theory (MUT). Preference weighting was conducted by subjects using an importance scale (0-100 ration scale). Individual values given by subjects for each dimension were averaged and then transformed so that the sum of the weights was equal to 1. The formula itself takes an additive approach shown in Figure 2 below. Information in the Figure below was taken from the Sintonen paper cited previously.

$$v_H = \sum_j I_j(x_j)[w_j(x_j)]$$

where $I_j(x_j)$ = the average relative importance people attach to various levels of dimension j (j = 1, 2,..,15), and $w_j(x_j)$ = the average value people place on various levels of dimension j.

**Figure 2.** 15D scoring function

# 6.0 CONFIRMATORY FACTOR ANALYSIS

The psychological sciences are a complex branch of study involving multiple relationships and complex activity within the human brain, which even today, are still difficult to truly categorize and pattern out. Often it is difficult to quantify relationships between complex topics such as spiritual well-being, relational well-being, and behavioral well-being because of the interconnected complex web of synapses that occurs. However, we can begin to shed some light utilizing techniques in confirmatory factor analysis (CFA). CFA is used to test how well measured variables represent the actual construct. Because exploratory factor analysis (EFA) and CFA share similar methods in design it is often difficult to denote a clear separation between the two methods. However, utilization of maximum likelihood (ML) or generalized least squares (GLS) can be thought of as the movement toward CFA, in that resulting factors and then goodness of fit can be tested. (Anderson et al., 1988)

In defining a model, EFA is used as an exploratory technique to determine an appropriate number of factors to be used and generally occurs much earlier in the process of CFA. (Brown, 2014) After EFA, CFA can be considered a correlative technique and usually a precursor to structural equation modeling (SEM). (Hoyle, 1995) In the psychological sciences and psychometric testing CFA is often utilized where multiple latent variables may exist without any knowledge of their influence on one another.

(Babyak et al 1993, Hopko et al 2003, Kline 2004, Scott et al 2016, Raykov 2001)

# 7.0 STRUCTURAL EQUATION MODELING

Often psychological domains such as the ones in this study are complex and have multiple relationships with one another. In addition, the very thing being studied in the psychological domain has correlative factors in areas such as personal, socio-cultural, and relational factors. (Weston, 2006) In statistics SEM is a type of multivariate statistical technique in testing hypotheses about relationships among observed and latent variables. (Bentler 1980, Bentler 2010, Hoyle, 1995) And unlike other statistical approaches, SEM is not a one stop statistical method, but rather is comprised of multiple techniques such as factor analysis, path analysis, and multivariate regression. In research such as this, often involving multiple variables (in our case domains) which are multi-faceted and of which we do not know the true relationships among the domains, and to avoid the potential for error, SEM is used to infer on these relationships. In fields such as psychology in which multiple complex systems are at work with latent variables, employing SEM can help define the relationships among these latent variables through observed ones. (Hancock, 2003) It is often described as an umbrella term in which areas of path analysis, factor analysis, and confirmatory factor analysis converge. (Schumacker et al., 2004) Furthermore, research has shown that the psychological space can benefit from causal models which give the opportunity to test complex relationships. (Fassinger, 1987)

On the area of sample size prior to performing SEM, it is widely contended that a large sample size is key. Issues arising from small sample sizes may include failure of estimation

convergence, improper solutions such as negative variance estimates and correlations > 1.0 or < -1.0 and small statistical power. (Wang et al., 2012) Wang and others state however that there is no consensus on a true value for sample size. Hoyle (Hoyle 1999) suggests it is possible to conduct advanced statistical functions on small sample sizes, while various other authors contend a sample size around 100 to 150. (Ding et al, 1995) In addition, Kline suggests that 10 to 20 participants be used per estimated parameter. Meaning that if there were 10 parameters, then the total participants should be around 10 x 10 = 100 participants. (Kline, 2004) However, to deal with smaller sample sizes Jung proposes applying a regularized extension of two-stage least squares estimation. The use of this method is particularly suited for smaller sample sizes due to its ability to integrate a ridge type of regularization into 2SLS. (Jung, 2012) Lastly, in a simulation study Holtmann found that a Bayesian approach to model estimation in comparison to traditional ML and WLSMV (weighted least squares, mean and variance adjusted) performed about the same for smaller sample sizes. Regarding performance Holtmann states, "For continuous indicators, Bayesian estimation did not show performance advantages over ML. For categorical indicators, Bayesian estimation outperformed WLSMV solely in case of strongly informative accurate priors." (Holtmann et al, 2016)

The process of SEM is often made up of five parts, and this is a general agreement among many researchers. (Teo et al., 2011, Schumacker & Lomax, 2004)

#### 7.1.1.1 SEM Model Specification

Beginning with model specification a path analysis diagram is created to show the hypothesis being tested. For future studies of this research, SEM will determine the impact and relationships of five well-being domains and their influence in determining overall well-being for a patient. Prior to conducting the SEM, model specifications should be determined using the five

domains of well-being and their observed variables in the form of subdomains. The hypothesized model for this paper states that the five domains used in this research have a direct effect on each other in shaping overall well-being. Future model specifications may be built using the path diagram shown in Appendix E. Model specification is the starting point for almost all SEM methods. One or two-way arrows denote the paths. The arrows connect latent variables, denoted by ellipsis, (the unknowns, or things being measured) to the observed variables (known), denoted by squares. Each known variable also has a measurement error associated with it, denoted by smaller circles attached via one-way arrows to the observed variables. In this first step, the model is formally stated.

#### 7.1.1.2 SEM Model Identification

Model identification is the next step in the five-step process. In the area of SEM, a model is known to be identified when there is at least one solution for each parameter. However, in this space it is best to have a model that is over identified (df > 0); that is, more than one optimal solution exists for each parameter estimate. It is good to have an over identified model when testing the hypothesis because merely "identifying" the model may not yield the desired result. Simply identifying a model means that df = 0 and a solution to equations are possible; however, testing for goodness of fit cannot be done. A researcher may push for the over identified model because there is a possibility of the model being incorrect and allows the identification of other parameter estimates, which may provide better fit. Moreover, if the model, which is over identified, turns out to be correct then there is more evidence to support your hypothesis. In this phase, it is suggested the SEM model be over identified, rather than under identified (lack of information). As Teo states (Teo, 2011), "Models need to be over identified in order to be estimated and in order to test hypotheses about the relationships among variables." The formula

used to compute elements in the correlation matrix is defined as ($p$ (p + 1))/2, where $p$ is the number of observed variables.

#### 7.1.1.3 SEM Model Estimation

In step 3, model estimation, the goal as Teo states (Teo, 2011), is to produce an estimated model-implied covariance matrix that resembles an estimated sample covariance matrix of the observed, with the residual matrix being as small as possible. It is also quite normal for this phase to be run using a common software package, such as AMOS, LISREL or SAS, to name a few. It is also in this phase that one would expect a normal distribution of the data and given this, a common approach is to use variations of ML; although as stated earlier, depending on the sample size, estimation methods may vary. The model estimation step is an iterative process, which reaches a stoppage point once minimum fitting criterion is achieved. In order to estimate the model, Maximum Likelihood Estimation (ML) can be used. In utilizing ML, it may be assumed that the sample size will be rather large, say near 1000 observations. However, a model may have under 1000 observations. In this case, a different estimation approach may be needed. A regularized extension of two-stage least squares (2SLS) estimation may be used to effectively handle the smaller sample sizes. Good model fit is attained when the difference between the observed (observed variables) and implied variance-covariance matrices residuals is minimized. Start values will be created to initiate the first run of the model. After the first run of estimation, a new set of estimates are created to produce a new model variance-covariance, which is then compared to the previous. This process is continued until the residuals are small enough where no new estimates improve from the previous run.

#### 7.1.1.4 SEM Model Testing

Step 4 of the SEM process is known as model fit or model evaluation. In this stage Teo states (Teo, 2011) "…the researcher wishes to compare the predicted model covariance (from the specified model) with the sample covariance matrix (from the obtained data)". In this step, a variety of fit models may be applied where appropriate. The Chi-Square ($\chi^2$) test to assess model fit is the most common; however, it comes with a few issues when dealing with sample size, especially in large sample sizes. The Chi-Square test usually rejects the model for large samples and in small samples lacks the power to discriminate between good fit vs. poor fit. Due to this sensitivity in sample size, other model fit tests exist. (Hooper, 2008) The root mean square error of approximation (RMSEA) tells us how well parameter estimates would fit the sample covariance matrix. In addition, RMSEA works well in situations with a large *df*, however, when dealing with a small *df* and small sample size RMSEA often indicates a poor fitting model. (Kenny et al., 2015)

The Normed Fit Index (NFI) and Non-Normed Fit Index (NNFI) are two other fit indices. An NFI = 1 indicates a well-fitted model and an improvement over the independence model. The NFI is affected by sample size, but overcomes this in using the NNFI model.

The comparative fit index (CFI). Interestingly CFI avoids the underestimation of fit often noted in small samples for Bentler and Bonnett's (1980) normed fit index. CFI can be comparable to NNFI, but is also less affected by sample size. (Hooper, 2008)

The goodness-of-fit-index (GFI) measures the number of variances and covariance in the covariance matrix. A value between 0 and 1 is usually stated with higher values indicating good fit, with .97 indicating good fit. The GFI will also decrease with increasing model complexity.

Figures 3 and 4 below describe a SEM model taken from Teo. (Teo, 2011) with the corresponding model fit measurements. Multiple fit indices may be utilized to determine an acceptable model.

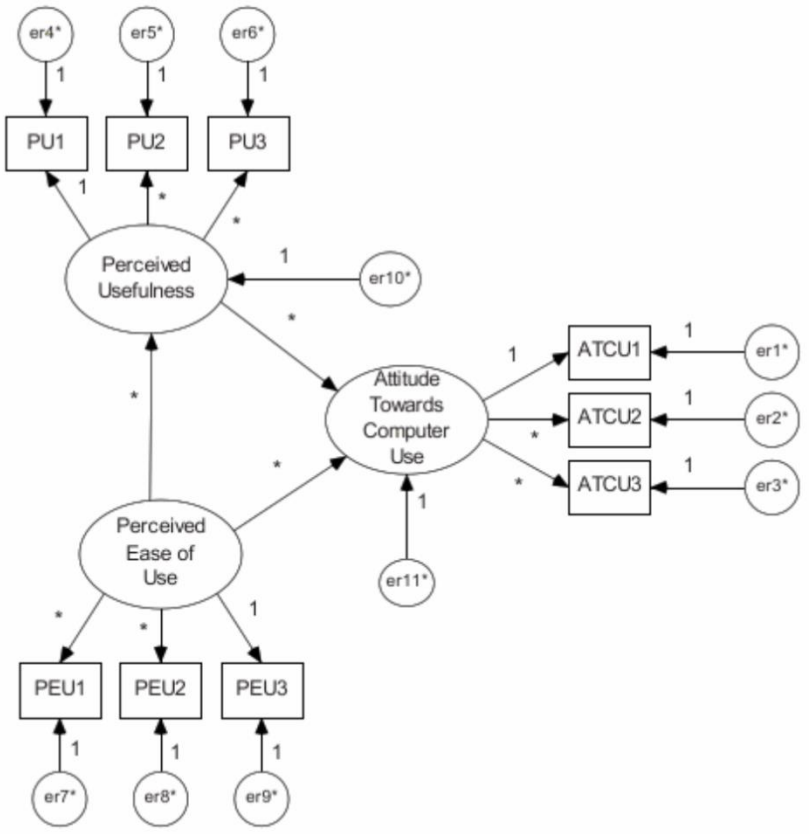



**Figure 3.** Example SEM model from Teo 2011

| Fit Index | Model in Figure 3 | Recommended level | Reference |
|---|---|---|---|
| $\chi^2$ | 61.135, significant | Non-significant | Hair et al. (2006) |
| GFI | .94 | < .95 | Schumacker & Lomax (2004) |
| AGFI | .89 | < .95 | Schumacker & Lomax (2004) |
| SRMR | .04 | < .08 | Hu & Bentler (1998) |
| RMSEA | .08 | < .07 | Hair et al. (2006) |
| CFI | .97 | > .95 | Schumacker & Lomax (2004) |
| TLI | .95 | > .95 | Schumacker & Lomax (2004) |

*Note: GFI= Goodness-of-Fit; AGFI=Adjusted Goodness-of-Fit; SRMR=Standardized Root Mean Residual; RMAES= Root Mean Square Error of Approximation; CFI=Comparative Fit Index; TLI=Tucker-Lewis Index*

**Figure 4.** Model fit indices for Figure 3

#### 7.1.1.5 SEM Model Modification

In the last step of SEM modeling- modification- the goal is to retest the SEM model and adjust the hypothesis if the model fit is not correct. In this process, parameters will be adjusted in order to achieve a good model fit. In addition, Teo states (Teo, 2011), "Additionally, parameters could be changed from fixed to free or from free to fixed. However, these must be done carefully since adjusting a model after initial testing increases the chance of making a Type I error." SEM model modification will be conducted through three possible statistical tools. A decision will be made between using either AMOS, Stata, or R to conduct model modification.

# 8.0 PRELIMINARY WORK

## 8.1 DEVELOPMENT OF A SURVEY BASED MOBILE APP FOR TRAUMA AFFECTED COMMUNITIES: A USABILITY STUDY

### 8.1.1 Introduction

Individual assessment of health and well-being has far-reaching capabilities and has shown to improve with increased community satisfaction. (Theodori, 2001) However, manual evaluation to assess well-being is time consuming, involves housing and maintaining large numbers of documents, and furthermore, physically performing records management can be costly.

TACs represent a disparaged sector of society, which has seen significant economic distress and personal loss. In order to effect change, the standard approach to health and welfare needs to be re-designed. Due to the low socio-economic standing, groups within these sectors have similarities with disparaged nations outside of the United States. As a corollary, many third world countries, which struggle economically to receive health and well-being care, have embraced mobile technology as a means to rebuild lacking infrastructure. Due to the shear cost of an actual person-hour, mobile devices can bridge the gap and act as a source of productivity. Mobile health technologies can be leveraged to aid in health assessment. (Luxton et al 2011, Milosevic et al., 2011, Rajput et al., 2012, Brian et al., 2014, Kallander et al., 2013, Larson-

Cooper 2016) The mobile phone is now embedded into human culture and almost all individuals who use a mobile device daily share a close symbiosis with their personalized device even to a point of addiction. (Leung et al., 2015, Choliz 2010) According to the Pew Research Center (PRC), as of October 2014, 64% of American adults own a smartphone. Ninety percent of American adults own a cell phone and 42% own a tablet computer. (Pew Research Center, 2015) Furthermore, analysis by PRC suggests that Americans, especially young adults, rely on their mobile devices exclusively for Internet activity. (Pew Research Center, 2017) In 2011, the National Institutes of Health (NIH) began to sponsor workshops aimed to better understand the mobile health applications' ability to improve health. The ubiquitous nature of mobile applications is helping to contribute to this movement to help transform healthcare assessment and overall health and well-being.

The goal of this research is to provide quality health and well-being assessment to TACs, while at the same time controlling costs. Studies similar to the one described in this dissertation, although not purely aimed at TACs, have suggested success in implementing mobile devices in socio-economic disparaged areas throughout the world. (Douglas et al 2003, Douglas et al 2010, Douglas et al 2011, Waters et al 2010, Manda et al 2011, Piette et al 2012, McKay et al 2008, Blaya et al 2010, Driessen et al 2013, Landis et al 2015, Gadabu et al 2014, Tilly et al 2012) In addition, these studies have shown that mobile based technologies can often times succeed in acting as the missing link in areas without proper infrastructure.

The imHealthy evaluation system represents an entire ecosystem of both mobile technologies coupled with various other software components. The imHealthy evaluation system is made up of various components to assess overall well-being including an open electronic medical record (EHR), a mobile application of a well-being questionnaire, and a relational

database tying all the components together, which are then pushed into an evaluation engine that will display results via a web portal. This gathered and quantified data can then be used to apply localized and personal interventions. In utilizing the imHealthy model, we will be able to assess the health and well-being of individuals, families and communities and to then recommend a path for personalized interventions.

### 8.1.2 Requirements Analysis

Prior to the implementation of a mobile app, the users of the system would interact with the patients and gather data via paper forms. They would create patient lists, and manually go through the paper questionnaire, etc. The goal of the app will be to facilitate the real-world functions of the users more efficiently, while at the same time maintaining the privacy and security of patients and their data. The mobile app is a digital representation of the real-world form and as such allows further refinements that a physical copy will not accomplish. Furthermore, the app must be easy to use, and navigation should be quick and fluid. The app should not be a burden over the standard paper form. The data generated from the app will be stored remotely. The data stored in the remote database will feed various agents, such as the web portal to show basic analytics on patient activity. Below are the key areas that the app must mimic.

The requirement analysis includes:

1. Authorization of who accesses the system
    a. Not storing personal information within the app. A unique identifier is created for each patient. Patient information is stored in a database on a different server.

b. The patients cannot be identified by the app data alone.

c. Authorized personal, social workers or behavioral health community organizers (BHCOs) enter the data. Patients do not work with the app; they simply respond to the BHCO who asks them the questions. In the future, this may change to a patient self-assessment procedure.

2. Large number of question sets

a. Because of the large number of questions, multiple questions will be placed onto one page. Single question sets will not be created since this will create an exhaustive number of pages per question.

b. Questions are split into domains and within those domains exists subdomains. (Peterson, 2017)

i. *Domains* – The survey has five domains and each domain has a set of subdomains associated with it. A user working with a patient will traverse through the main domains. This is the high-level view of the survey.

ii. *Subdomains* – Domains consist of subdomains. Subdomains are bucketed areas that contain all the questions. One or more questions can belong to a subdomain. For example, the Physical Domain is broken up into smaller subdomains like pain, fatigue and medication; the behavioral domain contains the subdomains' positive reactions, negative reactions, traumatic events and resilience.

3. Simplicity of Use

4. A design requirement is to make this questionnaire as simple to use as possible. This must take the place of the paper format and, therefore, a justification for speed, reliability and ease of use must be accomplished.
5. Scalable creating a large social network
    a. BHCOs will target the single patient and then lead to the assessment of the family, the patient, and then the street block, followed by the city and then the state and even the country as a whole.
6. Accessibility built in to address the cohort using the app
    a. Must address usability issues for older users (such as readability of font size, background color and general usability of user interface components).
7. Data collection and results to server
    a. The server handles all the data storage and analytics.
    b. The system is not limited by the power of the mobile app alone; rather, other components play a role (powerful external servers).

*Users and Patients* – The user of the system is the trained BHCO. They work with the patient to gather vital data and enter it into the mobile app. A BHCO can work with one or more patients. The patients are the key demographic of data collection for the app.

*Questions* – Most the questions should be simple to read and quick to answer. Additionally, a question can trigger a follow-up question(s). For example, if question 2 of the first domain is answered, a follow-up question will also need to be answered. Below is an example of a question with a follow-up question taken from the WRSCI questionnaire.

*Do you smoke cigarettes? (If no, skip the next question).*

*If you do smoke, how many cigarettes do you smoke in one day?*

Not all questions will have a follow-up. Some questions should allow for user input (for example a textbox-based question). Each question should have the ability to be reset (have the option to have "No Answer"), since not all questions will be answered.

### 8.1.3 System Design

The app design revolves around a core set of requirements established to collect information while at the same time privately store individual related information. The app serves as a data collection tool in a client server environment. Below are the design requirements for the mobile app.

1. Prior to a live patient assessment on the app, authorized personnel input the survey participant's private information into a separate secure server. The system assigns a generic ID to the survey participant keeping his/her data safe. The app receives the generic ID associated with the participant.
2. Due to the large amount of question sets, all the loading and storing of questions is done remotely and accessed by the mobile app. A separate database table houses all the questions.
    a. The structure of the database is built based on a standard star schema model, with various dimension and fact tables.
3. The app presents a simplified design to be more efficient than the paper counterpart . Areas of simplicity include:

a. Large fonts for better readability

b. Distinct background colors to make text easily readable

c. Large drop-down menus for easy and quick selection

d. A Linear navigation pane that pulls out via swipe gestures or a single button press

4. The app captures user input and via REST api submits to database server.

All of the analytics is performed on the server. The app simply acts as a data collection tool. Future enhancements can increase app functionality to provide some analytics, if needed.

## 8.2 USABILITY METHODS

The purpose of this study was to test the usability of a mobile application against a cohort of participants who would be using the app in the field. Originally, there was a middle phase in between phases 1 and 2, but due to data inconsistency and no change from phase 1, we decided to negate this middle phase and only use data from phase 1 to phase 2.

### 8.2.1 Study Participants and Inclusion Criteria

Inclusion criteria included an English-speaking cohort of varying age and gender who participate at the Focus Pittsburgh Free Health Center (FPFHC) where survey participants will be triaged. (Nine subjects participated in the usability study and all had backgrounds as BHCOs); in phase 2, two participants were lost due to scheduling conflicts. The study participants represent the target audience of the app itself, as they are the point of contact with the survey participants in real world scenarios. The BHCOs work at the FPFHC to triage patients and other individuals in the community to the center for treatment if needed. . Almost all the subjects use mobile devices on a daily basis and have used a smartphone device or tablet for over five years. The subjects make up a varying demographic background as shown in Table 3.

**Table 3.** Demographics and mobile phone use characteristics of sample (N=9)

| | |
|---|---|
| Female | 56% (5) |
| Male | 44% (4) |
| Age Group | |
| 18-24 | 11% (1) |
| 25-34 | 22% (2) |
| 35-44 | 22% (2) |
| 45-55 | 11% (1) |
| Over 55 | 33% (3) |
| Education Level | |
| GED | 11% (1) |
| BS | 22% (2) |
| MS | 44% (4) |
| PHD | 22% (2) |
| Mean years using mobile device (with standard deviation) | 8.4 (5.2) |
| <= 10 years | 77% (2.6) |
| > 10 years | 22% (5.6) |
| How often do you use a tablet? | |
| Daily | 88% (8) |
| Occasionally | 11% (1) |

### 8.2.2 Task Scenarios and Video Recording

Phase 1 of the usability study consisted of seven tasks involving an Android- based tablet. The prototype app was designed and loaded on the tablet. A server running on the laptop initiated the database and started the emulator running on to the tablet via WIFI. An overhead camera was used to capture the user's tactile response with the mobile app. The camera proved to be an invaluable resource in this study as it helped to aid retro- analysis of each user's initial learning curve with the app. The time on task data was gathered via a retrospective analysis of the video recordings. Video recordings were also used to time subjects on various task scenarios.

Phase 1 consisted of seven tasks aimed to test the major components of the app (Table 4). The study began with talk- aloud scenarios, as the principal investigator would read aloud each task scenario, followed with the subject completing the task. After the participant completed one task he/she was asked several follow-up questions and to rate the experience. Each subject was also timed on four key areas, which made up all of the tasks. Timed tasks included initial login into the app, traversing between domains, traversing between pages inside domains, and lastly, logging out. All tasks were carried out on a 9-inch Google Nexus tablet.

**Table 4.** Phase 1 Usability Tasks

| | Task | Description |
|---|---|---|
| Task 1 | Authentication | Users were given a user ID and password and asked to log into the app. |
| Task 2 | Patient Selection | Upon login, users are presented with a patient list. They are asked to select specific patients. |
| Task 3 | Navigation and User Interface User Interface (UI) | Users are asked to complete sets of tasks related to navigation across different pages and interact with various UI components. |
| Task 4 | Font Size Preference | Users are asked to traverse pages selecting their most preferred font size. |
| Task 5 | Background Color and Font Style | Users are asked to traverse pages selecting the preferred background color. |
| Task 6 | Typography | Users are asked to traverse pages selecting their most preferred font style. |
| Task 7 | Logout | Users are asked to logout of the app. |

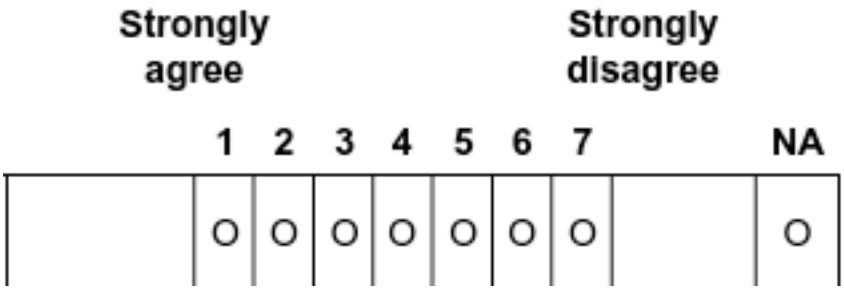
During phase 2 of the usability study, the tasks listed in Table 4 were optimized, since some phase 1 tasks were to gather user preferences. The task list for phase 2 is shown in Table 5.

**Table 5.** Phase 2 Usability Tasks

| | Task | Description |
|---|---|---|
| Task 1 | Authentication | Users are given a user ID and password and asked to log into the app. |
| Task 2 | Patient Selection | Upon login, users are presented with a patient list. They are asked to select specific patients. |
| Task 3 | Navigation and User Interface (UI) | Users are asked to complete sets of tasks related to navigation across different pages and also interact with various UI components. |
| Task 4 | Logout | Users are asked to logout of the app. |

At the end of each study, session participants were asked to complete the IBM Post-Study System Usability Questionnaire (PSSUQ). The PSSUQ (Table 6 was used to measure participants' overall satisfaction with the mobile app. The PSSUQ scores on a 7-point scale, where the lower the response, the higher a subject's satisfaction with the system.

**Table 6.** IBM PSSUQ Survey




1. Overall, I am satisfied with how easy it is to use this system.
2. It was simple to use this system.
3. I could effectively complete the tasks and scenarios using this system.
4. I was able to complete the tasks and scenarios quickly using this system.
5. I was able to efficiently complete the tasks and scenarios using this system.
6. I felt comfortable using this system.
7. It was easy to learn to use this system.
8. I believe I could become productive quickly using this system.
9. The system gave error messages that clearly told me how to fix problems.
10. Whenever I made a mistake using the system, I could recover easily and quickly.
11. The information (such as on-line help, on-screen messages, and other documentation) provided with this system was clear.
12. It was easy to find the information I needed.
13. The information provided for the system was easy to understand.
14. The information was effective in helping me complete the tasks and scenarios.
15. The organization of information on the system screens was clear.
16. The interface of this system was pleasant.
17. I liked using the interface of this system.
18. This system has all the functions and capabilities I expect it to have.
19. Overall, I am satisfied with this system.

### 8.2.3 Data Analysis

Descriptive statistics were used in all phases of the results. The average time on task for scenarios was used to show the effectiveness and usability of the mobile app. Within the PSSUQ results (Appendix D), averages and standard deviations (SD) were used. The SD was used to show dispersion of the data between users and between questions.

# 9.0 METHODOLOGY

The makeup of the app was discussed in the previous section and sets the stage for the next phase of this research, which is to build the weights and the scoring function associated with the questions in the mobile app. After the data has been saved to the server via the mobile app, then the process of building the well-being score (WBS) starts, which is comprised of four main steps:

1. Assign an answer weight to the selected answer to a question. Similar weighted answer levels were seen in weighted questionnaires such as the QWB, HUI3, EQ-5D, 15D and SF-6D.
2. Question weights are derived via an expert panel and community outreach.
3. The domain score was derived by multiplying the answer weights with the question weight.
4. The domain weight was assigned via expert raters.
5. The assigned domain weight was multiplied by each respective domain score to create the final WBS score. A WBS score equal to 1 represents good well-being and a score of 0 represents a failing score.

## 9.2 DERIVATION OF A WEIGHTING FORMULA

### 9.2.1 Answer Weights Calculation

In this study, the answer selected in the WRSCI questionnaire represents varying levels of patient states. For example, if a patient selects "Not at all" in response to "Are you limited physically", that response would represent a low severity situation for that patient. The answer weight is the first step in building our scoring function. Depending on how a patient answers a question, a weight will be applied.

The answer levels, $R_w$ for this research yield(Table 7):

**Table 7.** Answer level weights

| Severity Level | Weight |
|---|---|
| 1 | 1 |
| 2 | 0.83 |
| 3 | 0.69 |
| 4 | 0.58 |

A higher weight would be assigned to a better answer response, such as the example above. Moreover, a lower weight would be given to less preferred answers. For example, taking the sample question "Are you limited physically", an answer of "Extreme Amount" would be given a lower weight. The answer weights listed on Table 7 can be reversed depending on the context

of the question. For example, Table 8 shows the weight application based on the context of the question being asked.

**Table 8.** Weight ($\boldsymbol{R_w}$) assignments based on question context

| **Question** | **Answer Weight Assigned** | | | |
|---|---|---|---|---|
| | Not at all | Moderate amount | Very much | Extreme amount |
| To what extent do you feel that physical pain prevents you from what you need to do? | 1 | 0.83 | 0.69 | 0.58 |
| Do you have enough energy for everyday activities? | 0.58 | 0.69 | 0.83 | 1 |

### 9.2.2 Question Weights Calculation

The development of the question weight occurs via two sources and two adjustment variables (beta and gamma). The questions weights were assigned via expert raters and community panel members. The expert rater group is quite diverse with backgrounds in medicine, university research, and members of the local health clinic. Some of the expert raters are made up of individuals who work closely with the trauma affected population on a daily basis. The second group of individuals whose rating was considered are the community members. The community members were made up of patients who live within the trauma affected community. These patients attend the local health clinic and represent a cohort that is affected by the issues relating to trauma. The question score denoted by $Q_w$ was built by taking, $\beta * E_W$ which represents the expert weighted assessment of the question and lastly $\gamma * C_W$ which represents the community preference weight. The $Q_w$ was derived via a summation of the expert and community rated values.

$$Q_w = \sum(\beta E_W + \gamma C_W)$$

### 9.2.3 Domain Score Calculation

The WRSCI questionnaire contains roughly 100 questions with each question broken up among five domains. The domain score $D_s$ represents the summation of a patient's answer weight multiplied by the question weight generated in the previous section. Each domain will have a unique total score. The domain score was normalized and used to calculate the final well-being score.

$$D_s = \sum R_w * Q_w$$

The domain score was normalized:

$$X' = \frac{X - X_{min}}{X - X_{min}}$$

### 9.2.4 Domain Weight Calculation

The domain weight calculation represents the final weight assigned to each domain. This is different from the derived value of $D_s$, which represents the summation of the question weight times answer weight. Utilizing expert raters and a community panel, domain weights were assigned to each domain and adjusted via beta and gamma, respectively. Using the formula below, we attain the domain weight $D_w$.

$$D_w = \sum( \beta E_W + \gamma C_W)$$

### 9.2.5 WRSCI Wellness Score Calculation

The previous section outlined the first of three steps in building our wellness score formula. The wellness score was derived once the domain score and domain weights have been calculated.

A final score determines a patient's well-being. A higher score signifies good well-being and a low score signifies poor well-being and the need for possible interventions. The final scoring function is represented as:

$$WBS = \sum D_s * D_w$$

$WBS$ is the final calculated risk score for an individual. $D_s$ represents the domain score calculated in the beginning of the score building process, as the summation of the answer level, $R_w$ , multiplied by the question weight $Q_w$. $D_W$ represents the domain weight assigned via experts and the community panel. The score in this study was based on expert and community member preferences and is similar to other surveys utilizing patient population preference weighting.

## 9.3 PREFERENCE WEIGHTING STUDY PARTICIPANTS

Upon IRB approval, a cohort of 10-15 individuals from the trauma community were assembled to preference rate each question on a scale of 1 through 10. The given responses from these patients made up part of the scoring function described in the above methods section, which involves question weighting.

Inclusion Criteria:

- Patient is included in the current patient mix of trauma affected individuals at FOCUS Pittsburgh
- Permission from FOCUS to approach patient
- Patient agrees to sign informed consent

Exclusion Criteria:

- Under the age of 18
- Current BHCO member at FOCUS Pittsburgh

### 9.3.1 Study Procedure

In a previous study, prior to the start of this study, a consent form and background questionnaire was administered to study participants to gather demographic and baseline information. Prior to the start, participants were asked to rate each question based on importance to their own needs. The survey was administered via Qualtrics. Similar to how the expert raters assigned an importance value, the community panel in this study answered the same set of questions while utilizing the Qualtrics survey tools.

## 9.4 WEB PORTAL PILOT TESTING

### 9.4.1 Introduction

The importance of web portal usability testing is to ensure the user can easily interact with the website, and more importantly, continue to come back and use the web portal for the life of the project. According to Nielson, if the website is difficult to use, or the user does not know the purpose of the website, or if a user gets lost in the website, or if the information on the site is hard to read or does not answer a user's questions, then the user will leave. (Nielson, Usability 101 website) The purpose of the web portal as it pertains to this research is to serve as the single point of data entry and administration. The BHCO administrator will use the web portal to register BHCOs, create patient profiles, assign a patient to a BHCO and update both BHCO and patient information. Those are the main administrator functions. In addition to the BHCO administrator, BHCOs themselves will also sign into the web portal to view patient analytics with the patient and/or do general account maintenance such as changing his/her password. A non-administrator will not have access to patient registry and updating functionality.

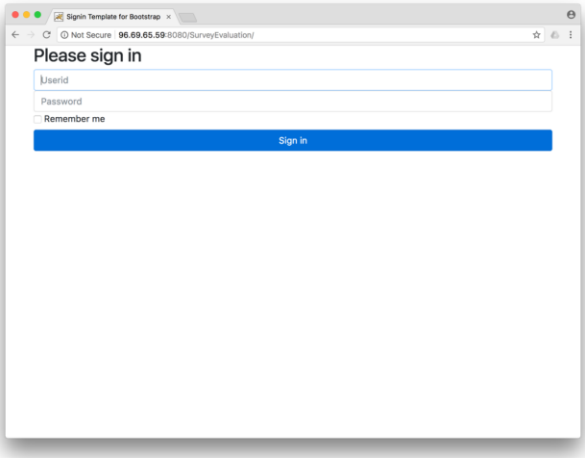
One of the main benefits of using this web portal is that it will completely eliminate paper entry. All information will be updated via web-based forms and stored on a database on the central server.

### 9.4.2 Pilot Testing

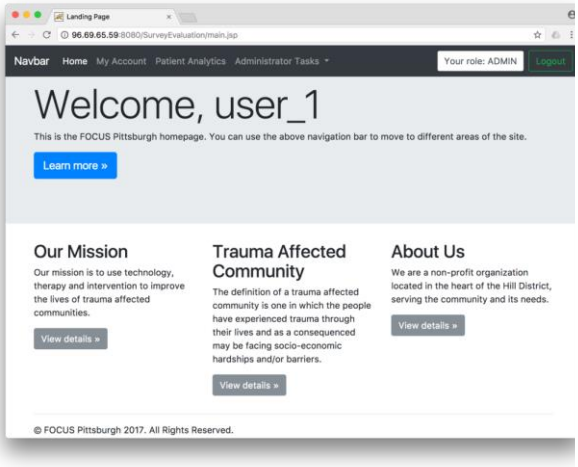
The final version of the designed web portal was built with ease of use and easy navigation in mind. Table 9 shows the final layout of the web portal pages which was seen during task scenarios.

**Table 9.** Web Portal Layouts

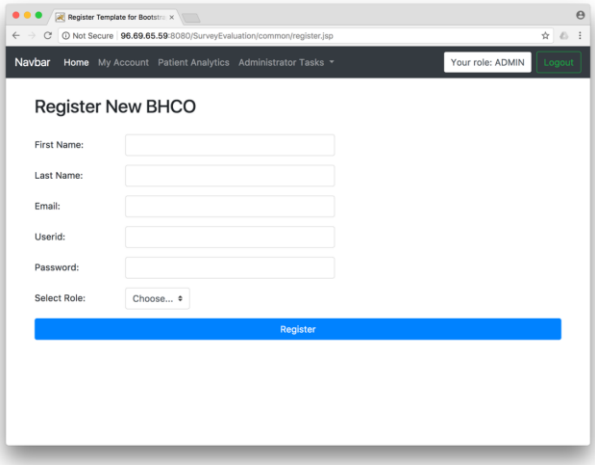
9a. Login Page



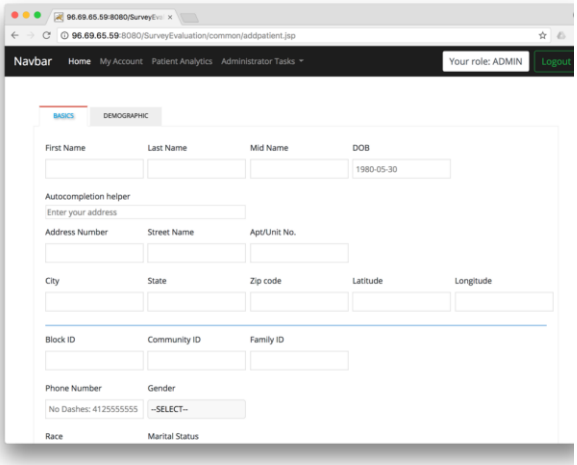

9b. Main Landing Page



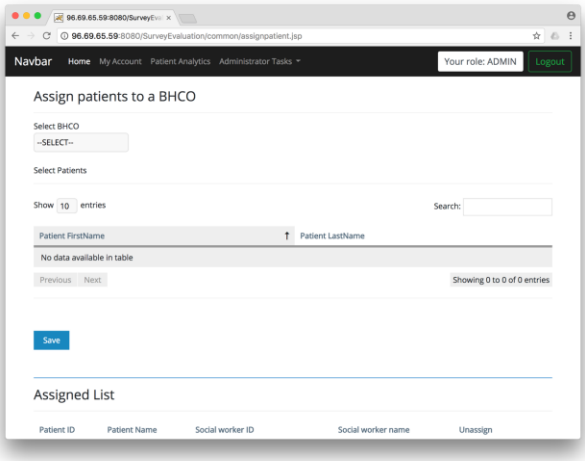

9c. BHCO Registration Page



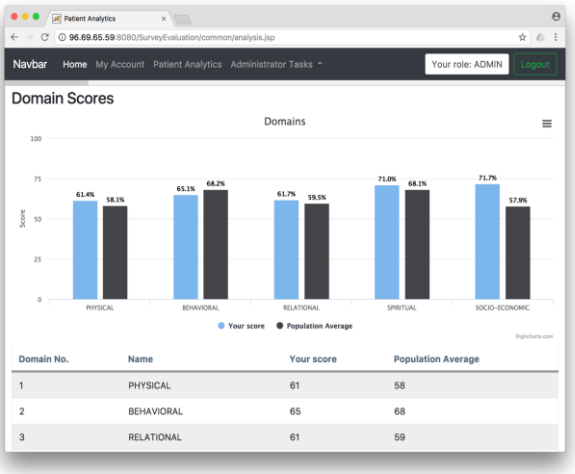

9d. Patient Registration Page



9e. Assign Patient Page




9f. Patient Analytics Page




The web portal will present the BHCO with various administrative functions including patient entry into the system and the ability to update information about the patient. It will also produce an analytic dashboard that will show various metrics regarding patient trends (see Table 9). The proposed pilot study was aimed at the acceptability, usability and satisfaction of the patient web portal. The intervention consisted of a set of tasks such as registering and updating information about BHCOs and their assigned patients. In addition, the web portal also supports reporting analytics such as displaying domain scores for a patient and the final overall well-being score. The portal was created to allow BHCOs to teach, both for themselves and to the patient, the results of the survey session. It is meant to be user friendly and a clinical tool during assessment. During the pilot testing, the BHCOs were given a unique user account for themselves and asked to complete the tasks listed in Table 10. The web portal serves as the final point in reporting all of the information that has been collected and processed within the WRSCI system.

The main expected outcomes are adherence to using the web portal as a source of information output and summarization. In addition, the second outcome to achieve will be the acceptability of the web portal system with the BHCOs. Upon completion of the portal usability tasks each BHCO was asked to complete the Computer System Usability Questionnaire (CSUQ) to determine satisfaction in using the system (Appendix G). To determine user satisfaction, descriptive statistics were utilized based on post survey questionnaires.

**Table 10.** Usability tasks for web portal

| | Task | Description |
|---|---|---|
| Task 1 | Authentication | Users will be given a user ID and password and asked to log into the portal |
| Task 2 | Register BHCO | Participant will be asked to register a BHCO |
| Task 3 | Register a patient | BHCO will add a new patient into the system |
| Task 4 | Assign a patient | Patient will be assigned to a BHCO |
| Task 5 | Interpret Analytics | Generate the patient's well-being scores |
| Task 6 | Update BHCO info | Update a BHCOs information |
| Task 7 | Logout | Logout of the system |

### 9.4.3 The After-Scenario Questionnaire (ASQ)

Upon completion of each task, the user was asked to complete a three-item questionnaire known as the After-Scenario Questionnaire (ASQ), developed by Lewis et al. (Lewis, 1995) The ASQ

is used to assess user satisfaction following a task/scenario. The items are set up in 7-point graphical scales with “Strongly Agree” for 1 and “Strongly Disagree” for 7. A lower score is better. One of the benefits of the ASQ is that it gathers key metrics on user satisfaction without sacrificing question fatigue on the part of the user. It is quick and allows the user to focus back on the next set of usability tasks. The ASQ is shown in Appendix H.

### 9.4.4 The CSUQ Questionnaire

Upon completion of the entire study, each participant was also asked to complete the 19-item CSUQ questionnaire shown in Appendix G. The CSUQ measures the satisfaction of the entire system, and like the ASQ, lower scores are better. We used all four scales of the CSUQ, shown in Figure 5 below.

| Score Name | Average the Responses to: |
|---|---|
| OVERALL | Items 1 through 19 |
| SYSUSE | Items 1 through 8 |
| INFOQUAL | Items 9 through 15 |
| INTERQUAL | Items 16 through 18 |

**Figure 5.** CSUQ Scales

## 9.5 RESULTS

### 9.5.1 Specific Aim 1 Results

**Specific Aim 1:** Perform a usability study to determine the barriers and discover issues with the mobile app interface and ease of use.

Users were tested on key majority items that would affect readability and interaction. For example, typography was one area in which users were tested. Users' preferences were rated on the fonts within the app. Next, we wanted to simply test background color preferences for optimal text readability. In the initial design of the app, we had a much smaller font, which was difficult for most of the study cohort to read. Based on the results, most (86%) of the cohort preferred the largest sized font. Various user interface components were tested to determine whether it was easy to interact with the items. Lastly, the amount of button presses needed to get specific interface items to respond was tested. Often the issue of response from an item is inherent to the hardware layers in conjunction with tactile feedback. It was found that a drop-down list posed a slight response challenge depending on the height and width of the UI component. The issue was corrected by centering the item and increasing the size of the UI item.

Logging into the app overall was well received. Users had some issue finding symbol keys (i.e. underscore) using the Android keyboard. The inability to quickly find specific keys may be due to the unfamiliarity with the Android keyboard layout; however, having had previous experience with mobile devices it was perceived that users would be aware of key placement on a QWERTY keyboard regardless of the operating system being used (Android, iOS or even

Windows). This unfamiliarity with the keyboard layout also caused increased time for logging in (on average a user spent over one minute typing in their login information). (Table 11).

During Task 2 (item selection), some basic issues arose that were overlooked during the initial design of the app. First, the design of the radio button answer values was based on an increasing Likert type scale. That is, numbers were placed next to the radio buttons originally. This proved to be a challenge, as most users preferred a text-based Likert scale. Secondly, during the design of the app, a counter was created to denote how many questions users had left to answer (Figure 6).


**Figure 6.** Counter showing questions unanswered

Some participants mistook this for the page number on which they were located. Third, dropdowns also posed an issue in the sizing, placement and background color of the drop-downs. Most users had issues selecting the main page drop-down, which controlled page movement. It was too small and difficult for all participants to easily select and move among the pages. Furthermore, the placement and background color of other drop-downs made it difficult for participants to easily find and select them. This proved to be the main usability issue for participants and created long lapses in response. During navigation between pages, some users also had difficulty reading the size of the fonts on the drop-down values themselves since they were too small. The page drop-down box was placed too close to the actual questionnaire and the questions "unanswered" counter (Figure 9). In confusion, a few participants clicked outside of

the touch area, which contained the drop-down menu itself. Participants also had difficulty touching the area to activate the drop-down accurately. In addition, the original drop-down box to switch among pages did not show the page number, so users had to mentally keep track of where they were. These minor design inconsistencies affected the time on task for each user. On average, it took about five seconds to select a value from the domains navigation pane; and, it took an average of twenty-three seconds to move among pages using the page drop-down list. Table 11 shows the time on task for users trying to press the drop-downs and receive a response (i.e. Navigation within areas). User 3 was a clear outlier due to a recent eye procedure.

**Table 11.** Phase 1 Usability Tasks (seconds)

| | Login | Navigation between areas (domains) | Navigation within areas (pages) | Logout |
|---|---|---|---|---|
| User1 | 66 | 3 | 27 | 19 |
| User2 | 49 | 4.5 | 34 | 21 |
| User3 | 263 | 5 | 60 | 62 |
| User4 | 64 | 10 | 17 | 10 |
| User5 | 24 | 14.5 | 28 | 24 |
| User6 | 36 | 2 | 12 | 2 |
| User7 | 34 | 3 | 6 | 3 |
| User8 | 41 | 2.5 | 17 | 7 |
| User9 | 49 | 1 | 6 | 11 |
| **Total** | **626** | **45.5** | **207** | **159** |
| **Average** | **69.56** | **5.06** | **23.00** | **17.67** |

Outside of page navigation, the main navigation pane (MNP) was straightforward for most users. The MNP controlled top-level movement among areas (domains). Based on the time on task in Table 11, most users (77% of users) were able to quickly find and select the components on the MNP. This quick response time may have been because values on the MNP were listed sequentially with appropriate spacing among values and no further UI manipulation was required. Lastly, our logout button was positioned in a small menu at the top right-hand corner. We timed users' ability to logout. Most could find the logout button menu, possibly due

to experiences of logging out on other apps. However, some users had trouble finding it and proceeded to press randomly on specific parts of the screen waiting for an interaction to occur.

Results of the task scenarios are shown in Table 12. It includes a summary of users' given preference on a 4-point Likert scale. It should be noted that nine people rated the response in Phase 1. Each section of the task scenario process ended with asking the user's preferred UI style, out of a best possible score of 36 (N = 9). For example, when a user completed a section on font preference (typography), they were asked to score their rating on a 4-point Likert scale for each font class. Most users preferred NotoSerif and Roboto font types. Each question on the questionnaire is housed within a UI component referred to as a listview. A listview can be thought of as a blank placeholder for values. Each listview has a background, and almost everyone preferred to look at white listview, given darker fonts. Users also preferred larger fonts overall, and that may be due to the majority of users being of older age (Table 3). Overall, the ease of use of the overall UI was good, except for the drop-down lists. Lastly, on average a user pressed a drop-down at least two times in order to get a response. The preferences gathered from these scenarios were used in modifying the app in Phase 2 of this usability study.

**Table 12.** User Interface Preferences of Sample (N=9)

| | |
|---|---|
| Typography Preference (Out of possible score of 36) | |
| Roboto | 77% (28) |
| NotoSerif | 81% (29) |
| NotoSans | 64% (23) |
| Helvetica | 64% (23) |
| Avenir | 61% (22) |
| Background Color Preference (Listview items, out of best possible 36) | |
| White | 94% (34) |
| Off White | 69% (25) |
| Dark | 44% (16) |
| Font Size Preference (Out of best possible 36) | |
| 14pt | 42% (15) |
| 16pt | 61% (22) |
| 20pt | 86% (31) |
| User Interface Ease of Use (Out of best possible 36) | |
| Radio buttons | 83% (30) |
| Drop-down List | 64% (23) |
| Slide-out Navigation | 94% (34) |
| Sliders | 86% (31) |
| # Drop-down presses till response (How many times a user had to press the page drop-down box until a response was returned from the app, N = 9) | |
| Avg. # of presses | 2 |
| Min. presses | 1 |
| Max. presses | 4 |

Within Phase 2 all the major issues from Phase 1 were included and a finalized mobile app, which included larger fonts, larger drop-down menus and easier navigational cues was

presented to the subjects. The logout button was consolidated into the main slide-out navigation window. This allowed us to remove any extra menu items from the taskbar. Having only one navigation pane simplified the user experience. The page selection drop-down also posed an issue in Phase 1 mainly due to its small size and location on the screen. It was important to separate anything related to page numbers from any other integer/counter-based interface items to limit confusion. In Phase 2, we enlarged the drop-down item and scaled it horizontally almost all the way to the width of the tablet. Figures 7 and 8 show the pre-and post (Phase 1, Phase 2) UI design changes running on a 9-in. tablet (respectively).

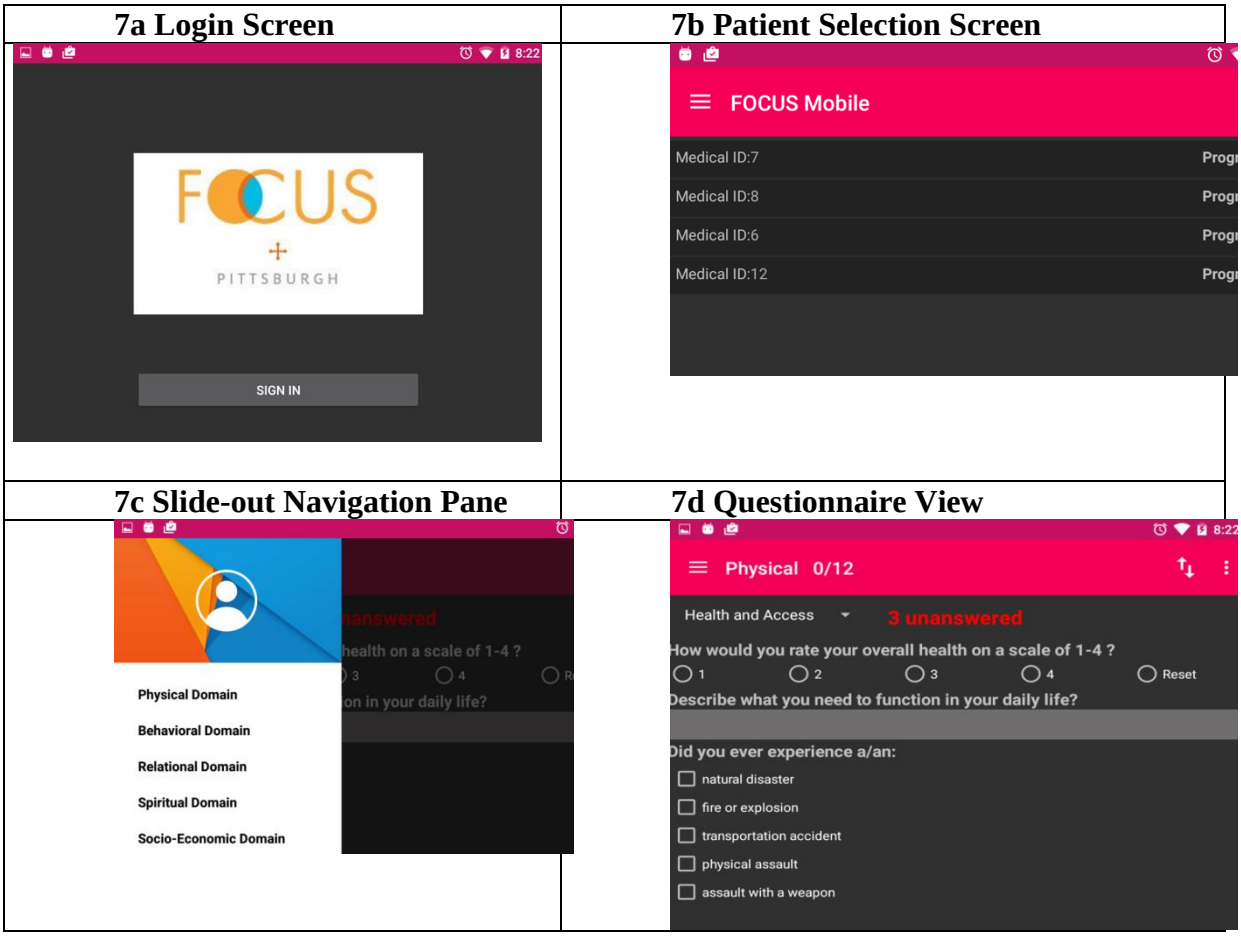



Figure 7. **Phase 1 initial UI design**

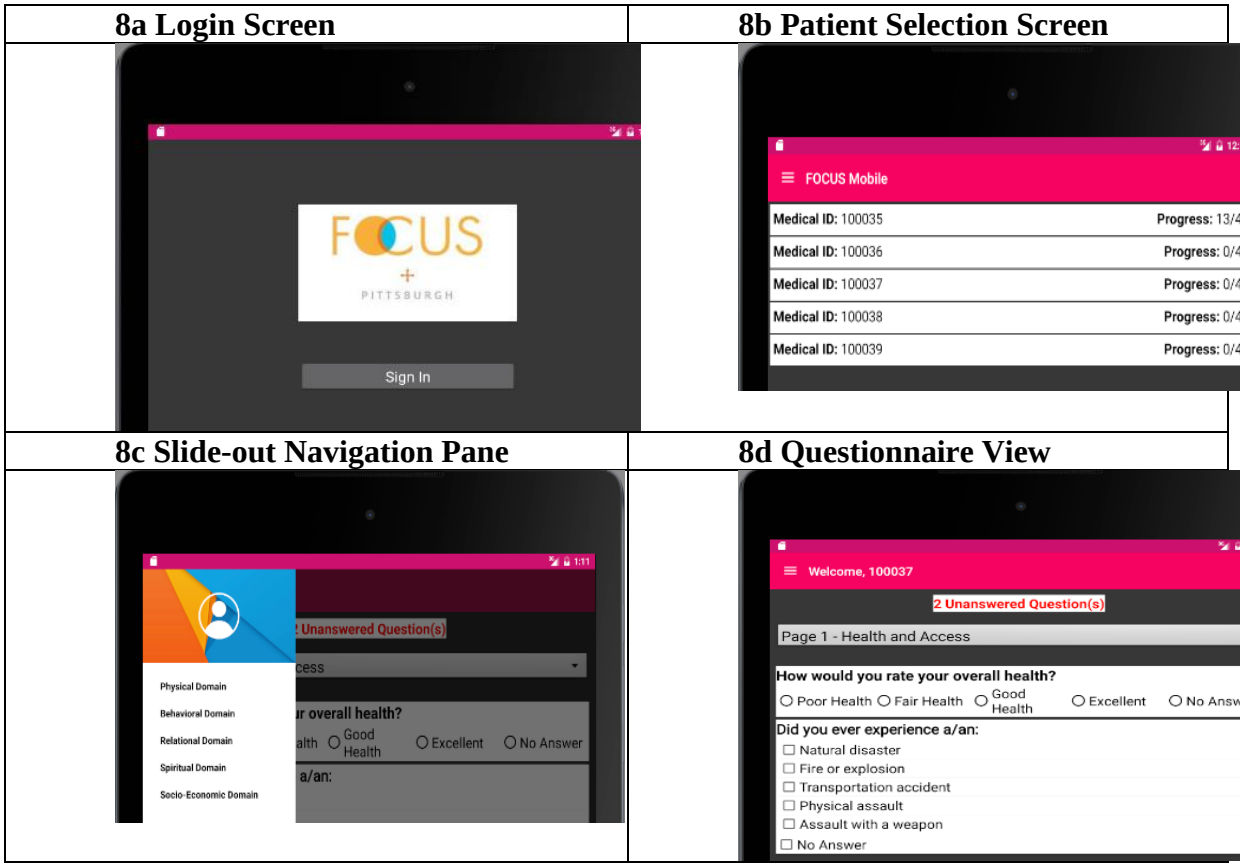



Figure 8. **Phase 2-post UI design**

Users who had issues with the app in Phase 1 saw them significantly reduced in Phase 2, mainly to UI enhancement. Furthermore, textual cues on the actual drop-down not only told them about the page number, but a brief description of the page was listed as well. It should be noted that one user who was an outlier in some tasks in Phase 1 continued to be an outlier in Phase 2 as well. This specific user ran into capacitive touch issues with the screen itself, mainly due to quick presses, which were not registering with the touchscreen. In addition, some users would at times accidently have another section of their hand (lower palm) touch the screen that would

cause the screen to register a touch, negate the current action, and cause them to restart the action. The time on task scenarios for Phase 2 are shown in Table 13 below.

**Table 13.** Phase 2 Initial Time on Task (seconds)

| | Login | Navigation between areas (domains) | Navigation within areas (pages) | Logout |
|---|---|---|---|---|
| User1 | DNF | DNF | DNF | DNF |
| User2 | 52 | 3.5 | 1.47 | 4 |
| User3 | 140 | 8.81 | 25.72 | 9 |
| User4 | 25 | 4.91 | 2.23 | 4 |
| User5 | 40 | 2.41 | 2.34 | 7 |
| User6 | 15 | 1.87 | 2 | 2.3 |
| User7 | DNF | DNF | DNF | DNF |
| User8 | 12.37 | 2.6 | 1.3 | 7 |
| User9 | 23 | 1.9 | 2.3 | 3.16 |
| **Total** | **307.37** | **26** | **37.36** | **36.46** |
| **Average** | **43.91** | **3.71** | **5.34** | **5.21** |

In comparison to the time on task of Phase 1, a significant drop in time to completion was seen, most likely due to a decrease in the initial learning curve and UI updates. The total time spent logging into the app dropped by 50%; navigation among domains dropped by 43%, navigation within pages dropped 82% and overall total time to logout dropped by 44%. Table 14 shows a breakdown of the various components that were rated during the talk aloud task scenarios in Phase 2 and their respective results. We see strong agreement in all areas of the update design.

For example, Figure 9 shows the redesigned page drop-down, which allows participants to move among pages. This change helped to reduce the time taken to complete many of the tasks.

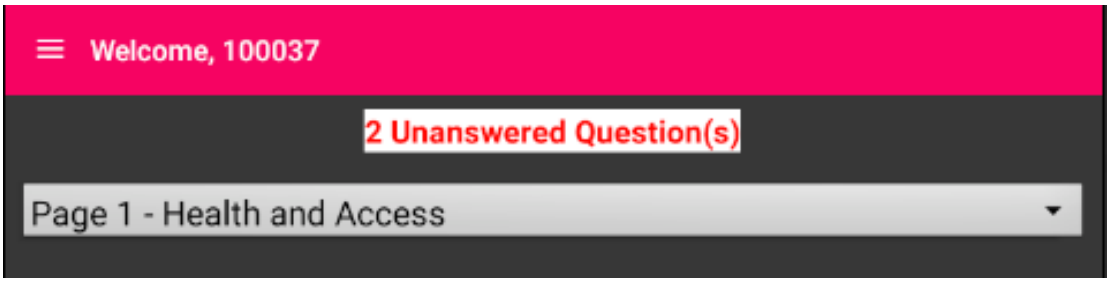



**Figure 9.** Phase 2-page navigation drop-down re-position

Overall, Phase 2 proved the turning point for a successful completion to the usability study per the IBM PSSUQ survey. The results in Phase 1 of the PSSUQ (Appendix D) are fairly scattered with issues still being present in the app build and is further backed by the dispersion of the SD value. In Phase 2, there is a clear distinction toward overall agreement of ease of use. In Phase 2 the SD saw a 62% decrease from Phase 1 (SD = 1.25 in Phase 1 vs. SD = .48 in Phase 2).

Almost all users (83% of participants) rated the app well.

**Table 14.** Phase 2 User Interface Preferences of Sample (N=7)

| | |
|---|---|
| **Answers easy to select** | |
| Strongly Agree | 57% (4) |
| Agree | 43% (3) |
| Disagree | 0% |
| Strongly Disagree | 0% |
| **Ease of navigation** | |
| Strongly Agree | 71% (5) |
| Agree | 29% (2) |
| Disagree | 0% |
| Strongly Disagree | 0% |
| **Easy to switch domains** | |
| Strongly Agree | 71% (5) |
| Agree | 29% (2) |
| Disagree | 0% |
| Strongly Disagree | 0% |
| **Easy to reset answers** | |
| Strongly Agree | 57% (4) |
| Agree | 43% (3) |
| Disagree | 0% |
| Strongly Disagree | 0% |
| **Easy to change answer** | |
| Strongly Agree | 71% (5) |
| Agree | 29% (2) |
| Disagree | 0% |
| Strongly Disagree | 0% |
| **Understood how many questions were left to answer (based on counter)** | |
| Strongly Agree | 57% (4) |
| Agree | 43% (3) |
| Disagree | 0% |
| Strongly Disagree | 0% |
| **Easy to logout** | |
| Strongly Agree | 57% (4) |
| Agree | 43% (3) |
| Disagree | 0% |
| Strongly Disagree | 0% |

### 9.5.2 Specific Aim 2 Results

**Specific Aim 2:** Develop a weighted scoring function, which will score an individual's risk based on five domains of well-being.

This section is broken up into three parts. Section 1 includes the results prior to algorithm calibration (Appendix I). Section 2 includes the calibration methods based on a real-world outcome (Appendix K). Section 3 includes the modified app weights. Based on expert rater re-test we modify our scoring function and re-ran an ICC (Appendix L).

#### 9.5.2.1 Initial pre-calibration Phase 1 ICC results

As expected the initial results are highly varied (Table 15). Conducting the ICC test prior to algorithm calibration showed very low correlations among domain scores generated via the app vs. the expert raters (Appendix I.).

**Table 15.** Intraclass Correlation Coefficients for Phase 1

| | **Intraclass Correlation Coefficients Phase 1** | | | | |
|---|---|---|---|---|---|
| | Physical | Behavioral | Relational | Spiritual | Socio-Economic |
| Avg. Measures | 0.279 | 0.237 | 0.029 | 0.497 | -0.268 |

The physical domain (app) vs. the expert rater generated on average an ICC value of .279 suggesting poor inter-rater reliability between the two entities. The behavioral domain (app) vs. the expert rater generated on average an ICC value of .237 suggesting poor inter-rater reliability. The relational domain comparison between the two rating entities also was low with an average ICC value of .029, the lowest of all the domains. The spiritual domain had the highest ICC value

for the entire domain set with a value of .497; however, this was still a low overall value for reliability. The socio-economic domain (app) vs. the expert rater generated on average an ICC value of -.268.

#### 9.5.2.2 Calibration process and Phase 2 ICC results

The ICC test conducted for Specific Aim 2 showed low correlations between the expert rater and the mobile app. In order to address this issue, the calibration phase was started. Phase 1 of the algorithm calibration will consist of addressing areas in which experts and the app differ in domain scores. In order to conduct a re-test of Phase 1, a step-wise calibration is discussed below.

As a starting point, we used the real answers given by the patients within the questionnaire itself. This data serves as the truth in determining what well-being state a patient is currently in, based on their answers. For example, since the patient has given an answer to their physical state, we now have a measurable point to begin calibrating the app vs. the expert rater, and to see if the expert raters' expectations of a patient needed to be either increased or decreased, or vice versa. In Step 1 of calibration, a case is created per patient. A numerical interval between 1 and 4 was given to each Likert scale answer value. All the real-world answers per patient per domain were then averaged. The intervals fall between a **low**, **moderate**, or **high** standing based on the patient's real-world answers. Table 16 shows the ranges generated for each scale value.

**Table 16.** Interval Scales for Patient Answers

| | |
|---|---|
| Low | Less than 3 |
| Moderate | 3.00 - 3.99 |
| High | >= 4 |

A value of "Low" suggests that the patient selected an unfavorable Likert scale value based on the question while completing a certain section of the questionnaire and denotes poor well-being scores in one domain. A "moderate" designation denotes an increase toward better well-being selected Likert scale answer and "high" equals a patient who selected the most optimal Likert scale answer and therefore, is doing well in that domain. This information was provided back to the expert rater who had given values during the start of this study. At this point the expert rater had to re-rate, or adjust up or down his/her original answers given these new real-world ratings by the patient.

Each case is shown in Appendix J, along with the real-world score rating. A flag indicator represents a case where an expert rater may have misjudged a patient and as a result requires re-analysis. Upon receiving the new expert re-rated values an ICC test was run. This is Phase 2 of the ICC statistics: unchanged app values (from ICC test 1) were compared with the re-rated expert assignments. The results of each domain ICC test for Phase 2 is shown in Appendix K. The table below summarizes the results. The physical domain saw a correlation increase, most likely due to the chance of the expert rater adjusting his/her perception. Overall, the correlations did not change when compared with Phase 1 outcomes.

**Table 17.** Intraclass Correlation Coefficients for Phase 2

| | **Intraclass Correlation Coefficients Phase 2** | | | | |
|---|---|---|---|---|---|
| | Physical | Behavioral | Relational | Spiritual | Socio-Economic |
| Avg. Measures | 0.497 | 0.169 | 0.225 | 0.401 | 0.023 |

### 9.5.2.3 Calibration process and Phase 3 ICC results

Lastly, in this comparison phase the mobile app weights are adjusted to conform to the re-rated expert perceptions. In order to significantly change the scoring to be closer to real world expectations the $R_w$ answer weights (discussed in the methods section) were adjusted to the values shown in Figure 10 below.

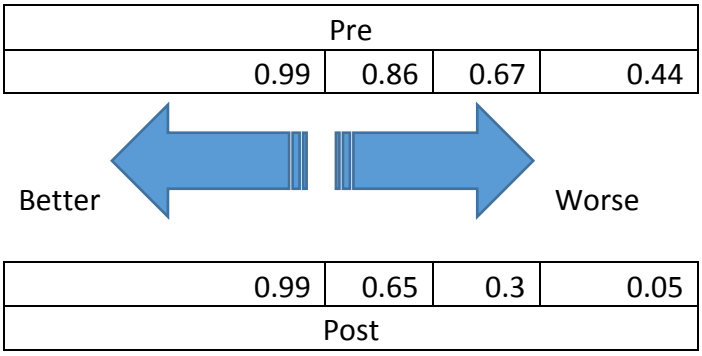



Figure 10. **Answer Weights Re-adjustment**

Given the new adjusted values (post in figure above), a new interclass correlation test was re-administered. There was significant improvement between app and expert raters (Table 18). The physical domain ICC value moved to .797. The behavioral improved to .749; relational domain improved to .742; and, the spiritual domain went up to .905. The socio-economic domain did not show significant correlation improvement at .286, however, it did improve from previous Phase 1 and Phase 2.

**Table 18.** Intraclass Correlation Coefficients for Phase 3

| | **Intraclass Correlation Coefficients Phase 3** | | | | |
|---|---|---|---|---|---|
| | Physical | Behavioral | Relational | Spiritual | Socio-Economic |
| Avg. Measures | 0.797 | 0.749 | 0.742 | 0.905 | 0.286 |

### 9.5.3 Specific Aim 3 Results

**Specific Aim 3:** Design, develop and test a web portal interface, which will present data analytics for reporting to the BHCO and patients.

#### 9.5.3.1 Web portal usability results

The web portal usability study tested the participants' ability to easily navigate and perform the different tasks which pertain to the daily tasks of a BHCO. It also tested the likability of the web portal and whether or not participants would return to the use the web portal. The ASQ was administered after each task. Lower ASQ scores are better. The results of the ASQ were well founded for each participant. The best value for a given task (Strongly Agree) was 1 and the worst for a given task was 3 (still favoring strong agreement). The median score given for a task was 1. The ASQ averages for each participant are shown in Table 19 below and an overall average is also shown.

**Table 19.** ASQ Task Scenario Averages

| | Task 1 | Task 2 | Task 3 | Task 4 | Task 5 | Task 6 | Task 7 | Overall |
|---|---|---|---|---|---|---|---|---|
| User1 | 1.67 | 1.33 | 1.33 | 2.00 | 1.00 | 2.00 | 1.00 | 1.48 |
| User2 | 1.00 | 1.00 | 1.67 | 1.33 | 2.00 | 1.67 | 2.00 | 1.52 |
| User3 | 1.00 | 1.00 | 1.33 | 1.33 | 1.00 | 1.00 | 1.00 | 1.10 |
| User4 | 1.33 | 1.33 | 1.33 | 1.00 | 1.00 | 1.67 | 1.00 | 1.24 |
| User5 | 1.33 | 1.33 | 1.67 | 1.00 | 1.00 | 1.00 | 2.00 | 1.33 |
| User6 | 1.00 | 1.33 | 1.00 | 1.33 | 1.00 | 1.00 | 1.00 | 1.10 |
| User7 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

The results of the ASQ suggest that the design of the web portal was well received among the participants. After the completion of the entire session, a participant was asked to complete the CSUQ questionnaire. The results for the CSUQ were highly favorable with no disagreement among the participants rating each question. The median value selected by each participant was 1 (Strongly Agree). The minimum value selected was 1 and the maximum value selected was 3 (from a worst case 7). The participant scale averages are shown in Table 20 below.

**Table 20.** CSUQ Scale Averages

| | Overall Score | Sysuse | Infoqual | Interqual |
|---|---|---|---|---|
| User1 | 1.95 | 2.00 | 1.86 | 2.00 |
| User2 | 1.63 | 1.50 | 2.00 | 1.00 |
| User3 | 1.11 | 1.00 | 1.14 | 1.33 |
| User4 | 1.16 | 1.00 | 1.29 | 1.33 |
| User5 | 1.32 | 1.13 | 1.71 | 1.00 |
| User6 | 1.16 | 1.00 | 1.43 | 1.00 |
| User7 | 1.00 | 1.00 | 1.00 | 1.00 |

In addition to the post questionnaires that were administered during this study, time on task measurements were also taken to rate the time spent on a scenario. Overall participants completed each task in a reasonable time. Table 21 shows the time on task scenarios per participant.

**Table 21.** Time on Task (in Seconds)

| | Task 1 | Task 2 | Task 3 | Task 4 | Task 5 | Task 6 | Task 7 | User Avg. |
|---|---|---|---|---|---|---|---|---|
| User1 | 27 | 110 | 200 | 47 | 56 | 90 | 23 | 79 |
| User2 | 26 | 47 | 110 | 25 | 47 | 20 | 4 | 40 |
| User3 | 11 | 60 | 120 | 35 | 37 | 13 | 2 | 40 |
| User4 | 6 | 70 | 122 | 60 | 65 | 15 | 21 | 51 |
| User5 | 10 | 37 | 70 | 19 | 33 | 11 | 2 | 26 |
| User6 | 8 | 40 | 65 | 18 | 30 | 17 | 2 | 26 |
| User7 | 26 | 45 | 80 | 10 | 28 | 35 | 2 | 32 |
| Overall Avg. | 16 | 58 | 110 | 31 | 42 | 29 | 8 | |

In general, logging in and logging out took the least time to complete with an average time of 16 seconds and 8 seconds, respectively. Registering a patient took the longest time (as expected) due to the multiple textbox entries with an average time of under 2 minutes. The next longest time spent on a task was to register a BHCO with an average of under 1 minute. Again, this is normal due to the initial learning curve and amount of textbox interactions. Assigning a patient took on average 31 seconds; viewing patient analytics was averaged at 42 seconds; and lastly, updating user information took an average of 29 seconds.

## 9.6 DISCUSSION

### 9.6.1 Specific Aim 1 Web App Usability Study Discussion

In this study a mobile app was tested against a cohort of participants which consisted of BHCOs from the FPFHC. Surprisingly, most of the usability issues were initially caught by the first five participants, backing Nielsen's postulate of the +5 rule. Despite the background of the participants having used smartphones and continuing to use mobile devices regularly/daily, there was still difficulty in finding specific values on the Android virtual keyboard. Most of the initial usability issues dealt with UI sizing, positioning and initial learning curve. Once all the buttons and menus were enlarged, the process of completing a task improved, and there was a consensus of general satisfaction and likability. Because most of the participants represented a slightly older age group, similarities were seen with a few of the participants in this study with behavior seen in a study testing touchscreen usability. (Page, 2014) One user was an outlier due to a recent surgical procedure which slightly affected his/her ability to quickly select and react to drop-downs. However, given a washout period of 2.5 months, in Phase 2 the same user continued to be an outlier in a few of the tasks.

It was interesting to note that most of the participants had issues working with the QWERTY keyboard even-though participants had used smartphones for many years based on pre-interview demographics questions.

Overall, Phase 2 proved to be the turning point for a successful completion to the usability study. Almost all users rated the app well with the following comments:

"The app is much better with increased font and dialog box sizes"

“The app is great”

“App is much easier to use”

“Having used the iPhone for so long it is still difficult because the small buttons. This version’s icons and buttons are larger and easy to select"

Post usability study the app was further enhanced to deal with the issue of session management. A patient may complete the questionnaire more than once during the lifetime of their use, and thus create a timeline of well-being progress for that given patient. Session management addresses this by keeping a record of sessions a patient may have created (22a). Another small addition post usability study was the numbering of each question to help guide the BHCO as they are working with a patient (22b). These additions are shown in Figure 11 below.

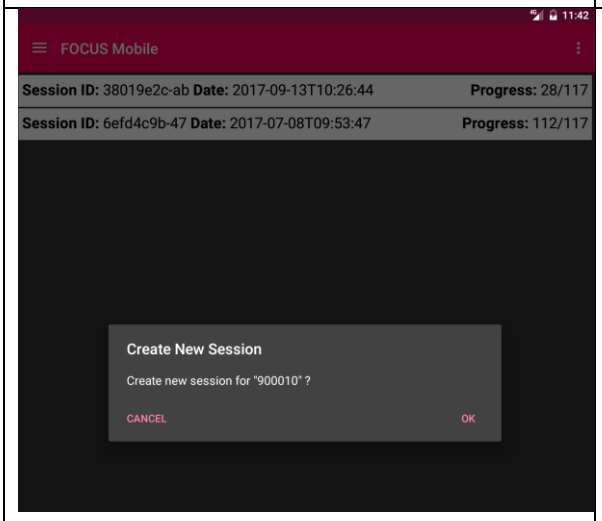
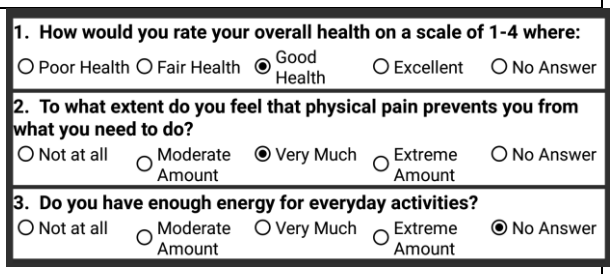
| 22a. Session Management Interface | 22b. Numbered Questions |
| --- | --- |
|  |  |



**Figure 11.** Post Usability Changes

### 9.6.2 Specific Aim 2 Algorithm Calibration Discussion

The most significant outcome from the calibration process was that the app scores do in fact come very close to actual expert re-rated domain values. In tuning the algorithm to adjust to the re-rated values a few areas were looked at. First, the major portion of the scoring occurs from the question weights themselves, however, no modification occurred here as these values are almost certainly set in stone since it would require a complete re-test of community and expert preference weighting. More focus was given to the answer weights as these are the driving values of the entire algorithm. Thus, since most of the algorithm is multiplicative in nature, changing the answer weights will have the most effect when multiplied by the question weights (because the question weights will not change once assigned by the expert raters).

The ICC process was not expected to significantly change during Phase 1 and Phase 2 as in these two phases the app function was not modified. Given the ICC results in Phases 1 and 2 it was reassuring to note that no major fluctuations actually occurred and that all of the significant changes were seen in Phase 3. For a few patient scores the app actually trended almost 1:1 when compared with the re-rated expert scores.

### 9.6.3 Specific Aim 3 – Web Portal Usability Study Discussion

It should be noted that this was truly the first instance of using this web portal by each participant, so initial increase in time spent on tasks was to be expected due to the learning curve. The transition through each task was fairly straightforward. Some additional technical issues were discovered as participants were working on specific tasks. For example, during the BHCO

registration task, one user accidentally pressed the Enter key mid-way causing the page to execute saving the patient. The saving was successful but because a confirmation dialog box was not implemented, the user was saved to the database with partial information. Another occurrence was formatting of date-of-birth (DOB) fields. Date-of-birth (DOB) fields can often times be entered in a free form manner, but because our settings were to have slashes it posed a small issue when the user had to go back and re-enter the DOB. In retrospect, date fields should be free form and have the application handle the formatting automatically. Next, during the patient assignment task some users forgot to press the checkbox, denoting that the patient was selected. For example, the participant saw the patient listed as needing to be assigned but because the checkbox field was so small the participant did not check the box and clicked 'Save' instead, which led to an error page. Increasing the size of the checkbox and moving the checkbox to the left side of the patient name, (instead of the current right side), should alleviate this issue. One other area for improvement is the patient analytics screen. During the usability session participants at times seemed to be waiting for a queue from the web page for their next action. That is, when on the patient analytics page, the first thing is to select a patient and his/her session. This task was easily accomplished. Then the participant clicked the 'Generate Analytics' button. This process flowed well also. However, it was at this point where the participant needed a queue to press the tabs in order to view the bar charts. It should be noted that the bar charts do not automatically appear for security reasons. In the design phase, and for confidentiality, the BHCO must initiate a button press to view the bar charts. Perhaps adding a queue to inform the BHCO that it is time to click the view analytics tab may help.

## 9.7 CONCLUSION

In this dissertation the researcher has explored introducing mobile based solutions in the area of TACs. While doing so, a first of a kind weighted mobile application in the area of TACs was built from the ground up. In addition, a weighted scoring algorithm was applied to the mobile questionnaire. To test the efficacy of the mobile solution two usability studies were conducted. First, a preliminary usability study was conducted testing the ease of use of the mobile app's user interface. Subjects in this study rated their preferability toward a number of UI components and in addition rated their overall experience with the app. A second usability study was also conducted to test the web portal which was designed as an administrative aid both for the BHCO and also for the BHCO to present data to the patients. BHCOs rated their satisfaction through two well established post survey questionnaires (ASQ and CSUQ). Overall, this dissertation has helped to initiate projects which will help to address the area of TACs with novel implementations of various mobile based tools.

## 9.8 LIMITATIONS

One of the major limiting factors in this research was the lack of study participants. Many of the statistical analyses discussed, such as CFA, requires a very large sample size. Due to the difficulty in gathering a large sample size, CFA was not conducted for this research and is listed as a future work. In order to conduct CFA it is recommended to have at least a sample size of N = 500 (five participants per item given our 100 items on the questionnaire). In addition, as outlined in the literature review of this paper, an SEM model may also be developed upon gathering a larger sample size.

A second limitation was seen when connecting the mobile app to low bandwidth Wi-Fi connections or cell networks with slow data rates. In addition, the app currently runs several processes on a single thread, which has caused some latency when connecting to the remote server during database transactions. As recommended in the future work section, app updates will address this issue.

A third potential limitation is the requirement for an always-on internet connection in order to complete the questionnaire. The data is transmitted using a RESTful protocol and does not save data locally. Therefore, any interruption in cell network or WiFi Internet connection will create the potential for data loss over TCP/IP.

Lastly, if the BHCO does not have any experience with using an Android-based tablet, there will certainly be a small learning curve before he/she becomes proficient with the nuances of the mobile app.

## 9.9 FUTURE WORK

There are two major goals to pursue upon study completion. First is to continue gathering patient data through the mobile app. By growing the dataset, more insightful analytics can be produced. For example, a dataset of at least 500 or more patients will allow a CFA model to be generated. In addition, the increased dataset will allow other researchers to tap into this volume of information for further interventions and conduct SEM. The increase in patient volume will also allow the re-testing of the algorithm to determine if the calibrations conducted in this study are valid over time.

The second goal is to continue to release updates to the mobile app. Periodic app updates will be essential to improve performance as mentioned in the limitations section.

# APPENDIX A

## WRSCI QUESTIONNAIRE

| | | | | | |
|---|---|---|---|---|---|
| | **Final Survey** | | | | |
| | **A. DEMOGRAPHIC SECTION** | | | | |
| | | | | | |
| | ID Number: | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | **Please answer each question by placing a checkmark or circling the most appropriate answer in the box on the right.** | | | | |
| | | | | | |
| | **B. PHYSICAL DOMAIN** | | | | |
| | **Subdomain: Health** | **1 poor health** | **2 fair health** | **3 good health** | **4 excellent health** |
| | How would you rate your overall health on a scale of 1(very poor health) -4 (excellent health)? | | | | |
| | | | | | |
| | **Subdomain: Pain** | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| | To what extent do you feel that physical pain prevents you from what you need to do? | | | | |
| | | | | | |
| | **Subdomain: Fatigue/Tired** | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| | Do you have enough energy | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | for everyday activities? | | | | |
| | | | | | |
| | **Subdomain: Medications** | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| | Do you take prescribed medications? **(If no, skip the next question)** | | | | |
| | Are there times when you do not take your prescribed meds when you are supposed to? (due to cost, access, etc.) | | | | |
| | | | | | |
| | **Subdomain: Sleep** | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| | Do you feel rested upon awaking? | | | | |
| | Is your sleep interrupted? | | | | |
| | Do you have nightmares? | | | | |
| | **Subdomain: Stress** | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| | In the last month, how often have you felt stressed? | | | | |
| | | | | | |
| | **Subdomain: Mobility and Exercise** | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| | Do you have difficulty performing daily tasks? (For example, cooking, bathing, getting dressed?) | | | | |
| | Have you found that you are doing tasks less frequently? | | | | |
| | Have you found that you are doing tasks in a different way than you used to do them? | | | | |
| | How satisfied are you with your ability to ambulate or move around? | | | | |
| | Are you able to run errands and shop without assistance? | | | | |
| | How many times a week do you exercise **moderately**? | 0 | 1-3 times | 4-5 times | 6 or more |
| | *Examples from the American* | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | *Heart Association include:* | | | | |
| | *Walking briskly (3 miles per hour or faster, but not race-walking)* | | | | |
| | *Water aerobics* | | | | |
| | *Bicycling slower than 10 miles per hour* | | | | |
| | *Tennis (doubles)* | | | | |
| | *Ballroom dancing* | | | | |
| | *General gardening* | | | | |
| | | | | | |
| | How many times a week do you exercise **vigorously**? | 0 | 1-3 times | 4-5 times | 6 or more |
| | *Examples from the American Heart Association include:* | | | | |
| | *Race walking, jogging, or running* | | | | |
| | *Swimming laps* | | | | |
| | *Tennis (singles)* | | | | |
| | *Aerobic dancing* | | | | |
| | *Bicycling 10 miles per hour or faster* | | | | |
| | *Jumping rope* | | | | |
| | *Heavy gardening (continuous digging or hoeing)* | | | | |
| | *Hiking uphill or with a heavy backpack* | | | | |
| **16** | | | | | |
| | **Subdomain: Drug/Alcohol Use** | | | | |
| | **Please circle the most appropriate choice to the right of the question.** | | | | |
| | | | | | |
| | Do you smoke cigarettes? **(If no, skip the next question)** | not at all | some days | everyday | refused |
| | If you do smoke, how many cigarettes do you smoke in one day? | 0-5 cigs | 6-10 cigs | 11-19 cigs | >20 cigs |
| | | | | | |
| | Do you currently use chewing tobacco, (snuff)? | not at all | sometimes | everyday | refused |
| | | | | | |
| | Do you drink alcohol? **(If no, skip the next two questions)** | not at all | sometimes | everyday | refused |
| | | | | | |
| | *Considering that one drink equals a 10-ounce beer, a 5-* | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | *ounce glass of wine, or a drink with one shot of liquor, please answer the following questions?* | | | | |
| | How many drinks do you have in a week? | 0-5 drinks | 6-10 drinks | 11-19 drinks | > 20 drinks |
| | | | | | |
| | How many drinks do you have at one time? | 1-2 drinks | 3-4 drinks | 5-6 drinks | > 6 drinks |
| | | | | | |
| | Do you smoke marijuana? **(If no, skip the next question)** | not at all | sometimes | everyday | refused |
| | How many times in a week do you smoke marijuana? | 0-5 times | 6-10 times | 11-19 times | >20 times |
| | | | | | |
| | Do you use any other recreational drugs (including drugs prescribed for other people)? **(If no, skip the next question)** | not at all | some days | everyday | refused |
| | How often do you use/take the drug(s)in a week? | 0-5 times | 6-10 times | 11-19 times | >20 times |
| | | | | | |
| | **Subdomain: Food Please circle the correct response** | | | | |
| | How many meals a day do you eat? | 0-1 | 2-3 | 4-5 | 6 or greater |
| **28** | How many glasses of water do you drink per day? | 0-1 | 2-3 | 4-5 | 6 or greater |
| | **Physical domain - 28 total items** | | | | |
| | **C. BEHAVIORAL DOMAIN** | | | | |
| | | | | | |
| | **Please answer each question by placing a checkmark in the appropriate box on the right.** | | | | |
| | **Subdomain: Positive Reactions** | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |

| | | | | | |
|---|---|---|---|---|---|
| | How much do you enjoy life? | | | | |
| | How much confidence do you have in yourself? | | | | |
| | How satisfied are you with the quality of your life? | | | | |
| **4** | How optimistic are you in your life? | | | | |
| | | | | | |
| | **Subdomain: Negative Reactions** | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| | How often do you have negative feelings? | | | | |
| | How much do feelings of sadness or depression interfere with your everyday functioning? | | | | |
| | Do you have trouble trusting other people? | | | | |
| | Do you have the ability to control strong feelings and impulses? | | | | |
| **5** | When bad things happen to me or anyone else, I feel no emotion. | | | | |
| | | | | | |
| | **Subdomain: Traumatic Event-- ACE Questionnaire** | | | | |
| | | | | | |
| | **Prior to the age of 18 years old, did you experience the following? Answer each yes or no question by placing an X in the box to the right.** | **Yes** | **No** | | |
| | 1. Did a parent or other adult in the household often or very often swear at you, insult you, put you down, or humiliate you, or act in a way that made you afraid that you | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | might be physically hurt? | | | | |
| | 2. Did a parent or other adult in the household often or very often push, grab, slap, or throw something at you, or ever hit you so hard that you had marks or were injured? | | | | |
| | 3. Did an adult or person at least 5 years older than you ever touch or fondle you, or have you touch their body in a sexual way, or attempt, or actually have oral, anal, or vaginal intercourse with you? | | | | |
| | 4. Did you often or very often feel that no one in your family loved you, or thought you were important, or special, or your family didn't look out for each other, feel close to each other, or support each other? | | | | |
| | 5. Did you often or very often feel that you didn't have enough to eat, had to wear dirty clothes, and had no one to protect you, or your parents were too drunk or high to take care of you, or take you to the doctor if you needed it? | | | | |
| | 6. Was a biological parent ever lost to you through divorce, abandonment, or other reason? | | | | |
| | 7. Was your parent or guardian, often or very often pushed, grabbed, slapped, or had something thrown at them, or sometimes, often, or very often kicked, bitten, hit with a fist, or hit with something hard, or ever repeatedly hit over at least a few minutes, or threatened with a gun or knife? | | | | |
| | 8. Did you live with anyone | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | who was a problem drinker, or alcoholic, or who used street drugs? | | | | |
| | 9. Was a household member depressed or mentally ill, or did a household member attempt suicide? | | | | |
| **10** | 10. Did a household member go to prison? | | | | |
| | | | | | |
| | **Subdomain: Traumatic Event** | | | | |
| | | | | | |
| | **The following questions will ask you if you have <u>ever</u> experienced or witnessed certain situations. Please circle either yes or no.** | | | | |
| | **If your answer is yes, please check the appropriate box on the right as to the EXTENT that if affected you at the time of the occurrence.** | | | | |
| | | | | | |
| | *Have you ever **experienced/witnessed** the following? If so, how did it affect you?* <u>*YES NO DATE*</u> | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| | a disaster such as a flood, tornado, or fire<br>YES NO | | | | |
| | a serious accident at home, work, or serious car accident<br>YES NO | | | | |
| | a physical assault | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | YES NO | | | | |
| | a sexual assault<br>YES NO | | | | |
| | a life-threatening illness<br>YES NO | | | | |
| | witness a death<br>YES NO | | | | |
| | Did you ever harm or seriously injure someone?<br>YES NO | | | | |
| | Did you ever feel that your life is in danger?<br>YES NO | | | | |
| | Did you ever have thoughts of hurting yourself?<br>YES NO | | | | |
| | Did you ever have thoughts of hurting someone else?<br>YES NO | | | | |
| **11** | Did anyone close to you ever experience any of the above-mentioned situations? If so how did it affect you? YES NO | | | | |
| | | | | | |
| | ***If you answered yes to any of the traumatic experiences mentioned above, please answer the following three questions as to how you are <u>CURRENTLY</u> feeling about the experience. (If you answered no to every question above, skip the next three questions)*** | | | | |
| | | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| | How often are you reminded of it? | | | | |
| | How often do images related to it pop into your mind? | | | | |
| | How often do you talk about it? | | | | |
| **3** | | | | | |

| | Subdomain: Resilience | Not at all | A Moderate amount | Very much | An extreme amount |
|---|---|---|---|---|---|
| | I know that I'll never lose my sense of who I am no matter what happens in my life | | | | |
| | I can see that new opportunities are available when my first plan does not work out | | | | |
| | I am likely to try to change things, when they are in need of changing. | | | | |
| | I can accept the way things work out | | | | |
| | I tend to feel pretty stable under stress. | | | | |
| | I can usually find a way of overcoming problems | | | | |
| **7** | I often expect something bad to happen to me | | | | |
| | | | | | |
| | **Behavioral domain - total 40 items** | | | | |
| | | | | | |
| | **D. RELATIONAL DOMAIN** | | | | |
| | **Please answer each question by placing a checkmark in the appropriate box on the right.** | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| | How satisfied are you with your personal/work relationships? | | | | |
| | *Who would you go to for support/help? How likely would it be:* | | | | |
| | A parent or guardian N/A (Circle N/A only if deceased) | | | | |
| | Family member such as sibling, grandparents, etc. | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | N/A " | | | | |
| | Spouse/Partner<br>N/A " | | | | |
| | Child/children<br>N/A " | | | | |
| | Friend | | | | |
| | Other (pastor, etc.) | | | | |
| | I put effort into my relationships | | | | |
| | People in my life care about me. | | | | |
| | I tend to distance myself when people get too close to me. | | | | |
| | I'm concerned about losing my independence in intimate relationships. | | | | |
| | **Relational domain - 11 items** | | | | |
| | **E. SPIRITUAL DOMAIN** | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| | To what extent do you have spiritual beliefs? **(If no, skip the next three questions)** | | | | |
| | To what extent does a connection to a spiritual being provide you with comfort/reassurance? | | | | |
| | To what extent do you feel inner spiritual strength in difficult times? | | | | |
| | To what extent does spirituality help you to accept your life circumstances? | | | | |
| | How satisfied are you with your faith community? | | | | |
| | How often do you participate in a faith community? | | | | |
| **6** | **Spiritual domain - 6 items** | | | | |
| | **F. SOCIO-ECONOMIC DOMAIN** | | | | |
| | | | | | |
| | **Please answer each** | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | **question by placing a checkmark in the appropriate box on the right.** | | | | |
| | **Subdomain: Financial** | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| **1** | How satisfied are you with your financial situation? | | | | |
| | | | | | |
| | **Subdomain: Transportation** | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| | How satisfied are you with public transportation? | | | | |
| **2** | To what extent do you have problems with transportation? | | | | |
| | | | | | |
| | **Subdomain: Environment (including home and safety)** | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| | To what extent is your rent or mortgage, taxes affordable? | | | | |
| | Do you feel safe where you live? | | | | |
| | How satisfied are you with your physical safety and security on your block? | | | | |
| | How satisfied are you with your physical safety and security in your community? | | | | |
| | *How satisfied are you with the following regarding the place where you live?* | | | | |
| | physical condition of the place that you live | | | | |
| | noise/disruptions | | | | |
| | violence in your neighborhood | | | | |
| **8** | neighbors | | | | |
| | | | | | |

| | Subdomain: Work | Not at all | A Moderate amount | Very much | An extreme amount |
|---|---|---|---|---|---|
| | How satisfied are you with the number of hours that you work in a week? | | | | |
| | How much do you believe that having a criminal record prevents you from getting a job? | | | | |
| | To what extent are you able to work? | | | | |
| 4 | To what extent are you actively looking for a job (or a different job) | | | | |
| | | | | | |
| | **Subdomain: Education** | **Not at all** | **A Moderate amount** | **Very much** | **An extreme amount** |
| 1 | To what extent are you satisfied with your educational attainment? | | | | |
| 16 | **Socioeconomic domain - 16 items** | | | | |
| | | | | | |
| | **Total = 101** | | | | |
| | **12 - could be skipped depending on the answer.** | | | | |

## APPENDIX B

## QWB SEVERITY LEVELS

Below are the weights associated with the QWB questionnaire severity levels.

| **Mobility Scale (MOB)** | | |
|---|---|---|
| Rank Severity | Definition | Weight |
| 1 | No Limitation for health reasons | -0.000 |
| 2 | Did not drive a car, health related (younger than 16); did not ride in a car as usual for age, and/or did not use public transportation, health related; or had or would have used more help than usual for age to use public transportation, health related | -0.062 |
| 3 | In hospital, health related | -0.090 |
| | | |
| | | |
| **Physical Activity Scale (PAC)** | | |
| 1 | No limitations for health reasons | -0.000 |
| 2 | In wheelchar, moved or controlled movement of wheelchair without help from someone els; or had trouble or did not try to lift, stoop, bend over, or use stairs or inclines, health related, and/or limped, used a cane, crutches, or walker, health related; and/or had any other physical limitation in walking, or did not try to walk as far or as fast as others the same age are able, health related | -0.060 |
| 3 | In wheelchair, did not move or control the movement of wheelchair without help from someone else, or in bed, chair, or couch for most or all of the day, health related | -0.077 |

| Social Activity Scale (SAC) | | |
|---|---|---|
| 1 | No limitation for health reasons | -0.000 |
| 2 | Limited in other role activity, health related | -0.061 |
| 3 | Limited in major (primary) role activity, health related | -0.061 |
| 4 | Performed no major role activity, health related, but did perform self-care activities | -0.061 |
| 5 | Performed no major role activity, health related, and did not perform or had more help than usual in performance of one or more self-care activities, health related | -0.106 |
| | | |
| | | |
| **Problem Complexes** | | |
| 1 | Death | -.727 |
| 2 | Loss of consciousness such as seizure, fainting, or coma | -.407 |
| 3 | Burn over large areas of face, body, arms, or legs | -.367 |
| 4 | Pain, bleeding, itching, or discharge from sexual organs; does not include normal menstrual bleeding | -.349 |
| 5 | Trouble learning, remembering, or thinking clearly | -.340 |
| 6 | Any combination of one or more hands, feet arms, or legs either missing, deformed, paralyzed, or broken; includes wearing artificial limbs or braces | -.333 |
| 7 | Pain, stiffness, weakness, numbness or other discomfort in chest, stomach, side, neck, back, hips, or any joints of hands, feet, arms, or legs | -.299 |
| 8 | Pain, burning, bleeding, itching, or other difficulty with rectum, bowel movements, or urination | -.292 |
| 9 | Sick or upset stomach, vomitting or loose bowel movements, with or without fever, chills, or aching all over | -.290 |
| 10 | General tiredness, weakness, or weight loss | -.259 |
| 11 | Cough, wheezing, or shortness of breath with or without fever, chills, or aching all over | -.257 |
| 12 | Spells of feeling upset, being depressed, or of crying | -.257 |
| 13 | Headache, or dizziness, or ringing in ears, or spells of feeling hot, nervous, or shaky | -.244 |
| 14 | Burning or itching rash on large areas of face, body, arms, or legs | -.240 |
| 15 | Trouble talking such as lisp, stuttering, hoarseness, or inability to speak | -.237 |
| 16 | Pain or discomfort in one or both eyes, or any trouble seeing after correction | -.230 |
| 17 | Overweight for age and height or skin defect of face, body, arms, or legs, such as scars, pimples, warts, bruises, or changes in color | -.186 |
| 18 | Pain in ear, to the, jaw, throat, lips, tongue; missing or crooked permanent teeth(includes wearing bridges or false teeth); stuffy, runny nose; any trouble hearing (includes wearing a hearing aid) | -.170 |
| 19 | Taking medication or staying ona prescribed diet for health reasons | -.144 |
| 20 | Wore eyeglasses or contact lenses | -.101 |
| 21 | Breathing smog or unpleasant air | -.101 |
| 22 | No Symptoms or problem (not on respondent's card) | -.000 |
| 23 | Standard symptom/problem (not on respondent's card) | -.257 |

## APPENDIX C

## QWB QUESTION WEIGHTS

| **Acute & Chronic Symptoms (only showing comparable questions)** | |
|---|---|
| blindness or severely impaired vision in both eyes? | 0.523 |
| blindness or severely impaired vision in only one eye? | 0.358 |
| speech problems such as stuttering or being unable to speak clearly? | 0.358 |
| missing or paralyzed hands, feet, arms, or legs? | 0.423 |
| missing or paralyzed fingers or toes? | 0.297 |
| any *deformity* of the face, fingers, hand or arm, foot or leg, or back (e.g. severe scoliosis)? | 0.408 |
| general fatigue, tiredness, or weakness? | 0.256 |
| a problem with unwanted weight gain or weight loss? | 0.233 |
| a problem with being under or over weight? | 0.225 |
| problems chewing your food adequately? | 0.204 |
| any hearing loss or deafness? | 0.274 |
| any noticeable skin problems, such as bad acne or large burns or scars on | |
| face, body, arms, or legs? | 0.187 |
| eczema or burning/itching rash? | 0.187 |
| | |
| Did you have… | |
| loss of consciousness, fainting, or seizures? | |
| pain stiffness, cramps, weakness, or numbness | |
| …in the neck or back? | |
| …in the hips or sides? | |
| …in any of the joints or muscles of the hand, feet, arms, or legs? | |

| | |
|---|---|
| difficulty with your balance, standing, or walking? | |
| | |
| You have had… | |
| trouble falling asleep or staying asleep? | 0.296 |
| spells of feeling nervous or shaky? | 0.286 |
| spells of feelings upset, downhearted, or blue? | 0.327 |
| excessive worry or anxiety? | 0.324 |
| feelings that you had little or no control over events in your life? | 0.43 |
| feelings of being lonely or isolated? | 0.311 |
| feelings of frustration, irritation, or close to losing your temper? | 0.378 |
| a hangover? | 0.297 |
| any decrease of sexual interest or performance? | 0.307 |
| confusion, difficulty understanding the written or spoken word, or significant memory loss? | 0.559 |
| thoughts or images you could not get out of your mind? | 0.255 |
| to take any medication including over the counter remedies? | 0.16 |
| to stay on a medically prescribed diet for health reasons? | 0.201 |
| a loss of appetite or over-eating? | 0.223 |
| | |
| **Self-Care** | |
| Because of any impairment or health problem, did you need help with your personal care needs, such as eating, dressing, bathing, or getting around your home? | 0.096 |
| | |
| **Mobility** | |
| which days did you use public transportation such as a bus, subway, Medi-van, train, or airplane? | 0 |
| which days did you either not drive a motor vehicle or not use public transportation because of your health or need help from another person to use? | 0.031 |
| | |
| **Physical Activity** | |
| Have trouble climbing stairs or inclines or walking off the curb? | 0.072 |
| Avoid walking, have trouble walking, or walk more slowly than other people your age | 0.072 |
| avoid or have trouble bending over, stooping, or kneeling | 0.072 |
| Have any trouble lifting or carrying everyday objects such as books, a briefcase, or groceries | 0.072 |
| have any other limitations in physical movements | 0.072 |

| | |
|---|---|
| spend all or most of the day in a bed, chair, or couch because of health reasons | 0.163 |
| spend all or most of the day in a wheelchair? | 0.102 |
| **Usual Activities** | |
| because of any physical or emotional health reasons, on which days did you avoid, need help with, or were limited in doing some of your usual activities, such as **work, school, or housekeeping**? | 0.054 |
| because of physical or emotional health reasons, on which days did you avoid or feel limited in doing some of your usual activities, such as **visiting family/friends, hobbies, shopping, recreational, or religious activities**? | 0.054 |
| on which days did you have to change any of your plans or activities because of your health that you did not report on the previous two questions? | 0.054 |

## APPENDIX D

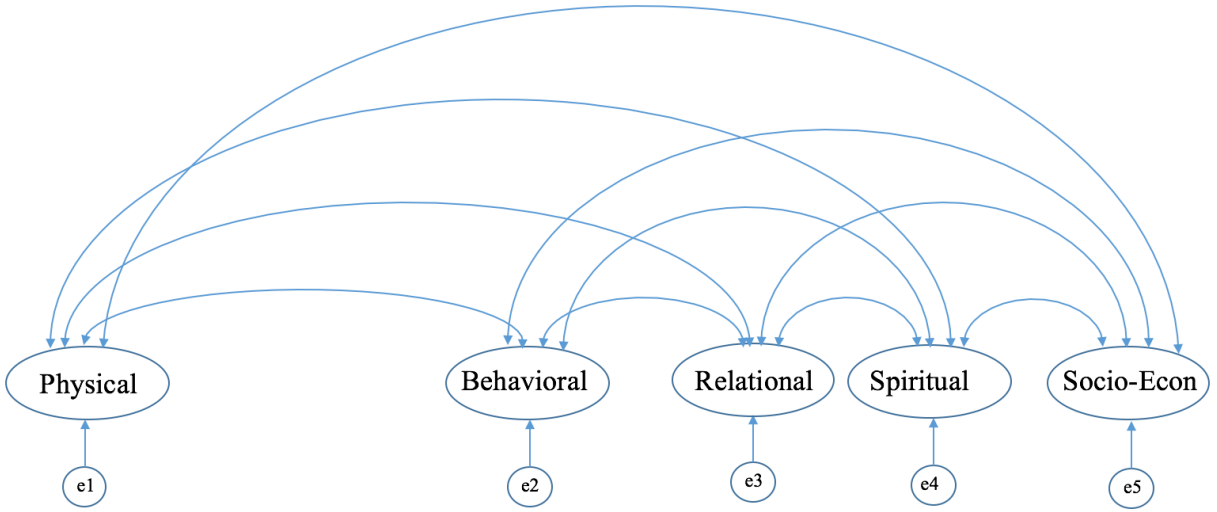
## PSSUQ PHASE 1 AND PHASE 2 RESULTS

| PHASE 1 | User 1 | User 2 | User 3 | User 4 | User 5 | User 6 | User 7 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Categories** | | | | | | | | **TOTAL** | **AVG** | **SD** |
| 1 | 5 | DNF | 1 | 6 | 2 | 1 | 1 | **16** | **2.67** | **2.25** |
| 2 | 5 | DNF | 1 | 6 | 2 | 4 | 1 | **19** | **3.17** | **2.14** |
| 3 | 5 | DNF | 2 | 5 | 2 | 2 | 2 | **18** | **3.00** | **1.55** |
| 4 | 5 | DNF | 2 | 5 | 2 | 5 | 2 | **21** | **3.50** | **1.64** |
| 5 | 5 | DNF | 2 | 5 | 2 | 1 | 2 | **17** | **2.83** | **1.72** |
| 6 | 5 | DNF | 1 | 6 | 3 | 5 | 1 | **21** | **3.50** | **2.17** |
| 7 | 0 | DNF | 1 | 4 | 2 | 4 | 1 | **12** | **2.00** | **1.67** |
| 8 | 4 | DNF | 1 | 5 | 1 | 1 | 1 | **13** | **2.17** | **1.83** |
| 9 | 7 | DNF | 7 | 6 | N/A | 7 | 2 | **29** | **5.80** | **2.17** |
| 10 | 4 | DNF | 2 | 4 | 2 | 2 | 2 | **16** | **2.67** | **1.03** |
| 11 | 7 | DNF | 5 | 6 | 2 | 1 | 2 | **23** | **3.83** | **2.48** |
| 12 | 4 | DNF | 4 | 6 | 3 | 3 | 1 | **21** | **3.50** | **1.64** |
| 13 | 4 | DNF | 2 | 5 | 2 | 5 | 1 | **19** | **3.17** | **1.72** |
| 14 | 5 | DNF | 3 | 4 | 2 | N/A | 1 | **15** | **3.00** | **1.58** |
| 15 | 3 | DNF | 3 | 4 | 1 | 3 | 1 | **15** | **2.50** | **1.22** |
| 16 | 3 | DNF | 1 | 5 | 1 | 1 | 1 | **12** | **2.00** | **1.67** |
| 17 | 4 | DNF | 1 | 5 | 1 | 2 | 1 | **14** | **2.33** | **1.75** |
| 18 | 5 | DNF | 1 | 5 | 1 | 3 | 1 | **16** | **2.67** | **1.97** |
| 19 | 4 | DNF | 1 | 5 | 2 | 1 | 1 | **14** | **2.33** | **1.75** |
| **TOTAL** | **84** | **DNF** | **41** | **97** | **33** | **51** | **25** | | | |
| **AVG** | **4.42** | **DNF** | **2.16** | **5.11** | **1.83** | **2.83** | **1.32** | | | |
| **SD** | **1.50** | **DNF** | **1.64** | **0.74** | **0.62** | **1.82** | **0.48** | | | |
| **NOTE: User 2 was at all sessions, except ran out of time due to schedule** | | | | | | | | | | |

| PHASE 2 | User 1 | User 2 | User 3 | User 4 | User 5 | User 6 | User 7 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Categories** | | | | | | | | **TOTAL** | **AVG** | **SD** |
| 1 | 1 | 2 | 1 | 4 | 1 | 1 | 1 | **11** | **1.57** | **1.13** |
| 2 | 1 | 2 | 1 | 4 | 1 | 1 | 1 | **11** | **1.57** | **1.13** |
| 3 | 1 | 2 | 1 | 4 | 1 | 1 | 1 | **11** | **1.57** | **1.13** |
| 4 | 2 | 1 | 1 | 3 | 1 | 1 | 1 | **10** | **1.43** | **0.79** |
| 5 | 2 | 1 | 1 | 4 | 1 | 1 | 1 | **11** | **1.57** | **1.13** |
| 6 | 2 | 3 | 1 | 3 | 1 | 1 | 1 | **12** | **1.71** | **0.95** |
| 7 | 1 | 2 | 1 | 3 | 1 | 1 | 1 | **10** | **1.43** | **0.79** |
| 8 | 1 | 2 | 1 | 3 | 1 | 1 | 1 | **10** | **1.43** | **0.79** |
| 9 | N/A | 1 | N/A | N/A | N/A | 4 | 2 | **7** | **2.33** | **1.53** |
| 10 | 1 | 2 | 1 | 3 | 1 | 4 | 1 | **13** | **1.86** | **1.21** |
| 11 | N/A | 1 | N/A | 4 | N/A | 1 | 1 | **7** | **1.75** | **1.50** |
| 12 | 2 | 2 | 1 | 4 | 1 | 1 | 1 | **12** | **1.71** | **1.11** |
| 13 | 2 | 1 | 1 | 3 | 1 | 1 | 1 | **10** | **1.43** | **0.79** |
| 14 | 1 | 2 | 1 | 4 | 1 | 1 | 1 | **11** | **1.57** | **1.13** |
| 15 | 1 | 2 | 1 | 3 | 1 | 1 | 1 | **10** | **1.43** | **0.79** |
| 16 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | **9** | **1.29** | **0.76** |
| 17 | 1 | 2 | 1 | 4 | 1 | 1 | 1 | **11** | **1.57** | **1.13** |
| 18 | 1 | 1 | 1 | 4 | 1 | 1 | 1 | **10** | **1.43** | **1.13** |
| 19 | 1 | 2 | 1 | 4 | 1 | 1 | 1 | **11** | **1.57** | **1.13** |
| **TOTAL** | **22** | **32** | **17** | **64** | **17** | **25** | **20** | | | |
| **AVG** | **1.29** | **1.68** | **1.00** | **3.56** | **1.00** | **1.32** | **1.05** | | | |
| **SD** | **0.47** | **0.58** | **0.00** | **0.51** | **0.00** | **0.95** | **0.23** | | | |

## APPENDIX E

## HYPOTHESIZED EXPLORATORY SEM MODEL



# APPENDIX F

# HUI3 MULTIPLICATIVE MULTI-ATTRIBUTE UTILITY SCORING

1. Multiplicative multi-attribute utility scores on the Dead/Perfect Health scale

The HUI3 multi-attribute utility score for a health state is calculated according to the following, for the Dead/Perfect Health scale:

$$u^* = 1.371\ (b_1 \times b_2 \times b_3 \times b_4 \times b_5 \times b_6 \times b_7 \times b_8) - 0.371$$

where $u^*$ is the utility of a chronic health state on the utility scale where dead has a utility of 0.00, and Perfect Health has a utility of 1.00. The $b_j$'s are substituted from Table 1 for the appropriate attribute and level ($x_j$).

Table 1

| Vision | | Hearing | | Speech | | Ambulation | | Dexterity | | Emotion | | Cognition | | Pain | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $x_1$ | $b_1$ | $x_2$ | $b_2$ | $x_3$ | $b_3$ | $x_4$ | $b_4$ | $x_5$ | $b_5$ | $x_6$ | $b_6$ | $x_7$ | $b_7$ | $x_8$ | $b_8$ |
| 1 | 1.00 | 1 | 1.00 | 1 | 1.00 | 1 | 1.00 | 1 | 1.00 | 1 | 1.00 | 1 | 1.00 | 1 | 1.00 |
| 2 | 0.98 | 2 | 0.95 | 2 | 0.94 | 2 | 0.93 | 2 | 0.95 | 2 | 0.95 | 2 | 0.92 | 2 | 0.96 |
| 3 | 0.89 | 3 | 0.89 | 3 | 0.89 | 3 | 0.86 | 3 | 0.88 | 3 | 0.85 | 3 | 0.95 | 3 | 0.90 |
| 4 | 0.84 | 4 | 0.80 | 4 | 0.81 | 4 | 0.73 | 4 | 0.76 | 4 | 0.64 | 4 | 0.83 | 4 | 0.77 |
| 5 | 0.75 | 5 | 0.74 | 5 | 0.68 | 5 | 0.65 | 5 | 0.65 | 5 | 0.46 | 5 | 0.60 | 5 | 0.55 |
| 6 | 0.61 | 6 | 0.61 | - | - | 6 | 0.58 | 6 | 0.56 | - | - | 6 | 0.42 | - | - |

Example calculation:

A patient reports their health status as follows:

| | Vision | Hearing | Speech | Ambulation | Dexterity | Emotion | Cognition | Pain |
|---|---|---|---|---|---|---|---|---|
| Level | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 3 |

Referring to the table above, substitute the appropriate scores for $b_j$ for each attribute as follows:

$$u^* = 1.371\ (0.98 \times 1.00 \times 1.00 \times 0.93 \times 1.00 \times 0.95 \times 1.00 \times 0.90) - 0.371$$

$$= 0.70$$

The utility score for this individual's health state is 0.70 on the Dead/Perfect Health scale.

# APPENDIX G

## COMPUTER SYSTEM USABILITY QUESTIONNAIRE

### Computer System Usability Questionnaire

**Based on:** Lewis, J. R. (1995) *IBM Computer Usability Satisfaction Questionnaires: Psychometric Evaluation and Instructions for Use*. **International Journal of Human-Computer Interaction**, 7:1, 57-78. Abstract | About quest.cgi

Please rate the usability of the system.

- Try to respond to all the items.
- For items that are not applicable, use: **NA**
- Make sure these fields are filled in: **System: Email to:**
- Add a comment about an item by clicking on its icon, or add comment fields for all items by clicking on **Comment All**.
- To mail in your results, click on: **Mail Data**

**System**: **Email to:**
Optionally provide comments and your email address in the box.

Mail Data | Comment All | RETURN TO REFERRING PAGE

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | NA |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Overall, I am satisfied with how easy it is to use this system | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 2. It was simple to use this system | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 3. I can effectively complete my work using this system | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 4. I am able to complete my work quickly using this system | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 5. I am able to efficiently complete my work using this system | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 6. I feel comfortable using this system | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 7. It was easy to learn to use this system | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 8. I believe I became productive quickly using this system | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 9. The system gives error messages that clearly tell me how to fix problems | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 10. Whenever I make a mistake using the system, I recover easily and quickly | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 11. The information (such as online help, on-screen messages, and other documentation) provided with this system is clear | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 12. It is easy to find the information I needed | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 13. The information provided for the system is easy to understand | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 14. The information is effective in helping me complete the tasks and scenarios | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 15. The organization of information on the system screens is clear | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 16. The interface of this system is pleasant | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 17. I like using the interface of this system | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 18. This system has all the functions and capabilities I expect it to have | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |
| 19. Overall, I am satisfied with this system | strongly disagree | ○ | ○ | ○ | ○ | ○ | ○ | ○ | strongly agree | ○ |

## APPENDIX H

## AFTER-SCENARIO QUESTIONNAIRE

***The After-Scenario Questionnaire (ASQ)***

*Administration and Scoring.* Give the questionnaire to a participant after he or she has completed a scenario during a usability evaluation. Average (with the arithmetic mean) the scores from the three items to obtain the ASQ score for a participant's satisfaction with the system for a given scenario. Low scores are better than high scores due to the anchors used in the 7-point scales. If a participant does not answer an item or marks N/A, average the remaining items to obtain the ASQ score.

*Instructions and Items.* The questionnaire's instructions and items are:

For each of the statements below, circle the rating of your choice.

1. Overall, I am satisfied with the ease of completing this task.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **STRONGLY AGREE** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **STRONGLY DISAGREE** |

2. Overall, I am satisfied with the amount of time it took to complete this task.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **STRONGLY AGREE** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **STRONGLY DISAGREE** |

3. Overall, I am satisfied with the support information (on-line help, messages, documentation) when completing this task.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **STRONGLY AGREE** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **STRONGLY DISAGREE** |

**APPENDIX I**

**PRE-CALIBRATION ICC RESULTS**

## Intraclass Correlation Coefficient Physical Domain

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .162[a] | -.108 | .499 | 2.067 | 17 | 17 | .072 |
| Average Measures | .279[c] | -.242 | .666 | 2.067 | 17 | 17 | .072 |

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type A intraclass correlation coefficients using an absolute agreement definition.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## Intraclass Correlation Coefficient Behavioral Domain

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .134[a] | -.215 | .510 | 1.407 | 17 | 17 | .244 |
| Average Measures | .237[c] | -.548 | .676 | 1.407 | 17 | 17 | .244 |

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type A intraclass correlation coefficients using an absolute agreement definition.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## Intraclass Correlation Coefficient Relational Domain

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .015[a] | -.437 | .465 | 1.030 | 17 | 17 | .476 |
| Average Measures | .029[c] | -1.554 | .635 | 1.030 | 17 | 17 | .476 |

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type A intraclass correlation coefficients using an absolute agreement definition.
c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## Intraclass Correlation Coefficient Spiritual Domain

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .331[a] | -.091 | .678 | 2.682 | 16 | 16 | .028 |
| Average Measures | .497[c] | -.200 | .808 | 2.682 | 16 | 16 | .028 |

Two-way mixed effects model where people effects are random and measures effects are fixed.
a. The estimator is the same, whether the interaction effect is present or not.
b. Type A intraclass correlation coefficients using an absolute agreement definition.
c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## Intraclass Correlation Coefficient Socio-Economic Domain

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | -.118[a] | -.589 | .376 | .800 | 17 | 17 | .675 |
| Average Measures | -.268[c] | -2.867 | .547 | .800 | 17 | 17 | .675 |

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type A intraclass correlation coefficients using an absolute agreement definition.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## Intraclass Correlation Coefficient Overall Well-Being Score

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .232[a] | -.279 | .629 | 1.570 | 17 | 17 | .181 |
| Average Measures | .376[c] | -.774 | .772 | 1.570 | 17 | 17 | .181 |

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type A intraclass correlation coefficients using an absolute agreement definition.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## APPENDIX J

## EXPERT RATER RE-EVALUATION

| PatientID | Domain | Real World Response | Expert Rating | Indicator |
|---|---|---|---|---|
| 900001 | PHYSICAL | Low | 55.25 | FLAG |
| 900001 | BEHAVIORAL | Low | 49.3 | |
| 900001 | RELATIONAL | Low | 75 | FLAG |
| 900001 | SPIRITUAL | Moderate | 72.5 | FLAG |
| 900001 | SOCIOECON | Low | 55 | FLAG |
| 900002 | PHYSICAL | Low | 52.5 | FLAG |
| 900002 | BEHAVIORAL | Moderate | 77.5 | |
| 900002 | RELATIONAL | Moderate | 70 | |
| 900002 | SPIRITUAL | Moderate | 77.5 | |
| 900002 | SOCIOECON | Low | 82.5 | FLAG |
| 900003 | PHYSICAL | Low | 70 | FLAG |
| 900003 | BEHAVIORAL | Low | 50 | |
| 900003 | RELATIONAL | Low | 40 | |
| 900003 | SPIRITUAL | Moderate | 50 | FLAG |
| 900003 | SOCIOECON | Low | 75 | FLAG |
| 900005 | PHYSICAL | Moderate | 92.5 | FLAG |
| 900005 | BEHAVIORAL | Moderate | 55 | FLAG |
| 900005 | RELATIONAL | Moderate | 55 | FLAG |
| 900005 | SPIRITUAL | Moderate | 62.5 | |
| 900005 | SOCIOECON | Low | 50 | |
| 900006 | PHYSICAL | Moderate | 77.5 | |
| 900006 | BEHAVIORAL | Low | 52.5 | FLAG |
| 900006 | RELATIONAL | Low | 47.5 | |
| 900006 | SPIRITUAL | Moderate | 52.5 | FLAG |
| 900006 | SOCIOECON | Low | 55 | FLAG |

| | | | | | |
|---|---|---|---|---|---|
| 900007 | PHYSICAL | Low | | 67.5 | FLAG |
| 900007 | BEHAVIORAL | Low | | 70 | FLAG |
| 900007 | RELATIONAL | Low | | 77.5 | FLAG |
| 900007 | SPIRITUAL | Low | | 80 | FLAG |
| 900007 | SOCIOECON | Low | | 75 | FLAG |
| 900008 | PHYSICAL | Moderate | | 75 | |
| 900008 | BEHAVIORAL | Moderate | | 70 | |
| 900008 | RELATIONAL | Moderate | | 75 | |
| 900008 | SPIRITUAL | High | NA | | FLAG |
| 900008 | SOCIOECON | Low | | 80 | FLAG |
| 900009 | PHYSICAL | Low | | 66 | FLAG |
| 900009 | BEHAVIORAL | Moderate | | 60.5 | |
| 900009 | RELATIONAL | Low | | 45 | |
| 900009 | SPIRITUAL | Low | | 37.5 | |
| 900009 | SOCIOECON | Low | | 60 | FLAG |
| 900010 | PHYSICAL | Moderate | | 90 | FLAG |
| 900010 | BEHAVIORAL | Low | | 60 | FLAG |
| 900010 | RELATIONAL | Low | | 40 | |
| 900010 | SPIRITUAL | Low | | 40 | |
| 900010 | SOCIOECON | Moderate | | 40 | FLAG |
| 900011 | PHYSICAL | Moderate | | 75 | FLAG |
| 900011 | BEHAVIORAL | Low | | 55 | FLAG |
| 900011 | RELATIONAL | Low | | 35 | |
| 900011 | SPIRITUAL | Low | | 25 | |
| 900011 | SOCIOECON | Low | | 55 | FLAG |
| 900012 | PHYSICAL | Low | | 77.5 | FLAG |
| 900012 | BEHAVIORAL | Low | | 70 | FLAG |
| 900012 | RELATIONAL | Low | | 67.5 | FLAG |
| 900012 | SPIRITUAL | Moderate | | 62.5 | |
| 900012 | SOCIOECON | Low | | 55 | FLAG |
| 900013 | PHYSICAL | Low | | 66.75 | FLAG |
| 900013 | BEHAVIORAL | Low | | 43.75 | |
| 900013 | RELATIONAL | Low | | 62.5 | FLAG |
| 900013 | SPIRITUAL | Low | | 77.5 | FLAG |
| 900013 | SOCIOECON | Low | | 45 | |
| 900014 | PHYSICAL | Moderate | | 68.75 | |
| 900014 | BEHAVIORAL | Moderate | | 58.75 | FLAG |
| 900014 | RELATIONAL | Low | | 72.5 | FLAG |
| 900014 | SPIRITUAL | Moderate | | 60 | |
| 900014 | SOCIOECON | Low | | 55 | FLAG |
| 900015 | PHYSICAL | Low | | 86.25 | FLAG |
| 900015 | BEHAVIORAL | Low | | 80 | FLAG |
| 900015 | RELATIONAL | Low | | 70 | FLAG |
| 900015 | SPIRITUAL | High | | 90 | |

| | | | | |
|---|---|---|---|---|
| 900015 | SOCIOECON | Low | 65 | FLAG |
| 900016 | PHYSICAL | Low | 75 | FLAG |
| 900016 | BEHAVIORAL | Low | 50 | |
| 900016 | RELATIONAL | Low | 40 | |
| 900016 | SPIRITUAL | Low | 25 | |
| 900016 | SOCIOECON | Low | 60 | FLAG |
| 900017 | PHYSICAL | Low | 63.5 | FLAG |
| 900017 | BEHAVIORAL | Low | 60 | FLAG |
| 900017 | RELATIONAL | Low | 50 | |
| 900017 | SPIRITUAL | Low | 47.5 | |
| 900017 | SOCIOECON | Low | 60 | FLAG |
| 900018 | PHYSICAL | Moderate | 67.5 | |
| 900018 | BEHAVIORAL | Low | 75 | FLAG |
| 900018 | RELATIONAL | Low | 85 | FLAG |
| 900018 | SPIRITUAL | Low | 70 | FLAG |
| 900018 | SOCIOECON | Low | 80 | FLAG |
| 900019 | PHYSICAL | Moderate | 80 | FLAG |
| 900019 | BEHAVIORAL | Moderate | 60 | |
| 900019 | RELATIONAL | Moderate | 30 | FLAG |
| 900019 | SPIRITUAL | Low | 32.5 | |
| 900019 | SOCIOECON | Low | 35 | |

## APPENDIX K

## PHASE 2 ICC RESULTS (ORIGINAL APP VALUES VS. EXPERT RE-RATE)

### Physical Intraclass Correlation Coefficient

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .330[a] | -.088 | .673 | 2.735 | 17 | 17 | .023 |
| Average Measures | .497[c] | -.193 | .804 | 2.735 | 17 | 17 | .023 |

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type A intraclass correlation coefficients using an absolute agreement definition.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## Behavioral Intraclass Correlation Coefficient

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .092[a] | -.051 | .368 | 2.677 | 17 | 17 | .025 |
| Average Measures | .169[c] | -.107 | .538 | 2.677 | 17 | 17 | .025 |

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type A intraclass correlation coefficients using an absolute agreement definition.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## Relational Intraclass Correlation Coefficient

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .127[a] | -.059 | .448 | 3.148 | 17 | 17 | .012 |
| Average Measures | .225[c] | -.124 | .619 | 3.148 | 17 | 17 | .012 |

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.
b. Type A intraclass correlation coefficients using an absolute agreement definition.
c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## Spiritual Intraclass Correlation Coefficient

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .251[a] | -.079 | .640 | 4.796 | 17 | 17 | .001 |
| Average Measures | .401[c] | -.170 | .781 | 4.796 | 17 | 17 | .001 |

Two-way mixed effects model where people effects are random and measures effects are fixed.
a. The estimator is the same, whether the interaction effect is present or not.
b. Type A intraclass correlation coefficients using an absolute agreement definition.
c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## Socio-econ Intraclass Correlation Coefficient

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .012[a] | -.066 | .173 | 1.111 | 17 | 17 | .415 |
| Average Measures | .023[c] | -.141 | .295 | 1.111 | 17 | 17 | .415 |

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.
b. Type A intraclass correlation coefficients using an absolute agreement definition.
c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## APPENDIX L

### PHASE 3 ICC RESULTS (APP RE-RATE VS. EXPERT RE-RATE)

**Physical Intraclass Correlation Coefficient**

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .663[a] | .303 | .858 | 4.886 | 17 | 17 | .001 |
| Average Measures | .797[c] | .466 | .924 | 4.886 | 17 | 17 | .001 |

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type A intraclass correlation coefficients using an absolute agreement definition.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## Behavioral Intraclass Correlation Coefficient

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .599[a] | .138 | .836 | 5.266 | 17 | 17 | .001 |
| Average Measures | .749[c] | .243 | .911 | 5.266 | 17 | 17 | .001 |

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type A intraclass correlation coefficients using an absolute agreement definition.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## Relational Intraclass Correlation Coefficient

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .590[a] | .180 | .824 | 3.766 | 17 | 17 | .005 |
| Average Measures | .742[c] | .305 | .904 | 3.766 | 17 | 17 | .005 |

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type A intraclass correlation coefficients using an absolute agreement definition.
c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## Spiritual Intraclass Correlation Coefficient

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .827[a] | .594 | .932 | 11.634 | 17 | 17 | .000 |
| Average Measures | .905[c] | .745 | .965 | 11.634 | 17 | 17 | .000 |

Two-way mixed effects model where people effects are random and measures effects are fixed.
a. The estimator is the same, whether the interaction effect is present or not.
b. Type A intraclass correlation coefficients using an absolute agreement definition.
c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

## Socio-econ Intraclass Correlation Coefficient

| | Intraclass Correlation[b] | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | .167[a] | -.337 | .585 | 1.383 | 17 | 17 | .256 |
| Average Measures | .286[c] | -1.016 | .738 | 1.383 | 17 | 17 | .256 |

Two-way mixed effects model where people effects are random and measures effects are fixed.
a. The estimator is the same, whether the interaction effect is present or not.

b. Type A intraclass correlation coefficients using an absolute agreement definition.
c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

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