THE UTILIZATION OF GPS TECHNOLOGY IN TRACKING HOMELESS ADULTS: A PILOT STUDY

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DEDICATION

I would like to thank the members of my Graduate Committee for supporting me throughout this process. I would also like to thank my family and friends, who given me all of the love and support I could have ever asked for. Mom and Dad thank you for encouraging me all the way since the beginning of my studies. Dad thank you for all of your sacrifices you have made for your children's education. I could not have asked for better parents.

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by

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ABSTRACT

The purposes of the present study were to examine the feasibility of using GPS technology in a difficult-to-follow homeless population and to develop GPS tracking methods that researchers can utilize in future studies. Twenty individuals were recruited from a homeless day center. Each carried a GPS unit to record their movements for approximately 24 hours. Participants completed interviews consisting of demographic questions, a pre-tracking survey, and a post-tracking survey about planned and reported travels respectively and also submitted urine specimens for substance use testing. GPS data were downloaded from the tracking device and exported into ArcMap 10 and SAS 9.3 for analysis. Concerted efforts were made to achieve successful deployment with the first eight participants, necessitating refinement of the research procedures. Thereafter, 81% success was attained in collecting adequate deployment data. Travel distances varied (.05-36 miles), mostly taken on foot and by city bus. No GPS units were lost during deployment, although one was water-damaged in a shower. Challenges encountered in the study included battery problems (power drainage, theft), signal loss, lengthy initial calibrations (up to 15 minutes), inaccurate recordings due to drift of satellite anchors to positions, and difficulties re-engaging with participants post deployment. The study demonstrated the feasibility of using GPS technology to track movements of a difficult-to-track population. This work has clarified the need to integrate GPS and

report data to maximize the precision of geospatial data. The success of this pilot study suggests novel potentials for GPS technology to improve service access and identify geospatial barriers to care.

Keywords: homeless, tracking, global positioning systems (GPS), geographic information systems (GIS), service

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF DEFINITIONS/ABBREVIATIONS

GIS: Geographic Information System

GPS: Global Positioning Systems

ICH: Interagency Council on Homelessness

NAEH: National Alliance to End Homelessness

CHAPTER ONE

Introduction

Homelessness is a one of the most pressing social issues in the United States. On any given day more than 750,000 people experience homelessness (United States Department of Housing and Urban Development [HUD], 2007; Schindler & Coley, 2007) and 2.3 million to 3.5 million individuals annually (Kushel & Miaskowski, 2006). The majority of these individuals are found in emergency shelters, transitional housing, or supportive housing, and the remainder lives in places not meant for human habitation (HUD, 2007). Researchers have attempted to measure the actual number of homeless people in the United States, but this proves to be a challenging task. People who are homeless have been found to have high rates of mental illness and substance abuse problems (North, Eyrich-Garg, Pollio, & Spitznagel, 2004; Harpaz-Rotem, Rosenheck, & Desai, 2006), health complications (Padgett, Struening, & Andrews, 1990; Baggett, Singer, Rao, O'Connell, Bharel, & Rigotti, 2010), and barriers to obtaining services (Page, 2007; Young et al., 2005). In addition to these risks, homeless individuals are more likely to experience legal problems, hospitalizations, incarcerations, and social discrimination (White, Chafetz, & Collins-Bride, 2006).

Programs have been developed to assist individuals who are homeless including those providing housing, medical care, mental health services,

substance abuse treatment, case management, food services, and domestic violence shelters. In 1996 the National Survey of Homeless Assistance Providers and Clients (Burt, Aron, Douglas, & Valente, 1999) estimated that 40,000 homeless programs existed in the United States. Even though homeless services are available, many homeless individuals do not access and utilize these resources. This may relate to their lack of insight into their problems (North & Smith, 1993) and/or inconvenient locations and timing of available services. In order to investigate and identify geographic and temporal barriers to services researchers may want to examine homeless individuals' travels, and develop reliable and applicable techniques for tracking these travels.

Practical methods for tracking difficult-to-follow populations are needed in order to appropriately place resources in the community. Previous methods for documenting the travels of these populations have included obtaining individuals personal information, obtaining service utilization statistics, and following individuals by cell phone contact. Optimal understanding of various issues including travel times and destinations among the homeless population requires more sophisticated techniques for tracking individuals.

The purpose of the present study was to examine the feasibility of using global positioning systems (GPS) technology in a difficult to follow population and to develop GPS tracking methods that researchers can utilize in future studies.

CHAPTER TWO

Review of the Literature

Historical Perspective on Homelessness

Homelessness is a pressing issue in modern society. The concept of the homelessness-has evolved over the past few decades. Many of the earliest investigations into homelessness focused on the "skid row" areas of the country, where men congregated in boarding houses, labor employment agencies, and cheap single-room-occupancy hotels. Even though these individuals technically had places to stay, they were considered to be homeless due to their lack of social ties and stable housing of their own. Homelessness was generally not conceptualized as a housing problem but rather as a social anomaly in which individuals severed family ties (Bahr, 1967). Researchers posited that the combination of the development of anti-psychotics in the 1950s and deinstitutionalization in the 1960s resulted in significant increases in homeless populations nationwide (Pollack, 1975; Shlay & Rossi, 1992; Shibusawa & Padgett, 2009).

Deinstitutionalization began in 1963 when the federal government passed the Community Mental Health Center Act, which led to the release of patients from psychiatric hospitals. The hope was that they would be cared for by community clinics. Long-term psychiatric patients were released from state

hospitals into Single Room Occupancies and referred to community health care centers for follow-up and medication-management appointments. The expectation that society would take care of the patients proved to be too lofty, as communities did not have the financial or professional resources to accommodate large numbers of mentally ill individuals. Researchers have speculated that the combination of this legislation (Shibusawa & Padgett, 2009; Brousseau 2009), lack of affordable housing, and the crack cocaine epidemic of the mid-1980s (O'Toole, Conde-Martel, Gibbon, Hanusa, Freyder, & Fine, 2004) contributed to the increase in homeless populations nationwide.

Until the 1970s, the homeless stereotype was that of an older white alcoholic man who sat on the street corner and begged for change (Pollack, 1975; Shlay& Rossi, 1992). Research and media outlets dissolved this stereotype in the early 1980s. During this time the country faced economic distress and high unemployment rates, and homelessness was recognized as an epidemic (Brousseau, 2009). Homeless individuals became more visible throughout urban communities, spilling out of skid rows and into public places. The new image of the homeless individual was the deinstitutionalized, forsaken victim of the nation's mental health and social systems. This stereotype included the bag ladies and severely mentally ill young men seen muttering to themselves in alleyways (Jones, 1983; Appleby & Desai, 1985; Torrey, 1986; Lamb, 1984). Society characterized the homeless as seriously mentally ill (Snow, Baker, Anderson, and

Martin 1986). Researchers added to the stereotype by reporting that 50% to 75% of the homeless were estimated to be schizophrenic (Lipton, Sabatini, & Katz, 1983; Torrey, 1986) and 84% to 100% purportedly suffered from mental illness (Bassuk, Rubin, & Lauriat, 1986; Arce, Tadlock, Vergare, & Shapiro, 1983). In response to the increasing financial burden that the homeless population placed on cities and rural locales nationwide, the government enacted the Stewart B. McKinney Homeless Assistance Act in 1987. This legislation was the first major federal allowance specifically designated to assist homeless individuals in finding shelter (Burt, Aron, Lee, & Valente, 2007; United States Department of Housing and Urban Development, n.d.). The law established a variety of services including emergency food and shelter, education, and job training (Burt, et al., 2007).

After further social movements that transpired in the late 1980s to early 1990s, the concept of homelessness changed yet again. An influx of the "new homeless" at shelters and local outreach services occurred. Overall the number of homeless people grew dramatically during the 1980s (Susser, Valencia, & Conover, 1993). Studies portrayed the *new* homeless population as younger and more heterogeneous, including a greater proportion of single women and an overrepresentation of minorities (Fischer, 1988). Many existing homeless facilities had to expand to accommodate the growing population.

Definition of Homelessness

Current definitions of homelessness can range from the limited view that identifies the homeless individual as one living on the streets or in shelters to a broader conceptualization that classifies homelessness as a living situation "without permanent housing" (Fazel, Khosla, Doll, & Geddes, 2008). Contemporary definitions of homelessness are linked to individuals' housing situations rather than their lack of social ties (Shlay & Rossi, 1992). Many policies and social service programs identify a homeless person as an individual who lacks a fixed, regular, and adequate nighttime residence (US Department of Housing and Urban Development 2011).

The United States government's definition of homelessness originates from the McKinney Act originally passed in 1983 and renamed to the Stewart B. McKinney Assistance Act in 1987. This description of homeless populations encompasses individuals who sleep at primary nighttime residences including publicly or privately operated shelters, institutions that provide temporary residences for individuals who have been recently discharged from penal or mental institutions, public or private places not designed for or ordinarily used as a regular sleeping accommodations for human beings (United States Department of Housing and Urban Development, 2011). Some researchers extend the definition to include individuals who are in shelters, jails, or single room hotels (Fischer & Breakey, 1986), but not all agree on inclusion of these living

arrangements. The definition for homelessness emphasizes that the distinguishing feature of homelessness is the instability of an individual's living arrangement.

Researchers do not agree on one definition of homelessness. The varying definitions each support different views of the magnitude of the homelessness problem. For example, advocates for the homeless favor more inclusive definitions that would increase the estimated number of homeless individuals (Kondratas 1991).

Demographics

Determining the characteristics of homeless individuals is important for developing resources. Researchers estimate that each year, 1% of the United States population will face homelessness for at least one night (Thompson, 2003). According to the United States Department of Housing and Urban Development (2007), the most common demographic features of homeless individuals are: male gender, members of minority groups, individuals over the age of 31, and single marital status. In 2009 HUD (HUD, 2009) collected data across the United States from two sources: single-night, point-in-time counts of both sheltered and unsheltered homeless populations reported by HUD applications and counts of the sheltered homeless population over a full year in community samples based on data in the Homeless Management Information Systems. The majority of all homeless people are African-American (45%) and Caucasian (41%) with Latinos (5.7%) and mixed race (5.1%) individuals composing a small minority (HUD,

2007). Over 40% of all homeless individuals are between 31 and 50 years old, approximately 21% are between 18 and 30, 22% are under 18, and 11% are over the age of 51 (HUD, 2007).

Homeless Youth

Young adults ages 18 to 24 are vulnerable to homelessness. Ensign (2004) found that homelessness among young individuals is more common than homelessness among older adults. Reasons for homelessness among youth have been found to be parental conflict, violence between family members, or physical, sexual, or emotional abuse by a family member (Johnson, Rew, & Sternglanz, 2006; Rosenthal, Mallett, & Myers, 2006). Drug abuse has been found to be associated with youthfulness among homeless individuals (Smith, North, & Spitznagel, 1991).

Measuring the actual number of homeless people in the United States proves challenging because many homeless individuals are "hidden" (Smith, North, & Spitznagel, 1991). Many homeless people are unseen to researchers and reside in places such as abandoned buildings, tunnels, and acquaintances' couches. Additionally, many of these individuals are not forthcoming about their current living situation. Estimates of the population prevalence of homelessness vary by millions because of sampling biases (North, Eyrich, Pollio, & Spitznagel, 2004). Link and colleagues (1994) suggested that these sampling biases are due to problems in finding hidden homeless individuals, including people who deny

that they are homeless, and researchers missing individuals who experience relatively short episodes of homelessness.

Risk Factors for Homelessness

Factors that contribute to homelessness are diverse. Individuals who are likely to be homeless have a history of alcohol problems (Castaneda, Lifshutz, Galanter, & Franco, 1993; Robertson, Zlotnick, & Westerfelt, 1997; North et al., 2004), substance use disorders (North et al., 2009), suicide attempts (Geissler et al., 1995), and legal issues (Susser, Struening, & Conover, 1989). In addition to these factors, psychiatric illness has long been identified as a risk factor for homelessness (Forchuk, Russell, Kingston-MacClure, Turner, & Dill, 2006). In particular, substance use disorders appear to be major risk factors for homelessness (Susser et al., 1989; Breakey et al., 1989; North et al., 2004). Social factors including lack of affordable housing and family experiences also play an important role in homelessness (United States Department of Labor Bureau of Labor Statistics, 2003). Individuals who come from families with parental instabilities, poor care from parents, and inadequate family support during adulthood are at increased risk for homelessness (Caton et al. 1994; Winkleby & White, 1992).

Psychiatric Disorders among the Homeless Population

The prevalence of psychiatric disorders among homeless individuals is significantly higher compared to the prevalence of psychiatric disorders in

society. The most prevalent psychiatric disorders found in homeless populations are substance use disorders (Breakey et al., 1989; Smith, North, & Spitznagel, 1992, 1993; Welte & Barnes, 1992). The percentage of individuals who meet criteria for substance use disorders ranges from 31% to 72% (Haughland, Siegel, Hopper, & Alexander, 1997; Kushel, Vittinghoff, & Hass, 2001; Smith et al., 1992). The second most common psychiatric disorder reported in studies of homeless populations is major depressive disorder (Koegel et al., 1988), but researchers have noted that a portion of the major depression experienced in the homeless population may be confounded with difficult environmental circumstances (North, Eyrich, Pollio, Foster, Cottler, & Spitznagel, 1997). In one study, researchers found that approximately 25% of homeless men met diagnostic criteria for antisocial personality disorder (North, Smith, & Spitznagel, 1993).

Before the 1990s, published information about the prevalence of psychiatric illnesses among the homeless population was unreliable and imprecise (Smith et al., 1992). Many research efforts lacked standardized interviews and diagnostic criteria, which led to sample inadequacies and biases. For example, during the early 1980s, research studies overestimated the prevalence of schizophrenia in homeless populations (Lipton et al., 1983; Torrey, 1986). Subsequent studies using more sophisticated methods such as structured interviews estimated the prevalence to be a more realistic 5% to 15% (North, Eyrich, Pollio, & Spitznagel, 2004; Smith, North, & Spitznagel, 1991). In the

past two decades, researchers have developed and implemented reliable tools for measuring mental illness specifically for homeless populations. Researchers utilizing standardized diagnostic criteria and interviews estimate the prevalence of schizophrenia aside from substance use disorders have documented a range from 2% to 8% (Smith, North, & Spitznagel, 1992; Fischer & Breakey, 1986; Susser et al., 1989; North, Eyrich, Pollio, & Spitznagel, 2004).

North, Eyrich, Pollio, and Spitznagel (2004) collected data on homeless individuals spanning three decades. The team examined the prevalence of psychiatric illnesses among samples of individuals who met the study's criteria for homelessness in St. Louis from 1980, 1990, and 2000. The results indicated that the prevalence rates of mental illnesses in homeless populations are not static. For example, they found that from 1980 to 2000, increased proportions of individuals met criteria for bipolar disorder, major depression, and panic disorder.

Substance Use among the Homeless Population

Substance use disorders are the most common psychiatric disorders found in the homeless population (Fazel, Khosla, Doll, & Geddes, 2008; North, Eyrich, Pollio, & Spitznagel, 2004). Substance abuse/dependence is both a risk factor and a confounding issue of homelessness. Over the past 15 years, studies have documented current drug use in homeless individuals in proportions ranging from 29 to 79% (Appel, Hoffman, Blane, Frank, Oldak, & Burke, 2001; Haughland, Siegel, Hopper, & Alexander, 1997; Lambert & Caces, 1995; Lee & Schrek,

2005). The prevalence of current substance use disorders among the homeless ranges from 31% to 72% (Haughland et al., 1997; Kushel, Vittinghoff, & Hass, 2001).

Alcohol abuse/dependence is more common in older generations, while other substance abuse/dependence is more common in homeless youth and young adults (Didenko & Pankratz, 2007). Recent research has suggested that patterns of substance use disorders have evolved over the past two decades among the homeless (Fischer & Breakey, 1991; North et al., 2004). In a study conducted by North, Eyrich-Garg, Pollio, & Thirthalli (2004), urinalysis and self-report measures measured substance use and abuse among homeless individuals over time. This study found that substance use disorders increased dramatically in both homeless men and women over the past two decades. The most commonly abused substance was crack cocaine, which has been observed to rise in use among the homeless population in the past twenty years (Fischer & Breakey, 1991; North et al., 2004).

Utilization of Resources by Homeless Individuals

Services for homeless individuals include emergency shelters, temporary housing facilities, case management services, health services, transportation, vocational training services, and drug and alcohol rehabilitation services. In the 1960s homeless individuals were corralled into the criminal justice system (Aaronson, Dienes, & Musheno, 1978). In the 1970s the United States

government responded with a push of decriminalization of drunkenness with the Uniform Alcoholism and Intoxication Treatment Act. This act encouraged states to decriminalize public inebriation and paved the way for rehabilitation and detoxification centers and halfway houses. When the demographics of the homeless population changed in the 1980s, the need for different services became evident to researchers and policy makers (Bachrach, 1984; Lamb, 1984). Researchers began to note that rehabilitation facilities and halfway houses alone were not meeting the needs of the homeless population.

The Stewart B. McKinney Homeless Assistance Act of 1987 funds the majority of homeless assistance initiatives. This legislation continues to represent the most significant federal response to homelessness in American history, and it funds 20 assistance programs administered by six federal departments. Since 1987, the McKinney Act has been reconfigured and reauthorized by amendments that increased the budget from 326 million dollars (Foscarinis, 1996) to almost 2.5 billion dollars (National Coalition for the Homeless, 2008). Initially these funds were directed towards building emergency shelters for the homeless, which offered short-term shelter options to meet the immediate need for housing. Currently, emergency shelters are considered to be the first line of defense in caring for homeless populations.

In 1987 the McKinney funds also introduced a new type of shelter: the transitional housing shelter (National Coalition for the Homeless, 2008).

Transitional housing options are temporary solutions that provide clients with up to, but no more than, 24 months in a transitional housing facility. Transitional housing services are typically directed towards achieving "housing readiness" for homeless individuals by incorporating case management services, mental health services, and vocational training opportunities (Wong, Park, & Nemon, 2006).

Barriers to Services

Homeless individuals face numerous barriers when trying to access services. These barriers include reluctance of service providers to treat homeless patients (Cohen, 1989), homeless individuals' distrust of providers and authorities (Appleby & Desai, 1985), and lack of insurance (Folsom et al., 2005). Homeless young adults may not access resources due to lack of familiarity with health care resources (Klein et al., 2000), transportation problems, and lack of respect for providers (Ensign & Panke, 2002).

In the last decade, organizations such as the National Alliance to End Homelessness (NAEH) and the Interagency Council on Homelessness (ICH) have encouraged communities to create and execute state and local plans to end homelessness. One of these endeavors is Housing First, which focuses on housing the chronically homeless who may encounter barriers to receiving services. Housing First is an alternative to emergency shelters and transitional housing programs. Instead of moving individuals through different levels of

housing, the program moves the homeless individual immediately from the street or homeless shelter into his/her own apartment.

As of 2006, more than 40,000 agencies offer services to the homeless (Mitka, 2006). It is difficult to ascertain if these services are decreasing the number of homeless individuals, but researchers have noted that service utilization is correlated with positive outcomes (Pollio, North, Eyrich, Foster, & Spitznagel, 2003). In particular, Pollio and colleagues (2003) found that stable housing is predicted by service utilization. In spite of the services available, many individuals do not utilize them (Padgett et al., 1990; Folsom et al., 2005). Part of the underutilization of mental health services may be related to the lack of perceived need for them (Padgett et al., 1990; North & Smith, 1993). Because homeless individuals usually lack health insurance, they tend to neglect routine management of chronic illnesses such as hypertension, heart disease, diabetes, and emphysema (Sachs-Ericsson, Wise, Debrody, & Paniucki, 1999). Homeless persons have higher rates of emergency room visits (Burt et al., 1999) and hospitalization (Kushel et al., 2001) compared to the general population.

Tracking Efforts within Homeless Populations

To appropriately allocate and place services in the community, researchers must understand the movement patterns of homeless populations. To accomplish this, reliable and applicable techniques for following homeless populations should be developed. The need for practical methods for tracking difficult-to-follow

populations has been recognized among researchers (Bindman, Grumbach, Keane, & Lurie, 1993; Conover et al., 1997; Pollio et al., 2003), especially for individuals who suffer from psychiatric illness and socioeconomic deprivation (North et al. 2004). Previous tracking methods for socially marginalized populations have primarily consisted of obtaining individuals' contact information (Bale, Cabrera, & Brown, 1977; Cohen et al., 1993; Cottler et al., 1996) and using agency contacts (Bale et al., 1984; Craig, 1979). Aside from these methods, researchers have utilized cell phones to track difficult populations (Wright, 1993).

A study conducted by McKenzie, Tulsky, Long, and Chesney (1999) systematically reviewed previous tracking studies and follow-up of difficult-to-locate participants. They examined fifteen articles and found ten variables that predicted successful tracking. These components included (1) collection of contact information, (2) organized efforts, (3) research staff training and support, (4) use of phone and mail follow-up, (5) use of incentives, (6) establishing rapport with participants, (7) emphasis of confidentiality, (8) use of agency tracking, (9) use of field tracking, (10) and attention to staff and participant safety (McKenzie et al., 1999).

A study conducted by Pollio, Thompson, and North (2000) explored agency-based tracking methods for runaway and homeless youth. Data were collected from three agencies that provided services to this particular population in St. Louis. The team collected data from a total of 118 individuals who were

under 18 and met the inclusion criteria for the study. Individuals who participated in the study must have "absented themselves from their homes or places of legal residence without parental or legal guardian approval." Tracking the participants consisted of staff members calling various locations at different times to locate and interview participants. After three months Pollio, Thompson, and North (2000) located 69% of the participants and 59% agreed to be interviewed. The study broke new ground in agency-based tracking of difficult-to-follow homeless populations.

North, Black, and Pollio (2012, in press) conducted a longitudinal study that followed 400 homeless individuals over a twenty-four month period using various tracking methods. The team used letters, phone calls, posters, and personal visits to contact participants. Approximately three-fourths of the sample was successfully tracked. The tracking method that most successfully tracked participants was telephone contact.

Optimal understanding of various issues among the homeless population requires research investigation of the longitudinal course of homelessness. This calls for investigation and development of research methods for successful tracking. Innovations in GPS technology have stimulated researchers' interests in the development of technologies using portable and wearable GPS tracking devices (Oliver, Badland, Movoa, Duncan, & Duncan, 2010). GPS technology has been used for tracking criminals, following individuals with memory

impairments, assessing physical activity, and monitoring adolescent driving behaviors (Rainham, Krewski, McDowell, Sawada, & Liekens, 2008). GPS networks pinpoint specific locations by using radio signal transmissions from satellites to GPS receivers on the planet (a process known as trilateration), and the combination of a series of specific locations can be used to represent routes traveled.

GPS technology can be combined with geographic information systems (GIS) technology. GIS technology consists of computer programs or applications that integrate information about geographic locations and spatial correlations. GIS technology combines spatial data with computer graphics and databases to create a background (Badland, Duncan, Oliver, Duncan, & Mavoa, 2010) such as a map embedded with various types of geographic, social, political, and ecological data. A GPS database depicting routes traveled can be combined with a GIS database to display the geographic area with the routes overlaid and information about selected characteristics of the area. These methods have potential for use in studying the movements of homeless populations.

Purpose of the Present Study

The study was conducted for the purposes of learning about the different types of relationships between geographic areas, substance use, and service utilization that are part of homeless individuals' everyday lives. By mapping out the routes taken by multiple individuals, researchers can identify common spaces,

potential pitfalls, and services utilized. This study the examined the potential to collect data and use it to test the following sample hypotheses:

(1) When asked to predict their travel in advance, participants will overestimate the mileage they will cover during deployment of the GPS device over approximately 24 hours.

(2) Compared to the participants who test negative for substances, those who test positive will travel significantly more miles.

(3) Participants who are younger than 30 years old will travel significantly farther than participants who are 30 years old and older.

Tangible products of this study are revised interviews (Appendices A and B), a field manual (Appendix C) describing detailed methods for conducting a study of this nature based on the experience of administering them to this study's research participants, and datasets for analysis in SAS and inspection of data in ArcGIS and Google™ Earth.

CHAPTER THREE

Methodology

Preliminary Work in Preparation of the GPS Device and Optimization of Settings

Because this study was intended as a pilot study and one of its aims was to develop, pioneer, and refine the methods for tracking homeless populations, this section incorporates subsequent refinements of the originally planned methodology based on this study's experience. Problems encountered in the field during this study are considered findings of the study and are thus presented, along with a description of subsequent procedural modifications addressing these methodological issues, in the Results section. A point-by-point description of the finalized version of this study's methods with incorporated modifications resulting from the experience of this research (with a level of detail in excess of that warranted for the body of this thesis) are provided in the manual in Appendix C, permitting future researchers to replicate this work with complete instructions for every step.

The GPS device used for tracking study participants' geospatial movements in this study was the Trackstick II by Telespial Systems, Inc. (Telespial Systems, Marina Del Rey, CA). Use of this device required extensive exploration of its capabilities and field testing under varying-conditions relevant to the research design to ready it for use in this homeless tracking study. Specific

functions and measures to be explored and mastered were: (1) the device settings: power level, data recording frequency settings, stop thresholds; (2) time duration required for initial activation/location of satellite positions; (3) expected battery life under different conditions (inside/obstructed vs. outside/unobstructed) and on various combinations of power settings and adjustments; (4) uploading data from the device to software on a computer and exporting the data in formats required by various programs for viewing and analysis; and (5) depiction of data in output: determining time required for powering on and off; representation of data records (data points), tracks (data collected between powering on and off of the device), and routes (data collected between stops); accuracy of recordings in unobstructed and obstructed areas (e.g., under highway overpasses or in buildings. Once the device was mastered and readied for use in the field, trouble-shooting of unusual behaviors of the device (e.g., drain of battery power, drift of signal, and problems with erratic on/off recordings) was necessary to ensure optimal functioning of the device to obtain the research data.

Systematic experimentation to determine variability of the GPS device for the purposes of this study was conducted using a version 2.2 Trackstick II GPS device left in a stationary location to determine the relative life of the batteries on different power settings and interval settings, both indoors and outdoors.

Stationary pre-testing of battery life in the device was conducted in both indoor and outdoor locations using different settings of the device. The

researcher conducted tests of battery life on both high ("slow track") and low ("fast track") power settings both indoors and outdoors. The high power setting was tested at the most frequent recording interval, one minute, to maximize the amount of data and precision of recorded travels to be obtained. The low power setting had only one option, auto-adjusting intervals beginning with 15 seconds. The indoor testing was conducted on the fourth floor of a multi-story university building, and the outdoor testing was conducted on a second-floor balcony of a two-story building with an unobstructed view of sky. As seen in Table 1, when the device was left outside with an unobstructed view of the sky, the time to drain one pair of batteries ranged from 12 to 33 hours, depending on the setting. When the device was tested inside a building, the batteries lasted 5 to 14 hours, depending on the setting. The batteries lasted longer on the high-power setting than on the low-power setting. The batteries also lasted longer when the device was left outside with an unobstructed view of the sky than when it was left inside a building structure.

The researcher also pre-tested the length of time required to activate the device (acquire satellite positions) at different settings in open environments. The high-power setting took more time to activate (see Table 2).

The researcher self-deployed with the device in different experimental environments using various combinations of power settings and adjustments to examine the accuracy of the recorded routes and depiction of recorded data points

using the device's different power settings. Inspection of the pre-deployment recordings revealed that the high-power ("slow track") setting appeared to have less geographic accuracy, with more drift and deviation in recording the route taken, compared to the low-power ("fast track") setting.

Based on the findings of these pre-study experiments with the GPS device, it was determined that the most suitable setting for the device in the current study would be the low-power ("fast track") mode on the fixed 15-second recording interval because it provided a more detailed record of the participants' movements. Because this setting drained the power from the batteries faster than in the high-power mode, it would be necessary to provide participants with a fresh pair of replacement batteries to insert in the device at the start of the second day of deployment when the original batteries would be depleted.

Sample

The participants in this project were people who use services at the Fort Worth Day Resource Center. For the purposes of this study, individuals who received services from the Day Resource Center were considered to be homeless. Because the pilot study was primarily focused on the feasibility of the methods and the reception among homeless individuals, the sample size was relatively small. The study was designed to obtain complete data from 20 participants.

Location

The study was conducted at the Fort Worth Day Resource Center in Fort Worth, Texas. This center offers basic services including showers, laundry facilities, mailing address, access to computers, and case management resources. The site also hosts representatives from homelessness assistance agencies. The Fort Worth Day Resource Center is a popular destination for homeless individuals in Fort Worth, serving over 150 people every day.

Procedure

The project was approved in advance by the University of Texas Southwestern Medical Center Institutional Review Board for data collection and subsequent data analysis. Protected health information collected in the study was not disclosed outside the members of the research team.

Recruitment of study participants proceeded over a period of approximately twelve months (December 2010 through December 2011). The researcher recruited the sample by approaching clients at the Fort Worth Day Resource Center for the Homeless who were identified by staff at the Center as consistent utilizers of services at the Center. The researcher provided an introduction, briefly explained the study, and asked the prospective participant if he or she would be interested in participating in a research study. For individuals expressing interest, the researcher provided detailed information about the study and invited the person to participate. Only those willing and able to sign informed consent were enrolled in the study, and all participants provided written

informed consent before entering the study. Participants who agreed to enroll in the study reviewed the consent and HIPAA authorization forms with the research assistant who answered any participant questions. Children and minors under age 18 were excluded from the study.

Pre-tracking procedure. After willing participants were consented and enrolled in the study, the researcher administered a baseline interview consisting of 67 personal and demographic questions and a pre-tracking survey. The participant then submitted a baseline urine sample. Next, the researcher provided the participant instructions for carrying the GPS device and optimal use of the instrument.

These instructions were:

(1) Carry the GPS device with you during the entire deployment period.

(2) Avoid turning the GPS device on and off.

(3) Do not allow the GPS device to get wet.

(4) Do not place the GPS device adjacent to a cell phone because this may interfere with the ability of the device to communicate with satellites to locate position.

(5) During the night, the GPS device will most likely drain its batteries; thus the device will likely be nonfunctional in the morning. First thing in the morning, replace the spent batteries in the device with the fresh replacement batteries, and then stand outside with the device to orient to satellites and location.

When the green light begins to blink, the device will begin to track geographical movements and is ready to use.

Participants were encouraged not to alter their normal routes of travel while carrying the GPS units.

Tracking procedure. The tracking procedure began with the issuance of a GPS unit and a replacement pair of batteries to the participant. The researcher instructed the participant to attach the device onto the participant's own backpack or clothing item. The researcher then escorted the participant outside the Day Resource Center to a nearby location with unobstructed sky and powered on the GPS device so that it could obtain its satellite positions. The researcher demonstrated to the participant how to position the globe on the front of the device toward the sky without obstructions by metal objects or concrete walls. The researcher then stood with the participant for up to fifteen minutes as required by the device to obtain its satellite positions, to ensure that the unit was functioning at the start of its deployment with the participant. The participant's deployment period began when GPS device indicated that it had obtained positioning (a blinking green light). The participant and researcher then mutually agreed on a specific time and place to meet for the follow-up survey and retrieval of the GPS device approximately 24 hours later, and the participant and researcher parted company.

Post-tracking procedure. At the end of the deployment period, the participant met the research assistant and returned the GPS unit at the previously agreed-upon time and place. The researcher conducted a short post-deployment interview with the participant to obtain details about the participant's travels, destinations, and purposes for traveling to those destinations during the deployment period. The researcher uploaded the recorded data on to a laptop and examined the time records and routes travelled by the participant. Once familiar with these components, the researcher administered the post-tracking survey. The participant then submitted a post-deployment urine specimen. After returning the GPS device with at least 20 hours of recorded data, completing the post-deployment interview, and providing the post-deployment urine sample, the participant received an incentive of $10.00. This process continued until 20 individuals returned the GPS with at least 20 hours of data.

Participants who failed to generate at least 20 hours of recorded data were asked as part of the post-tracking procedure about their experience with the GPS device over the course of their deployment period. These participants were provided an opportunity to re-deploy with the device for another 24-hour period with the goal of collecting at least 20 hours of recorded data. The researcher provided assistance with trouble-shooting potential sources of failure of the device to record more data. Participants who returned the device after re-deployment with at least 20 hours of data and completed the post-deployment

interview and submitted a post-deployment urine sample received the $10.00 incentive and were considered study completers.

Instruments of Measure

Interviews. The researcher collected data about participants and their travels through personal interviews both before and after the tracking procedure. In the pre-tracking interview, the researcher asked the participant to provide personal and demographic information, including age, race, ethnicity, education, income level and sources of income, residential history with history of homelessness, medical and mental health history including substance use, service use, legal history, social networks, and information about the participant's relationships with family and friends. The researcher also conducted a pre-tracking survey about the participant's travel plans for the upcoming 24-hour tracking period, specifically a consecutive list of intended travels to specific locations and purposes for the travel to each destination.

The post-tracking interview inquired about drug and alcohol use, service utilization, and a consecutive description of all geographic movements (locations, reasons for travel, and means of transportation) during the 24-hour tracking period. If the participant's account of travels during the deployment periods differed from routes documented in the GPS records, the researcher queried and recorded details about any discrepancies.

Testing for substances of abuse. As part of the consent procedure prior to conducting the interviews, study participants were informed that they would be asked to provide urine specimens for substance use testing. Urine samples were collected before and after GPS unit deployment using a rapid drug screen device (Instant Technologies, iCup®, Norfolk, VA) that immediate test results for the presence of marijuana, amphetamine, methamphetamine, methylenedioxymethamphetamine (MDMA), phencyclidine (PCP), cocaine, and opiates. The researcher immediately discarded the sample following collection and analysis without implementation of chain of evidence, to protect participants' privacy. Alcohol was not formally tested in urine screening, but for participants with an obvious odor of alcohol on their breath and observed indications of intoxication (e.g., slurred speech), the researcher made a notation in the record that the participant was positive for alcohol.

GPS tracking instrument. The GPS device used in this study is a 4 ½" x 1 ¼" x ¾" Trackstick model unit that can be clipped on a belt or carried in a backpack and is powered by two AAA batteries. The tracking device was selected for its recording capability, durability, memory capacity, simplistic design, and reasonable price (approximately $200). In particular, a GPS device without additional functions such as cellular telephone was sought to make the device less desirable to steal and thus reduce the likelihood of loss of devices in the field. While a live tracker that feeds information to the researcher in real time

would have been more advantageous to the study, cost constraints necessitated use of a less expensive device that records to itself with data that can be downloaded in person to the researcher at the completion of the deployment.

To map its position, the GPS device used in this study requires an initial stationary period of fifteen minutes with an unobstructed view of the sky. The device collects GPS location data at an adjustable rate that can be set to range from as often as every five seconds to as infrequently as every fifteen minutes. The device has two power mode settings. The high-power ("slow track") mode registers data points at a fixed adjustable rate with a range of settings varying from once every one to fifteen minutes. The low-power ("fast track") mode registers data points at a set initial rate of every fifteen seconds, but then the device automatically adjusts its rate to the rate of movement of the device (i.e., the device records data points more frequently as the rate of movement increases). On this low-power setting, the device automatically powers off when there is no satellite signal, such as when the device is inside a building after a specified duration (and this duration can be pre-set; alternatively, the device's default duration is five minutes).

Data Preparation and Management

Data reported from each participant in the pre and post-tracking interviews were coded and recorded in a Microsoft Access database. Recordings from the GPS device were downloaded from the device to a laptop computer using

Trackstick Manager 3.1.1 (Telespial Systems) and stored as *.tsf files (one for each participant's deployment). Data from the approximately 24-hour tracking period for each participant were exported from Trackstick Manager as individual *.kmz files to Google™ Earth (Google™ Inc.) to create spatial maps displaying the recorded travels of each participant's deployment for inspection by the researcher and the participant. Figure 1 illustrates the image seen of a participant's travels recorded by the GPS device. Google™ Earth displays the routes taken by the participant overlaid on a map of the area as well as speed and locations of signals sent from the device at various locations and times. A horizontal toggle in the left upper corner of the map allows the user to drag the toggle across time, and the map shows corresponding progress along the route taken as well as the time, speed, and direction. The demarcations on the left side of the screen provide information about individual tracks of the individual travel file, and these display stops, stop durations, and corresponding record numbers and times.

The data were also imported into ArcGIS version 9.3 (ESRI, Redlands, CA), a software system that enables the creation of study-specific databases that contain layers of environmental features of interest (e.g., land utilization, public transportation) and GPS data. To do this, the Trackstick Manager *.tsf files (one for each participant's deployment) were first converted into *.csv files and then opened within a Microsoft Excel environment for data cleaning that involved revision of variable names to make them recognizable by ArcGIS by removing

spaces in the names. The cleaned *.csv files were then imported into ArcMap 10, a program within ArcGIS that allows the user to view, edit, create, and analyze geospatial data, explore data within a data set, and create maps. In ArcMap 10, the data were converted into ESRI (Environmental Systems Research Institute) shapefile formats using ArcGIS software. After conversion of the data into shapefile formats, the researcher changed the names of the "longitude" and "latitude" variables in each participant's tracking data file respectively to "X" and "Y" as required for plotting in the ArcMap program, (see Figure 2).

For this project, shapefiles of local public transportation lines (e.g., roads, railroads, water ways), land use, buildings, and pedestrian walkways were obtained for the geographic area being studied. These shapefiles were also uploaded into ArcMap 10, providing a background layer with a map of the area showing roads, businesses, and land use, all viewable underneath the layer of tracking data imported into the program as described above. Once this was accomplished, the researcher separately edited each one of the participant data files in ArcMap to correct for drift in the recorded GPS data. This was done manually with inspection of each recorded data point and dragging the point to the obvious route taken by the individual. (For example, missing or inaccurate data points may result in a visual path that is implausible, such as through a body of water or a building. In cases such as this, the data point last recorded before the path deviated through the implausible structure was dragged forward on the

route to display the actual path taken.) Geographic computation of distances between all data points in the tracking files was calculated by ArcGIS. The cleaned data for each participant's deployment with the distance calculations were saved into revised shapefiles which the researcher converted into *.csv files within ArcMap. The *.csv files were then imported into SAS 9.2 ((SAS Institute Inc, Cary, NC) for data analysis.

Data from both the pre-tracking interview and the post-tracking interview representing-self-reported locations of travels planned and travels taken respectively were mapped in Google™ Earth and saved as *.kmz files. Total reported distances planned and traveled respectively were calculating by summation of distances to all destinations. The routes in the maps created from the post-tracking interviews were visually inspected and compared with the recorded travel routes in ArcMap to identify discrepancies between reported travels and actual travels. Information from post-tracking interviews about locations visited by participants was used to organize the recorded data into segments defined by distances between destinations. Additional self-report data for each destination (e.g., purpose of travel and means of travel) were applied to corresponding travel segments in this manner.

For four participants, visual inspection of the recorded travels compared to verbal reports of travels during deployment revealed that on occasion the timer on the device was turned on before the device acquired its satellite positions, and the

individual traveled a distance not registered by the device while the timer was running and the device was not recording locations. This resulted in the appearance of distances traveled with no time elapsed. To adjust for this problem, using the participant's self-reported information on travels and circumstances during that time, it was possible to extrapolate the amount of time taken by the participant to travel that distance. This extrapolated time was substituted for zero time for those distances traveled when this problem occurred.

Statistical Analysis

Descriptive statistics were generated for all study variables with results for categorical variables presented as raw numbers, percentages, and for numerical variables as means with standard deviations, median values, and the range of values. T-tests were performed for prediction of continuous variables from dichotomous variables, using Satterthwaite analysis for cases of unequal variances. A paired t-test was performed for comparison of individuals' mean predicted and recorded deployment mileages. Level of significance was set at alpha $\leq .05$.

CHAPTER FOUR

Results

Experience in the Field Leading to Refinement of Procedures

During the course of the data collection for this study, a total of 29 participants deployed with the tracking device. Of these, 14 returned the GPS device with at least 20 hours of recorded data and 15 others returned the device with less than 20 hours of recorded data. Six of these 15 declined to re-deploy or were lost to the study and were considered study dropouts, and nine re-deployed for a second 24-hour period. Six of the nine who re-deployed successfully returned the GPS device with 20 or more hours of data and three returned with less than 20 hours of recorded data and declined to re-deploy again. Those who never succeeded in returning a GPS device with at least 20 hours of data were considered study non-completers. In all, 20 participants returned the GPS device after a deployment with at least 20 hours of recorded data each.

No devices were lost during this pilot study. One device, however, was damaged when a participant took the GPS device into the shower, leading to permanent device malfunctioning and data loss on that deployment and the next (when the discovery of the damage to the device was made). To prevent similar incidents, an additional instruction was added to avoid contact of the device with water, and no further devices were damaged.

Further development of methods to conduct studies to track homeless populations was an aim of this pilot study, and therefore the description of experience in the field to refine the methods is presented as part of the results of this study. Numerous unexpected complications occurred as the devices were deployed with the study participants. Of the first eight participants deployed with the device, only one returned with more than 20 hours of recorded data.

The first two participants to be deployed were friends, and they were deployed with the GPS devices at approximately the same time on the same day (i.e., one right after the other). One of the two appeared for the post-deployment appointment at the agreed time and place to return the device and complete the post-deployment procedures, and the other forgot but two days later met with the researcher to return the device and complete the study post-deployment procedures after being reminded by his case worker. Examination of the data recorded by these first two devices deployed was conducted at a later time in the research offices. The recorded time on both of these devices was less than two hours, and the batteries were drained in both devices, and the participants could not be reached to ask them about any problems or issues they experienced in deploying with the devices. After much discussion of the researcher with team members about possible reasons for the failure of the device to provide sufficient data, it was discovered that the spent batteries returned with the devices were not the same brand of battery that was originally deployed with the devices. It was

surmised that both participants had replaced the new batteries with depleted batteries so that they could use the batteries for their own purposes or sell them. A new procedural stipulation was made to the protocol that the participant must return with at least 20 hours of recorded data and the original pair of the batteries still in the device in order to be considered a study completer. Participants were given their batteries to keep if there was any power left in them. Once participants received this instruction as part of their pre-deployment information, no further incidents of replaced batteries occurred during this study.

Of the next six deployments, only one returned with more than 20 hours of recorded data. Inspection of the recordings revealed that all five of these next six deployments had spent the night in a large overnight shelter in which the device could not acquire satellite positions, and repeated efforts of the device to reconnect with satellites and repeated auto-powering off by the device drained the batteries during the night. This prompted further exploration of battery life using different settings of the device. Systematic experiments to optimize the settings revealed that use of the high-power ("slow track") setting would preserve sufficient battery power to last 24 hours, the precision of the recorded data was insufficient for the study's needs. Therefore, it was elected to continue with the low-power ("fast track") setting and deploy participants with a second set of fresh batteries with instructions for replacing them in the morning. Additionally during these deployments it was found that participants deployed inside a building did

not attain connection of the GPS device with satellite positions, and repeated efforts by the device to seek satellites drained the batteries quickly, and thus no recordings were obtained on these deployments. Therefore, all subsequent participants were instructed to initiate deployment with a 15-minute calibration period outside with an unobstructed view of the sky. With these new changes in the protocol, most subsequent deployments yielded more than 20 hours of recorded data, except for a very few deployments by participants who forgot to change the batteries in the morning. Once all the above adjustments were made to the research protocol, only 4 out of the subsequent 21 participants deployed did not return at least 20 hours of recorded data by the end of the study (an 81% success rate).

It turned out, however, that one participant who turned in a device with more than 20 hours of recorded time on it had only 0.14 mile of travel distance over 47 hours and 42 minutes during which time she reported that she traveled distances that totaled 40.46 miles. Inspection of her Google™ Earth recording revealed that she had traveled about one block from the night shelter to the day center at the beginning of the deployment and then no further travel after that over the next 47-plus hours. It was surmised that the participant had left the device in her backpack and the day center while she proceeded with the rest of her travels. When she returned the device, the batteries were not yet drained of power. The recording reflected an instance of the device powering off and then later

repowering for an extended amount of time, suggesting that she had replaced the batteries at that time. This was the last participant deployed in this study.

The experience gained from this deployment was that the methods must include inspection of travels taken as well as total deployment time displayed on the recording, as this deployment demonstrated that it is possible to return unusable travel data despite having a sufficient duration of recording. This participant's GPS data could not be used as part of the analyses for this study. Therefore the total number of participants with usable data was 19.

The interviews for this study were further field tested as part of this project. One specific adjustment made to these interviews was to add specified categories for reasons for travel to specific destinations. These were developed after examining the data from all the participant interviews. These revised instruments are provided as a product of this project in Appendix A and B.

Findings from Individual Travels

Each of the participant's travel files provided a glimpse into this individual's daily life, highlighting the struggles and barriers to services encountered by homeless individuals trying to conduct their daily business. A striking example is the travel record of participant #8812. When asked to predict her travels in advance, she estimated she would travel about 13 miles. Her predicted travels with intended destinations are mapped in Figure 3. Table 3 provides detailed information about each destination and calculated distance

between each anticipated location. This woman actually traveled more than 36 miles (recorded on the GPS unit during her deployment of approximately 26 hours), far exceeding her predicted mileage. Her recorded travels are displayed in Figure 4. When asked to describe in systematic detail the routes she had traveled, the participant revealed that one of her unplanned journeys involved a 7.3-mile excursion beyond her anticipated travel in pursuit of repairing her eyeglasses, only to find that the eyeglass repair place was closed.

Descriptive Data

The sample represented a heterogeneous group with regard to gender, ethnicity, age, education, marital status, and history of homelessness. Tables 4 and 5 display selected demographic information for the sample of 19 individuals with sufficient tracking data. The sample was more than two-thirds female and nearly three-fourths African American. Average age was in nearly 40. Nearly one-third of the participants had less than a high school education, 42% completed high school, or a Graduate Equivalency Degree (GED), and more than one-fourth had an educational degree past high school. More than one-fourth of the participants were gainfully employed, nearly one-half were currently unemployed, and more than one-fourth were disabled. The main source of income over the past year was from earnings or employment, but additional sources of income included welfare, recycling, handouts, and panhandling. The

large majority had been incarcerated, and more than one-fourth had been in prison; more than one-third were convicted felons.

The large majority (84.2%, n=16) of study participants had experienced a previous episode of homelessness, and 42.1% (n=8) had been homeless at least two other times in the last three years. Table 5 lists other characteristics of the sample's homeless experience. Most of the participants said that they had stayed in a shelter the previous night; other locations included a hotel and unsheltered settings. When asked to identify the reason for becoming homeless, the most commonly cited reason was related to lack of money and unemployment, and others noted family/relationship issues or dislike of their housing situation; none cited alcohol or drug or other mental health problems.

Table 6 shows self-reported use of substances in the last six months and in the last month and post-deployment urine test results. Alcohol was the most commonly used substance; 10% or fewer reported use of other substances. Two individuals had positive post-deployment urine substance tests, one with both cannabis and cocaine and one with cannabis only. Two individuals had positive pre-deployment urine substance tests, both for cannabis; one of the two also had a positive post-deployment urine test. Two individuals had the physical appearance of having used alcohol, and both of these individuals reported that they had been drinking.

Table 7 displays selected travel variables including total distance travelled, predicted travel distance, reported travel distance, and duration of deployment. The average mileages predicted at the pre-tracking interview, recorded from actual travel, and reported at the post-tracking interview were similar ($p>.05$ in t-test comparisons of all pairs of the three variables), around eight to eleven miles. The highest recorded distance was 36 miles. Before the researcher included times that the GPS unit did not attain satellite position, the average number of recorded time was approximately 27.3 hours. Upon examination of individual data points and recalculation of total deployment time, the participants provided an average of 27.7 hours of recorded data from the GPS device. Participants (n=18) reported that in these travels they visited a mean (SD) of 7.56 (4.53) and a median of eight destinations with a maximum of 16. Table 8 shows the average number of destinations by each means of travel and by reported purpose of travel to the destinations, based on self-reported information provided in the post-tracking interview. The most common method of travel was by walking, followed by bus; few destinations were reached by driving or riding with a friend. No individuals traveled by train, handicapped services, or hitch-hiking. The most commonly visited destinations were for the purposes of eating, sleeping, personal tasks, and "hanging out."

Hypothesis Testing

Hypothesis One. Participants will overestimate the mileage they will cover during their deployment period compared to the mileage recorded on the GPS device. A paired t-test analysis revealed that the difference between the mean predicted mileage and the mean recorded mileage (see Table 7) for the deployment were not significantly different (t=0.21, df=18, p=.834).

Hypothesis Two. Compared to the participants who test negative for substances after their deployment, those who test positive will travel significantly more miles. The two participants with positive post-deployment urine tests traveled mean=7.87, SD=10.89 miles and the 17 with negative post-deployment urine tests traveled mean=9.16, SD=11.22 miles during deployment, a nonsignificant difference (t=0.15, df=17, p=.879).

Hypothesis Three. Participants who are younger than 30 years old will travel significantly farther than participants who are 30 years old and older. The 15 participants who were age 30 or above traveled mean=8.93, SD=11.94 miles during deployment, compared to the four participants under age 30, who traveled mean=9.38, SD=6.78 miles, a nonsignificant difference (t=0.07, df=17, p=.943). (To further test the association with age and miles traveled with maximal statistical power, a dichotomized age variable at the median value of 39 was compared with miles traveled, and this also yielded a nonsignificant difference, p=.540).

CHAPTER FIVE

Discussion

The need for methods to track difficult-to-follow populations, in particular homeless individuals, has been underscored by researchers for decades (Bale, Cabrera, & Brown, 1977; (Bale, Arnoldussen, & Quittner, 1984; Wright, 1993). Self-report and agency-reported tracking methods have been useful in creating overviews of homeless individuals' movements, but have been unable to capture important details of travels, such as movement velocity, precise travel routes, and time spent at each destination. The advance of GPS technology provides a unique method to investigate elusive populations' movements. The goals of this pilot study were therefore to utilize this new GPS technology to demonstrate its feasibility in tracking homeless individuals and to develop replicable methods of recording movements of these individuals through space and time. Both objectives were accomplished over the course of the study.

Knowledge Gained from This Study

Methodological advances.

The study not unexpectedly encountered many methodological difficulties necessitating trouble-shooting and refinement of the methods. Eight deployments were completed before sufficient tracking data could be consistently obtained. Some of the problems encountered during this early part of the study involved technical issues with the device. These problems were drainage of batteries

caused by GPS device settings that used excessive power, need to calibrate the device's fix on satellites outdoors with an unobstructed view of the sky for up to 15 minutes at the start of the deployment, and insufficient battery life of no longer than about 24 hours. Other problems encountered were related to human behavior, including theft of batteries, forgetting to reload batteries on the second day, water damage to the GPS device, and failure to meet the interviewer for the post-tracking appointment. A problem that was anticipated but did not occur was theft or loss of the GPS devices. On the positive side, several participants were also willing to re-deploy after failing to provide sufficient study on their initial deployment. None of the participants expressed concerns or worries about, or demonstrated resistance to, their travel being recorded.

The last set of problems encountered was related to mastering the GPS and GIS software. These issues included uploading the data from the GPS device, learning how to read and understand the travel records, and mastering the settings to optimize recording quality and balance level of quality against drainage of batteries. Additionally, the researcher had to convert recorded travel data to different formats for inspection and data analysis, master the ArcGIS program, and correct obvious problems with drift of the recorded paths taken into impossible locations.

Modifications were made to the methods in efforts to prevent or correct the problems encountered in the field. The problems with insufficient battery life

were resolved by using optimal settings on the GPS device to preserve battery life, providing additional instructions to participants for calibration of satellite positions at the beginning of the deployment, and providing a fresh set of batteries to be placed into the GPS device-on the second day. Human-related obstacles to gathering GPS data were resolved by providing participants additional opportunities to deploy and return with sufficient data to obtain the incentive. The complete methods for this tracking study, including the modifications arising from experience of this study, are preserved in the research manual in Appendix C.

Travel characteristics of homeless people.

The travel characteristics of the homeless individuals recorded in this study's data are illustrated with considerable variation in distances traveled, number of destinations, means of travel, and purposes of travels. Research participants visited eight destinations and traveled nine miles on average, and the majority of these travels were on foot. Their main reasons for travel were to eat and to sleep. Actual recorded distances traveled were not significantly different from reported distances traveled or from predicted distances, indicating that self report of travel may provide meaningful data although not as precise as actual measurement of travels.

Individual travel records illustrated the kinds of obstacles that homeless individuals face on a daily basis in trying to conduct their business. For example,

records of one participant revealed that she had taken an unplanned 7-mile side trip on public transportation for the specific purpose of having her eyeglasses repaired, only to find that the service was closed. This particular example demonstrates potential frustrations and unrewarding efforts that homeless individuals may encounter on a daily basis. It further illustrates the potential for geospatial research on movements of homeless people in space and time to inform the development and placement of services at places and times that are most accessible to homeless populations.

Methodological Strengths

This is the first known study to utilize GPS technology in research on tracking of homeless populations. It pioneered the use of the device under the conditions in the field and collected meaningful research data that can be successfully examined in GIS formats and analyzed as a SAS database for such purposes as depiction of descriptive data and hypothesis testing. Solutions were identified for problems of premature battery drainage, accuracy of recorded travel data, and human behaviors among a homeless population. Methods were developed and refined to create a research manual for the conduct of future studies. Although none of the study hypotheses generating statistically significant findings, the study demonstrated that tracking data relevant to questions of interest can be successfully collected, processed, and analyzed.

The demographic characteristics of the sample were similar to those found in other studies (North & Smith, 1993; North, Eyrich-Garg, Pollio, & Thirthalli, 2009) with predominantly African-American participants who average 41 years of age. These characteristics of the sample are very similar to findings of homeless populations nationwide reported by HUD (2007). This suggests that at least in terms of age and race, this sample was representative of more general homeless populations.

Methodological Limitations

There were several limitations to this pilot study with the most obvious being the small sample size. The sample size was, however, appropriate for a pilot study designed to pioneer an innovative new technology such as this in a difficult-to-study population. The sample size of this study was small; therefore the power of the study was small. Because the participants were hand-selected for likelihood of reliability, the sample may not be representative of other homeless populations in important ways other than race and age. Studies of more representative homeless populations might encounter more difficulties in conducting the research, e.g., loss of devices, inability to gather sufficient data, etc. Even though the study's sample was representative of more general homeless samples from epidemiologic studies in terms of race and education, other characteristics (e.g. sex and substance use) were not. The geographical area

where the study was conducted may not be representative of all places where homeless populations travel.

Limitations of the methodology of this study that remain even after refinements were made based on this study's experience in the field relate to the GPS device used. Studies with more resources may be able to utilize devices with more powerful characteristics, such as ability to transfer data in real time to the researchers while the participant is in the field, greater precision of recording, additional features such as accelerometers and devices that can transmit signals through obstructions, longer battery life, and greater durability (such as being waterproof). Geospatial databases describing a greater variety of environmental attributes (e.g., crime locations, census data, zoning areas, and service locations) could also be added to future projects to address limitations in amount of available environmental data in this study.

Implications for Service Delivery

The results from this pilot study suggest the potential benefits for GPS technology to improve service access and identify geospatial barriers to care beyond currently available methodologies. Geospatial barriers include lack of public transportation to and from service locations, lengthy routes between necessary services, and travels through dangerous neighbors in efforts-to access services. When GPS data is layered on top of a GIS database, researchers can examine potential pitfalls of service placements.

The combination of GPS data with self-report data captures more elements of an individual's travels than self report alone, which is prone to forgetting, errors, and misrepresentations of locations. GPS technology overcomes-many potential errors of self reporting.

Future Research Directions

Results from this study point to several directions for future research. The methods developed in this thesis can be used in other studies of homeless individuals for examining distances to services, placing services in ideal locations (i.e., placing services where people travel and avoiding potential pitfalls such as placing substance abuse services in a location where its users must cross a city park where people commonly use drugs), and comparing movement patterns in different settings to inform optimal placement of services. An ideal result from understanding homeless individuals' travels in different locales is the ability of service providers to tailor service sites and timing of service availability to particular environments and the timing of travels of service users.

The study participants' willingness and apparent interest in joining the study also provided evidence of the feasibility of these types of studies. This result may assure researchers who have apprehensions about study participants' receptions to novel technology, such as GPS devices. As evidenced throughout this project, tracking and obtaining information concerning substance use and service utilization is not only feasible for homeless individuals, but it may also be

a powerful tool for informing effective placement and timing of service provision for homeless populations.

Table 1.

Experimental Battery Life Testing

<u>High power</u> ("slow track") set for 1-minute intervals	
Indoors	12-14 hours
Outdoors	32-33 hours
<u>Low power</u> ("fast track") with 15-second intervals (auto-adjusting)	
Indoors	5-6 hours
Outdoors	10-12 hours

Table 2.

Time to Activate Device (Time to Acquire Satellite Positions)

High power ("slow track") set for 1-minute intervals	10 minutes
Low power ("fast track") using 15-second interval (auto-adjusting)	3 minutes

Table 3.

Pre-tracking Distance Prediction for Participant #8812 with Detailed Information about Each Destination the Participant Planned to Visit and the Distance between Each Location

Destination and Address	Distance in Miles from Previous Destination*
Room in the Inn 801 West First Street, Fort Worth, TX	3.700
Day Resource Center 1415 East Lancaster Avenue, Fort Worth, TX	3.000
Baylor Hospital 1400 8th Avenue, Fort Worth, TX	2.900
Union Gospel Mission 1331 East Lancaster Avenue, Fort Worth, TX	3.100
Day Resource Center 1415 East Lancaster Avenue, Fort Worth, TX	0.062
Presbyterian Night Shelter	0.100

2400 Cypress, Fort Worth, TX	
Union Gospel Mission 1331 East Lancaster Avenue, Fort Worth, TX	0.200
Day Resource Center 1415 East Lancaster Avenue, Fort Worth, TX	0.062
Total predicted	**13.124**

*Pre-Deployment calculations assume the participant left the Day Resource Center before arriving to the first destination listed above.

Table 4.

Demographic Characteristics of Participants

Variable	Percentage or Mean (SD)	N
Gender		
Male	31.6%	6
Female	68.4%	13
Age	39.9 (12.0)	20
	(median=39; range=20-59)	
18-30	21.1%	4
31-44	42.1%	8
≥45	36.8%	7
Ethnicity		
African American	73.7%	14
Caucasian	26.3%	5
Hispanic	0.0%	0
Other	0.0%	0
Education	11.6 (2.8)*	19
<12 years	31.6%	6
High school graduate	21.1%	4
G.E.D.	21.1%	4

Associate's degree	21.1%	4
Bachelor's Degree	5.3%	1
Employment		
Working for pay	26.3%	5
Unemployed	47.4%	9
Disabled	26.3%	5
Sources of income in last year**		
Earnings or employment	42.1%	8
Welfare	10.5%	2
Disability	0.0%	0
Recycling	26.3%	5
Handouts from family/friends	26.3%	5
Panhandling	10.5%	2
Legal history		
History of incarceration	78.9%	15
Prison incarceration history	26.3%	5
Convicted felon	36.8%	7

*Years of education is calculated as years of school with GED=12

**Numbers sum to more than 100% because multiple responses were allowed

Table 5.

Characteristics of Homeless Experience

	Percentage	N
Where spent last night		
Shelter	78.9%	15
Hotel	5.3%	1
Campsite	5.3%	1
Tent on street	5.3%	1
Declined to answer	5.3%	1
Reasons for homelessness*		
No money/job	63.2%	12
Family/relationship issues	21.1%	3
Did not like former housing situation	5.3%	1
Alcohol/drugs	0.0%	0
Mental health	0.0%	0
Physical health	0.0%	0
Other	26.3%	5
Unable to answer	5.3%	1

*Numbers sum to more than 100% because multiple responses were allowed

Table 6.

Baseline Substance Use by Self-Report (in Last Year) and Urine Drug Test

Substance	Self-reported use		Positive urine test
	In last 6 months % (n)	In last month % (n)	% (n)
Alcohol	52.6% (10)	21.1% (4)	--
Cocaine	10.5% (2)	5.3% (1)	5.6% (1)
Cannabis	10.5% (2)	5.3% (1)	5.6% (1)
Amphetamines	10.5% (2)	0.0% (0)	0.0% (0)
Benzodiazepines	5.3% (1)	5.3% (1)	--
MDMA	5.3% (1)	5.3% (1)	0.0% (0)
K2	5.3% (1)	5.3% (1)	--
Opiates	0.0% (0)	0.0% (0)	0.0% (0)
PCP	0.0% (0)	0.0% (0)	0.0% (0)

Table 7.

Travel Distances

Variables	Mean	SD	Median	Minimum	Maximum	N
Predicted travel distance	8.41	13.27	3	0.12	47.06	19
Recorded travel distance	9.02	10.89	5	0.05	36.43	19
Reported travel distance	10.58	12.45	8	0.20	45.00	18
Duration of recording (minutes)*	1659.63	384.09	1547	1200	2496	19

*Includes extrapolated durations for segments with missing duration data

Table 8.

Means and Purposes of Travel

	Number of destinations	
Means of travel	Mean (SD)	N
Walk	5.37 (3.53)	19
Bus	1.53 (1.81)	19
Ride from friend	0.11(0.46)	19
Drive	0.05 (0.23)	19
Self-reported reasons for visiting locations	Number of destinations Mean (SD)	N
Eat	2.78 (2.30)	19
Sleep	1.42 (1.22)	19
Personal task	1.42 (1.07)	19
Hang out	1.32 (1.92)	19
Shop	0.32 (0.75)	19
Socialize	0.21 (0.42)	19
Purchase cigarettes	0.16 (0.50)	19
Medical care	0.16 (0.37)	19
Drop off/collect belongings	0.11 (0.32)	19
Work	0.05 (0.23)	19

Use homeless service	0.05 (0.23)	19
Use drugs	0.05 (0.23)	19
Mental health care	0.05 (0.23)	19
Shower	0.05 (0.23)	19
Purchase alcohol	0.00 (0.00)	19
Smoke cigarettes	0.00 (0.00)	19
Education	0.00 (0.00)	19
Consume alcohol	0.00 (0.00)	19
Declined to answer	0.05 (0.23)	19

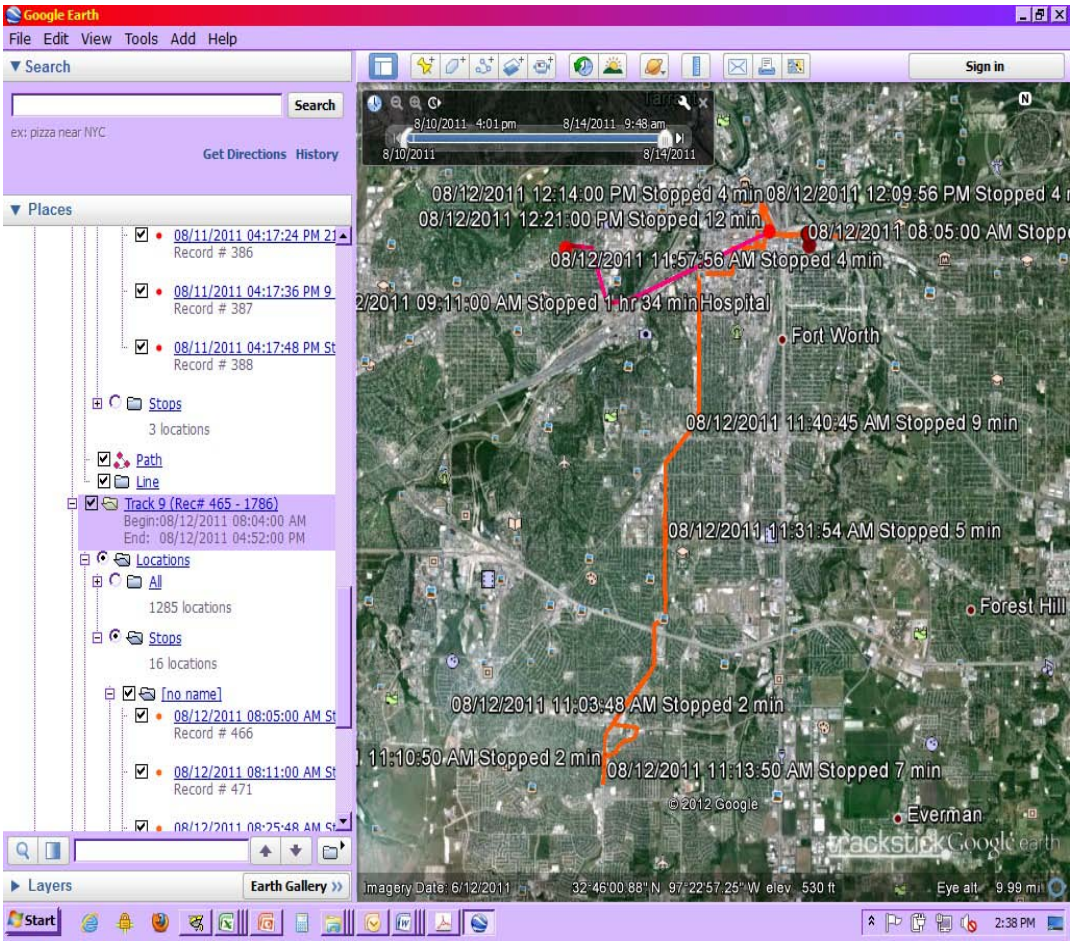

Figure 1. Example of a participant's recorded travels displayed in Google™ Earth (participant #8812).

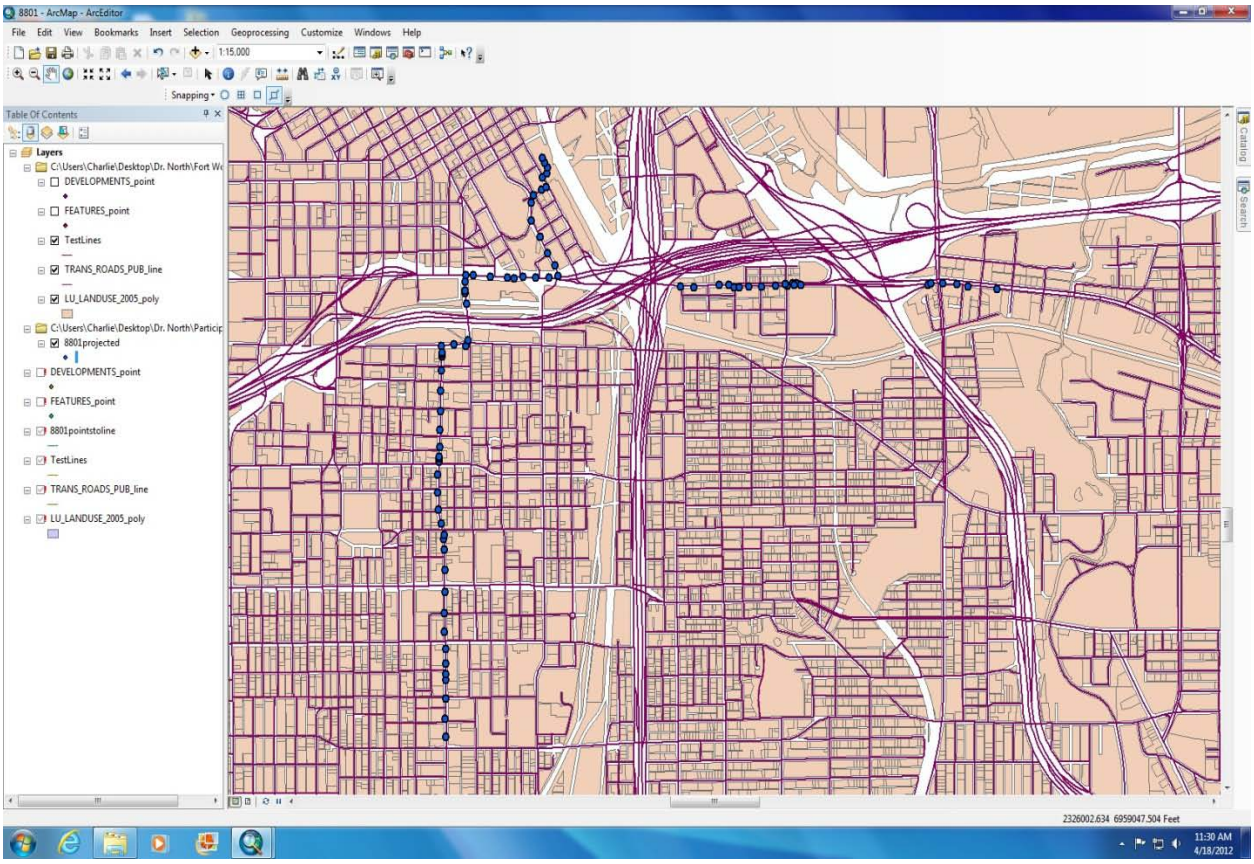

Figure 2. Example of a participant's travels displayed in ArcMap (participant #8801).

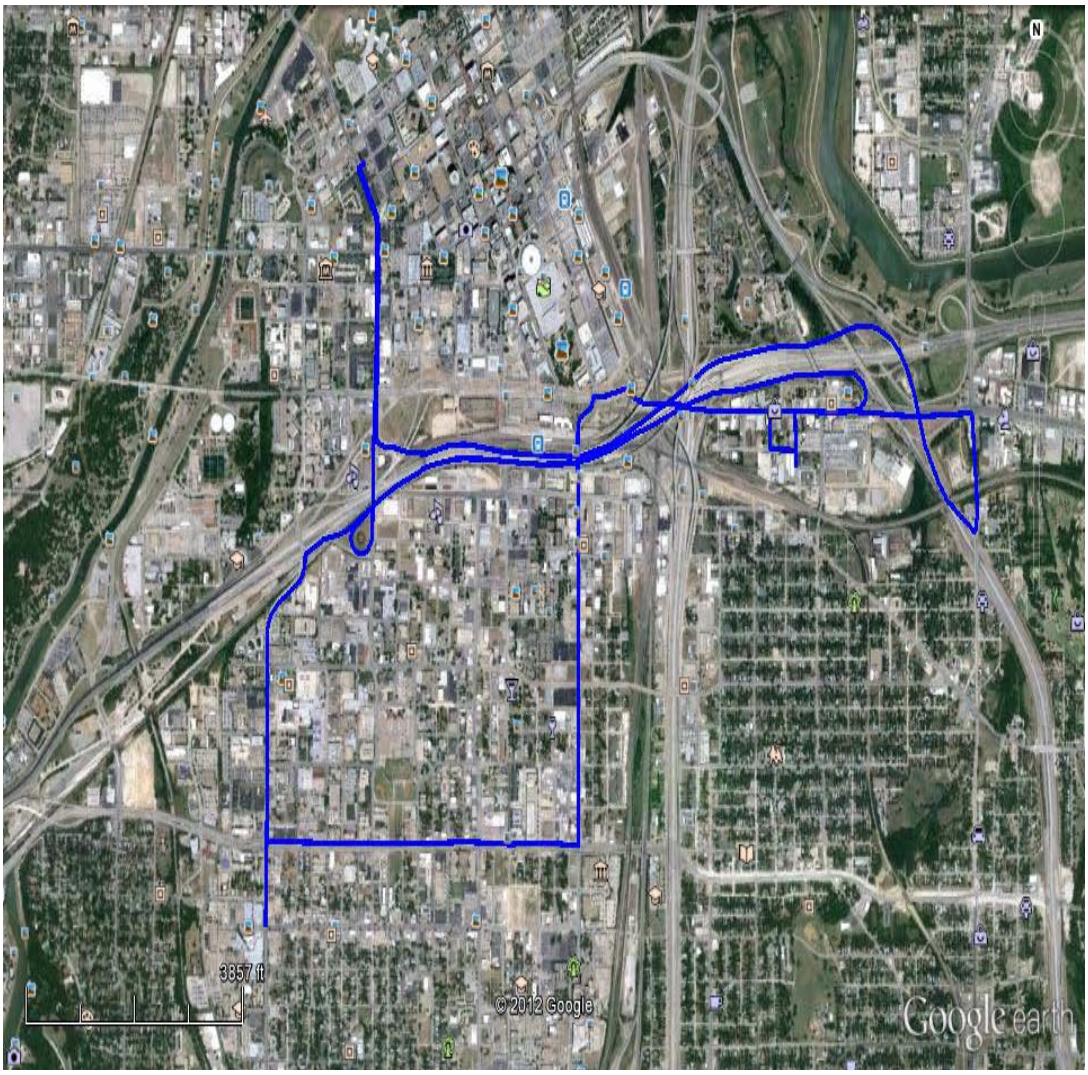

Figure 3. An individual's pre-deployment description of predicted travels overlaid on a Google™ map (participant #8812). The participant estimated that she would travel 13.12 miles in 48 hours.

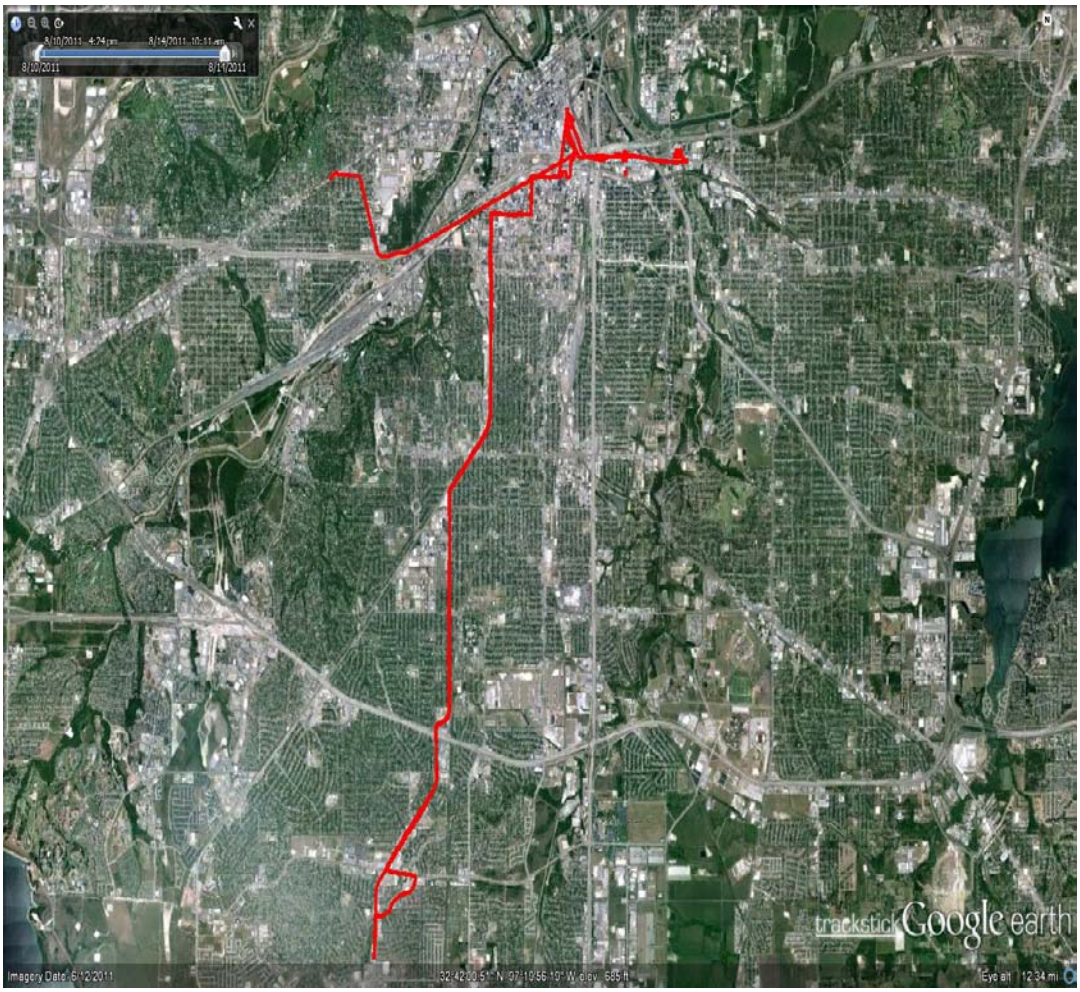

Figure 4. An individual's travels over the course of 26 hours and 49 minutes and 0 seconds (participant #8812). The total distance travelled in this deployment was 36.428972 miles. The participant stopped at 14 different locations.

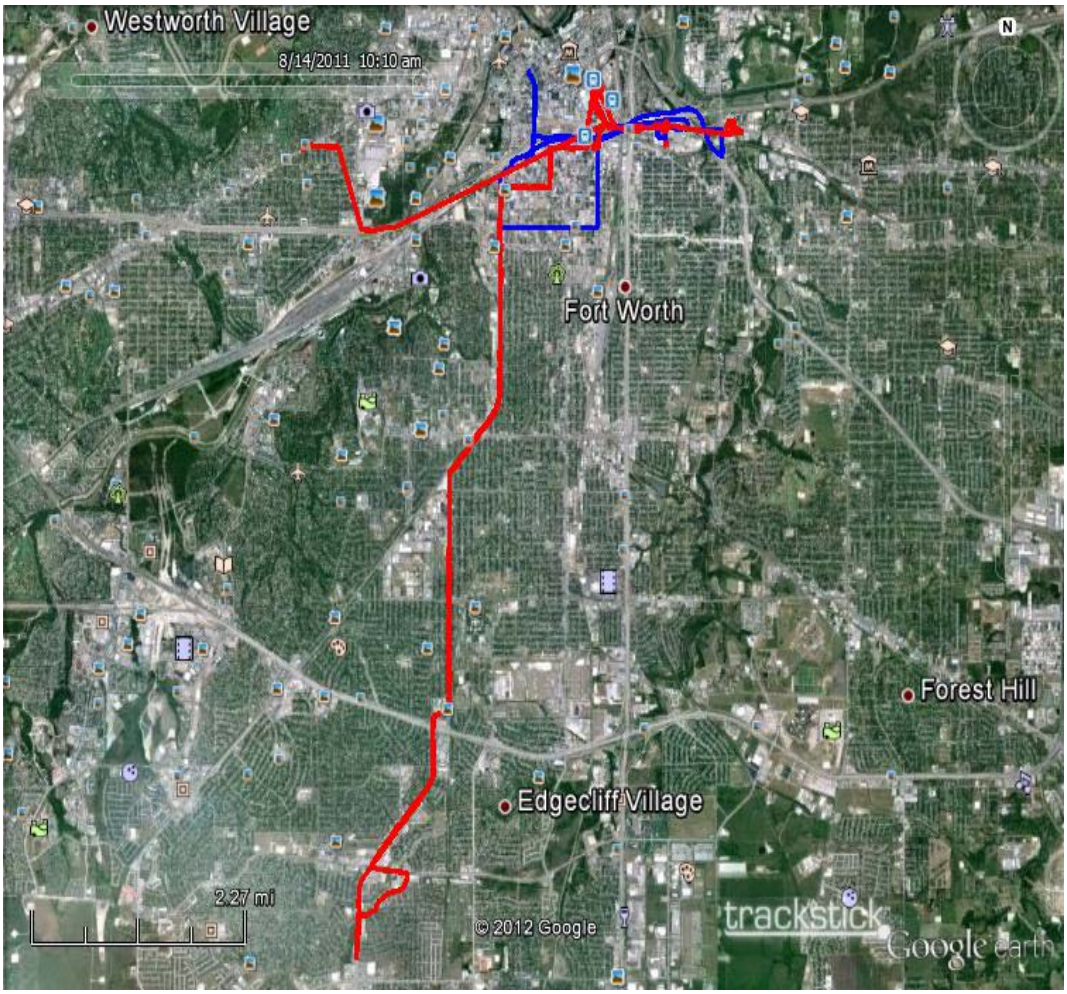

Figure 5. A participant's recorded paths (in red) overlaid on the individual's predicted travels (in blue).

APPENDIX A

Demographics Questionnaire

IDENTIFYING INFORMATION

1. Name:
First:_____ Middle:_____ Last:_____

2. Sex: __M __F __ Other, specify: _____

3. Race/ethnicity (check ALL that apply)
__ European/White
__ African Origin
__ Hispanic (if yes go to 3a)
__ Asian/Pacific Islander
__ Native American
__ Other, specify: _____

3a: If you are Hispanic, are you of
__ Mexican Origin, or __ other (specify) _____

4. Age: _____ **5.** DOB:_____ **6.** Phone:_____

CURRENT RESIDENCE

7. Where do you currently live? (Provide address or cross streets, even if living on the street.)
_____
_____
_____

8. What type of housing is it?
__ Shelter
__ Transitional Housing
__ Safe Haven
__ Own apartment or home
__ Family's home
__ Girlfriend or boyfriend's home

__ Hotel/motel
__ Drug and alcohol treatment center
__ Hospital (was it __ medical or __ mental health/psychiatric?)
__ Jail
__ On the streets with no stable residence (like in a car, abandoned building, park, etc)
__ Other (specify) _____

9. How long have you lived there? Days:_____ Months:_____ Years:_____

10. Who else lives with you? (check ALL that apply)
__ Husband/Wife
__ Sexual partner (not married)
__ Children
__ Parents
__ Other family
__ Friends
__ Alone
__ Sheltermates, hospitalmates, jailmates
__ Other, specify: _____

11. Is this your first time experiencing homelessness? __Yes __No

12. If no: How many times have you been homeless in the last 3 years? _____

13. How long has it been since you had a regular place of your own to stay?
Days:_____ Months:_____ Years:_____

14. Why did you move to your current location?

Check ALL that apply:		**Check which one is the MAIN reason**
☐	Couldn't afford previous housing lost job/income/benefits	☐
☐	Didn't like previous housing	☐
☐	Job opportunity	☐
☐	Relationship ended, abusive relationship, family conflict	☐
☐	Drugs and alcohol, Admitted to drug and alcohol treatment program	☐
☐	Incarcerated	☐
☐	Medical problem, Hospital admission/discharge	☐
☐	Mental health problem, psychiatric admission/discharge	☐
☐	Other, specify: _____	☐

15. How long do you intend to live at your current location?
Days_____ Months_____ Years_____

16. Do you have any family living in the area?

		If yes or no: Where do they currently live?
Mother?	☐ yes ☐ no ☐ don't know ☐ none ☐ deceased	
Father?	☐ yes ☐ no ☐ don't know ☐ none ☐ deceased	
Siblings?	☐ yes ☐ no ☐ don't know ☐ none ☐ deceased	
Children?	☐ yes ☐ no ☐ don't know ☐ none ☐ deceased	
Other?	☐ yes ☐ no ☐ don't know ☐ none ☐ deceased	

17. What friends or relatives have you visited in the last month? (Provide addresses or cross streets.)?

_____

_____

_____

_____

PRIOR RESIDENCE

18. Where did you live (including rehab facilities, prison, etc.) just prior to your current location? (Provide address or cross streets, even if living on the street.)

_____

_____

_____

_____

19. What type of housing was it?
__ Shelter
__ Transitional Housing
__ Safe Haven
__ Own apartment or home

__ Family's home
__ Girlfriend or boyfriend's home
__ Hotel/motel
__ Drug and alcohol treatment center
__ Hospital (was it __ medical or __ mental health/psychiatric?)
__ Jail
__ On the streets with no stable residence (like in a car, abandoned building, park, etc)
__ Other (specify) _____

20. When did you live there? (For how long?)
From (MM/DD/YYYY)_____ to (MM/DD/YYYY)_____

21. Who else lived there? (check ALL that apply)
__ Husband/Wife
__ Sexual partner (not married)
__ Children
__ Parents
__ Other family
__ Friends
__ Alone
__ Sheltermates, hospitalmates, jailmates
__ Other (specify) _____

22. Why did you move from there?

Check ALL that apply:		**Check which one is the MAIN reason**
☐	Couldn't afford it, lost job/income/benefits	☐
☐	Didn't like it there	☐
☐	Job opportunity	☐
☐	Relationship ended, abusive relationship, family conflict	☐
☐	Drugs and alcohol, Admitted to drug and alcohol treatment program	☐
☐	Incarcerated	☐
☐	Medical problem, Hospital admission/discharge	☐
☐	Mental health problem, psychiatric admission/discharge	☐
☐	Other, specify: _____	☐

LAST STABLE HOUSING

23. Where was the last full address that you owned or helped pay rent for at least 6 months?

_____
_____
_____

24. What type of housing was it?
__ Own apartment or home
__ Family's home
__ Girlfriend or boyfriend's home

__ Hotel/motel
__ Shelter
__ Drug and alcohol treatment center
__ Hospital (was it __ medical or __ mental health/psychiatric?)
__ Jail
__ On the streets with no stable residence (like in a car, abandoned building, park, etc)
__ Other (specify) _____

25. When did you live at this stable address? (For how long?)
From (MM/DD/YYYY)_____ to (MM/DD/YYYY)_____

26. Why did you move from this stable address?

Check ALL that apply:		**Check which one is the MAIN reason**
☐	Couldn't afford it, lost job/income/benefits	☐
☐	Didn't like it there	☐
☐	Job opportunity	☐
☐	Relationship ended, abusive relationship, family conflict	☐
☐	Drugs and alcohol, Admitted to drug and alcohol treatment program	☐
☐	Incarcerated	☐
☐	Medical problem, Hospital admission/discharge	☐
☐	Mental health problem, psychiatric admission/discharge	☐
☐	Other, specify: _____	☐

CHILDHOOD RESIDENCE

27. Where did you grow up (before age 18)?

Check ALL that apply:		**Check which one is the MAIN one**
☐	Rural area	☐
☐	Small town	☐
☐	Suburb	☐
☐	City	☐
☐	Moved around a lot	☐
☐	Other, specify: _____	☐

28. What states did you live in before age 18? CIRCLE the MAIN one.

_____

_____

_____

29. If Texas is the main state, what was the MAIN city?

_____

30. How many years have you lived in the DFW area? _____

TRANSPORTATION

31. Do you have a valid driver's license? __Yes __No

32. Do you have an automobile available for your use? __Yes __No

33. What means of transportation have you used in the last month?

Check ALL that apply:		**Check which one is the MAIN method**
☐	Driving yourself	☐
☐	Get a ride from somebody I know	☐
☐	Walking	☐
☐	Bus	☐
☐	Train	☐
☐	Handi-ride	☐
☐	Hitchhiking	☐
☐	Other, specify: _____	☐

34. Do you have any problems getting where you need or want to go these days? __Yes __No

35. If yes, what problem are you having getting where you need or want to go?

Check ALL that apply:		**Check which one is the MAIN problem**
☐	Don't have enough money	☐
☐	Don't know my way around	☐
☐	Physical disability	☐
☐	Mental disability	☐
☐	Transportation not handicapped accessible	☐

☐	Lack of motivation/energy	☐
☐	Worried about safety of possessions while unattended	☐
☐	Other, specify: _____	☐

EDUCATION

36. What is the highest grade of school you completed? _____

37. Did you ever receive a GED? __Yes __No

38. Highest degree:
__ High school/GED
__ Associates degree
__ Bachelors degree
__ Masters degree
__ Doctorate
__ None

39. Do you have a profession, trade, or skill (i.e. an employable and transferable skill acquired through specialized training or education)? __Yes __No
(If yes, specify:
_____

VETERAN STATUS

40. Have you ever served in the US military? __Yes __No If NO, then SKIP this section.

41. What branch:
__ Army
__ Air Force
__ Navy
__ Marines
__ Coast Guard
__ National Guard
__ Other, specify: _____

42. Are you currently serving in the US military? __Yes __No

43. Highest rank: _____

44. Type of discharge and year?
_____

LEGAL STATUS

45. Have you been convicted of a felony? __ Yes __ No

46. Are you currently on probation or parole? __Yes __No

47. How many times have you been to prison (not jail)? _____

48. How much time have you ever spent in jail or prison? _____

EMPLOYMENT & FINANCES

49. What is your current employment situation? Are you:

☐	working now for pay?	**If yes:** is the work: ☐ part time ☐ full time ☐ temporary/irregular work/day labor
☐	working for room/board?	
☐	unemployed	**If yes:** are you looking for work? ☐ yes ☐ no
☐	retired?	
☐	disabled?	
☐	a homemaker?	
☐	a student?	
☐	Other	**If yes:** specify: _____

50. If working: How many hours a week do you work on your main job? _____

51. If working: How much money do you receive per month from any work you might do? [If R is reluctant to answer this section, remind him/her that the information is confidential. Round up to the nearest dollar.] $_____/month

52. If unemployed: What are the reasons you are now unemployed?

Check ALL that apply:		**Check which one is the MAIN reason**
☐	Looking but can't find a job	☐
☐	Don't want/need a job	☐
☐	Physical disability, health	☐
☐	Mental disability, mental health	☐
☐	Criminal history	☐
☐	Don't have ID	☐
☐	Immigration status	☐
☐	Other, specify: _____	☐

53. What were your sources of income during the past year, such as work, benefits, even illegal activities?

Check ALL that apply:			**Check which one is the MAIN source**
☐	job		☐
☐	SSDI	**If yes**: Is the covered disability ☐ physical ☐ mental ☐ both	☐
☐	SSI	**If yes:** Is the covered disability ☐ physical ☐ mental ☐ both	☐
☐	VA Disability	**If yes:** Is the covered disability ☐ physical ☐ mental ☐ both	☐
☐	Pensions	**If yes:** Is it ☐ Social Security ☐ VA	☐

		☐ other, specify:_____	
☐	Handouts from family/friends		☐
☐	Panhandling		☐
☐	Recycling/scavenging (cans, scrap metal, etc)		☐
☐	Gambling		☐
☐	Selling drugs		☐
☐	Sex trade		☐
☐	Stealing		☐
☐	Other, specify: _____		☐

54. For the MAIN source checked above, how much do you receive per month? Round up to the nearest dollar. $_____/month

55. What is the TOTAL amount you receive per month? Round up to the nearest dollar. $_____/month

56. Do receive any health benefits, such as:
__Medicare
__Medicaid
__VA
__Public/county health system
__Private health insurance
__Other, specify: _____

57. Do you have a valid driver's license or state ID? __ Yes __No

HEALTH

58. Have you gotten care for a medical problem (e.g., surgery, heart problems, diabetes, blood pressure, HIV/AIDS, paralysis, colds, flu, etc; do not include mental health/psychiatric problems or problems caused *ONLY* by alcohol or drugs)?

In the: **READ LIST**

Last 6 mo?	**If yes: Last month?**	
☐ yes ☐ no	☐ yes ☐ no	Emergency Room
☐ yes ☐ no	☐ yes ☐ no	Admission/overnight stay in a hospital (do not include being in the emergency room overnight)
☐ yes ☐ no	☐ yes ☐ no	Outpatient doctor or clinic
☐ yes ☐ no	☐ yes ☐ no	Called 911/taken by police or ambulance
☐ yes ☐ no	☐ yes ☐ no	Other, specify: _____

59. Do your health problems limit you in doing things that most people your age are able to do?
__ Yes __ No

60. If yes, how?

Check ALL that apply:		**Check which one is the MAIN problem**
☐	Mobility?	☐
☐	Lifting?	☐
☐	Fatigue, feeling tired?	☐

☐	Cognitive functioning?	☐
☐	Problems with your emotions or nerves?	
☐	Other, specify: _____	☐

61. Do you use an assistive device, such as wheelchair, walker, prosthesis, etc.)? __Yes __No

If yes, specify device: _____

62. Do you need such a device but are unable to obtain one? __ Yes __ No

If yes, why are you unable to obtain it?_____

PSYCHIATRIC TREATMENT

63. Have you gotten care specifically for your emotions, nerves, or mental health (don't include hospitalizations medical illness only or problems caused alcohol or drugs only)?

In the: **READ LIST**

Last 6 mo?	**If yes: Last month?**	
☐ yes ☐ no	☐ yes ☐ no	Emergency Room
☐ yes ☐ no	☐ yes ☐ no	Admission/overnight stay in a hospital (do not include being in the emergency room overnight)
☐ yes ☐ no	☐ yes ☐ no	Outpatient doctor or clinic
☐ yes ☐ no	☐ yes ☐ no	Called 911/taken by police or ambulance
☐ yes ☐ no	☐ yes ☐ no	Other, specify: _____

64. Have you used any of the following substances? **READ LIST**

Last 6 mo?	**If yes: Last month?**		**If yes to any, which is substance of choice?**
☐ yes ☐ no	☐ yes ☐ no	Alcohol	☐
☐ yes ☐ no	☐ yes ☐ no	Cocaine/Crack	☐
☐ yes ☐ no	☐ yes ☐ no	Methamphetamine	☐
☐ yes ☐ no	☐ yes ☐ no	Marijuana	☐
☐ yes ☐ no	☐ yes ☐ no	Opiates/Heroin	☐
☐ yes ☐ no	☐ yes ☐ no	Benzodiazepines (Xanax, Valium, etc)	☐
☐ yes ☐ no	☐ yes ☐ no	Other, specify: _____	☐

65. Have you received treatment specifically for a problem with using too much alcohol or drugs? In the : **READ LIST**

Last 6 mo?	**If yes: Last month?**	
☐ yes ☐ no	☐ yes ☐ no	Emergency Room
☐ yes ☐ no	☐ yes ☐ no	Admission/overnight stay in a hospital (do not include being in the emergency room overnight)
☐ yes ☐ no	☐ yes ☐ no	Outpatient doctor or clinic
☐ yes ☐ no	☐ yes ☐ no	Called 911/taken by police or ambulance
☐ yes ☐ no	☐ yes ☐ no	Detox
☐ yes ☐ no	☐ yes ☐ no	Rehab program (do not include AA/NA/support group)
☐ yes ☐ no	☐ yes ☐ no	AA/NA meetings, other support groups
☐ yes ☐ no	☐ yes ☐ no	Other, specify: _____

SERVICE USE

66. Have you used any of the following services? **READ LIST**

Last 6 mo?	**If yes: Last month?**	
☐ yes ☐ no	☐ yes ☐ no	Employment/Vocational Rehabilitation Services (for example: Goodwill Industries, Project WISH, Division of Rehabilitation Services)
☐ yes ☐ no	☐ yes ☐ no	Education Services
☐ yes ☐ no	☐ yes ☐ no	Shelter (for example: Day Resource Center, Presbyterian Night Shelter, Safe Haven, Union Gospel Mission, Salvation Army, Emergency Youth Shelter, Arlington Life Shelter)
☐ yes ☐ no	☐ yes ☐ no	Long Term/Transitional Housing Services (for example: FW Housing Authority, Samaritan House, SIMON Program)
☐ yes ☐ no	☐ yes ☐ no	Case Management (for example: Texas Re-Entry Services, Lighthouse Services, Cornerstone Comprehensive Care, VA)
☐ yes ☐ no	☐ yes ☐ no	Food Services (for example: Beautiful Feet, Broadway Baptist, First Street Methodist Mission, Presbyterian Night Shelter, Salvation Army, Union Gospel Mission)
☐ yes ☐ no	☐ yes ☐ no	Clothing Services
☐ yes ☐ no	☐ yes ☐ no	Domestic Violence Services (for example: Open Arms, Safe Haven)
☐ yes ☐ no	☐ yes ☐ no	Legal Services (for example: Legal Aid)
☐ yes ☐ no	☐ yes ☐ no	Other, specify: _____

67. What needed services are you unable to access now, and why?

		If yes: ask why?
☐	Employment/ Vocational Rehabilitation Services	
☐	Education Services	
☐	Shelter	
☐	Long Term/Transitional Housing Services	
☐	Case Management	
☐	Food Services	
☐	Clothing Services	
☐	Domestic Violence Services	
☐	Legal Services	
☐	Medical Services	
☐	Mental Health/Psychiatric Services	
☐	Substance Abuse Services	
☐	Dental Services	
☐	Other, specify: _____	

NEXT: PROCEED TO PRE AND POST-TRACKING INTERVIEWS

APPENDIX B

Pre-Tracking and Post-Tracking Interviews

Pre-Tracking Interview: Ask when handing out the tracker BEFORE the FIRST 24-hour tracking period.

I'm going to ask you some questions about your daily activities. Remember that what you tell me will be used for the research only and not shared with any of the shelter staff and the information will be recorded by a number and not by your name.

A1. Where do you usually hang out in the daytime?

Check ALL that apply:			**Check which one is the MAIN place**
☐	At my job, working, day labor		☐
☐	Day Resource Center		☐
☐	Library		☐
☐	Labor hall		☐
☐	Clubhouse or day center other than the Day Resource Center)		☐
☐	Riding public transportation		☐
☐	Somebody's house or apt	**If yes:** Whose:_____ ___ Cross-streets: _____	☐
☐	Street	**If yes:**	☐

		cross-streets____________________________	
☐	Other, specify: ____		☐

A2. Do you hang out with anyone in particular? ____ Yes ____ No

If so, who?____

A3. Have you left the East Lancaster area in the last 24 hours? ___ Yes ___ No

A4. Now I'm going to ask you some questions about how you plan to spend the next 24 hours. (Use continuation pages if necessary)

For each destination	**Destination 1**	**Destination 2**	**Destination 3**	**Destination 4**
Where do you plan to go?				
How will you get there? Check ALL that apply. Circle the MAIN one.	☐ Drive myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: _______________	☐ Drive myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: _______________	☐ Drive myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: _______________	☐ Drive myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: _______________
What are you going to do there?	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/pick up belongings ☐ Buy alcohol	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/pick up belongings ☐ Buy alcohol	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/pick up belongings ☐ Buy alcohol	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/pick up belongings ☐ Buy alcohol

	☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer

Post-Tracking Interview 1: Ask when the tracker is returned AFTER the FIRST 24-hour tracking period.

B1. Now I would like to ask you some questions about what you did after you received the tracker. (Use continuation pages if necessary)

For each destination	**Destination 1**	**Destination 2**	**Destination 3**	**Destination 4**
Where did you go?				
How did you get there? Check ALL that apply. Circle the MAIN one.	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ________________	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ________________	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ________________	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ________________
Why did you go there?	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer
Did you accomplish what you	☐ Yes ☐ No Explain:	☐ Yes ☐ No Explain:	☐ Yes ☐ No Explain:	☐ Yes ☐ No Explain:

went there to do?				

B2. Now I'd like to ask you some questions about what you did when you were out.

Did you use any alcohol or drugs?		**If YES to any:**		
		When?	**Where?**	**How much?**
☐ yes ☐ no	Alcohol			
☐ yes ☐ no	Cocaine/Crack			
☐ yes ☐ no	Methamphetamine			
☐ yes ☐ no	Marijuana			
☐ yes ☐ no	Opiates/Heroin			
☐ yes ☐ no	Benzodiazepines			
☐ yes ☐ no	Other, specify:			

B3. Where did you stay the night last night?

_____

_____

B4. . Did you change your behavior/where you went because you had the tracker with you?

Yes ___ No

If so, how?

_____

_____

Post-Tracking Interview 2: Ask when the tracker is returned AFTER the FIRST 24-hour tracking period.

C1. Now I would like to ask you some questions about what you did after you received the tracker. (Use continuation pages if necessary)

For each destination	Destination 1	Destination 2	Destination 3	Destination 4
Where did you go?				
How did you get there? Check ALL that apply. Circle the MAIN one.	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: _______________	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: _______________	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: _______________ ___	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: _______________ __
Why did you go there?	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer

Did you accomplish what you went there to do?	☐ Yes ☐ No Explain:	☐ Yes ☐ No Explain:	☐ Yes ☐ No Explain:	☐ Yes ☐ No Explain:

C2. Now I'd like to ask you some questions about what you did when you were out.

Did you use any alcohol or drugs?		**If YES to any:**		
		When?	**Where?**	**How much?**
☐ yes ☐ no	Alcohol			
☐ yes ☐ no	Cocaine/Crack			
☐ yes ☐ no	Methamphetamine			
☐ yes ☐ no	Marijuana			
☐ yes ☐ no	Opiates/Heroin			
☐ yes ☐ no	Benzodiazepines			
☐ yes ☐ no	Other, specify:			

C3. Where did you stay the night last night?

_____

_____

C4. Did you change your behavior/where you went because you had the tracker with you? ___ Yes ___ No

If so, how?

_____

CONTINUATION PAGES

Pre-Tracking Interview Continuation Pages

For each destination	Destination ___	Destination ___	Destination ___	Destination ___
Where do you plan to go?				
How will you get there? Check ALL that apply. Circle the MAIN one.	☐ Drive myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ______________	☐ Drive myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ______________	☐ Drive myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ______________	☐ Drive myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ______________
What are you going to do there?	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer

Post-Tracking Continuation Pages: Check ONE: ☐ Post-tracking Interview 1 ☐ Post-tracking Interview 2

For each destination	**Destination ___**	**Destination ___**	**Destination ___**	**Destination __**
Where did you go?				
How did you get there? Check ALL that apply. Circle the MAIN one.	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ______________	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: _____________	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ______________	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ______________
Why did you go there?	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer

Did you accomplish what you went there to do?	☐ Yes ☐ No Explain:	☐ Yes ☐ No Explain:	☐ Yes ☐ No Explain:	☐ Yes ☐ No Explain:

Post-Tracking Continuation Pages: Check ONE: ☐ Post-tracking Interview 1 ☐ Post-tracking Interview 2

For each destination	**Destination ___**	**Destination ___**	**Destination ___**	**Destination ___**
Where did you go?				
How did you get there? Check ALL that apply. Circle the MAIN one.	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ______________	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ______________	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ______________	☐ Drove myself ☐ Ride from friend ☐ Walking ☐ Bus ☐ Train ☐ Handi-ride ☐ Hitchhiking ☐ Other, specify: ______________
Why did you go there?	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer	☐ Eat a meal ☐ Sleep ☐ Hangout ☐ Personal task ☐ Socialize ☐ Work ☐ Drop off/ pick up belongings ☐ Buy alcohol ☐ Buy cigarettes ☐ Shop ☐ Homeless services ☐ Use drugs ☐ Drink ☐ Mental health care ☐ Medical care ☐ Smoke ☐ Shower ☐ Education ☐ Declined to answer

Did you accomplish what you went there to do?	☐ Yes ☐ No Explain:	☐ Yes ☐ No Explain:	☐ Yes ☐ No Explain:	☐ Yes ☐ No Explain:

Appendix C

A MANUAL FOR TRACKING THE MOVEMENTS OF HOMELESS INDIVIDUALS ACROSS SPACE AND TIME USING GPS TECHNOLOGY

TABLE OF CONTENTS

Introduction

This manual provides detailed instructions for conducting a Global Positioning System (GPS) study to track the movements of homeless individuals across space and time. It will explain the steps required to successfully deploy GPS tracking devices, retrieve the geospatial data from the tracking device, and format the data for analysis.

Procedures

The major procedures are obtaining baseline information and the individual's plans for geographical movements during the deployment period and a urine sample; deployment of the GPS tracking device; recovery of the GPS device and inspecting its data; obtaining post-tracking information about geographical movements that occurred and substances used during deployment of the device; and collecting a post-deployment urine sample.

The following materials should be brought by the investigator to a pre-deployment meeting with one participant:

- Two consent forms (one for the participant and one for the assistant)
- Two copies of the HIPAA authorization forms
- Pre/post-tracking interview forms
- One GPS tracking device with one pair of additional batteries
- One urine test cup.

The following materials should be brought by the investigator to a post-deployment meeting with one participant:

- Pre/post-tracking interview forms
- One urine test cup
- One pair of additional batteries (in case of need for re-deployment)
- The incentive payment.

Internet access must be secured for examination of the data on Google™ Earth when the participant brings the data back at the end of the deployment period.

Pre-deployment procedures. These activities include conducting a pre-tracking interview, obtaining a urine sample, instructing the participant on optimal use of the GPS device, and making arrangements to retrieve the device and its data.

It is possible for one investigator to deploy two participants with a GPS device one after another on the same morning. The first participant is enrolled at approximately 8:00 a.m., and following approximately 90 minutes of pre-deployment activities the participant is deployed at approximately 9:30 a.m. Another participant may be enrolled at approximately 9:30 a.m. and deployed by approximately 11:00 a.m. (These times will mean that the end of the deployment

period will be on the morning of the following day, approximately 24 hours later for this study.)

After the participant is enrolled into the study, a pre-tracking interview is conducted, which requires approximately 60 to 90 minutes. This interview obtains baseline information including demographic information, residential history, social networks, service use, sources of income, and medical and mental health history including substance use. The participant is then asked to describe detailed plans for geographical movements during the period of deployment of the GPS device, reasons for going to the planned locations (e.g., to use services, purchase items, meet with social contacts), and source of transportation to and from these locations.

The participant is asked to provide a urine specimen for testing of substances of abuse, in private, into a cup, without invoking chain of evidence procedures (to reduce participant concerns about potential legal consequences and thus facilitate participation in the urine sampling). The specimen is tested immediately for the presence of substances of abuse using a rapid drug screen procedure (Instant Technologies, iCup®, Norfolk, VA) that provides immediate test results for the presence of specific substances. The cup has test strips that come in contact with the urine and indicate the presence of specific substances and the temperature of the urine (to help ensure that the specimen is fresh urine, presumably of the participant). The results are viewed by removing a peel-off label on the outside of the cup that reveals the test results. The results are recorded and the urine sample can then be discarded. Substances tested are cannabinoids, amphetamine, methamphetamines, methylenedioxymethamphetamine (MDMA), phencyclidine (PCP), cocaine, and opiates.

The participant is provided with a replacement pair of batteries for the GPS device and instructed on optimal use of the GPS device during deployment. These instructions are:

1) Carry the GPS device with you during the entire deployment period.
2) Avoid turning the GPS device off and on.
3) Do not allow the GPS device to get wet. (Do not shower with it. Be careful not to drop it in the toilet.)
4) Do not place the GPS device adjacent to a cell phone (e.g., don't put them in the same pocket) because this can interfere with the ability of the device to connect with satellites to locate positions.
5) During the night, the GPS device will probably drain the batteries in it, and it will likely be dead in the morning. Replace the dead batteries in the device with the replacement batteries first thing in the morning. Then stand outside with the device to allow the device to orient to satellites and orient to location. When the green light begins to blink, the device will begin to track

geographical movements and is ready to use. (It may take up to 15 minutes or more for the device to find its position and the green light to begin blinking.)

The participant is informed that the deployment period is 24 hours. The participant is provided with a phone number to call in case there is need to contact the investigator. An appointment is set for a time and place to meet with the investigator for recovery of the GPS device and its data and post-deployment data collection. It is explained to the participant that when the device is returned at the end of the deployment period, it must contain at least 20 hours of tracking data (adding to the total the number of hours spent in a shelter when the device was unable to record position data as hours of tracking data, if it can be determined that the participant did spend these hours in the shelter). If the GPS device does not have the desired data, the participant will help the investigator trouble-shoot any problems in the use of the device by providing details of the deployment and what the participant observed, so that any problems encountered in the use of the device may be understood. It is explained that if sufficient tracking data do not result from the first deployment period, the participant will have additional opportunities to deploy with the GPS device to obtain sufficient tracking data and receive the incentive for completion of the study procedures.

Deployment. After receiving instructions about the GPS device and the upcoming deployment, the participant is escorted outside to allow the device to obtain satellite positions. The GPS device is turned on and the globe on the front of the device positioned toward the sky with no obstruction of the view to the sky by metal objects. The deployment period begins when the light on the GPS device begins blinking green.

Post-deployment procedures. At the end of the 24-hour deployment period, the participant and the investigator meet at the previously agreed upon time and place. The GPS device is retrieved from the participant and the participant is asked to provide another urine sample for substance testing. The urine is again tested immediately, the results recorded, and the sample discarded.

While the participant is providing the urine specimen in private, the investigator uploads the data on the GPS device to a laptop. Using an internet connection, the investigator views the data in a Google™ Earth software program for examination of the time records and routes travelled during the participant's deployment period. The participant is informed of how many hours and minutes of time were recorded on the GPS device. If the data are insufficient to satisfy the needs of the study, the participant is asked recount how the deployment went, if there were any difficulties in carrying the GPS device, and anything the participant noted about its use that may have affected the ability of the device to obtain the data. After this trouble-shooting discussion and provision of advice, if any, on how to modify the use of the GPS device to improve its ability to collect the data, the participant is invited to re-deploy with the device for another 24

hours in an effort to obtain sufficient study data and receive payment for completion of the study. Regardless of whether the data obtained from the deployment are sufficient to consider the participant successful in completion of the study, the investigator administers the post-tracking interview while viewing the deployment record on the laptop. The participant is asked to recount all the places traveled and the reasons for traveling there, methods of travel, what was accomplished at the destination, information about what substances were used, if any, where the participant spent the previous night, and if the participant changed any movement behavior because of carrying the GPS device. If the participant's account of travels during the deployment differ from the record viewed by the interviewer on the laptop, the participant is queried about the discrepant results and the findings are recorded. At the completion of the post-tracking survey, participants who have completed the study receive an incentive payment ($10 in this study).

Instructions for Use of the GPS Device

Trackstick II™ by Telespial Systems, Inc. is used by this study to record the geographic routes taken by participants. This 4 ½" x 1 ¼" x ¾" GPS device can be clipped onto a belt or carried in a backpack or purse or in a pocket. It is powered by two AAA batteries. The device has two power settings: high power ("slow track") and low power ("fast track"). The high power setting provides additional options for recording intervals ranging from fifteen seconds to fifteen minutes. The low power setting does not provide any options for recording intervals, and it is factory set at fifteen seconds.

A computer software program is required for selecting the settings on the GPS device and for downloading data from the GPS device to a computer to examine and process the data. Trackstick II uses Trackstick Manager software. (A laptop computer is optimal if the tracking study occurs in the field where computer portability is essential.) Trackstick Manager is free of charge and can be downloaded from the following website: http://www.worldtrackingsolutions.com/trackstick_utilities.htm. After successful installation of the software on the computer, the Trackstick device is plugged into the computer's USB port. Working batteries must be inserted into the Trackstick for it to be recognized by the software. The Trackstick device is plugged into the laptop and then the device is switched to the "on" position. A red light should appear on the Trackstick and the computer software program recognizes the device. The Trackstick Manager software then automatically syncs the Trackstick device with the computer software program to activate the Trackstick and allow it to communicate its data to the computer. The GPS device settings must be set through controls in the Trackstick Manager software on the

computer; there is no direct procedure for changing the settings on the Trackstick device itself.

The GPS device requires an unobstructed view of the sky to obtain satellite signals and calculate positions. Before first use of the device, it should be tested to ensure that satellite signals can be obtained and positions calculated.

Experimentation to determine variability of the GPS device for the purposes of this study was conducted using a version 2.2 Trackstick II GPS device left in a stationary location to determine the relative life of the batteries on different power settings and interval settings both indoors and outdoors. The device was also pre-deployed by the investigator to examine the accuracy of the recorded routes using the device's different power settings. The high power ("slow track") setting had less geographic accuracy, with more drift and deviation in recording the route taken, than the low power ("fast track") setting. The batteries lasted longer on the high power than on the low power setting. The batteries also lasted longer when the device was left outside with an unobstructed view of the sky than when it was left inside a building structure. Using two different devices, results of pre-study device testing of battery life were:

Experimental Battery Life Testing	
High power ("slow track") using 1-minute interval	
Indoors	12-14 hours
Outdoors	32-33 hours
Low power ("fast track") using fixed 15-second interval	
Indoors	5-6 hours
Outdoors	10-12 hours
Note: indoor testing was inside a multi-story university building; outdoor testing was on a second-floor balcony of a two-story building with an unobstructed view of sky	

Time to Activate Device (Time to Obtain Satellite Positions)	
High power ("slow track") using 1-minute interval	10 minutes
Low power ("fast track") using fixed 15-second interval	3 minutes

Based on these pre-study deployment experiments, it was determined that the most suitable setting for the device in the current study would be the low power ("fast track") mode on the fixed 15-second recording interval. The main advantage to this setting is better accuracy for recording positions and movements.

The batteries can be expected to last throughout the deployment day (Day 1) if the individual spends time outdoors. A fully charged pair of batteries is

placed in the device at the time of deployment (the morning of Day 1) and again approximately 24 hours later (first thing in the morning of Day 2 as the participant leaves the overnight shelter). This second pair of batteries should then last until the device is returned to the investigator later in the afternoon on Day 2. The first pair of batteries will undoubtedly be drained of power during the participant's stay in an overnight shelter (usually about 13 hours, beginning around 5:00 p.m.). Thus, the participant is instructed to replace the batteries with a fresh pair the next morning upon proceeding out of the overnight shelter to pursue the next day's activities. (If the recorded data show that the participant entered the shelter by nighttime and left the shelter the next morning and the participant reports having stayed the night in the shelter, then it is assumed for the purposes of the study that the participant's position remained at a single point within the shelter throughout the night until the recording of movement picks up the next morning, even after the recording stops when the batteries are drained of power. Of note, the nighttime record inside the shelter typically reveals about ten power off/on tracings either in rapid succession or spread over the course of a couple hours as the batteries are completely draining.)

In summary, the recording session begins when the device is deployed with the participant on the morning of Day 1 and ends when the participant returns at the end of the deployment with the device. To formally end the recording session on the device, the device must be connected to the Trackstick Manager program on the computer and the data cleared from the device. To do this, the Trackstick Manager "Settings" icon is selected, and underneath the "Memory" heading, the "Erase All" button is selected. (*Of course, the data file must be downloaded to the computer and saved on the hard drive prior to erasing the record on the device if the data file is to be preserved.*)

Downloading Recorded Data from the GPS Device to Computer

Plug the GPS Trackstick device into the computer's USB port. Open the Trackstick Manager. Select "Download Trackstick Data." A prompt then requests a name to save the data file in a folder (which will be saved into a default directory created by the program on the computer, or a different directory can be specified by the user). The file is saved as a "Trackstick File" (*.tsf).

The Trackstick Manager can be programmed to automatically open the Trackstick Manager program and download the data file from the GPS device. In the Trackstick Manager program, select the "Options" icon, and under the "General" tab, below "Downloading," select "Prompt for download." Once the Trackstick Manager is programmed to open automatically for downloading, when the GPS device is first plugged into the computer, the Trackstick Manager program on the computer will automatically open and provide an option: "Trackstick detected. Do you want to download recorded locations?" Select

"Yes." A prompt then requests a name to save the data file in a folder (which will be saved into a default directory created by the program on the computer, or a different directory can be specified by the user). The file is saved as a "TrackStick File" (*.tsf).

If a new session of data recording is planned for the next use of the GPS device, then the data on the device must be cleared, otherwise the next recording will continue within the previous session rather than starting as a new session. Therefore, when recording is finished for a given participant, it is good practice to erase the data session from the GPS device's memory (*after, of course, the data file has been saved to computer*).

Viewing Downloaded Data in Trackstick Manager on the Computer

Recorded information is presented in Trackstick Manager in four different ways:

1. All: All data points are displayed in a grid that includes longitude and latitude positions, estimated velocities, and the satellite signal strengths.
2. Tracks: Successive data points ("records") indicating the locations recorded during the time interval from the time the GPS device is powered on until the time it is powered off in a recorded session are grouped into *tracks*. The Trackstick Manager calculates distance between recorded points by measuring the distance between each successive record in the track. Each session is stored as a single *.tsf data file.
3. Routes: Whenever the GPS device does not detect movement within a track, i.e., there were no detected changes in position for a specified period of time, it introduces a *stop* into the track. The data points between these stops are grouped by the program into *routes* representing movement between stops. (The amount of time of no movement that defines a stop can be set for the device using the Trackstick Manager in advance of deployment of the device.)
4. Dates: Data points are displayed according to the dates and times they were recorded.

When viewing data points in Trackstick Manager, different filtering options can be used to examine the data collected. Specific groups of records can be viewed by choosing different filtering options on the Trackstick Manager's menus. Once the filtering options are selected, "Update View" must be selected for the filter to be applied to the data.

Exporting Trackstick Data to Other Formats

The GPS data can be exported from Trackstick Manager and saved in different formats for use in other software programs using the following instructions:

- Open Trackstick Manager. Within the Trackstick Manager program, open the *.tsf Trackstick data file to be exported.
- Click the "Export to" icon at the top of the computer screen.
  - Everything contained within the data file will be exported unless filtering options are applied and "Update View" is selected, in which case only the selected records will be exported.
  - The format for the exported file must be selected from seven options provided on a drop-down menu in the export command. These options are: Google™ Earth fly-through (*.kmz), Google™ Earth timeline (*.kmz), Google™ Earth pushpins (*.kmz), Web Page (*.html), Rich Text Format (*.rtf), Comma Separated Value (*.csv), and GPS Exchange Format (*.gpx). More description of these formats is provided below.

Viewing Trackstick Data in Other Formats

Google™ Earth

Google™ Earth software can be used to display the *.kmz files to view Fly-Through, Timeline, and Pushpins data formats. Google™ Earth software may be downloaded free of charge from the website address www.earth.google.com. To view data within Google™ Earth, the Google™ Earth program is opened and then the *.kmz data files can be uploaded in Google™ Earth.

Google™ Earth *Fly-Through* (*.kmz) is the most direct and commonly used mode for viewing GPS data in Google™ Earth. The Fly-Through format displays a record of travels taken by the GPS device. The data are displayed as colored lines of travel. The colors may be selected by the user. The investigator can view a 3-D "virtual tour" of the travels taken by the GPS device. The virtual tour is started by selecting "Route" under the "Places" heading on the left side of the display and select the "Play" button. The program will then "fly" the viewer through the entire session from start to finish. The user can pause and re-start the action as desired by operating the Play-and-Pause button located across the bottom of the display.

Google™ Earth *Timeline* (*.kmz) displays travels in the form of dots for individual locations and lines between them, in an animated sequence operated by sliding a toggle on a timeline feature located in the upper left side of the display. The software can be programmed to display the time stamps at specific locations on the map.

Google™ Earth *Pushpins* (*.kmz) displays each record (i.e., each individual data point) saved during the session. Each record is represented with a "Pushpin," an icon resembling a push-pin type of thumb tack used to affix items to a bulletin board. This mode is well suited for viewing details of specific locations.

Other formats

HTML (HyperText Markup Language) files are formatted as *.html. This format permits media documents to be shared in different World Wide Web applications and allows users who do not have Google™ Earth installed on their computer to view the data images with an internet connection and to transfer data images that can be viewed by others.

Rich Text Format (*.rtf) provides a simple means to integrate recorded location data into Microsoft Word text file and a diverse array of programs for reading documents. Data included in these formats include dates and times, distances, power status, signal strength, velocity, direction of travel, links to points on Google™ maps, and details of latitude, longitude, and altitude for individual records.

Comma-Separated Values (*.csv) format is conducive to importing into spreadsheets such as Microsoft Excel. This format is used to import data into ArcGIS software through first opening it into a spreadsheet format which will then allow importation of the data into ArcGIS for further analysis. Variable names created by the Trackstick Manager require some modification to import correctly into ArcGIS. The *.csv format is particularly well suited in this process because of the ease of modification of variable names that it provides.

GPS Exchange Format (*.gpx) is a generic format that can be used by other programs besides Google™ Earth to read the GPS data. This format provides an avenue for computers, smartphones, and GPS devices to store and exchange GPS data.

Instructions for Processing and Cleaning Data in ArcGIS

Uploading GPS files into ArcGIS

1. Convert the GPS tracking data *.tsf file to a *.csv file using the Trackstick Manager software.
2. The *.csv file must be prepared for use in ArcGIS. To do this, open the *.csv file; the data are displayed in a Microsoft Excel spreadsheet. One of the columns in the spreadsheet is entitled “GPS fix.” Delete the space between “GPS” and “fix” in the title and re-save the file. This step must be completed before the *.csv file can be uploaded to ArcGIS.
3. Deploy ArcMap 10 (a program within ArcGIS) and click the tab labeled “File.” A drop-down menu will appear; select “Open” and then select “blank document.”
4. GPS tracking data maps can be overlaid onto topographical maps embedded with various types of data points, such as arrest data records, placement of bars and pawn shops, and locations of ambulance calls. These are created by importing datasets of various types of geographical entities such as streets, hospitals, businesses, and zip code boundaries with their geometric features (e.g., point, line, or polygon) and location data into a software program such

as ArcGIS to create data files (called *shapefiles*), from which the data can be overlaid onto topographical maps. Many shapefiles are available through academic, industry, private, and public websites that can be downloaded (often with a fee) for personal use. Commonly available shapefiles depict local public transportation lines (e.g., roads, railroads, water ways), land use, buildings, and pedestrian walkways, and can be obtained for the geographic area being studied. These shapefiles can be uploaded into ArcMap 10 by selecting the "Add Data" icon. A drop-down menu will appear with a list of the shapefiles available in the local directory of the computer. On the shapefiles menu, click all the shapefiles desired for viewing on a map and then click "OK." A background map of the area of interest, showing specific shapefiles, such as roads, businesses, and land use, will appear.

*Converting the *.csv tracking file into a shapefiles document*

5. In ArcMap 10, upload the GPS tracking data *.csv file by selecting the "Add Data" icon at the top of the screen. The name of the data file (*.csv) will appear in the left column and right-click on it and select "Display XY Data." A window will pop up with setting options. For the "X Field," select "Longitude," and for the "Y Field," select "Latitude." Leave the "Z Field" blank. At the bottom of the window, click "Edit," and another window labeled "Spatial Reference Properties" will open. Click on the "Select…" button. Select the "Geographic Coordinate Systems" folder then "North America" and finally "NAD1983.prj," which is the widely available topographical database that is distributed as part of ArcGIS software. Click "OK" and the data points should appear on the map.
6. A new file ending with "Events" will appear on the left side of the screen under the "Layers" folder. Right-click on the file and select "Data" and then "Export." A window will open and underneath "Output feature class" the participant's identifier number followed by .shp will appear. Select "OK," and then ArcGIS will export the *.csv file to a shapefile (*.shp) format.

Editing data points in ArcGIS

7. Once the file is displayed in a *.shp format, open the "ArcToolbox" (an icon at the top of the screen in the shape of a toolbox). Select "Data Management Tools," then "Projections and Transformations," then "Feature," and then "Project." A window labeled "Project" will open. In the field labeled "Input Dataset or Feature Class" select the *.shp file for the participant data file desired. In the "Output Dataset or Feature Class," select the folder for the participant's data file and type in the participant's identifier number followed by "projected" in the "Name" field. Select "Save." In the field labeled "Output Coordinate System," press the icon to the right of the blank field. This will open a window labeled "Spatial Reference Properties." Press "Select…," then "Geographic Coordinate Systems," then "North America,"

and finally "NAD1983.prj." Press "OK," and the participant's shapefile will be transformed into finally a projected file, which is a file that allows the data points in ArcGIS to be edited.

8. Remove all files except for the participant's projected shapefile and the shapefiles for the geographic area of interest that are labeled "TestLines," "Trans_Roads_Pub_line," and "LU_LANDUSE_2005_poly." To do this, right-click unnecessary files and select "Remove."
9. To begin editing the data points, click on the "Customize" option at the top of the screen, and under "Toolbars," select "Editor." A toolbar will appear in the top left corner of the map. Click on the "Editor" drop-down menu and select "Start Editing." Choose the projected shapefile on the pop-up window and select "OK."
10. Once the shapefile appears on the map click on a data point and drag it to the desired location. After editing the data points, click on the "Editor" drop-down menu located on the Editor toolbar and select "Stop Editing." A prompt will appear to save the edits; select "Save." The changes made to the file will be saved.

Calculating Distance in ArcMap

1. After the projected shapefile is edited, the data points need to be connected with lines in order to measure the participant's travelled distance. This is done by selecting the "ArcToolbox" icon at the top of the screen. Click on "Data Management Tools," then "Features," and then "Points to Line."
2. A window labeled "Points to Line" will open. In the "Input Features" display, select the edited shapefile. In the "Output Feature Class" display, type in the participant's identifier number followed by the word "lines." Select "OK" at the bottom of the window, and ArcMap will connect the data points in the shapefile, creating a continuous path of the participant's travels. After connecting the points, save the shapefile and add the word "line" to the name of the file before the ".shp".
3. To measure the distance of the path, right-click the participant's shapefile (which now ends with the word "line") located on the left side of the screen. A drop-down menu will appear. Select "Open Attributes Table;" a table with three variables will appear. Click on the first icon at the top of the screen, and a drop-down menu will appear. Select "Add Field." Another window will appear that prompts the user to enter a name and type of variable. Type "distance" for the name of the variable and select "Double" for the type of variable.
5. The "distance" variable will appear on the table. Right-click on "distance" and select "Calculate Geometry." A window will appear, and in the "units" field,

select “miles” and press “OK.” A number will appear below the “distance” variable: this is the measured length of the participant’s travels.

Cleaning and Preparing the Data for Inspection and Analysis

In ArcGIS, the edited shapefile must be converted to a *.csv file which can then be imported into Microsoft Excel. Right-click on the participant’s shapefile and navigate down the pop-up menu to “Data” and select “Export Data.” In the “Export Data” dialog box, choose a location for the file to be stored. When naming the file, ensure that there are no spaces in the name (underscores may be inserted to represent spaces if needed). Click “OK.” This will export the shapefile into a *.csv file.

In Microsoft Excel, open the edited *.csv file. Insert a column labeled “ID” at the left-hand side of the sheet. Below the label “ID” type the participant’s identifier number in the first cell of each row for all the records of each participant. This step is crucial for importing the GPS tracking data into statistical software. After the “ID” variable has been added to the file, edit the column labeled “Status.” Add a column to the right of “Status” and label it “StopMin.” This variable will represent the number of minutes of each stop duration. Highlight the entire Status column. Select the “Find & Select” icon located in the top right-hand corner of the screen. A drop-down menu will appear; select “Replace…” from the list of options. In the space entitled “Find what:”, type in “mph” and do not type anything in the blank space named “Replace with” (it should be empty). Transfer the number of stopped minutes (e.g., 12) listed in the “Status” column to the “StopMin” column. Replace the contents of the cells of the “Status” column that contained the word “stopped” with a 0.

Next, create the distance between data points using a formula to calculate the distance from latitude and longitude coordinates. The formula to do this in Microsoft Excel is:

=ACOS(COS(RADIANS(90-E3)) *COS(RADIANS(90-E4))
+SIN(RADIANS(90-E3)) *SIN(RADIANS(90-E4)) *COS(RADIANS(F3-F4)))
*3958.756

(The user may need to consult Microsoft Excel instructions if information is needed on how to administer formulas to the data.)

Once this formula is applied and all the distance calculations are completed, inspect the time
the Excel data file is now ready to import into a software analysis program such as SAS for analysis of the data.

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